The understanding of any subject depends on a good knowledge of related literature. A good knowledge of the related literature helps not only to find out the scope of the subject but also to design the study in an improved manner. A brief review of the available studies in this field and related fields is attempted in the following paragraphs.

**BENEFITS OF IRRIGATION**

**Navalwala B.N. (1995)**: In the article ‘Water logging-Problems & Solutions’ stated about the importance of drainage as a measure to remove excess water from the soil. Proper attention on drainage of excess water from soil surface is not being paid even today while planning & designing for canal irrigation projects. Negligence to proper drainage system has created serious problems of water logging and of salinity & alkalinity in many irrigation projects in the dry & semi-dry areas.

**Rasis Ahmad (1998)**: In the article ‘Water for irrigation- An overview’ stated that for raising productivity of agriculture one has to switch from traditional to modernized & scientific system of farming for which regular supply of water for irrigation is necessary. In India 2/3rd farmers are small & marginal farmers and most of them continuing traditional system of farming. These 2/3rd cultivable area is dependent on scanty rainfall & any change in the timing or in the amount of rainfall leads to extensive damage to crops. India is served by south-west & the north-east monsoons. He mentioned 2 types of artificial irrigation systems:

→ Flow Irrigation: - Flow irrigation is dependent on the surface water & it is collected in rivers & canals.

→ Lift irrigation: - Lift irrigation is very economic & certain source for having adequate water for irrigation of various crops at proper time.

**Roy L.B. et al. (1999)**: In ‘Farmers Participation & the hare irrigated project’ stated that generally most farmers do not irrigate during night time because of the fear from mosquitoes, snake & other wild animals. Everywhere some
conflicts arise while irrigation. Some farmers use to illegally divert the water from the canal for continuous irrigation. Other farmers will report this matter to the local water committees. If the person is found guilty of such things, he will be penalized up to 50 birrs as per the ‘local water law’.

Narendra Kumar I. & Chandrasekar Rao G.(2007)4 : In ‘Impact of Irrigation on Employment’ analyzed on the basis of micro study that irrigation reduces the risk & uncertainty inherent in the rain fed cropping. Their study area is Kurnool district of Andhra Pradesh. The objective of the study is Impact of canal & Bore Wells irrigation sources on the farm output & generation of employment relating to the crops like paddy & Cotton. They conclude in their study that there is no significant difference between canal & bore well irrigation with in human labour & bullock labour.

Somashekaraiah N.T. & Mahendra kumar S. (2008)5 : In the article “Tube Irrigation on Resource Use Efficiency in Agriculture” made an attempt to assess the impact of tube well on resource use efficiency in agriculture with special reference to paddy cultivation in the study area.

Vairavan K.(2010)6 : In “Drip Irrigation Technology in Sugarcane” said that by adopting the drip irrigation technology in sugarcane, the farmer could save water up to 50% & achieve higher yield of 60 ton per acre.

IRRIGATION DEVELOPMENT

Nathan K.K., Sharma R.K. & Singh A.,(2001)7 : In “Irrigation Development & Future Possibilities” observed that before 1854 all the irrigation works were financed from general revenue. After 1854, the categories of irrigation viz, major & minor irrigation came into existence. The importance of small irrigation was first stressed by Indian irrigation Commission (1903) & then by Royal Commission on Agriculture (1928).Substantial development in the field of irrigation takes place only during 20th century. When we see the data provided below we can find that irrigated area in the country has increased.
• From about less than 1 million ha in 1800 – 5 million ha in 1900
• From 16 million ha in 1925 – 19 million ha in 1947

The importance of minor irrigation to food production was emphasized by Grow more food Committee (1925), Food grains Enquire Committee (1957) & Agricultural production team of the Food Foundation (1959). After Independence the country was left with total irrigated area of 19 million ha. from all sources. The major irrigation source in India today are wells (49%), canals (38%) & tanks (7%), which irrigate about 30% of net cropped area.

Navadkar D.S.et al.(2003)8 : In “A Boon for sustainable Agricultural Development in Maharasstra” described that in India, tremendous development has been witnessed through the successive Five Year Plans by developing the irrigation potential. Pattern of the expenditure for irrigation in India with the help of the data provided by Economic Survey,2008-09.Pattern of expenditure in 5 year plans were as follows:-

• During the 1st plan 15.82% of the total outlay was spent on irrigation & flood control.
• In 2nd plan amount embarked for irrigation & flood control was only 9.13 %
• In the 3rd plan total outlay was reduced to 7.75%.
• In the 4th plan outlay has increased to 8.58%.
• In the 5th plan outlay has increased to 9.83%.
• In the 6th plan the government spent 10% on irrigation.
• In the 7th plan the government spent has fallen to 7.58%.
• During 8th,9th,10th plan there is a substantial fall in the outlay allotted for irrigation & flood control.

This clearly shows irrigation expenditure has been falling steadily during the plan period.
John Bricose & Malik R.P.S.(2007)9: In “Hand Book of Water Resources in India Development, Management & Strategies”, narrated that irrigation in India has been practiced from pre-historic time & appears to have been contemporary with agriculture itself. Various references are found in the Vedas & other ancient Indian Literature to wells, tanks, canals & dams, their importance to the community, their efficient maintenance & operation, & the duties of the state in these matters. Archaeological investigations at the sites of the Indus Valley Civilization reveal evidence of stone dams (gabardunds) & earthen embankments (kachbunds). In southern India, irrigation was in vogue in the Cauvery delta more or less in the same periods as the Indus Valley Civilization. The Grand Anicut across the Cauvery was built in the second century A.D. Besides river diversion works, thousands of minor irrigation tanks were constructed in the 5th century AD by the Cheras, the cholas, & the Pandays. The Western Yamuna Canal was built in the 14th century AD, renovated by Mughals in the 16th century AD, & repaired in the 19th century by the British.

IRRIGATION MANAGEMENT

Maria Saleth R.(1995)10: In ‘Managing Irrigation Together: Practice & policy in India’ stated that unless a radical reform is urgently undertaken to change our present water institution (i.e. water policy, water law & water administration), it will be almost impossible to salvage & sustain our water economy.

- The emphasis was given a people-centered approach to water management- not on any romantic or idealistic grounds but on practical counts.
- The second was the crucial role of social engineering aspects in irrigation management.
- Thirdly, not only the farmers, irrigation officials, training & technical institutions, & private development agencies need to come
together in managing irrigation but also different segments of the system ranging from catchments to drainage systems need to be managed together.

- Fourthly, the authors highlight a serious legal deficiency, i.e., the unsuitability of the prevailing Acts for legally registering Water Management Associations (WMA).

- Fifthly, the authors also deal with one of the most crucial technical snags in ensuring equitable allocation of water & cost by WMAs.

- Sixthly, while the need for WMA’s is clear & the policy environment becomes increasingly favorable for their formation, WMAs are not always spontaneous except in cases where they face an immediate common threat like severe water shortage or share a common social bond.

Dewan J.M., Sudarshan K.N.(1996)11: In their book “Irrigation Management” they pointed out that new development in irrigation technology plus complementary advances in plant breeding, crop protection, & agronomy packages have increased the productivity & profitability of irrigation agriculture.

Dewan J.M., Sudarshan K.N.(1996) 12 : In their book on “Irrigation Management” highlighted that “Irrigation, being one of the important inputs of agriculture, becomes an equally important component of the rural infrastructure for the development. Sufficient weightage to irrigation development should be given. In India agriculture sector is the main stay of the national economy, yet by & large it depends on the vagaries of monsoon. The main function of irrigation is to mitigate the impact of inadequate & irregular rainfall.

Dewan J.M.,Sudarshan K.N.(1996)13: Mentioned that the average size of holding in India is as low as 2-3 hectare. Imbalance between the distribution of control over land & the number of dependents it breeds, social & economic inequalities. It also leads to unequal access to irrigation water more particularly
to surface water, i.e. Canal, & also to development activities, institutional facilities, decision making process.

**Dewan J.M., Sudarshan K.N.(1996)**: Said that canals were long thought to be superior in the quality of irrigation service they can provide. Experience in recent decades has however, produced much disillusionment about the performance of canals.

- The only group of irrigators in canal commands who usually have no or few complaint about the quality of irrigation service are in the mid-reach areas of the system.
- Those at the head-reach suffer from too much water, especially below ground surface, contributing over a period of time to water logging, soil salinity & reduced land productivity;
- Tail-enders of canal system are in the same situation as tank irrigators- on most of the canal systems, the irrigation system, if any, that tail-enders receives is usually neither timely, nor reliable, nor adequate.

Extensive evidence show that wells offer better quality irrigation service is that of control over timing & quantum of water application that they do not enjoy with canal irrigation. In case of canal, farmers have to use water when the canal managers choose to release it or when their turn comes, which may be after a week or two or more. So farmer prefer to make supplementary use of well water whenever possible.

**Shekhawat M.S. & Singh K.K. (1997)**: In his article ‘Better Management of Water” stated that in India just 25% rain water is being utilized for irrigation. The overall irrigation efficiency in the canal command area is very low & there is huge gap between the potential created & exploited. The loss of water is not only wastage of scare resource created at huge cost but it results in
the twin problems of water logging & soil salinization. They have suggested methods of water application in the following way:-

- Irrigation water may be applied to crops by flooding it on the surface,
- by applying it beneath the soil surface,
- by spraying it under pressure or by applying it in drops.

The Water supply, the type of soil, the topography of the land & the crop to be irrigated determine the correct method of irrigation to be used.

**Dhawan B.D. (1998)**: On the title “India’s irrigation Sector: Myths & Realities”, assessed that just as in studies pertaining to cost of cultivation where we use a couple of cost variants, we may have to do something similar while costing canal irrigation. 3 cost variants readily come to mind: Cost 1, Cost 2 & Cost 3. He also mentioned that a widely held view is that under-pricing of public irrigation in India is due to political reasons. This can best be done by focusing on the determinants of farmer’s ability to pay for canal waters. Benefits exceeding costs is a necessary but not a sufficient condition for full cost recovery from canal beneficiaries.

**Ratan Reddy (1998)**: In “Institutional Imperatives & Coproduction Strategies for Large Irrigation Systems in India.” mention that irrigation management in India is polarized between “top down” (centralized) & “bottom up” (farmer’s participation) approaches. Institutional reforms within the irrigation department are not given due importance in the recent debates. Instead lack of willingness & low ability of the farmers to pay for irrigation water are often used as excuses for continuing irrigation subsidies at the top level.

**Pasricha N.S. (2001)**: In “Growth in irrigation Development & Fertilizer Use in India- Impact on Food Production” viewed that since the beginning of Green Revolution irrigated area for all crops has increased rapidly. Despite of
increase in total irrigated land in country, per capita irrigated land will drop from 0.047ha in 2000 to 0.028 ha in the year 2030. According to him challenges on the food front can be meet or not in the coming decades depends on the quantum & direction in investments made today. Producing more food from less land, water & energy is a task that will call for the integration of the best in modern technology with ecological strength of traditional wisdom of farming practices.

**Tewari D.N. (2001)**: In his research article “Optimum use of Water resource in Agriculture” mentioned that land & water care is very necessary to feed a population of 1 billion & growing and to achieve “Food to all “. Use of water for increasing agricultural production has its own cost & benefit. With the stagnated net sown area in the country at about 142 million hectares & 63% of the cultivated land under rain fed, further expansion of irrigation, including additional irrigation through modernization/renovation of irrigation capacity is needed as a critical input to achieve the targeted growth rate of agricultural production.

**Dinesh K. Marothia (2003)**: In the article “Enhancing Sustainable Management of Water Resource in Agriculture Sector :The Role of Institutions” addressed that investment in canal & groundwater irrigation development has enhanced the productive capacity of land resource which has in turn enabled the nation to achieve steady agricultural growth. The Impacts of irrigation systems, particularly of canal irrigation, are besieged with a number of management & environmental problem. Management problem related to the allocation & use of water within the distribution network. Environmental problem like water logging, salinity & weed infestation in many projects are not commensurate with the large public investment & subsidies given to the farmers.

**Diwan (2003)**: In “Conflict Resolution in Water Sector through Institutional Development” analyzed that an inequity in irrigation water supply that in existing irrigation projects, there is often considerable inequity in distribution
of water to the disadvantage of the farmers in the lower reaches of the command. The anomalous situation arises over a period of time as the upstream farmers gradually switch over to a high water consuming crops like sugarcane & paddy because of incentives & higher returns offered by market forces. In extreme cases, because of the riparian rights of these farmers, established over the years, the objectives of original project planning in terms of area covered & cropping pattern are only partially realized be sided adverse environmental impacts like water logging & soil salinity. This lead to conflict between irrigation department & lower-end farmers. In some areas where farmers are resourceful, excessive ground pumping is resorted to, which ultimately leads to violation of permissible limits of ground water exploitation fixed by the concerned authorities. These areas are declared as ‘Grey’ or ‘black’ to prohibit further exploitation. The unrestricted changes in cropping pattern adopted by upper-end farmers is difficult to regulated through administrative or legislative interventions. This could only be achieved through mutual understanding & cooperation among the farmers through institutional development at the farmers through institutional development at the farmer’s level in the form of Water users Association (WUA) which should also take the responsibility of operating the distribution system. There are wide disparities in water allowances in different regions.

Dinesh Kumar M. (2003)22 : In his article on ‘Demand Management in the Face of Growing Water Scarcity & Conflicts in India Institutional & policy Alternatives for Future’ expressed that in India, irrigation water is heavily subsidized. The annual irrigation subsidies are estimated to be around 5400 Crores. After independence, the Indian governments saw irrigation as a means of welfare & were reluctant to raise the irrigation fee charged to poor farmers. As irrigation services declined & the agencies weak end, farmers became reluctant to pay the water charges. Charges are paid on an acre basis & are not reflective of volume of water used. It is believed that lack of linkage between volumetric water use, water charges, & lack of agency capability to recover
water charges & penalize free riders create an incentive for overuse or wasteful practices.

Jayanta Bandyopadhyay & Bidisha Malik (2003)23 : In their article on ‘Ecology & Economics in Sustainable Water Resource Development in India’ mentioned that uncontrolled & ill-informed extension of the tube-well & energized pumping technologies for irrigation in agriculture has, for instance, led to groundwater over-draughts, incurring abstraction level far exceeding the recharge.

Vayas, V.S. (2003)24 : In his book on India’s Agrarian Structure, Economics Policies & sustainable Development’ quoted that according to the Central Water commission, India receives average annual precipitation of 4000 Billion Cubic Meters (BCM). However, the total annual utilizable water resource of the country is estimated at 1122BCM or 28% of the annual precipitation.

Bulk of this water is used for irrigation, which accounted for 83% of the total water use in the country. Use of water for irrigation has expanded phenomenally during the last 21 years & so on. The net irrigated area increased from 31.1mha. in 1970-71 to 53.5 mha in 1995-96. The area irrigated more than once increased from 7.1 mha (in 1970-71) to 18 mha. (in 1995-96). Now approximately 38% of the gross cropped area in the country is irrigated. In 3 states in country more than 2/3rd of the net sown area is now irrigated. These states are Punjab (93%), Haryana(76%) & UP (66%).

Abdeen Mustafa Omer (2004)25: In his article ‘Water Resources Development & Management in the Republic of the Sudan’ stated that the most important research & development policies which have been adopted in different fields of water resources are:-

- The reuse of drainage water & groundwater;
- Irrigation Development;
- Water resources;
- Preventive Maintenance of existing facilities, including canals;
- Aquatic weed control & river channel development
- Protection plans for Water resources in general.

To him privatization is a part of a solution to improve services in delivery of water & sanitation sector.

Rao S.V.N.(2004)26 : In the article ‘Water Use of Surface & Groundwater for Coastal & Deltaic Systems’ observed that management of water resources in coastal & deltaic regions irrigated by run-of-the-river schemes involves two issues:-

→ First, availability of water resources in space & time,
→ Second, sea water intrusion

Koli P.A. & Bodhale A.C.(2006)27 : Argued in their book on ‘irrigation Development in India’ that successful cultivation is not possible in large part of our country; due to a lack of irrigation facilities, there are large areas in the country which often produce one crop.

John Briscoe & Malik R.P.S (2007)28 : In the article ‘India’s Water Economy: An overview’ discussed that irrigation is a predominant user of water resources in India. Irrigated agriculture contributes more than 55% of agricultural output. Although India has one of the largest irrigation systems in the world, irrigation development has not been impressive over time. India has a highly seasonal pattern of rainfall. With 50% of precipitation falling in just 15 days & over 90% of river flows in just 4 months. India can still store only relatively small quantities of its fickle rainfall. Whereas arid-rich countries has built over 5000 cubic meter of water storage per capita, & middle-income countries like South Africa, Mexico, & China can store only 200 cubic meters per person. India can store only about 30 days of rainfall. Water can be transformed from a curse to blessing only if major investments are made in water infrastructure. Recognizing this, the Prime Minister has recently called
the establishment of a Tennessee Valley Authority (TVA) for the Brahmaputra which would combine major water infrastructure with modern management approaches to make water a stimulus for growth.

**John Briscoe & Malik R.P.S.(2007)29**: In the book ‘Hand Book of Water Resources in India Development, Management, & Strategies’ mentioned that with regard to water stress & scarcity, the temporal & special variability of rainfall in India is a well-recognized fact. The average annual precipitation is 1170mm but varies from 11000mm in the north eastern region to 100mm in the western desert.50% of the precipitation take place in 15 days or so & less than 100 hours altogether in a year.

The per capita availability of water has been steadily declining since independence from 6008 m cube to 1829 m cube as of now. A water availability of less than 1700 m cube per capita is termed as a water stress condition while less than 1000 m cube is water scarce. Broadly, the breakdown of 1000m cube is 600 m cube for food security, many basins like Pennar & Sabarmati are already water scarce. One of the main reasons for water problems in the country is the low per capita storage(only about 200 m cube) as compared to Russia (6103), Australia(4733), Brazil(3145), Turkey(1739), Mexico(1245),Spain(1410),China (1111),& South Africa (753). For water stress to be avoided, a minimum per capita storage of 750 to 1000 m cube needs to be achieved. India has no option but to go ahead with its dam construction program.

**Lakshmi Narasaiah M.(2007)30**: In his book on “Irrigation & Economic Growth” said that a sharp inequality in water supplies between farmers in the head reaches of irrigation systems & those located downstream is another manifestation of poor performance. Investigations in the Tungabhadra irrigation scheme reveal that the tail-end of a major distributor commanding 25 % of the total area, received approximately 20-40% of the targeted discharge while the upper reaches got more than their share.
Andharia J.A. (2008)31: In his article ‘Agricultural production & Problems of Agriculture in India’ pointed out that food & water are considered as the most essential for maintaining our lives. To him India’s major food problem is irrigation. He observed that irrigation in India has yet remained dependent upon rainwater & a seasonal one. A huge amount of plan outlay has spent on small, medium & large irrigation schemes in India during Five Year plans. Yet, irrigated land has not been covered fully.

Ayan Hazra (2008)32: Studies on ‘Socio-Economic Evaluation of Water Management Activities in Chhattisgarh’ has found that in the traditional mind set of top down communication processes & farmers are regarded as passive receptor, ignorant, conservative & unwilling to change up with new paradigms.

Jat M.L. et al (2009)33: In their research article ‘Water Resources Management in a Water Deficit State’ that there is a big gap between water resources available & which is used in Rajasthan. The Water resources availability, therefore, needs to be increased by adopting appropriate strategy in the state. The strategies are Rainwater harvesting through farm ponds, Recharging the ground water Conservation of stored water in reservoirs & also in small water harvesting structures, Technique for compartmentation is an effective tool for water saving.

Gargi Parsai (2010)34: In the title on “Double Farm Growth Rate to Ensure Food Security Sustainable Technologies that can Produce More Need” pointed out that India commands about 2.3% of the world’s land area & about 4% of the earth’s fresh water resources, but feeds 17% of the world population. This put tremendous pressure on our resources & makes the need for newer & better technologies even more critical & which could produce more than less. He stressed the 3 fundamental principles of sustainable agriculture, viz live soil, Protection of biodiversity and Precision farming & nutrient cycle.
PRODUCTION & PRODUCTIVITY

Dewan J.M. (1996)35 : In “Irrigation Management” argued that availability of water for irrigation is not the sole factor for increased production. He explained this point from the fact that Haryana & UP having created high percentage of irrigation facilities have not registered increase in production as compared to Punjab. Therefore for optimal water use efficiency, a complete crop production technology is needed in which water is one of the important component.

Kushwaha K.S. et al.(1997)36 : In the article “Impact of Prudent Canal Water use on Land Utilization Pattern & Productivity in District Ghazipur, Uttar Pradesh” found that the productivity kharif i.e. paddy, wheat, vegetables, green fodder & moong has gone up but for coarse grain has gone down. The total production has increased by 39% between 1990-91 & 1995-96 due to prudent use of canal water.

Vaidyanathan A.(1999)37 : In the book on ‘Water resource management, Institutions & Irrigation Development in India’ attempted that water control institutions are the key elements of the Physical, Technological & socio-economic environment. These environments have a direct bearing on the nature of the water control problem & on the institutions for handling it. The immediate purpose of the water control is to help increase agriculture production.

Vaidyanathan A.(1999)38 : Pointed that increase in productivity per unit area & in total production depends not only on the extent of the water control system & its quality, but also on several other factors like climate, soil, nutrient use etc. Maximum amount of nutrients that the plants can use will be higher under irrigated conditions than under rain fed cultivation.

Narayanmoorthy A.(2000)39 : Studied ‘Farmers Education & Productivity of Crops in the village of Pudukkotai District of Tamil Nadu’. He found that farmer’s education has only a limited role in increasing the productivity of the
crops. The most important factors influencing the productivity are fertilizers & irrigation.

Archana Mathur S.et al (2006)40 : In the paper on ‘Status of Agriculture in India Trends & Prospects’ pointed out importance of role of public investment/government expenditure on agriculture. Public investment is a very important determinant for increasing the growth rate of agriculture production. Given other factors, a constant increase in public investment to 15% per annum lead to agricultural growth of 4%, which is accompanying with the projected growth in the 11th plan. They concluded that government expenditure in rural infrastructure is necessary.

Subbaish (2006)41 : In his article ‘Several Options Being Tapped’ pointed out that the challenge ahead is sustaining the productivity growth without endangering the natural resource base. Water is becoming increasingly scare and most of the Asian nations including India are expected to face serious water scarcity in the next 10-15 years. Thus, threaten the sustainability of irrigated rice production in Asia. Aerobic rice is a new concept aimed at decreasing water requirement in rice production.

Onyenweaku C.E. & Ohajianya D.O (2007)42: In their research work on ‘Technical Efficiency of Rice Farmers in South Eastern Nigeria’ pointed out that the wide variations in the level of technical efficiency indicate the ample opportunities exist for farmers to increase their productivity & income through improvements in technical efficiency. Credit, education, farming experience, farm size etc were found to be positively & significantly related to technical efficiency.

Swaminathan M.S.(2009)43 : Opined in the title on ‘Monsoon Blues may hit Rice Output by 15 pc’ that due to poor monsoon & scanty rains are likely to lower rice production by 15% this kharif season. Kharif rice production in 2008-09 was 86 million tones. If there is 15% decline in production this year, rice output may be about 73 million tones.
**Jelle Bruinsma 44**: In his book on World Agricultural Towards 2015/2030 at FAO Perspective, ‘crop production & natural resource use’ observed that share of irrigated production in total crop production of developing countries has been increasing. In 1997-1999, the share of arable land is 21% & it is expected to increase to 22 in 2030. Similarly the share of irrigated production in total production is 40% in 1997-99 & is expected to move to 47% in 2030.

**Yehuda Shevah 45**: In his research work on “Irrigation & Agriculture experience & Options in Israel” pointed out that Israel make irrigation obligatory for the development of intensive agriculture & food production.

**WATER USE**

**Dewan J.M. Sudarshan K.N.(1996)46**: In his book on “Irrigation Management” used the idea given by Robert wade that the comprehensive account of the scale, working & impact on irrigation efficiency & how O&M contracts are tapped for a share of contractors profits. Bribing is not a lubricant to the operating system, it is corrosive. In an era where the quality of aid is of increasing concern, donars could perhaps play a role in the two most attractive solutions advocated: First to promte irrigation user associations as a countervailing voice; second, to encourage professional training & a cadre of people dedicated to professional norms of efficient canal operation. Such small endeavors could have useful impact.

**Ghulam Nabi Bhat & Akram Ahmad Khan (1998)47**: In their article on ‘Sustainable Water Management: A necessity for Sustainable Agriculture’ pointed out that in the formulation of its policy regarding utilization & management of water resources, the government did not consider the role & importance of traditional sources of water. According to them allotment of water for irrigation will go down from the present level of 90% to 75-80% in next 10-15 years. Water supply can be augmented by adopting efficient irrigation techniques. Modern technology offers cost effective options not only to increase areas but also to increase productivity. For instance the evapotranspiration(ET) requirement for growing paddy is about 800-1000 mm
whereas in canal/tank command areas farmers use as much as 2000-25000mm which is not only wasteful but also effect the yield due to the drainage problem.

**Suraj Khan (1998)**: In his article on “Some aspects of On-farm Irrigation Management for High Crop Productivity & Water use Efficiency” stated that correct decision is to be taken in the selection of crops & their varieties to improve water productivity in agriculture sector. Productivity of available water per unit area & time could be enhanced considerably if more & more area is brought under double, treble & intercropping system.

**Tewari D.N. (2001)**: Observed in his study ‘Optimum Use of Water Resource in Agriculture’ observed that out of 142 million hectare net sown area 63% of the cultivated land are under rain fed. To achieve the targeted growth rate of agricultural production further expansion of irrigation through modernization/ renovation of irrigation capacity is necessary.

**Sivanappan R.K. (2001)**: In his article ‘Sustainable Management of Water Resources’ argued that the allocation of water for irrigation will be reduced from 84% to 71% & it will be increased to 20% from 8% for industries & municipal needs. In India about 40-45 % of water allotted for agriculture is used to grow rice crops. If water management practices are applied for paddy crops it is not difficult to save 10-15% of water.

**Dinesh Kumar M.(2003)**: In the article ‘Demand Management in the Face of Growing Water Scarcity & Conflicts in India Institutional & Policy Alternatives for Future’ mentioned that the crisis perpetuated by the growing water scarcity can be mitigated only through interventions that are aimed at achieving higher efficiencies in the existing uses & transferring water to high valued uses.

**Hanumantha Rao (2003)**: In his article on ‘Sustainable Use of Water for Irrigation in Indian Agriculture’ water resources are becoming extremely scare. According to the projections made by the National Commission for Integrated Water Resource Development Plan, requirement of water for irrigation in India will grow by more than 50% in the next 50 years. Water requirement for
household consumption & industry would rise even faster. Balance between the supply & demand for irrigation water can be achieved only improving the level of irrigation efficiency from 36% in 1993-94 to 60% in the year 2050.

**Hanumantha Rao (2003)**: Expressed in his article on ‘Sustainable Use of Water for Irrigation in Indian Agriculture’ that the steps taken so far for improving water-use-efficiency through modernization/renovation of existing system have not significant & which have deteriorated over the years. According to him the technology & public policy, institutions concerning water use hold the key to raising water productivity by bridging the vast gap that now exists between knowledge & its application.

**Singh C.J.(2003)**: In his research work on ‘Efficient Use of Water in Canal Command of Punjab’ studied the adaptive research-cum-demonstration trails were conducted in the canal command area of the village Jaisingh wala, of the Bathinda distributory. The trials on wheat, cotton, mustard, berseem & jawar crops were intended to evaluate the soundness of the improved irrigation practices & other farming techniques which directly or indirectly reduce the wasteful expense of scare irrigation water & increase the water use efficiency.

**Palanisamy (2004)**: In his research work ‘Policies for Sustainable Use of Water’ that inequities in water supply are more predominant in the tail-end region which result in conflicts & inefficiency in water use. He pointed out that investment in secondary & tertiary distributor system to improve the water use efficiency.

**Yoji Hisao & Yasuda Hiroshi (2005)**: In their study on ‘Necessity to Increase Efficiency of Irrigation’ pointed out that about 40% of the world’s food crops is produced from irrigated agricultural field which constitute only 17% of the total agricultural field. It is estimated that food production must be increased to 1.4 times the present level by 2025 to support an increasing world population. He concluded that to increase irrigation efficiency is the key for sustainable & effective use of the already developed water resources.
Anil Kumar Singh & Rajput T.B.S. (2005) 57: In their on ‘Optimizing Water Uses & Recharging of Aquifers’ that the dominant method of irrigation practiced in the country is flood irrigation, in which the crop utilizes only one-half of the water released & the rest is lost in conveyance, runoff & evaporation.

Singh K.K., Ojha C.S.P. (2005) 58: In their article on ‘Improvement in Irrigation Efficiency Using On-Farm Reservoir & its Efficient Operation’ that during irrigation of the crops a huge quantity of water is wasted due to poor efficiencies of irrigation systems. This wastage can be minimized by adapting suitable string excess water of irrigation in On-Farm-Reservoir(OFR) & later using this water in a specific way. The study suggests that the use of water of OFR invariably increase water irrigation efficiency.

Haque T. (2006) 59: In his research article on ‘Resource Use Efficiency in Agriculture’ pointed out that low irrigation charges encourage farmers not to care about water use efficiency & also cause the problem of rapid depletion of ground water in Punjab & Haryana. Availability of good quality of irrigation, drainage system & appropriate method of application as well as pricing of irrigation water would be crucial for sustainable use of land & water resources.

Narasaiah (2006) 60: In his book ‘Agriculture & Water Management’ investigated in the Tungabhadra Irrigation Scheme revealed that the tail-end of a majority distributor commanding 25% of the total area, received approximately 20-40% of the targeted discharge while the upper reaches got more than their share.

Ronald C. Griffin (2006) 61: In his article ‘Achieving Water Use Efficiency in Irrigation Districts’ mention that achieving efficient use of water is a important challenge. The main problem is that operational rules are not designed in a manner that it fits in the modern era of water scarcity.
**Suresh Pal (2006)** In the article ‘Resource Use Efficiency, Particularly in Irrigated Area’ pointed out that efficiency of water use has increased over time but still it is less than 40%. They argued that present price policy regime, there are strong incentives for growing rice & wheat & there is little possibility of large scale diversification to other crops, which require less water & generate higher income.

**Bhagirath (2007)** Pointed out in his article on ‘Year 2007 Declared as Water Year’ that at present the per capita storage capacity in India is only about 207 cubic meters as compared to 1111 cubic meter in China. As a result of growing population, the per capita water availability in India is declining every year & as per an estimate, it will be about 1341 cubic meter by the year 2025 & about 1140 cubic meter by the year 2025. Therefore it is necessary to create infrastructure & adopt appropriate management practices to augment the utilizable water resources & to improve the efficiency of the created efficiency.

**John Briscoe & Malik R.P.S. (2007)** In the title ‘Irrigation Water Use Efficiency’ explain that at the planning stage irrigation efficiency is assumed as 55-60% but in actual practice it is below 30%. Irrigation efficiency is low in the country due to a combination of factors-low water tariff, poor state of canal system due to lack of maintenance.

**Hanumantha Rao C.H. (2008)** In the article ‘Wastages & Inefficiencies in Water Use’ pointed out that inefficiency in the use of water is because of absence of financial accountability on the part of the project authorities & low rates charged for the water.

**Arvind Panagariya (2008)** In the book ‘India: The Emerging Giant’ pointed out that bigger the farmer, the larger the amount of water & electricity he uses because of free electricity. According to him the subsidies are distortionary because they lead to highly wasteful use of canal water, ecological degradation from water logging, & excessive use of electricity. He suggested that from the efficiency & equity viewpoints, it is desirable to charge farmers for the electricity they use.
Pandey M.P. & Ghosh A. (2008) 67 : In his article “Challenges to the Future of Agriculture-Global Perspective” pointed out that an estimation by the IPCC, the average temperature would increase by about 0.3 c per decade over next century. Consequently, level of sea water could rise by at least 2-4 cm per decade. Therefore, impact of global warming on entire agriculture growth is apprehended to be worse.

N. Bashkaran (2010)68 : In Lining of Canals can Improve Irrigation efficiency by over 15%’ stated that only around 53% of water from head reservoirs actually reach farmers field, the rest represents losses during transit due to percolation & evaporation. He suggested that plastic or concrete lining of canal can reduce water seepage & percolation losses by 15% or more, thereby significantly improving irrigation efficiency level.

COST BENEFIT ANALYSIS

Burton (1966) 69: Discussed the difficulties inherent in the use of benefit cost analysis in taking decisions for India’s water resource development. It suggests that project alternative should be rather on the basis of selected criteria, which should include :

1. Maximum economic development ;
2. Fundamental Social Progress; &

It list the variable which can be included in the list of criteria for water resource development.

Anagol Jayakumar (1969)70 :Discusses a comprehensive strategy for acute development with reference to the Tungabhadra Project & Upper Kishna Project. It is possible to reconcile to a great extent the objective of protective irrigation & total crop failure to the largest possible area, & that of productive irrigation maximizing agricultural production through suitable choice of crops. This pre-supposed sound ayacut development under the major irrigation
projects covering not merely the agricultural aspects such as soils, crops & water management but also the broader economic & social aspects which impinge on speedy & full use of the irrigation on speedy & full use of the irrigation potential.

**Krishnan, G.R. (1972)**: Has discussed on appropriate method to determine the additional production rate of paddy due to irrigation. It may be observed that the net additional production of paddy in the case of high-yielding strain in about twice that of local strain along with high-yielding strains with the present percentage of their spread. Based on this norm of net additional production, the benefit cost ratio relating to a project may be worked out.

**Mukhopadhyay Arunendu (1973)**: The researcher aims at a comparative economic evaluation of deep tube-well & shallow tube-well as alternative devices of irrigation in Naida District. The comparative economic analysis has been done on the basis of 3 alternative discounted measures, namely

- Benefit cost ratio;
- Net Present work;
- Internal rate of return to gauge

Whether these three criteria give different ranking of the alternative projects. An attempt is made to present a sensitivity analysis of these two alternative projects by calculating their respective net present worth & benefit cost ratio at different discount rates on the basis of sensitivity to the changes in the discount rate shallow tube-well will be reduced to a considerable extent, if it is run by electricity.

**Sinha M.L. & P.K. Prasad (1973)**: Have attempted to evaluate the relative efficiency of lift irrigation & major irrigation projects in Palamare district. The data on cost & benefit of irrigation by electric pump-sets installed on wells were collected in 1972-73 from a cross-section of 54 farmers in 4 villages. The gross benefit per acre of irrigation for the 2 sources of irrigation was estimated fitting a linear equation to the observed data. It is observed from the study that
the benefit cost ratio are substantially greater than unity in the case of canal irrigation. This ratio was relatively much higher. Both the capital cost & operating cost of canal irrigation are much lower than those of lift irrigation where the choice between 2 alternatives is possible.

Sisodia J.S. (1973)74: The object of this study is to examine the costs & returns from land leveling & irrigation land development in the command area of the Tawa project in the Hoshangabad district of Madhya Pradesh. It aimed at land shaping, construction of water courses, field channels, drainage system & introduction of irrigation agriculture in 1000 acres. It is observed that the intensity of cropping & the net farm income have increased after the development of the project. The investment in irrigation land development has a favorable rate of return & it worked out to Rs 4.90 for every rupee invested.

Chawla J.S. (1973)75: The study seeks to evaluate the achievement of the minor irrigation works financed by different banks on the recommendations of the S.F.D.A. Officer in Amritsar district. The investigation was confined to the Tandila Block during 1968-73. Cob-Dougalas production function applied to compute the marginal value productivities of operating capital, fixed capital & human capital went up. The cost benefit ratio worked out to 1:1.74 showing the feasibility of the installation of tube-wells.

Bhati J.P. Tiwari R.N. & Singh L.R. (1973)76: Have studied, the benefit cost analysis of irrigation projects Methodological issues with reference to tube well. To provide canal irrigation in Badayun district is considered costly tube-wells were proposed to be installed & considered more feasible.

Bhatia M.S. Bihari Bipin (1973)77: This study benefit cost analysis of small farmers development agency projects, in Raibareli district while analyzing the cost benefit analyzing cost hence taken direct cost & indirect cost benefit analysis. The project programmes are expected to increase the additional irrigation potential by about 19 thousands hectares & that of food grain by 28 lakhs tones by 1973-74.
Dagupta A.K. & Barce D.W. (1973)78: Have studied the Damodar Valley Flood control scheme. A series of dams have been constructed up stream & the flood is contained in the dams. The Cost incurred in the construction of dams, the year-wise damage done by floods has been computed & cost benefit analysis has been worked-out.

Rajendra Prasad & S.B. Lal Gupta (1974)79: This study has been undertaken to evaluate only that part of immediate benefits which includes the increased production from irrigated land in the command area of the projects, terms as direct benefits. The study is based on hypothesis: The direct benefits exceed the cost-ratio is greater than unity. The procedure followed for measuring costs & benefits:

1. Evolution of direct benefits as the increase in the net return of farms produce with the project & the net returns which could occur without it;

2. Evolution of the project costs which include an annual operating cost & the interest & depreciation on total capital outlay of the project. Project cost in the value of goods & services used operate a project.

The benefit cost ratio worked out for the project exceeds unity, since the project exhibits direct benefit of Rs 1.74 per rupee annual cost.

Sovani N.V. (1976)80: Discusses the mutual relationship between the criterion of financial return & that of the benefit cost ratio & emphasized the necessity of laying down uniform procedures in the calculation of benefit cost ratio of different state governments. The author stressed the need for examining the whole gamut of water resource development, as the overall objective to maximize national welfare. He illustrated the problem involved in taking decisions on choice & ranking by referring to the Maharashtra Government proposed project for an earth-cum-mansory dam at Khiyagaon, opposition to the same by the people who were going to be displaced & the proposal of an alternative project known as the Nandali Project. He also refers to two more cases:
I. Where irrigation & power generation are competitive; &

II. Where they are only competitive, where the problem of choice becomes even more complicated.

For example:

a. The case of Bhakra Project; &

b. The Koyan Krishna Project for irrigation & power.

He concluded by stating that the benefit cost ratio should be used only to determine the economic efficiency of the project & not get loaded with other objectives, because this result in calculations that are complicated & not very satisfactory.

Bhalerao M.M.S. Salilram (1978)81: This study was undertaken in 5 villages with a sample of 50 cultivators in the district of Varanasi, to find-out the extent & cause of under-utilization of minor-irrigation potential in the region. Minor irrigation has affected favorably the cropping intensity in the area, the proportion of double cropped to net-sown area being 52% for the sample cultivators. The reasons for under utilization were lack of funds, administrative difficulties irregular & inadequate water supply from tube-wells, their break-down & high irrigation charges, & lack of credit for construction of wells. It is suggested that these difficulties should be removed by improving tube-well administration & by providing timely adequate medium or long-term credit through service co-operatives & land development bank. This will help the farmers to construct separate wells so as to fit up persion wheels or pump-sets where-ever possible.

Puthashwamiah K. (1978)82: The author make an attempt to examine the pros & cons of the economics of the major irrigation projects vis-à-vis, the minor irrigation projects. In the author’s observation, the minor irrigation projects from the benefit-cost angle. Considering the poor returns, it is emphasized to concentrate on major & medium irrigation works only when they are technically proved to be economically remunerative. Sanction of major
& medium irrigation projects should be preceded by the cost benefit studies. A sharp acceleration of the tempo of expansion of irrigation facilities with emphasis on small irrigation facilities with emphasis on small irrigation works like well etc. should be regarded as the kind-plan of economic development strategy for the future-plans.

**Wade Robert (1978)**: Has been undertaken to examine the connection between the irrigation bureaucracy & the pattern of distribution of irrigation benefits. Research has been done to assess the likelihood of big improvements in productivity as a result of irrigation & to be reassured that small farmer will at least not be made worse off & to know about how irrigation officials at various levels actually take decision about the sort of pressures that are brought to bear to them, & their response to those pressures. Evidence on the actual distribution of irrigation benefits, the out-come of various influences is hard to find. Past studies by Thorner, Bhakva, Reidinger & Prasad report the evidently the biggest size group (of land lord) gets the maximum irrigation facility, standing probably the power theory of distribution. Tendencies towards growing inequalities of irrigation benefits might be offset, by a variety of institutional measures. Introduction of legalized water trading & reduction of operation costs may benefit small farmers.

**Jayaraman J.K. (1979)**: He examined the criteria of benefit cost analysis on internal rate of return, which are now widely applied for appraisal of irrigation projects. Though there are limitations in regard to adequacy of data which will be reflecting the social costs & benefits in the analysis, but the present practice of evaluating benefit cost ratio seems to be fair enough as far as the need for ranking of projects is concerned. In evaluating a single project sophisticated analysis in terms of deriving benefits & costs at internal prices & allowance for adjustment for correcting labor costs at shadow wage rate seems mere desirable.
Rao, G.V.K. (1980)85: The report deals with the development of irrigation during the planning period & the policy issues thereof. The establishment of the central ground water broad in 1972 leads to a systematic survey for exploration of ground water which was intensified in continuation of the earlier work. Comprehensive legislator procedures were evolved for construction, maintenance & management and to benefits in which context the National Commission on Agriculture is playing a commendable role.

The production benefit ratio to irrigation potentiality utilized is to be improved by efficient water management & assured marketing. By teaming up the administration of the command area development supported by J.S.V. up to the expectation of both scientists & farmers dedicated to feed million of our hungry people.

Dholakia Ravindra H. Sudarsham Iybagar (1980)86: The study has mainly concentrated on the practical problem which tend to get neglected at the stage of projects & also on same issues that exists at the formulation level. The problem relate to Administrative delays, accounting problem which lead to audit problems, contract system vis-à-vis the departmental work, & lack of risk taking at decision making level. These come in the way of implementation. The application of PERT/CPM techniques in implementation of projects will make it a successful one.

Jagdish Mohan & Agrawal B.L. (1981)87: Discussed the importance of social benefit cost analysis over the Economic & Financial criteria which do not fulfill social obligations. The objective of social benefit cost analysis is to maximize national economic profitability represented by the appropriately weighted sum of net benefit occurring to different objective embodied in the plan.

A detailed social benefit cost analysis of various irrigation projects on the individual project basis will serve as tool to evaluate projects in terms of national objectives underlying development planning. The case study has been taken for the Eastern Ganga Canal project of Uttar Pradesh. The methodology
& logic behind the estimation of the social costs & benefits to enable the application of appropriate shadow or accounting prices thereof have been discussed. The sensitivity analysis of the project has also been worked out. The benefit cost ratio at social prices works out higher than at market prices. At 12% social rate of discount, benefit cost ratio is less than 1.5 & the project would not be considered economically viable except from social considerations which give the benefit cost ratio as 1.86. The sensitivity analysis shows that the project benefits are higher, sensitive to decrease in yield & escalation of prices. As the internal rate of return is higher than the present bank rate- the project is economically sound.

**Shamsi N.B. & Singh Ratar (1981)88**: Have studied benefit cost analyzing of Dhora irrigation system. The net benefit received annually was computed by taking the difference of annual gross value of & associated cost of construction, running & maintenance of the irrigation system.

**Pal S. P. & Roy C.G. (1982)89**: Examines the general nature of socio-economic effects of the environmental impacts of irrigation & to investigate whether it is possible to encompass these impacts in the overall economic evolution. The environmental impacts of irrigation project are categorized repairable & irreparable. The social benefit cost analysis is applied with explicit statement about the social welfare objective of a nation. The approach to measure the social & environmental costs should basically be the least cost method of achieving acceptable social & environmental standards. For the chose least cost alternative, the benefit is greater than or equal to cost. Lack of scientific knowledge is the major stumbling block in developing appropriate qualitative measures for assessing impacts. The prediction of environmental impacts with a fair degree of certainty is a necessary condition for the development of relevant economic analysis of these impacts.
Sinha Basawan & Ramesh Bhatia (1982)90: The study reviews alternative approaches to presentation appraisal of irrigation projects such as those suggested by the second irrigation commission 1972. The World Bank & the UNIDO details of alternative methodologies & social benefit cost analysis of various technical alternatives have been presented by using the Arrange Reservoir Project in Bihar as an illustration. A computer programmed in Fortran IV has been included as a useful tool for performing necessary appraisals & sensitivity analysis.

Summary: Proper attention on drainage of excess water from soil surface has been given so that water logging, salinity and alkalinity are removed.

Farmers have to do the cultivation from traditional to modernized system to get good results in shape crops. Flow irrigation and lift irrigation may be adopted for irrigation.

Drip technology in sugarcane crop is most profitable.

The area of irrigation has increased from 1 million in 1800 to 19 million ha in 1947 and is being increased.

The major irrigation source in India and wells 49 per cent and 38 per cent and tank 7 per cent and thus net cropped area is 20 per cent net cropped area. The canal irrigation has to the managed by government with the cooperation of farmers.

Unless the present water policy, water law and water administration is reformed, the economy of water will be jeopardised.

The holding of farmer is as low as 2 to 3 ha. Hence proper management is absolutely necessary. The irrigation water must be distributed equally in head reaches, middle reaches and tail reaches.

The following formula has to be applied to get book value of canal irrigation:

\[ \text{Cost} = WE + r \times k + d \times k \]
The instructional reforms of irrigation department is the most important reforms to be done.

Agriculture contributes more than 55 per cent of agriculture output. Water can also become boon if major investment is made one infrastructure.

For Brahmaputra, terminuses valley authority like institution is necessary to get good crop. The farmers must be trained to adopt scientific methods.

Rain water harvesting, recharging of ground water, legislative measures for management of ground water must be taken to get good crop from economic use of water.

Use of fertilizers with irrigation can produce good crops.

Water is becoming Scarce hence economic use of water is utmost necessary.

In short irrigation management is most important factor if good crop is needed.

For high crop productivity the following consideration is necessary.

1. Proper selection of crop
2. Proper fixing of crop pattern
3. Scientific and systematic application of water with proper method.
4. Adequate fertilizer
5. Timely need control
6. Irrigation in alternate furrows in crops like potato and sugarcane
If proper water management is done 10 to 15 per cent of water can be saved.

Since there will be scarcity of water in 10 to 15 years, water management is absolutely required.

With the increase in population, proper management of irrigation has to made to produce good crop.

The farmers need to be encouraged to produce crop which need less water and generate higher income.

Wastages and water use inefficiencies have to be controlled to save water. This is due to absence of financial accountability.

Lining of canals can improve irrigation efficiency.

For solving the investment difficulties in use of benefit cost analysis.

The following criteria should be considered

1. Maximum economic development
2. Fundamental social progress
3. Efficiency and effectiveness of government measures.

By land leveling and development of commanded area, intensity of cropping and net income have considerably increase.

In the Damodar valley flood control scheme many small dams have been constructed, which control the flood. And due to this BC ratio has increased in this command.

In Varanasi the tube-wells have given the good BC ratio, hence farmer need to be given credit so that their income increases, hence government should provide credit to farmers.

It is essential that officials take proper and timely decision for irrigation. This will improve the income of small farmers.

The present practice of evaluating benefit cost ratio, is fair enough as for ranking of projects is concerned.
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