CHAPTER I
INTRODUCTION

1.1 Significance of Irrigation Water Use in Agriculture

In India nothing moves unless agriculture moves and no input for agriculture is more important than water. Water is a primary necessity of plant growth. Agricultural output and its efficiency, to a great extent depends upon inputs applied and the methods adopted.¹ The main restraint in the attempts for modernization of agriculture is the inadequate supply of water. In the major portions of India, the natural supply through rainfall, at times may not be inadequate, but it is generally unevenly distributed spatially as well as over time. The same can be said about Haryana also. Moreover, the growing population and fixed land surface limit the scope for bringing more and more land under cultivation and calls for efficient use of land through optimal utilization of water resource.

Efficient utilization of water resources is essential for agricultural production for meeting the challenge of feeding the ever-increasing human population particularly in a country such as ours. Land and water being limited, their efficient use is basic to the survival of an ever-increasing population in the world.

Conscious efforts are being made continuously to supplement rainfall by supplying water artificially to parched lands. This artificial supply of water is known as irrigation. The term "irrigation" includes all operations or practices in artificially supplying water to the soil for growing crops. It is a means by which water is conveyed to water deficit areas from rivers, reservoirs or wells to increase the fertility of land. It is the science of harnessing and controlling various natural resources of water for the benefit of agriculture. Scientific irrigation involves knowledge of the available water supply, its characteristics and needs of the different types of soil and the requirements of the various crops to be produced. The role of irrigation vary according to the condition. In some areas, it may be a precaution against the inherent variability of rainfall and in others an essential requirement for the mere production of a crop or for obtaining substantial yields per unit per hectare.

The role of irrigation water has been underlined since long. It was pointed out that irrigation is everything in India: water is more valuable than land because when water is applied to land it increases its productiveness at least six fold and renders great extents of land productive, which otherwise would produce nothing or next to nothing.² It has

² Quoted in K. Narasihulu, & A. Rama Mohan Reddy, "Role of Irrigation in Agriculture in Andhra Pradesh," Yojana Sept. 16-30, 1988 p.17
been repeatedly stressed that the irrigation works have made security of life. They have increased the yields, and the value of land and the revenue derived from it. They have lessened the cost of famine relief and have helped to civilize the whole region. In addition, they yield handsome profits to the government.³

Water Utilization can be analyzed with respect to three aspects of irrigation viz. engineering, agricultural and socio-economics. Under engineering aspect are included the design and construction of structures required for storage, diversion, conveyance, delivery and distribution through channels and distributories - determination of water yields of river and water supply for irrigated lands.

The agricultural aspect refers to the use of the irrigation water and various agricultural practices and cropping pattern, methods of application and the quantity of water for single irrigation. In agricultural aspect three sub-aspects are included. They are, Protective aspect that refers to make up the moisture deficiency in soils during the cropping season so as to ensure proper and sustained growth of crops grown; Additional land use aspect is to enable a second or third crop being raised on the land provided with irrigation which could otherwise not to be cultivated efficiently more particularly during the past or

pre-monsoon period. The third aspect relates to augmentation and preservation of the properties of soils by application of adequate supply of water.

The socio-economic aspect refers to the material and psychological satisfaction for the social needs and desires, which is essential for any community enterprise.

Irrigation is essential for the maximization of production of most farm crops. According to the Indian Council of Agricultural Research, the production of irrigated crop is on an average 50 to 100 percent higher than that of the need for irrigation is of great necessity because of lack of moisture in the soils. Sandy soils require more frequent saturation than the alluvial or black soils.

The traditional method of irrigation in India, has been the use of water drawn out from the wells and wherever tank or river facilities were available, water was directly taken from them also. Undoubtedly, in modern times, there has been considerable change in the means of irrigation. Pumping sets and tube-wells are the new means which are providing on the spot water facilities to the farm land. However, the canals are also playing a vital role.

I.1 a OVERVIEW OF LITERATURE:

It has been observed by a number of studies that irrigation is the most important pre-requisite for agricultural development in Indian situation where moisture factor is more important than the heat factor. It is also a very potent factor in explaining the fluctuations in area of different crops particularly in the arid areas. In plays a protective role against the vagaries of monsoon. In traditional agriculture irrigation was recognised as a factor only for its protective role. But with a new strategy of high yielding varieties and multiple cropping, controlled irrigation has become a basic pre-requisite for high yield. S.K. Rao has pointed out that irrigation has become like a technological constraint in Indian agriculture and once this is removed the farmer tends to apply the complementary inputs to regular watering and adopt the cropping pattern that brings the high yields.\(^5\)

Asopa and Tripathi examined in detail, the technological, institutional and organizational factors responsible for the under-utilization of created irrigation potential, in particular on farm development works, supply of inputs, and creation of supporting infrastructure, They have also analysed the performance of irrigation administration in relation to development of irrigated

agriculture. He has emphasised the need for a policy for conservation and better utilization of water resources consistent with maximum agricultural production. 6

Seminar focused attention on the following important aspects of the role of irrigation on Agricultural development, utilization of existing irrigation facilities, investment in irrigation and returns on it, a national policy on underground/surface water use; and policy recommendations on the role of complementary inputs and integrated area development and formula of policy statement relating to an integrated and optimal utilization of current and potential irrigation 7

Jha has examined the various aspects of irrigation management and water management. Apart from examining the role of irrigation in economic development of Bihar, he analysed and evaluated the process of development of irrigation system in the context of agricultural development and a comparative study has been presented about unplanned and planned development of irrigation. He also analysed various systems and methods of water used in agriculture. In fact this research is an attempt to deal

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6 Asopa, V.N. and B.L. Tripathi "Irrigation Agriculture in Gujarat: Problems and Prospects (Ahmedabad: Centre for Management in Agriculture), 1975, p.154
7 Seminar on "Role of Irrigation in the development of India's Agriculture" by Indian Society of Agricultural Economics, 1976.
with that aspect of the problem which has remained neglected so far.\textsuperscript{8}

Satpathy studied the irrigation development from an economic perspective. Economic development in context of irrigation growth has been analysed in depth, through aggregative as well as disaggregation of irrigation, impact of irrigation development on the farm and inter-district disparity in irrigation development etc.\textsuperscript{9}

Pandey in his study of one command area has made an attempt to high-light the infrastructural weaknesses in the area which retarded the development processes in the command area and had focused on irrigation and cropping pattern of the Kiul-badua Chanda Command Area Development.\textsuperscript{10}

Sharma has analysed the trends of irrigation development in the district over the planned era so as to determine its dynamics of development in relation to the state and also examined the contribution of DPAP in the field of water development. He studied the importance of water development under DPAP on employment, output, productivity etc. The approach adopted for evaluating the schemes has been the well-known social benefit-cost approach and given more emphasis on irrigation

\textsuperscript{8} Jha, U.M. "Irrigation and Agricultural Development." Deep & Deep Publishing House, Delhi 1984 p.246

\textsuperscript{9} Satpathy, T. "Irrigation and Economic Development." Ashish Publishing House, 1984, p.224

\textsuperscript{10} Pandey, M.P. "The Impact of Irrigation on Rural Development." Concept Publishing Company, Delhi, 1979 p.191
developed and water management under DPAP in Palamau, district in Bihar.¹¹

Rao, small is viewed as an input in rural development - not merely agricultural production - irrigation has other points of contact with development economics as the irrigation in Indian rural economy begins to move from the wings towards the centre of the stage.¹²

In Israel almost all of the increase in farmed area consist of land brought under irrigation. Irrigation is also the most important single contributor to agricultural growth in Greece between 1950-60 (USDA).¹³

Krishana Murthy has evaluated the influence of Mettur irrigation and hydro-electric project on agriculture and agroindustries in Puttukotal taluk of Tanjore district of Tamil Nadu State. The topics covered are - area under irrigation, net cultivated area, intensity of cropping, yield rates, food supply, agricultural employment cultivation practices, land scale and indebtedness. In all these aspects, it has been observed that the project area has an edge over the non-project area in general and wet cultivators over dry cultivators in particular.¹⁴

¹¹ Sharma, L. "Water Management in Drought Prone Areas." Criterion Publication Delhi, 1985, p. 236
In another study it was observed that optimum allocation of the available water increased the efficiency of the irrigation system and resulted in big saving of water to the extent of 60 per cent which could be further used to bring additional area under irrigation.15

Singh and Singh studied and compared the rate at which and the extent to which irrigation by Bhakhra Dam has contributed in ameliorating the economic and social conditions of inhabitants of this tract. They have observed that crop pattern, pattern of cultivation, crop intensity have changed in the villages under Bhakhra, with more secure agriculture condition and with more returns. The standard of living of farmers has gone up. Irrigation seems to have lowered the area under traditional crop bajra and increased the area under more profitable crops like cotton, sugarcane, rice, vegetables and gram.16

Maji and Heady in their study worked out the optimal cropping patterns and a reservoir management policy for the Mayurakshi irrigation project under conditions of average as well as variable monthly inflows. The results of their study indicated that a change in the existing cropping pattern and a reservoir management policy would give maximum net return. They also developed a monthly schedule of operations for the

reservoir, indicating desired storage of water in the reservoir, discharge of water from the reservoir to the producing regions through the net work of canals and spillage of water the reservoir.\textsuperscript{17}

Divakar Jha's study deals with the direct and indirect benefits of irrigation under the Tribeni Canal in the Champaran district of Bihar (under the Gandak river). He categorically concluded that the irrigation has definitely brought prosperity to the project and cultivators.\textsuperscript{18}

Venkataryappa in his study gave about the prosperity and plenty brought about due to provision of irrigation. He reported that irrigation brought thorough changes in all aspects of village life.\textsuperscript{19}

Similar findings were reported by Epstein.\textsuperscript{20}

Palanisami has worked out the impact of water availability on cropping pattern, input use and crop yield and studied the pattern of water allocation and use. He introduced three stage model: Water, input and crop yield. He has obtained Regression coefficients and standard errors of variables related to water supply, input use, and


yield in head, middle and tail portions. He derived conclusion from his analysis, that water availability had a greater influence on both input use and crop yield.21

Rao, et. al. in their study measured the extent of shortfall in the utilization of irrigation potential created by Ghod Project in Maharastra. The Shortfall in the use of irrigation potential was observed to be greater during the Kharif season whereas it was only marginal in the rabi season. The reasons for under utilization of irrigation water were inadequate and untimely supply of canal water, defective cannal water distribution system and lack of infrastructural facilities on the farms.22

Kumar has studied the impact of construction of field channels on the cropping pattern, cropping intensity, enlargement of irrigated area, irrigation problems and also worked out the input-output relationship and compared the mean levels of them in villages with and without field channels. He has also measured the impact of improved irrigation system on the utilization of family labour. He has applied a theoretical description of the generalized

21 Palanisami, K. "Irrigation Water Management: The Determinants of Canal Water Distribution In India - A Micro Analysis." Agricole Publishing Academy, Delhi, 1984, p. 120
least squares estimation procedure for linear Regression Model with random coefficients.\textsuperscript{23}

Mukherji stressed the need for more rational distribution of reservoir water. According to him, influential farmers near the head or middle reaches of the project, used to draw more water and did over-irrigation, depriving the tail-enders of their share of water for irrigation dry crops. Even the regulators and water channels were blocked to divert water for all tail-enders. He emphasized that unless this was checked, irrigation might create social tension among the farmers.\textsuperscript{24}

Kumar, et.al. through a systems approach technique studied the optimal cropping pattern for Gandak Command Area and observed with the introduction of intensive surface irrigation in this area, the hydrological balance of ground water was disturbed. The water table was rising and in some places, water-logging had occurred. However, during the rabi season, there was an acute shortage of water. Therefore, to control the water table and also to make more water available during the rabi season, further exploitation of ground water was desirable. So they suggested an optimal cropping pattern for conjunctive use of ground and surface water. Their study indicated that by further pumping out

\textsuperscript{23} Kumar, P. *Economics of Water Management: A Study of Field Channels.* Heritage Publishing Delhi, 1977 p.117.

\textsuperscript{24} Mukherji, S.P., *Irrigation Management.* Bhagirath, 26(2) 1979,p.p.59-61
about 600 million cubic meters of water, more area could be brought under irrigation and cropping pattern could be changed for the benefit of the farmers. This would also help in controlling of water logging as well.  

Singh and Sirohi in their study determined the optimal allocation of canal water to various branch canals in Upper Ganga Canal in Western Uttar Pradesh, with maximization of gross returns of crops less the cost of tubewell water as the objective function.

Maji and Sarkar, made an attempt to determine the optimal combination of improvements in the individual component efficiencies in order to raise the existing overall irrigation efficiency of the system and cropping pattern in the command area under various levels of irrigation efficiency so as to utilize available resources in the best possible manner. They also determined the optimal level of overall irrigation efficiency and the corresponding level of investments.

Rao has analysed, the role of uncertainty and risk element in determining productivity. He has argued that specification of desirable levels of Irrigation efficiencies

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are not purely a matter of hydrological concern, but the optimal efficiencies should be evolved using economic cost-benefit analysis.\textsuperscript{28}

Sisodia, in his study observed that assured irrigation would increase area under high yielding varieties with consequent increase in production and income of the farmers.\textsuperscript{29}

Hassan has highlighted the relevance and urgency of evolving irrigation structure with flexibility for the purpose of delivering right quantity of water at the right time. He has pointed out that empirical investigations on water-plant-yield relationship are very important in order to examine rational water release policies leading to higher productivity.\textsuperscript{30}

Venkataramanan, Narayan and Shenoy have analysed production, yield, cropping intensity levels and cropping pattern in irrigated and rainfed areas in Karnataka and they found that wasteful utilisation of irrigation water was the main reason for low crop intensity. Their analysis has been


\textsuperscript{29} Sisodia, J.S. "Economic Evaluation of Chambal Irrigation Project in Madhya Pradesh," Indian Journal of Agricultural Economics 33 (4) 1978 p.263

based on data from a sample of 154 farmers in irrigated and rainfed districts of Karnataka. They have not applied any advanced statistical methods in their analysis. They have found that irrigation has played its role in increasing agricultural production.31

Michael has reviewed the changed role of irrigation in the post-independence period with the onset of the new strategy for increasing agricultural production. The adoption of new strategy for increasing agricultural production by the farmers, quite successfully on a comparatively large scale, had changed the role of irrigation. It was viewed as a highly productive input. He has also pointed out that the low intensity of irrigation to the non-availability of timely credit and the lack of dependable irrigation facilities for small farmers. He has advocated detailed soil and topographical surveys, land consolidation measures, drainage systems in the command area, and the use of ground water resources as a defence against droughts.32

Gita has analysed the irrigation cropping, landuse pattern of Tamil Nadu and made an attempt to analyse the

part played by water in agricultural development. She has examined the contribution of water in the agricultural development of this macro-region and as well as it brought out the regional agricultural and economic disparities.33

Bhatt has analysed the patterns of general landuse, agricultural landuse area and production of different crops, value of crops and availability of irrigation facilities in relation to agricultural development.34

Srivastava has analysed the variation in agriculture. As regards to the productivity, the standard method of computing productivity in terms of values per unit area was used and also determined the utilization of Agricultural Water.35

Jairath, discussed the technological characteristics of the two major sources of irrigation such as canals, and shallow tubewells and also discussed the distribution of the modes of irrigation over different categories of farmers. He also analysed the district wise growth of irrigation and production variables.36

Sinha analysed the three canal systems in Haryana and pointed out the reasons for failure of irrigation projects.

33 Gita, R.K., "Role of Water Resources in Agricultural Development: A Case Study in Tamil Nadu" Dissertation submitted to CSRD/SSS/JNU, New Delhi, 1973 p.188.
35 Srivastava, R.C. "Water Utilization and Agricultural Productivity in Uttar Pradesh" (M.Phil. dissertation),CSRD/SSS/JNU, New Delhi, 1984,p.149.
In his view, there were certain technical weaknesses in the project such as failure to provide for the link canal to feed these systems, inadequate field channels and on farm development work and failure to work out the optimum water use plans.  

Kaushik, Gangwar and Pangal and Singh in their studies described the optimum allocation of water of Jui and Siwani canals in Haryana among various branch canals and crops.  

Levine made different studies in Phillipines, Taiwan and other parts of Asia, From these studies, he developed an opinion that irrigation systems in developing countries were often inefficient.  

Iqbal Singh conducted a study of allocation of irrigation water of Upper Ganga in Western Uttar pradesh. The study revealed that optimal allocation of water between regions and crops increased total returns by 24 percent of this, 7.6 percent was due to optimal allocation of canal water between various branch canals and the remaining 16.4 per cent increase was due to optimal allocation of water, fertilizer and land among different crop areas within the

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regions. The former demands optimal scheduling of water between various branch canals and is relevant for the canal authorities. In this study, the optimal plan II suggested the direction of adjustments in regional allocation of water through branch canals water distribution policy in the area.

Singh, and Singh, conducted a study on data collected from a sample of 34 farmers in a village in Bichpuri Block in U.P. in 1970-71. The average intensity of cropping was found to be higher on owned tubewell irrigated farms being 180 per cent as compared to 168 per cent and 158 per cent on hired tubewell irrigated farms and well irrigated farms respectively. The production of high yielding varieties of wheat was high at 34 quintals per hectare on owned tubewell irrigation farm as against 27 and 25 quintals per hectare respectively, on hired tubewell irrigated and well irrigated farms.

Hall and Buras developed a procedure based upon dynamic programming for optimal allocation of water various stages of crop, presuming that the production function and the seasonal distribution of water is known.

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Rogers and Smith, Proposed a model to determine water balance for a project area and interaction of surface water and ground water systems. The programme proposed by them selects the number of tubewells, canal and surface drainage capacity, the project size and cropping pattern. The system was operated in such a way as to contribute most effectively to the goal of maximizing net returns at the same times satisfying constraints of canal diversion capacity, crop water requirement, crop land constraint, maximum and minimum area to different crops. etc.\textsuperscript{43}

Salter & Goode found that water at different stages of growth has different effects on yields. Soil moisture during flowering and early grain formation seems particularly critical in determining yields.\textsuperscript{44}

Garg and Ali in their study on Impact of Tubewell Irrigation on Farm Economy, indicated an increase in level of investment per hectare on irrigation structure between 1966-67 and 1973-74 from Rs. 484 to Rs. 1858, about 80 percent of the additional demand for investment. Capital being met by the co-operative bank. The additional expenditure particularly for fertilizers and improved seeds was met by co-operative societies and state government. The


\textsuperscript{44} Salter, P.J. and Goode, J.E. "Crop Responses to Water at Different Stage of Growth," Commonwealth Agricultural Bureau. 1987. p.82.
HYV’s of wheat and paddy covered 36 and 31 percent of the total cropped area respectively after the introduction of tubewell. The intensity of cropping increased in 1973-74, thereby leading to an increase in employment of human labour by 58 per cent on the small farms and 65 per cent on the large farms. As a result of the introduction of tubewells adoption of modern technology, gross income and net income per hectare increased by 159 percent and 369 percent respectively.  

Dhawan in his study on Economics of Ground Water Utilization held that given the skewed distribution of land ownership and the small size of the average farm, the adverse externalities of tubewell technology cannot be avoided in a free enterprise framework, even if the state legislatures enact legislation of control and regulate the use of ground water. The externalities could however, be internalised if public agency undertook to supply ground water public tubewells, wherever feasible, wherever not only the best means for managing ground water resources efficiently, but were the only way to overcome the problem of lack of utilization of ground water resources in certain area afflicted by fragmented, tenanted small holdings.

Dhawan in still another study examined the impact upon the living standards of small and marginal farmers of new ground water technology and held that ground water withdrawals lowered the depth of the water table, led to diminished water availability and raised the marginal operational cost. Since the operational cost of new ground water techniques was much less than those of traditional methods and as measures were available to the rich adopters of new ground water technology to maintain intact the ground water output, the users of high variable cost additional water lifts experienced sizeable external diseconomies due to a permanent lowering of the water table by the introduction of new ground water technology in the vicinity.

Patel in his study of Development of Irrigation potential, highlighted that at present only less than half of the utilizable water resources in country have been harnessed so far. The quick and optimum development of our water resources is essential for providing the infrastructure for the economic development of the country, particularly of the rural areas, Concerted attention, therefore, is proposed to be paid to preparation of master

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plans for multi-objective and multi-purpose development
of the available water resources for efficient use.\textsuperscript{48}

Kuldip Singh, in his study of lining water courses in Punjab State found that a large portion of irrigation water is lost through seepage from the unlined conveyance system comprising part of the Punjab State where soil is sandy, the losses through seepage were particularly high ranging between 20 and 40 per cent. The problem of scarcity of irrigation water in this area was further aggravated by the underground water being brackish. However, this problem could be solved if water lost in the long runs of unlined water courses is saved by lining them with some suitable material.\textsuperscript{49}

Irrigation is a vast subject and both its content and impact vary with the source on it is based. In the new planning strategy now being worked out, irrigation is being assigned a major role in rural development and employment generation.\textsuperscript{50}

I.2 Water Resources - Some Salient Features :-

\textsuperscript{50} Rao, V.K.R.V. Forward of Impact of Irrigation (1979), Ibid.
1.2 a Total Availability of Water Resources in India

In its very ordinariness, water is extra-ordinary. Total water resource on the earth is estimated to be about 1360 million cubic kilometres, which is 0.25% of the planet's mass and if spread evenly over its surface, it would cover the planet to a height of 2.7 Kms. But more than 97% is in the form of oceans and seas, 2% is locked in ice-caps and glaciers and a large proportion of remaining 1% lies far too deep in the ground to exploit.

India's water resources are just 4% of the total average annual run-off in the rivers of the world whereas it possesses about 17% of global population. In 1987, the per capita average run-off in India was only 2500 cubic metres per year.

India receives about 4000 cubic kilometres of precipitation every year. The distribution of rainfall is also highly uneven with 100 m.m. in Western Rajasthan to over 11000 m.m. at Cherrapunji in Meghalaya. The uneven water availability from basin to basin as can be seen in the fact that Rajasthan although having 8% of India's population, possesses just 1% of the country's water resources.

1.2 b Utilisable Water - Surface and Ground Both.

The present utilisable water resources are estimated to be 690 cubic kms. as surface water resource and 450 cubic
kms. as ground water resource which give 1140 cubic kms. as the country’s total utilisable resource.

Thus, per capita water supplies world-wide are a third lower now than in 1970 due to the 1.8 billion people added to the planet since then. With India’s population growth rate (during eighties) being 2.1% every year 18 million people are added to our population.

The need of hour is to recognise the potential of water use efficiency and conservation improvements to save enough water to meet new human demands and to satisfy environmental needs of water.

I.2.c Potential for Irrigation

At the time of independence the total irrigation potential created (22.6 million ha.) was being fully utilised and there was no gap between potential created and its utilisation. From the end of first five year plan onwards this gap increased from 1.91 m.ha to 8.30 m.ha at the end of 1992-93. The estimated investment locked in unutilised irrigation potential already created could be about Rs. 160 billion. One of its main reasons has been that we have followed the construction oriented approach for the programme of creation of new irrigation potential instead of productivity management approach.
On an average, water use efficiency in the existing irrigation projects is put at 40% which means bulk of water diverted for agriculture never benefits a crop. Also, the overall agricultural productivity in case of cereals in India is as low as about 1.65 tonnes per ha. (1992-93) as compared to other countries like China, South Korea having overall productivity of 4.0 and 6.0 tonnes per ha. respectively.

It is estimated that management improvements including increasing water use efficiency to 60% in India alone could allow an additional 8 million ha. to receive irrigation waters from existing irrigation facilities. In other words the present irrigated area could be increased by little over 11% and thereby yield from this newly irrigated land could be doubled without developing any new water sources.

**Water Pricing:**

Water charge, on an average in India are very low—typically amount charging, to 2-3% of the harvest’s value in most states. The cost of irrigation water on the basis of investment, on an average, works out to 91 paise per thousand liters against which the prevailing water charges, are 11.6 paise per thousand liters. The direct fall out of such low irrigation water rates with added problem of low recovery is that today the water charges collected do not covers even working expenses, not to speak of depreciation charges and contributing even a moderate return on the
investment. It is estimated that financial loss (difference between working expenses and revenue collected) as incurred by the irrigation sector during the seventh plan period (1985-90) was Rs. 36 billion (without considering interest) and Rs. 89 billion (with interest on investment). On an average, gross revenue collection per ha. of irrigated command is found to be about Rs. 68/- against which the estimated working expenses are Rs. 217/- per ha. and thereby resulting in financial loss of Rs. 149/- per ha. per year. (Navalawala, 1997)

I.2 d Creation of Irrigation Capacity and Its Use

At the end of the 7th plan, total irrigation potential created and utilisation achieved are set to be about 78 million ha. and 71 million ha. respectively against ultimate irrigation potential of 113.5 million ha. The 1990 level of utilisation (552 cubic km.) was about 48% of total utilisable water resource comprised of 52.5% of utilisable surface water and about 42% of utilisable ground water. Level of utilisable will increase to about 66% by the year 2000 and about 92% by the year 2025. Various technological as well as institution remedial measures to ensure the optimisation of water use efficiency should be considered as a first charge for any new investment. If the area is drought prone/Water short area, additional measures for

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water saving like use of micro irrigation system, conjunctive use of flow and lift, recycled use of waste water etc. should be considered. Take the case of Israel who treats about 70% of the total sewage and reuses it to irrigate 19000 ha. of agricultural lands and it has planned that by 2020 all the water for agriculture in Israel will be recycled from waste water. Since agro-climatic conditions of Haryana state are very much closer to Israel, the use of such technology for utilisation of sewage water can be adopted in Haryana state. To improve crop production with the limited water supply available, one of such ways is to cover the soil between crop rows with polythene which would cut down evaporation (and thereby resulting in substantial saving in water consumption) and heat up the root zone causing plants to use water more efficiently as well as improve the productivity per unit of land, almost double. It will be quite interesting to know what Mexico City, faced with water shortage did in this regard. Mexico City has launched an ambitious program to replace conventional toilets (using about 16 liters) with the 6 liters models in public places, commercial buildings and private residences. By late 1991, more than 350,000 toilets have already been upgraded which save nearly 28 million cubic metres of water per year which is enough to meet the household needs of water in 1990.
The end result of all such exercises would be limited to the water use level without affecting efficiency and output in all water consumers sector, be it agriculture or industries or domestic or hydropower. It is estimated that with technology and methods available today, water consumption for agriculture could be curtailed by 10-15%, industries by 40-90% and cities by a third with no sacrifice of economic output or quality of life. (Navalawala, 1997).

1.3 Concept of Conjunctive Use

The term 'conjunctive use' of water resources implies their coordinated and harmonious development for increased efficiency of water from different sources. Amongst the specific objectives of conjunctive use are mitigating the shortages in canal supplies increasing the dependability of existing water supplies, alleviating the problems of high water table and soil salinity resulting from the introduction of canal irrigation, and facilitating the use of saline ground water which cannot be otherwise used profitably.

The quality and the quantity of available water resources have long been recognized as the limiting factors in the agricultural development of arid and semi-arid regions. Optimal utilization of existing resources is therefore, of utmost importance recognition of the fact that surface water and ground water are two forms of the same resource leads to the realization that maximum
utilization of water resources can most economically be attained if extraction of ground water is considered complimentary to the supply of surface water. The joint use of rain water, surface water facilities, and groundwater reservoirs has been designated by a variety of names like conjunctive use, coordinated development of surface and ground water resources to serve the same general objective and the conjunctive operation of the surface and ground water reservoir is that the separate definite yield of water in case of independent development is replaced by the more economic joint yield in the case of conjunctive use planning.

For integrated conjunctive planning and utilization it is essential to have simultaneous utilization of surface and ground water resources through a judicious combination of surface irrigation projects and ground water schemes (sixth plan page 154) the G.O.I. formulated a number of policies/programmes to harvest rain-water to increase the water-table, natural replenishment of the soil, moisture content in the soil and the vegetative cover in the dry regions to activate evapo-transpiration. One such measure to look into all these components is the Watershed Development Programme.

In most of the cases, the conjunctive use of ground water is wrongly identified with the use of ground water as a supplement to surface water irrigation. The concept of
conjunctive use essentially envisages the simultaneous and balanced use of both surface and ground water, keeping in view the agro-climatic conditions as well as ecological integrity of a command. In fact, our plan estimates of potential created do not distinguish between the gross area irrigated by ground water as a sole source and as a supplement to surface irrigation works.

This distinction between sole and supplementary irrigation by wells is unfortunately not observed by any state other than Tamil Nadu. To that extent, the estimates of potential reported in the plan documents are not strictly comparable with those compiled under land use and cropping statistics. Another problem is the separation of responsibilities for surface and ground water resources which gives rise to overly optimistic resource availability by projections at times conflicting exploitation projects, ineffective control of ground water build up and inefficient investments. The increased resources potential from short-term and long-term conjunctive management is yet to be realised. At institutional level, we should consolidate responsibilities for surface and ground water and assign to the same functional units in the areas of planning operations/services and regulatory with equal attention to this principle at all levels of Government. This consolidation is usually easier and yields more
immediate benefits than many other institutional changes attempted. (Navalawala, 1997).

1.4 Water Management

Need for Water Management System:

Though reforms are essential in all spheres, yet water law reforms are more significant since water has a special role in human survival and progress. Water is not only necessary to meet the basic needs of human beings, animals, plants etc. but also the basic input for modern needs like power generation, industries, navigation etc. There is no effective water resource management system for its sustainable use to be economically efficient, distributionally justified and ecologically sound. In a country like ours its optimum use has special significance because:

1. We are a monsoon dependent agrarian economy which is uneven and full of uncertainty. In over populated country like ours with rapid population growth the ever increasing demand for food and other products needed for economic development can not be adequately met without an assured irrigation system.

2. Irrigation, at present accounts for more than three-fourth of our total national water use. It is unlikely to be met with the increasing water demand for non-agricultural use like, drinking, domestic, industrial purposes.
3. Though irrigation accounts for a large share of our total water resources use. But even if we could develop fully our water resource potential, only 60% of our cultivated land can be irrigated. (Dhawan, 1992)

"The major threat to the sustainability of our irrigated agriculture is going to come neither from ... the utilization gap i.e. the gap between our water resource bounty and the extent of its use, nor from the so-called irrigation gap i.e. the gap between our irritation demand and the irrigation potential created so far; but from the persistence of the incentive gap i.e. the gap between the scarcity value of water and value underlying the current pattern of water utilization and management." (Saleth, 1991).

Infact both the earlier gaps can be reduced by correcting the incentive gap. The subsidised supply of canal water induces them to maximise water per unit of output rather than to maximise output per unit of water leading to overuse of water. The competition to use ground water among farmers is paradoxical that unlike other economic goods where scarcity prompts efficiency and conservation, water resources continue to be over-used along with its increasing scarcity. The absence of economic incentive among farmers to conserve

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water both surface and ground water resources leads to ecological damages like waterlogging, water and soil salinity, alkalinity and land subsidence.

This is all due to the absence of effective water laws, institutions of water market and proper water right system. It is opined by experts that without correcting the existing water laws, institutions and water right system, it is not possible to ensure ecological security, economic efficiency or social equity in water use.

Ground water, besides irrigation is the major source of drinking water particularly for rural areas and as the main source of clean water for industry as well. Ground water is India’s most valuable water resource. Roughly 35 million ha. can be irrigated from ground water—a figure which exceeds the 33 million ha. of irrigation potential created through all major and medium irrigation works (Dhawan, 1990). According to one estimate ground water irrigation accounts for 75–80% of the value of irrigated production in India.

Over use of ground water problems are becoming evident in the form of its extraction approaching to total recharge, rapid fall in water table. Fall in water table are creating problems like salinity, alkalinity etc. In Haryana
state, where about 65% of the area is underlaine by saline ground water, fresh water pockets are heavily tapped.

These emerging problems call for more effective management of ground water resource. Over exploitation of ground water has resulted in steady decline in water levels leading to infructuous investment in dug wells and bore wells. Though ground water is an efficient and independent means of irrigation, but unplanned growth of pumping for irrigation may create the problem of shortage of drinking water in the near future.

Although, under the constitution, water is a state subject, yet the central Government circulated model bills at various times—the first was prepared and circulated in 1971 and the latest updated version was distributed in 1992. The model bills reveal the thinking of the central Government on the approach of ground water management and provides the guidance to the states to formulate laws for the optimun use and protection of ground water. Except a few states such as Gujrat, Maharastra, Karnataka and Tamil Nadu the states have been unable to pass such legislations. The fact that extraction of ground water is the sole right of land owners and they have the ultimate right to use the water in any manner or quantity they like.

Any attempt to regulate the use of ground water is consideration by well owners as an attack or control on the
use of their personal resource. So there is little hope for effective implementation of such laws.

The growing attention in India is that without active participation or co-operation of the local people no attempt to regulate ground water use is possible. The present thinking is towards greater user participation in water resource management. But in the updated model bill (1992) there is no provision for user participation in the management of ground water resource.

In the recent years this thinking is growing because of the new ideology of people oriented development along with technology oriented development. (Moench, 1994).

1.5 Purpose of the Study

The quality and quantity of available water resources have long been recognized as the limiting factors in the agricultural development of arid and semi-arid regions. Optimal utilization of existing resources is therefore, of utmost importance. Recognition of the same resources leads to the realization that maximum utilization of water resources can be attained if extraction of ground water is considered complimentary to the surface water. Rain water can be effectively utilized through storage in rice fields, farm ponds and through recharge wells. Most efficient use

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The development of ground water has registered a phenomenal growth during the last few decades.

According to the Seventh plan document, it accounted at the Sixth plan, for as much as 26.1 million hectares in terms of gross area irrigated. This figure it needs to be noted, is marginally in excess of the area served by big irrigation projects, which stood at 25.3 million hectares. What is however, of even grater significance is the fact that ground water irrigation is vastly more productive than that provided by big canal systems mainly because, unlike the latter, it enables the farmer to apply water to his land exactly when and to the extent, it is required for the crop.

This well-known fact is borne out by a recent study by prof B.D. Dhawan of the Institute of Economic Growth, New Delhi. According to this study, the productivity of ground water irrigation is around 100 per cent more than that of canal irrigation. This means that the 26.1 mh of ground water irrigated areas are equivalent to around 52 mh of canal irrigated areas. This fact alone should be more than enough to establish the pre-eminence of ground water as a source of irrigation and water supply in the country. But it has also to be seen in the context of the fact that big surface water projects are today in a state of unprecedented crisis created by a number of factors; the most important of which are:
(a) the excessively large number of projects.
(b) the tremendous cost escalations which have accompanied time over runs and have pushed the cost of "creation" of potential alone to around Rs. 30,000 per hectare in the Seventh Plan and the cost of its "Utilisation" to a still higher figure;
(c) the huge gap of 8.3 mh between potential created and potential utilised which existed at the end of 1992-93.
(d) the colossal efforts which need to be made to prevent canal irrigated lands being damaged by water logging and salinisation in the future, let alone reclaim the 7 odd mh which have been lost to production already.
(e) The need to make huge further investments by way of CAD programmes in order to improve the productivity of canal irrigated lands and.
(f) The need to prevent the financial losses, of around Rs.800 crores per annum, which are being incurred by big irrigation projects.

If these factors are also taken into account no room is left for any doubt that the future of water management in India will belong increasingly to the ground water and small storage sectors rather than to big surface projects.

It is a great pity that the irrigation establishments of the country which are still in the hands of people who are used to thinking only in terms of big dams and canal systems have not yet been able to appreciate the true
significance of ground water as a resource which is incomparably easier, cheaper and quicker to tap than surface water and that too at the farmer’s own cost and initiative. In contrast, big surface water projects demand huge public investments for the construction of storage and transport systems, require the submergence of much valuable land, take years and often decades to complete, suffer from serious losses of water by evaporation and seepage and often create acute problems of water-logging in command areas. It is worth mentioning that there are today around 10 million privately owned pumpsets in the country and the fact that roughly half this number are powered by diesel engines shows that farmers are not unduly deterred by the non-availability of electricity from exploiting this resource even though this entails much higher levels of both capital and recurring costs.

This insatiable demand for ground water which has resulted in serious falls in water tables in many parts of the country where the Green Revolution has been most successful. Farmers have met this situation by incurring further heavy expenditure by way of deeping of tubewells and lowering of pumpsets.

1.6 Organization of the Study.

The present study is organized into six chapters. In first chapter of Introduction, the problems under study have been introduced. It also includes a brief overview of the
literature concerning the problem. This chapter also contains the objectives of the study as well as the organization of the study. The second chapter Research Methodology, gives an idea about the study area (i.e. Haryana), the collection of data and with its sources and the methods used in this study.

The third chapter, Availability of Water Resources, gives a detailed analysis of the availability of surface and ground water resources in the State of Haryana.

The fourth chapter, Utilization of Water in Haryana, provides a glimpse of the utilization of surface and ground water.

In the fifth chapter, Water Resources and Agricultural Development, an attempt has been made to assess the role of water Rescues or irrigation in bringing changes in Net Sown Area and Gross Cropped Area, Changes in other selected factors such as Tube -wells, Tractors, Fertilizer Consumption and number of Male Agricultural Workers.

The sixth and final chapter, Summary and Conclusions brings out the summary of the problems and conclusions drawn out of it.