CHAPTER VII
SUMMARY OF CONCLUSIONS

Irrigation has been an effective mean of countering the adverse effects of dry spells on the agricultural output and of increasing agricultural productivity. In India, expansion of surface irrigation, on a large scale, began during the British period in some selected areas such as Punjab, Doab of Western Uttar Pradesh, Narmada Valley in Gujarat and Godavari delta. However, concerted efforts for development of irrigation resources of the country were made only after the independence. Created irrigation potential of the country at the time of independence was about 22.6 million hectares. Irrigation potential of the country increased at the rate of about 0.7 million hectares per annum during the First Five Year Plan. Growth rate of the irrigation potential during Fifth and Sixth Five Year Plan period was about 1.6 and 2.2 million hectares per annum respectively. Seventh Five Year Plan had a target of creating an irrigation potential of about 2.5 million hectares per annum. At the end of the year 1988-89, created irrigation potential of the country was sufficient to irrigate about 76.36 million hectares of land. The 'ultimate irrigation potential' of the country is
estimated to be 113.5 million hectares. This target is expected to be achieved by 2010 A.D.

Despite the growth of irrigational facilities and attempt to introduce land reforms after independence, the agricultural sector was unable to meet the growing demand of the foodgrains and agricultural raw materials. Two consecutive droughts during mid sixties further showed the vulnerability of Indian agriculture to the vagaries of Monsoon and inadequacy of agricultural technology to mitigate adverse effects of weather on agricultural output. Post drought period in mid sixties witnessed the shift in the strategy of agricultural development whereby emphasis was laid on technological advancement rather than institutional reforms. This marked the introduction of package technology and beginning of the 'Green Revolution' in Indian agriculture. Irrigation was an integral component of the package technology along with HYV of seeds, chemical fertilizers and insecticides and pesticides. Infact, assured supply of soil moisture through irrigation was a launching pad of 'Green Revolution' as it has been successful in irrigated areas only. Irrigation has helped the agricultural development by ensuring sustained growth of the agricultural output and productivity, providing protection from the adverse effects of droughts and dryspells and maintaining stability in agricultural output.
The success of new strategy of agricultural development and the vital role of the irrigation in countering adverse effects of weather on agriculture further encouraged the irrigation planners to develop irrigational facilities in arid and semi-arid regions of the country. Indira Gandhi canal project is such an effort to transform the backward and subsistence agricultural economy in the arid land of northwestern Rajasthan. Indira Gandhi canal is one of the largest canal systems of the world and proposes to irrigate about 13.94 lakh hectares of land per annum. Culturable command area of the canal is estimated to be 15.42 lakh hectares which cuts across the Thar Desert of Western Rajasthan in the district of Ganganagar, Bikaner, Jaisalmer, Barmer, Jodhpur, Nagaur and Churu. This irrigation project was launched on March 31, 1958 and its construction has already been completed in Stage I and is in progress in Stage II. Command area of Stage I of the project lies in Ganganagar and Bikaner districts. Overall strategy of irrigation development in Indira Gandhi canal command area is to provide protective irrigation. However, the strategy of irrigation development is different in the command areas of two stages. In the command area of Stage I the strategy is to develop intensive irrigation with an irrigation intensity of 110 percent and water allowance of
5.23 cusecs, whereas extensive irrigation is the strategy of irrigation development in Stage II of the command area. The proposed irrigation intensity in this region is 80 percent with a water allowance of 3.5 cusecs.

Irrigation was introduced in the command area of Stage I in early sixties and the command area of Stage II in mid eighties. Construction of the canal network was completed in Stage I in early eighties while it is still in progress in Stage II. Expansion of the irrigation facilities in the command area of Stage I during early sixties to mid eighties has brought about a perceptible transformation in agricultural economy, environmental and socio-economic conditions of the people. Availability of assured water supply through surface irrigation has helped in change in the landuse pattern in favour of agriculture, intensification of cropping, shift in the cropping pattern in favour of high value crops, use of modern agricultural inputs such as HYV of seeds, chemical fertilizers and insecticides and pesticides and sustained growth in agricultural productivity and output. Allotment of the land and expansion of irrigation has also brought about perceptible change in the socio-economic conditions of the people in terms of relationship with means of production (land), change in the tenancy structure, increase in the employment opportunity and shift in the occupational
pattern, and large scale immigration and redistribution of population in the region. Besides a complete transformation of agricultural economy and the resultant change in the socio-economic conditions of the people, the introduction of irrigation has significantly influenced the physical environment of the region. Influence of irrigation on the environmental conditions of the region is bidirectional, both positive and negative. Positive impact of irrigation on environmental conditions of this region includes an attempt to restoration of ecological balance of already fragile environment through afforestation, pasture development and sand dune stabilisation. It has led to arresting wind erosion hazard and initiating structural change in the loose sandy soils. However, negative influence of the irrigation on environmental conditions is more pronounced and threatens to defeat the very purpose of introducing irrigation in the region. Introduction of intensive irrigation unmindful of the presence of strong salt regime and kankar pan on or near the surface of land has led to sharp rise in groundwater table, waterlogging and developing alkalinity and salinity in the soils. Objectives of the present study are (i) to evaluate the progress of irrigation development and its utilization in the command area of Stage I; (ii) to examine the influence of irrigation on subsoil water table, soil salinity and
alkalinity, structure of sandy soils and vegetal cover and restoration of ecological balance; (iii) to examine the influence of irrigation on agriculture i.e. landuse pattern, cropping pattern, use of modern agricultural inputs and levels of agricultural productivity; (iv) and to examine the process of land allotment and influence of irrigation expansion and land allotment on some parameters of socio-economic conditions of the people i.e. migration and redistribution of population, shift in the occupational pattern, change in the relationship of various sections of the society with means of production (land) and tenancy structure. Data used in the present study have been taken from secondary sources and were generated through primary survey. While primary data has been generated through a field survey in the command area of Stage I from four sample villages during the period December 1988 to March 1989. Secondary data has been collected from various departments of Indira Gandhi Canal Project, CAD, Bikaner.

Underutilisation of the medium and major irrigation project in the country has been a serious cause of concern because of precarious balance between the demand for irrigation and existing water resources in moisture deficient regions, as well as heavy financial investment in this public sector venture. At the end of the Fourth Five Year Plan only about 82 percent of the created irrigation
potential of medium and major irrigation projects was utilised. The situation was not very different in Indira Gandhi Canal command area too as about 89 percent of created irrigation potential was utilised in 1974. Fifth Five Year Plan took a comprehensive view of the situation arising out of the lag between created irrigation potential and its utilisation and the problems of soil and water management. It was realised that these problems can be overcome and optimum agricultural productivity from the irrigated land can be achieved only if an integrated area development approach is adopted towards the command areas of medium and major irrigation projects. This new approach towards irrigation development was termed as 'Command Area Development'. Heavy conveyance loss of water both above and below the outlet, intensive irrigation in upper parts of the command areas, shift in the cropping pattern in favour of water intensive crops and lack of modern infrastructural facilities are considered to be main reasons of under utilisation of irrigation potential of medium and major irrigation projects. Hence, the Fifth Five Year Plan maintained that Command Area Development (CAD) programme requires enforcing twofold efforts - (a) lining of field channels and water courses, and levelling and shaping the land, (b) fixing and enforcing suitable cropping pattern and developing infrastructural facilities to ensure supply of
modern agricultural inputs, credit and agricultural extension training and demonstration. Adopting of an integrated approach towards irrigation development was all the more necessary in the command area of Indira Gandhi canal because of (a) the lack of communication and infrastructural facilities, (b) sandy and sandy loam texture of the soils, undulating and sand dunes infested relief, presence of calcareous and clayey pan near the surface and severe wind hazard in absence of vegetal cover.

CAD programme in the Stage I command area of Indira Gandhi canal was introduced in July 1974. This programme has taken up the task of on-farm development which includes soil survey and planning, watercourse lining, land shaping and levelling; afforestation; pasture development and sand dune stabilisation; monitoring groundwater table; providing infrastructural facilities in newly colonised areas; and arranging for agricultural extension and training. However, the progress of the implementation of this programme has not been quite satisfactory particularly in terms of on-farm development which includes watercourse lining and land shaping and levelling. About 23.3 percent of the command area under Phase I of the programme was unlined after the completion of project in 1983. Phase II of CAD programme in the command area of Stage I was expected
to be completed in 1988. But only about 50 percent of the target of watercourse lining was completed at the end of year 1986-87. In 1980-81, the utilisation level of the created irrigation potential in the command area of fully lined watercourses was 122 percent, i.e. 22 percent more than that envisaged in the project. Contrary to this only about 75 percent of the created irrigation potential was utilised in the command areas of unlined and partially lined watercourses.

Distance from the head of the main canal, time lag involved in development of irrigational facilities, relief and soil texture also exert significant influence on the utilisation level of created irrigation potential. It generally declines from the head towards the tail in the command area of Stage I. Infact, the command areas of some irrigation systems located near the head of the main canal are irrigating more area than envisaged in the project. In the command areas of Rawatsar and Naurangdesar branches utilisation level of created irrigation potential was 125 percent and 148 percent respectively in 1986-87. Utilisation level of the created irrigation potential in upper command area of Stage I (command areas of all the irrigation systems taking off up to 74 Km. of the main canal) was about 114 percent. On the other hand, irrigation potential in the lower parts of the command area of Stage I
is grossly under utilised. Only about 37 percent of the created irrigation potential in the lower command area of Stage I (between 74 to 189 Km. of the main canal) was utilised. The irrigation intensity also exhibits spatial variation. In the upper command area of Stage I irrigation intensity is much higher than that stipulated in the irrigation project (110 percent). Irrigation intensity is very low in the command area of Stage I, below 74 Km. This underlines the fact that in the upper command area of Stage I not only the application of irrigation water per unit of cultivated land is higher than that envisaged in the project but also more area than that stipulated in the project is being irrigated. Indira Gandhi Canal Project has been designed to provide protective irrigation in northwestern Rajasthan. Over utilisation of irrigation resources in the upper command area of Stage I is not only contrary to the principle of protective irrigation and has possible implication of reduction in the water allowance and irrigated area in the lower command area but also runs the risk of creating the environmental problems like waterlogging and soil salinity. This may defeat the very purpose of the introduction of irrigation in this region, i.e., realising the optimum agricultural productivity, equitable distribution of its gains among the people and eco-development.
Besides, the absence of a strict control of the canal authorities over water distribution and consequent intensive and over utilisation of irrigation resources in the upper parts of the command area this irrigation project also has not taken the cognisance of adverse effects of irrigation on physical environment. Like other major and medium irrigation projects the guiding factors behind the execution of Indira Gandhi Canal Projects also have been economic and engineering viabilities. Though, the entire command area of Indira Gandhi canal has strong salt regime, calcareous and clayey pan near the surface, brackish subsoil water and very high rate of evapotranspiration. Providing canal irrigation without developing drainage facilities in such an area is bound to have adverse effects on the physical environment.

Ever since the introduction of canal irrigation in the command area of Stage I about three decades ago, groundwater table has risen sharply. Both primary and secondary informations regarding subsoil water table suggest such a situation. Rise in the water table is relatively higher in the upper parts of the command area in Hanumangarh and Tibi tehsils where intensity of irrigation is comparatively higher. As per informations provided by Commissioner, CAD, Bikaner rise in the water table during
the period 1970 to 1979 in the upper parts of the command area of Stage I was 1.7 metres per annum. Whereas it increased at the rate of about one metre per annum in the middle parts of the command area during this period of time. Information collected during the field survey revealed that level of groundwater table in upper parts of the command area of Stage I (village 9MND) increased at the rate of about 1.2 metres per annum after the introduction of canal irrigation. Rate of the increase in the water table in the middle and lower parts of the command area is found to be 70 to 80 centimeters per annum. In fact, the depth of groundwater in many parts of the upper command area of Stage I is less than 5 metres. Some low lying areas near the head of the main canal are permanently covered by a sheet of water. The fact that waterlogging has posed a serious threat in Indira Gandhi canal command area is also substantiated by the data provided by the project 'Monitoring of Water Table' of Groundwater Department. This project covers an area of about 8000 sq. Km. in the command area of Stage I and Ghaggar basin in Ganganagar district. Waterlogged or critical area (where depth of groundwater table is less than 6 metres) has expanded rapidly in the project area. In 1981 about 9 percent of the project area, located in two regions around Tibi (in upper part of the command area) and Baropal village (east of Suratgarh), was
identified to be critical area. Critical area had doubled within a period of five years. In 1986 critical area occupied about 18 percent of the project area including some new areas around Vijayanagar, east of Anupgarh. If the present rise in water table is not arrested immediately about 50 percent of the project area would have subsoil water table within the depth of 6 metres below surface by the turn of the 20th century. Although detailed informations regarding the groundwater table of lower parts of Stage I command area are not available, waterlogging problem in this region is expected to be further accentuated due to the impeded drainage, incidence of calcareous and clay-layer near the surface and sandy texture of soils.

Soil salinity is another widespread irrigation induced environmental hazard in the command area of Stage I of Indira Gandhi canal. Although, both irrigated and unirrigated soils are generally alkaline in reaction but the concentration of soluble salts is comparatively higher in irrigated soils. Among irrigated soils incidence of salinity is comparatively low in upper part of the command area of Stage I where watertable has risen rapidly following intensive irrigation. Incidence of soil salinity is comparatively higher in lower and middle parts of the command area. Infact proportion of number of soil samples
affected by extreme soil salinity and alkalinity (pH value 9 and above) is comparatively higher in Pugal, Chhatargarh and Anupgarh extension districts in the lower parts of the command area. Very high concentration of soluble salts in the irrigated land in interdunal depressions is clearly visible as one passes through this region. In the sample village Jagdevwala in Bikaner tehsil, soil alkalinity is quite high in an irrigated interdunal basin where pH of the soil has been recorded to be 8.8. This has forced the farmers to sow only cotton and some varieties of wheat which are salt resistant crops. Spatial variations in the incidence of soil salinity and alkalinity indicates the fact that the presence of strong salt regime and calcareous and clay pans near the surface are the main determinants in developing soil salinity rather than waterlogging in irrigated areas of the command area.

Contrary to aforementioned environmental degradation, introduction of irrigation through Indira Gandhi canal has also brought about positive impact on the fragile environment of western Rajasthan. Increase in the vegetal cover by means of cultivation, afforestation and pasture development programmes has set in the process of eco-development in the region. The difference between the structure of irrigated and unirrigated soils is evidently visible. Introduction of irrigation and repeated
application of water has led to compaction of loose sandy soils. Besides increase in crops and other vegetal cover and application of chemical fertilisers have helped in increase in humus and other soil nutrients; and consequent rise in the microbial activities associated with humification and soil decomposition. This has also helped in the improvement of soil structure. Resistance of irrigated sandy soils to wind erosion has also increased following the application of water and increase in vegetal cover. Wind erosion hazard in the region is also minimised following afforestation and pasture development under CAD programme in the command area of Stage I. More than one lakh hectares of land has been brought under afforestation under this programme in Stage I. About 60 percent of afforested area is meant for sand dune stabilisation and pasture development. Other forms of plantation in the region included shelterbelt plantation along the sides of canals and roads and block plantation in the vicinity of new human settlements. However, siltation rates of canals and cultivated land during summer continues to be very high and often cause irregular flow of distributories and water courses and destroying the crops particularly in lower parts of the command area. This also shows that eco-development along with irrigation development is a prerequisite for realising the economic development in the command area of
Stage II in Bikaner, Jaisalmer and Barmer districts.

Prior to the introduction of canal irrigation land resources were grossly underutilised in the command area of Indira Gandhi canal. Soil moisture has been the most limiting factor not only for the cultivation of land but also for the growth of natural vegetation. Moreover, cultivation has been confined to interdunal plains and sandy flats only because of severe wind erosion and incidence of shifting sand dunes. Expansion of the canal irrigation in the regions has brought about conspicuous change in the agricultural land use pattern. Duny and undulating land is also being levelled and brought under cultivation with the help of assured supply of soil moisture through irrigation. This has led to an impressive increase in net sown area. There is very high positive correlation (0.85) between the growth in the proportion of net sown area and intensity of irrigation (an indicator of expansion of irrigation). Expansion of irrigation also exhibits spatial variation in proportion of net sown area in the command area of Stage I. Proportion of net sown area to the total area was about 80 percent in the upper parts of the command area in Hanumangarh extension district and less than 20 percent in lower parts of the command areas of Stage I in Pugal and Chhatargarh extension districts in 1980-81. Proportion of
cultural waste land (primarily shifting sandunes and other degraded land left uncultivated for years because of extreme aridity and wind erosion hazards) in total area has declined sharply in the region following extension of canal irrigation and levelling of land for cultivation. Correlation between proportion of culturable wasteland and intensity of irrigation is very high and negative (-0.97). Decline in the proportion of culturable waste during seventies was more pronounced in suratgarh, Anupgarh and Chhatargarh extension districts of Stage I. This period witnessed a high growth in irrigational facilities in this area. Culturable wasteland occupied less than 5 percent of total geographical area in upper parts of the command area in Hanumangarh extension district in 1980-81. Whereas, it accounted for about 70 percent of the geographical area in lower parts of the command area in Pugal and Chhatargarh extension districts. Proportion of area under fallow land is almost stagnant. However, proportion of area under current fallow has declined in upper and middle parts of the command area of Stage I. Though, forests and grazing lands occupied less than 5 percent of the total geographical area of the command area of Stage I in 1980-81, area under these two categories of landuse has increased in Anupgarh extension district. This is because of the afforestation and pasture development being carried under CAD programme in
the middle and lower parts of the command area of Stage I. Among other landuse categories proportion of area under land put to non-agricultural uses has increased because of colonisation of the region and construction of canal system and roads.

Expansion of canal irrigation is solely responsible for double cropping in the region. It was not possible to raise crops during rabi season before introduction of canal in most parts of the region because of soil moisture deficiency. Infact, irrigation plan of the project emphasises irrigating rabi crops as envisaged ratio of irrigation intensity between kharif and rabi crops has been 47:63. Irrigation intensity and cropping intensity as expected, have very high positive correlation (0.89). Cropping intensity is very high in upper and middle parts of the command area. Comparatively low cropping intensity in lower parts of the command area is ascribed to underutilisation of irrigational facilities.

 Expansion of canal irrigation has brought about a perceptible shift in the cropping pattern in the stage I of the command area of Indira Gandhi canal. In the initial stages when irrigation was introduced in early sixties gram, guar and bajra were main irrigated crops in the region. Cropping pattern was quite diversified during mid-
sixties and apart from above mentioned crops the combination also included cotton, mustard, jowar and mixed foodgrains (gochani and bejar) in rabi season. However, wheat and cotton have emerged as remunerative crops in rabi, and kharif seasons respectively after mid-sixties. Groundnut is also emerging as a significant crop in lower and middle parts of the command area of Stage I. Wheat and cotton were first and second ranking crops respectively in the command area of Stage I in 1985-88. Gram and guar had been relegated to third and fifth places respectively in six crop combination. Mustard and groundnut were included in the six crop combination in 1985-88. Upper and middle parts of the command area of stage I, up to Anupgarh branch system is the wheat-cotton dominated region. In the command area of Naurangdesar branch cotton is first ranking crop while wheat ranks second. Cropping pattern of the command area below 74 km. of the main canal is entirely different from that of upper and middle parts of the command area. Cropping pattern in this region is still dominated by traditional crops (gram and guar). However, groundnut is emerging as an important crop in this region. Groundnut is first ranking crop in the command area of Lunkaransar - Bikaner lift canal. Spatial variations in the cropping pattern of the command area is attributed to time lag in the introduction of canal irrigation and difference in the
environmental conditions. Foodgrains occupied about 41.8 percent of gross cropped area in the command area of Stage I in 1985-88. In fact, proportion of area under foodgrains in the region has consistently declined since 1965-68. Cereals occupied about 27 percent of the gross cropped area in 1985-88. Proportion of area under cereal crops increased during the period 1965-68 to 1975-78 from about 21 percent to 27 percent. However, proportion of area under these crops stagnated after 1975-78. Wheat is the main cereal crop. Proportion of area under wheat has increased from about 1.8 percent in 1965-68 to about 23.5 percent in 1985-88. Growth in the proportion of area under wheat was very impressive till 1975-78. However, its proportion stagnated afterwards because of stiff competition offered by gram and irregular flow of water in canal in the lower parts of the command area of Stage I. Proportion of area under wheat shows an increasing trend in upper and middle parts of the command area. Rice is not a significant crop in the region except in the Ghaggar Flood Plain. Rice occupied about 12.6 percent of the gross cropped area in 1985-88 in the upper reaches of the command area. In the lower part of the command area of Stage I, rice cultivation is unknown. Bajra which was main cereal crop in the region prior to the introduction of irrigation has been relegated to an insignificant position. Proportion of area under bajra has
dwindled from about 9.3 percent in 1965-68 to about 0.8 percent in 1985-88. Other cereal crops in the region jowar and barley occupy less than 1 percent of the gross cropped area. Proportion of area under these crops has also declined. Pulses occupied about 15 percent of the gross cropped area in 1985-88. Proportion of area under pulses has declined sharply following expansion of canal irrigation in the region. Pulses occupied about 30 percent of the gross cropped area in the command area in 1965-68. Decline in the proportion of area under pulses is attributed to replacement of gram by wheat. Proportion of area under gram has declined from about 29.6 percent in 1965-68 to about 14.3 percent in 1985-88. It shows declining trend in the region except in the lower parts of the command area. Proportion of area under oilseeds has increased from about 7.1 percent to 22.2 percent over the period 1965-68 to 1985-88. Rape and mustard occupied about 13.8 percent of the gross cropped area in the command area of Stage I in 1985-88. Proportion of area under rape and mustard was only about 7.1 percent in 1965-68. Groundnut is a newly introduced oilseed crop in the region, which occupied about 8.3 percent of the gross cropped area in 1985-88. Proportion of its area is comparatively higher in the lower parts of the command area. Although area under groundnut has registered growth throughout the command area, it is
very impressive in the lower command area irrigated by Lunkaransar-Bikaner lift canal and direct outlets from main canal between 74 and 189 km. Cotton and guar are other main crops in the region. Proportion of area under cotton has increased from about 7.6 percent in 1965-68 to about 20.7 percent. Stagnation in the proportion of area under cotton after 1980-83 is attributed to the fact that this crop has failed to make a breakthrough in the lower parts of the command area of Stage I where groundnut has emerged as a major remunerative crop during the kharif season. Proportion of area under guar, has declined from about 16.4 percent in 1965-68 to about 10.7 percent in 1985-88 following a stiff competition with cotton and groundnut. The proportion of area under fodder crops has increased from about 0.5 percent to about 3.2 percent over the period 1965-68 to 1985-88.

Actual proportion of area under foodgrains in the command area in 1985-88 (41.8 percent) was lower than that envisaged in the project plan (63.4 percent). Proportion of area under both cereals and pulses is short of the target visualised by the project planners. This is primarily because of the fact that bajra and kharif pulses are not irrigated in the region. Besides, actual proportion of area under wheat and gram is also short of the visualised target. The proportion of area under oilseeds (both mustard and
groundnut) has exceeded the mark envisaged in the project. Proportion of area under cotton has also exceeded the visualised target in the project. Strangely, guar which occupied about 10.7 percent of the gross cropped area in the command area in 1985-88 does not find any place in the envisaged cropping pattern of the project. Project proposal of Indira Gandhi canal does not anticipate rainfed cultivation in the command area. Cropping intensity in the command area of Stage I is expected to be equivalent to irrigation intensity, i.e. 110 percent. However, primary informations collected through field survey reveal that about 39 percent of the gross cropped area is unirrigated. Guar, gram and moth are main crops in rainfed area. Rainfed cultivation is likely to continue even if the anticipated level of irrigation development is achieved throughout the command area of Stage I because strategy of irrigation development is to provide protection against the adverse climatic conditions. It is expected to irrigate about 42.7 percent of cultivable area in kharif and about 57.3 percent of cultivable area in rabi season.

Agricultural output and productivity in the command area of Indira Gandhi canal have registered tremendous growth with the expansion of canal irrigation and diffusion of modern agricultural technology. Growth in the
output of main high value crops (wheat, cotton, groundnut and mustard) has been very impressive as area under these crops has expanded rapidly with expansion in irrigational facilities. During the period mid-seventies to mid-eighties, increase in area under wheat, cotton, mustard, groundnut and rice was largely responsible for high growth in the production of these crops. Moreover, growth in the yield level of these crops except groundnut has also played a significant role in the increase of their output. On the other hand output of two traditional crops in the region, guar and gram, has declined over the period mid-seventies to mid-eighties. It is the yield and not the acreage which is primarily responsible for the decline in the output of these crops. Decline and continued low level of yield of gram and guar is because of the lack of breakthrough in the seed technology and very low level of consumption of chemical fertilizers. Moreover, these crops are losing fertile land to commercial crops and are being pushed to less fertile and newly levelled marginal land.

Agricultural productivity exhibits spatial variation and generally declines as moving from head to lower reaches in the command area of Stage I. Per hectare agricultural productivity in sample village 9MND (located in upper command area) is Rs. 6,962. Whereas, it is Rs. 1,456 per hectare in sample village Jagdevwala (located in lower
command area of Stage I) where only about 20 percent of gross cropped area is irrigated. Variation on the level of expansion and utilization of irrigation resources is a major factor causing spatial variations in the levels of agricultural productivity. Besides, environmental factors and time lag in irrigation and infrastructural development are other important factors in this respect. Adoption and diffusion of new agriculture technology, i.e. consumption of biochemical inputs and use of machinery is closely associated with the development of irrigation resources. Per hectare expenditure incurred on the biochemical inputs is comparatively higher in upper parts of the command area (Rs. 834 in village 9MND) and declines as moving southward (Rs.334 in village Jagdevvula) alongwith the decline in proportion of irrigated area. Use of biochemical inputs is comparatively higher among the fully irrigated crops (wheat, rice, cotton, groundnut and mustard) than the partially irrigated crops (gram, guar and bajra). Use of agricultural and irrigation machinery, i.e. tractors, threshers and pumps, has increased rapidly following expansion of canal irrigation in the region. Mechanical input in terms of horse power per 100 hectares of land is higher in the areas where proportion of irrigated area is comparatively higher (98.6 H.P in village 9MND). Labour requirement in agriculture has also increased in the region because of
increase in net sown area and scope of multiple cropping, introduction of labour intensive crops and increase in the agricultural operations. Consequently labour input in terms of mandays per hectare of net sown area is comparatively very high where proportion of irrigated area is higher. Cotton, groundnut and rice are most labour intensive crops in the region. Labour absorption is comparatively very low among traditional and partially irrigated crops such as guar, bajra and gram.

Per hectare agricultural productivity has high positive correlation with proportion of net irrigated area in net sown area. Correlation coefficient between agricultural productivity and proportion of irrigated area for total sample households is 0.72 and significant at 1 percent level of significance. Insignificant correlation between these two variables in village 9MND is because of the fact that about 90 percent of net sown area in the village is irrigated and there is not much interfarm variations in proportion of irrigated area. Average number of waterings in net irrigated area (an approximate indicator of volumetric application of water) has high correlation with agricultural productivity (0.78) in village 9MND. Other three sample villages also have significant correlation among these variables. Proportion of levelled
land in operational holding also has positive correlation with agricultural productivity and proportion of irrigated area. Agricultural productivity decreases with increase in distance of field from the outlet. Correlation coefficient between agricultural productivity and distance of the field from the outlet is low and negative (-0.24) but significant at 1 percent level of significance. Consumption of chemical fertilisers and use of insecticides and pesticides have very positive influence on per hectare agricultural productivity. It has very high positive correlation with per hectare consumption of chemical fertilisers and manure, use of insecticides and pesticides and per hectare expenditure incurred on biochemical inputs including seeds. In all the four sample villages correlation coefficient between agricultural productivity and expenditure incurred on biochemical inputs is above 0.75. Mechanisation index (machinery horse power per hectare) has low positive correlation (0.37) with agricultural productivity. Total number of mandays per hectare (human labour) is also positively associated with agricultural productivity. Correlation coefficient between these two variables for all sample households (0.80) is significant at 1 percent level of significance. Proportion of family labour in total labour has low negative correlation with agricultural productivity. Farms having higher agricultural
productivity have larger share of hired labour in total labour. Farm size and agricultural productivity are positively associated in 9MND and 8SHPD villages. Correlation coefficients between these two variables in two sample villages are low (0.41 and 0.31 respectively) but significant at 1 percent level of significance. However, farm size and productivity do not exhibit any relationship in village 1LSM and Jagdevwala where level of agricultural and irrigation development is comparatively low. Biochemical inputs, irrigation and Labour are primarily responsible for interfarm variations in per hectare agricultural productivity. Explanatory variables; expenditure incurred on biochemical inputs entered at the first step in stepwise regression analysis of sample villages and all the sample households except 9MND. Proportion of irrigated area entered at the second step in the regression analysis of village 8SHPD, Jagdevwala and all sample households and at third step in village 1LSM. Average number of waterings entered at first step in the regression analysis of village 9MND and explained about 61 percent of variation in agricultural productivity. Mechanisation index, biochemical inputs, labour and distance of the field from outlet entered at the following steps respectively. These five explanatory variables together explain about 72 percent variation in the level of
agricultural productivity. R value at the fifth step is significant at 1 percent level of significance. However, regression coefficient of biochemical inputs, labour and distance of the field from outlet were insignificant because of multicollinearity among explanatory variables. Biochemical inputs which entered at the first step in village 8SHPD explained about 61 percent of variation in agricultural productivity. Proportion of irrigated area, average number of waterings, distance of the field from outlet and human labour in terms of mandays per hectare entered at the following steps respectively. These variables together explained about 74.5 percent of variation in agricultural productivity. However, regression coefficients of distance of the field from outlet and labour are insignificant. Biochemical inputs entered at the first step followed by average number of waterings, proportion of irrigated area, distance of the field from outlet and mechanisation index respectively in village 1LSM. These variables together explained about 72.6 percent of variation in agricultural productivity. Regression coefficient except that of mechanisation index were significant at 1 percent level of significance. In stepwise regression analysis of village Jagdevwala also biochemical inputs entered at the first step followed by proportion of irrigated area, labour (mandays per hectare) mechanisation
index, farm size and distance of the field from outlet respectively. These explanatory variable together explained about 94 percent of variation in agricultural productivity. However, regression coefficient of two variables, farm size and distance of the field from outlet are not significant at 1 percent level of significance. Biochemical inputs entered at the first step in stepwise regression analysis of all sample households also had explained about 70 percent of variation in agricultural productivity. Proportion of irrigated area, labour mandays per hectare, farm size and mechanisation index entered at following steps respectively. Five explanatory variables together explained about 78 percent of variation in agricultural productivity. However, regression coefficient of mechanisation index is insignificant. Multicollinearity among independent variables has influenced the result of stepwise multiple regression analysis despite the deletion of some independent variables. There is high correlation among some independent variables, i.e. proportion of irrigated area, biochemical inputs and labour mandays per hectare.

A large proportion of land in western Rajasthan remained uninhabited and uncultivated prior to introduction of irrigation through Indira Gandhi canal owing to conducive environmental conditions for human settlement and cultivation. Most of this land was under the ownership
of Government of Rajasthan. The task of colonisation and allotment of land was taken up by the Colonisation Department of Indira Gandhi canal project in 1956. Land allotment is in progress and more than one lakh people were allotted land till September 1987. In stage I of the project about 85 percent of the land had been made available for allotment and about 6.5 lakh hectares land (both command and non-command) had been allotted to individuals for cultivation. As per Rajasthan Colonisation Rule 1975 landless person of the region have been given priority in land allotment. Till September 1987 about 93 percent of the land allottees in Stage I were landless. Landless allottees occupied about 95.4 percent of allotted land in the command area and about 97.8 percent of allotted land in the non-command area of Stage I. But as per the information collected throughout field survey in the command area of Stage I landless allottees constituted only about 76 percent of total land allottee households. This figure could be still lower as many respondents hesitated and are suspected to have furnished false information while answering this question. During informal talk, some respondents admitted that there were many cases where landowners have been allotted land in the name of landless. Scheduled Castes Component Plan of the project envisages to allot 30 percent of land to scheduled castes and tribes.
However, scheduled castes and tribes were allotted about 27.3 percent of allotted land in the command area and about 19.7 percent of allotted land in the non-command area of Stage I.

Despite certain loopholes and drawbacks the land allotment policy of Indira Gandhi canal project has resulted into change in the relationship of socially and economically deprived sections of the society with the land. Land allottees constitute about two third of sample landowner households. Only about 3.5 percent of the scheduled caste sample households owned land before arrival of Indira Gandhi canal. However, at present about 62.9 percent of the scheduled caste households are reported to be in possession of land. About 68.6 percent of backward caste households own land and more than 60 percent of them are land allottees. Overwhelming number of cultivating caste households (90 percent) are in possession of land and majority of them are also land allottees. About 23 percent of the cultivating caste households have purchased land and settled in the region. Half of the higher caste households are landowners and about 60 percent of them are also land allottees. Despite the effort of attaining social equity through land allotment a large proportion of scheduled caste (37 percent) and backward caste (31.4 percent) sample
households are landless. Furthermore there is also inequality in land distribution among the landowners. About 17.9 percent of the total landowners hold up to 2.5 hectares land and own only about 3.9 percent of the total owned land. Whereas, large land owners (having ownership above 25 hectares) constitute only about 2.4 percent of total landowners but own about 14 percent of the total owned area. Inequality in the distribution of land is inherent up to some extent in the policy of land allotment (in terms of various categories of land allotment an ineffectiveness of land ceiling) and further accentuated by fragmentation of the land holdings and sale/purchase of land. About 10 percent of the landowner households have purchased land in the region. Most of these households (about 78 percent) belong to cultivating castes (Jat Sikhs and Jats). Proportion of the households who have purchased land is comparatively higher in old revenue villages (9MND and Jagdevwala) because land is easily available for purchase from Khdratar landowners. Out of twelve households who are reported to have sold their land five are landless and three are small farmers (having land ownership below 2.5 hectares) at present. Meanwhile, the process of pauperisation of peasantry has set in the newly settled area also. Seven of the households who are reported to have sold their land are land allottees. All such land allottee
households except one belong to backward and scheduled castes. Besides, land allottees are expected to cultivate the land allotted to them. However, this has not come true. About 15.5 percent of landowner households have leased their land out which constitutes about 10 percent of the total owned area. This figure is likely to be higher as there is a large number of absentee landowners in newly settled area who could not be contacted during the course of field survey. Lease market is more pronounced in newly settled area because of absentee landowners. Pauperisation of the peasantry and lack of the availability of capital for investment in agriculture, particularly in case of land allottees belonging to backward and scheduled castes, are in fact major causes of sale and leasing out of land in the region. A large number of land lessors in developed areas (village 9MND) are small and medium landowners. However, in middle and lower parts of the command area a large number of lessors are medium and big landowners respectively. Moreover, a large proportion of lessors belong to scheduled castes (35.6 percent) and backward castes (33.3 percent). On the other hand, more than three-fifth of tenants are landowners and are in possession of about 65 percent of rented in land. Landless or pure tenants constitute about 36.8 percent of total tenants and possess about 35.2 percent of leased in land. Proportion of landless tenants is
particularly high in middle and lower parts of the command area because of absentee landowners and comparatively lower population pressure. A large proportion of landowner tenants in developed villages (9MND and 8SHPD) belongs to small and medium landownership categories. Whereas, a large number of landowner tenants in lower parts of the command area (village 1LSM and Jagdevwala) are medium and big landowners. A large proportion of tenants (about 44 percent) belong to cultivating castes. Backward castes and scheduled castes constitute about 26.3 and 21 percent of total tenants respectively. Share cropping (input and output) is most prevalent mode of lease contract in the region. Fixed cash rent is another important mode of lease contract. This mode of lease contract is more prevalent in old revenue villages.

Command area of Indira Gandhi was sparesly populated before introduction of canal irrigation. Scheduled castes constituted more than 20 percent of population in the command area of Stage I (Ganganagar and Bikaner districts) but less than 16 percent in the command area of Stage II (Bikaner and Jaisalmer districts). Population of scheduled tribes is numerically insignificant in the command area of Stage I, but they constituted 4 to 5 per cent of the population in the command area of Stage II in 1981. Expansion of canal
irrigation and consequent agricultural development has resulted in large scale immigration and redistribution of population in the command area of State I. About 64 percent of the total sample households are immigrants. Most of the immigrant households (more than 75 percent) belong to the nearby areas of the same district. Quite a large number of households in the upper parts of the command area (in Ganganagar district) have migrated from adjoining states particularly, Punjab and Haryana. On the other hand, a large number of immigrants in the lower parts of the command area of Stage I (in Bikaner district) are interdistrict immigrants and belong to Ganganagar district. There is a long time gap between the upper and lower parts of the command area of State I in settlement of immigrants because of time lag in the creation and utilisation of irrigational facilities and allotment and settlement of land. In the upper parts of the command area immigration began before 1961 and maximum number of immigrants settled during the period 1961 to 1970. However, in the lower parts of the command area of Stage I immigration began after 1970 in some areas. Land allotment is most significant motivation for immigration in this region. More than half of the immigrants have settled in the region to occupy and cultivate the land allocated to them. Employment opportunity as farm labour, purchase of land and tenancy are
other important factors which have motivated immigration in
the region. About 64.7 per cent of immigrants were
landless before settling in this region. Proportion of
landowner immigrants is comparatively higher in old revenue
villages (9MND and Jagdevwala) where purchased land is a
major motivation for immigration. Immigrants who have
purchased land were economically well off even before
settling in this region.

Expansion of irrigational facilities and
colonisation of the region have brought about a tremendous
change in the occupation pattern of people in the command
area of Stage I. While agriculture continues to be the main
source of income for about 90 per cent of sample households.
The proportion of households engaged in cultivation has
increased from about 51.9 per cent to 72.4 per cent
following introduction of canal irrigation. Contrarily, the
proportion of households engaged in farm labour has declined
from 37.3 per cent before introduction of irrigation to 16.8
per cent at present. Percentage of households engaged in
animal husbandry and artisanship has also declined. Though
overwhelming number of scheduled caste and backward caste
households are engaged in agriculture but a large number of
them have switched over from farm labour to cultivation.
Farm labour was main occupation of about 60 per cent of
scheduled caste and tribe households before introduction of canal irrigation. Whereas, at present about 60 per cent households belonging to these castes are engaged in cultivation. About 28 per cent of scheduled caste and tribe households still continue to earn their livings from farm labour. Proportion of backward caste households engaged in cultivation has also increased from about 45 per cent to 69 per cent following land allotment and expansion of irrigation in the region. Percentage of cultivating caste households engaged in cultivation has also increased slightly from about 90 per cent to 93 per cent. Proportion of higher caste households dependent on agricultural sector for earning their livings has declined from about 69 per cent to 62 per cent. This has happened despite the fact that proportion of higher caste households engaged in cultivation has increased from about 42 per cent to about 54 per cent. This is because of sharp decline in the proportion of higher caste households engaged in farm labour and impressive growth in the proportion of households engaged in non-farm economic activities. Drastic shift in the occupational structure in favour of cultivation is also evident from the fact that about 93 per cent of cultivating households pursue the same occupation and 56 per cent of sample households engaged in agriculture labour have switched over to cultivation following execution of Indira
Gandhi canal project. 60 per cent of the sample households engaged in animal husbandry and about 20 per cent of households employed in non-farm economic activities have also shifted to cultivation. Only about 3.3 per cent of cultivating households have switched over to farm labour. All such households belong to agriculturally developed villages (9MND and 8SHPD) where the process of impoverishment of peasantry has began. About 39 per cent of households employed in farm labour also continue the same occupation. A small proportion of households employed in farm sector have also taken up non-farm economic activities such as service and business.

Summing Up:

The hypotheses, i.e. implementation of Command Area Development programme has helped in increasing the utilisation levels of created irrigation potential; intensive irrigation has led to sharp rise in subsoil water table and caused the environmental problems — waterlogging and soil salinity; availability of irrigational facilities has helped in change in landuse pattern in favour of cultivation and led to efficient utilisation of land resources; assured supply of soil moisture through surface irrigation has led to replacement of drought resistant and low yielding crops by commercial and remunerative crops; irrigation along with modern agricultural inputs is
responsible for rapid increase in agricultural output and productivity; and land allotment and agricultural development following introduction of canal irrigation have resulted in large scale immigration in the region in the pursuit of employment and shift in the occupation pattern, are accepted. However, the hypothesis which states that priority in land allotment to landless and economically and socially backward section of the society has led to equitable distribution and access to land resources is not accepted. There are many loopholes in the land allotment policy and consequent manipulations in land allotment. Land allottees belonging to the deprived section of the society have been facing financial constraints to invest in land shaping and levelling and modern agricultural inputs. A large number of such land allottees have resorted to leasing out their land. Moreover, the process of pauperisation of the peasantry has also set in the agriculturally developed villages.

Policy Implications:

(i) Lack of the strict control of the project authorities on water distribution and not enforcing the envisaged cropping pattern in the project have resulted into exceeding the visualised irrigated area (irrigation
intensity) and application of water per unit of land (water allowance) in upper parts of the command area of Stage I of Indira Gandhi canal. This is likely to reduce the irrigation intensity and water allowance in lower parts of the command area.

(ii) The progress of CAD programme particularly in terms of lining of watercourses and levelling of undulating dune land is not satisfactory. This may also lead to underutilisation of the irrigation resources in lower parts of the command area of Stage I and entire command area of Stage II where land is infested with sand dunes and soil texture is sandy and loamy sand.

(iii) Intensive irrigation has led to sharp rise in the subsoil watertable and surfacing the serious environmental problems in terms of waterlogging and soil salinity in the command area of Stage I. This environmental problem is likely to be very serious in lower parts of the command area of Stage I and entire command area of Stage II once the irrigational facilities are provided and utilised in the region because of the presence of very strong salt regime and calcareous and clay pans near the surface in a large area. Permanent solution of this twin environmental problem lies in developing drainage facilities. Immediate mitigation of this problem may be initiated
developing vertical drainage (installing tubewells) and reclaiming salt affected soils with vertical mulches of sand, organic matter and gypsum powder and leaching of soils.

(iv) The measures of restoration of ecological balance, i.e. afforestation, pasture development and sand dune stabilisation, are inadequate and wind erosion and siltation of canals, water courses and cultivated land continues to be a serious problem particularly in lower parts of the command area of Stage I. In fact, eco-development is a prerequisite task for irrigation induced agricultural development in the command area of Stage II and lower command area of Stage I where wind erosion is very serious environmental hazard.

(v) Cropping pattern in the command area of Stage I has deviated from that envisaged in the project. It is guided by remunerative aspects of the crops and availability of irrigation water. Cropping pattern of lower parts of the command area of Stage I and the command area of Stage II should be reviewed. It should not include moisture intensive crops and include traditional crops of the region such as guar. Envisaged cropping pattern should be enforced strictly by project authorities.
(vi) A large number of land allottees who have been allotted land in the name of landless are not in fact landless. Moreover, a sizeable section of land allottees belonging to economically and socially deprived section of the society (scheduled castes and tribes) does not possess adequate capital to invest on land levelling and modern agricultural inputs. Consequently, a large number of them have resorted to leasing out their land. The process of impoverishment of peasantry has set in the agriculturally developed upper part of the command area and some of the land allottees belonging to deprived sections of the society have sold their land.