CONJUNCTIVE USE OF SURFACE AND GROUND WATER IN INDIA

BY

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1.0 INTRODUCTION

India having a geographical area of 329 m.ha and supporting a population of 845 million (1991) is a land of climatic contrasts. The season and weather conditions range from extreme cold to dry spell to extreme humidity and from drought conditions to torrential rains and floods. The rain takes place largely during the monsoon season but of about 1200 mm of annual average rainfall, 80% is recorded in four months from June to September and the remaining 20% during the winter months. If for certain reasons, monsoon is too much late or if it is not evenly distributed over rainy season or if the rainfall is too little or too much, then the whole agricultural sector is put in a tight corner. To ensure against the risk of vagaries of rainfall, irrigation has to be provided through systematic means. Rainfall has to be stored as much as possible and the portion of it which percolates below ground has to be pumped out in a planned and scientific manner. Water flowing in the rivers the year round can also be diverted or lifted for irrigation. Thus, irrigation is provided by tanks, canals, wells and tubewells. Each of these means of irrigation has its own role and uses in various regions of the country and it is well advised to develop in a planned and scientific manner the type of irrigation in a region for which it is most suited. It is only by developing assured and regular irrigation facilities which can protect the country side from economic disasters and develop the agriculture being the backbone of the economy. Both surface and ground water resources are being used for irrigation purposes. It is expected that by end of 1989-90, an irrigation potential of 79 m.ha would be available out of which 34.5 m.ha shall be through Ground Water Development. Presently, however, ground water irrigation is contributing about 1.4 m.ha of additional irrigation potential against 12.1 m.ha from surface water. The ultimate water resource available for irrigation is officially reported as 73 m.ha for surface water and 40 m.ha for ground water. However, Central Ground Water Board (CGWB) has tentatively revised the figure for ground water as 80 m.ha.

Presently the planning of two resources viz. surface and ground water is done separately and in an isolated way. The agency, organisation and implementation of two programmes is quite separate, However, inadequacy of irrigation water to meet the need of formers in space and time has lead to large scale utilisation of ground water through wells and tubewells in the command of irrigation project. And so the conjunctive use becomes a necessity. Nevertheless some efforts have been made to utilise ground water in conjunction with surface water. This paper describes in detail the present status and gives

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recommendations for future for the conjunctive use of surface and ground waters.

THE CONJUNCTIVE USE specifies not merely developed of groundwater resources in addition to surface water resources but the optimal development of the two considering, the land and water, the matrix of a dynamic ecological system taking into account the specific spatial and temporal availability and the variability of each, considering total river basins or even their interlinkages and the economics of development and transpiration of the total water resources to satisfy the multifarious and often conflicting demand with the consideration of socio-economic technological considerations.

2.0 LAND AND WATER RESOURCES

2.1 Land Resources

According to land utilisation of statistics for 1986-87, the land classification is as follows:

		Million ha.
1.	Geographical Area	328.73
2.	Reporting area for land utilisation statistics forest	304.58
3.	Forests	66.75
4.	Area of unculturable land	20.15
5.	Area put to non-agricultural use	20.49
6.	Permanent pastures and other grazing lands	11.98
7.	Land under misc. crops & grove not included in net area sown	3.54
8.	Culturable waste land	15.72
9.	Fellow lands	24.89
10.	Net area sown	141.06
11.	Total cropped area	177.33
12.	Net irrigated area	41.7
13.	Gross irrigated area	53.9

2.2 Water Resources

According to National Commission on Agriculture, the total precipitation is 400 million hectare meter. Out of this 115 m.ha.m is the surface water and 50 m.ha.m. is the ground water. 20 m.ha.m. of surface water has been shown as flow from outside India and thus, the total annual basic water resources of the country has been estimated as 185 m.ha. m. Ultimate usable potential for irrigation is 70 m.ha.m. for surface water and 26 m.ha.m. for ground water. The area figure being adopted by planning commission so far are:

Ultimate Water Resource Potential

		M.ha.
1.	Surface water - Major, Medium Irrigation	58
2.	Surface Water - Minor Irrigation	15
	Total	73
3.	Ground Water	40
	Grand total	113

The basins wise surface water flow as assessed by different agencies and compiled by CWC (1987) comes to as follows:

Average Annual Flow	=	180 m.ha.m.
Utilisable flow	=	68 m.ha.m.

In case of minor irrigation, Ministry of Water Resources has indicated a revised figure of 80 m.ha. for ground water and 17 m.ha. for surface water minor irrigation. A statewise estimate of the potential is given in Appendix II.

3.0 PHYSIOGRAPHIC AND HYDROGEOLOGICAL DIVISIONS

3.1 India has seven district physiographical divisions viz. (i) The Northern Mountains (2) The Great Plains (3) The Central Highlands (4) The Peninsular Plateau (5) The East Coast Belt (6) The West Coast Belt and (7) The Islands. The Himalayan range 2500 Km. in length and 250-400 km in width with a mean elevation of 6000 metres in the Central axial range, is the dominant geographical feature of India. It is a complex of several parallel and coverging ranges intersected by a number of valleys and plateaus. The location of the great Himalayas has an important role in the water resources of India. China and Burma (now Myenmar) in the East, the great Himalayan range is drained by a multitude of streams and rivers. The great Indo-Gangetic plains have been built up in the west by the Indus and its tributaries and in the centre and east by the Ganga and its tributaries. The Central Highlands lie between the great plains of north India and the plateaus of the Deccan. They form a compact block of mountains, hills and plateaus intersected by valleys basins largely covered by forest and account for one-sixth of the total area of India. The peninsular plateau lies between the Bay of Bengal in the east and the Arabian sea in the west. It is the largest of the physiographic divisions of India. The peninsular plateaus consist of five physiographic sub-divisions viz. the western ghats, the North Deccan Plateau, the South Deccan Plateau, the Eastern Plateau and the Eastern Ghats. The East coastbelt is washed by the waters of the Bay of Bengal. It extends for a distance of 100 km from Kanyakumari northewards to the united delts of the Krishna and the Godavari with an average width of 100-130 km. The West coast belt is washed by the waters of the Arabian sea runs more or less straight from Kanyakumari to Bharauch for a distance of 1500 km. The coastal plains are confined to a narrow belt 10-25 km wide between the Western Ghats and the sea. In the Arabian Sea, are the coral islands of the Lakshadweep and in the Bay of Bengal, the Andaman and Nicobar islands which are formed by the elevated portions of submarine mountains rising above the sea.

3.2 Climate and Rainfall

India has a very great diversity and variety of climate, and an even greater variety of weather conditions. The climate ranges from continental to oceanic from extreams of heat to extremes of cold from extreme aridity and negligible rainfall to excessive humidity and torrential rainfall. The climatic condition influences to a great extent the water resources utilisation of the country. Rainfall in India is dependent in differing degrees on the South West and North East monsoons, on shallow cyclonic depressions and disturbances and on violent local storms which form in regions where cool humid winds from the sea meet hot dry winds from the land and occasionally reach cyclonic dimension. Most of the rainfall in India takes places under the influence of South-West Monsoon between June to September, except in Tamil Nadu where it is under the influence of North East Monsoon during October and November. The rainfall in India shows great variations unequal seasonal distribution still more unequal geographical distribution and the frequent departures from the normal. It generally exceeds 1000 mm in areas to the east of longitude 780 E. It extends to 2500 mm along the entire West coast and Western Ghats and over most of Assam and Sub-Himalayan West Bengal. On the West of the line joining Porbandar to Delhi and then too Ferozpur, the rainfall diminishes rapidly from 500 mm to less than 150 mm in the extreme West. The Peninsula has large areas of rainfall less than 600 mm with pockets of even 500 mm. The estimate of areal average rainfall is subjective depending on the method adopted.

3.3 Hydrogeological Divisions

CGWB has evolved following categories to describe the hydrogeological characteristics of various rock types occurring in the country.

1. Porous Formation

   a. Area underlain by unconsolidated formations.
   b. Area underlain by semi-consolidated formations.

2. Fissured Formation

   a. Areas underlain by consolidated formations.

Porous Formation

a. Unconsolidated Formations:

The Quaternary sediments comprising Recent alluvium, older alluvium and coastal alluvium are by and large the important repositories of ground water. These are essentially composed of clays, silts, sands, gravels, pebbles, cobbles, boulders, ferruginous nodules, kankar (calcareous concretions), etc. The beds of sand and gravel and their admixtures form potential aquifers. The aquifer materials vary in particle size and rounding and in their degree of sorting. Consequently, their water yielding capabilities vary considerably. The coastal aquifers show wide variation in the water quality both laterally and vertically.

The piedmont zone of the Himalaya is skirted by artesian belt under free flowing conditions extending from Punjab to Assam. The hydrogeological environment and groundwater regime conditions in Indo-Ganga-Brahmaputra basin indicate the existence of fresh ground water reservoir about 600 m or more below land surface, for large scale development through heavy duty tubewells. Bestowed with high incidence of rainfall, this rainfall water reservoir gets replenished every year. The alluvial aquifers to the explored depth of 600 m have transmissivity values from 250 to 4000 m2/d and hydraulic conductivity from 10 to 800 m/d. The well yields range upto 100 lps and more but yields of 40-100 lps are common.

b. Semi-consolidated Formations:

The semi-consolidated formations belong to paleozoic Mesozoic and Cenozoic group of rocks extending from Carboniferous to Mio-pilocene in age. These are chiefly composed[of shales, sandstones, limestones, flysch and molasse beds. The terrestrial freshwater deposits belong to Gondwana System of the Peninsular shields are also included under this category. The sandstones in them form highly potential aquifers, locally, particularly in Peninsula. Elsewhere they are moderately potential and in places they yield meager supplies. These sediments normally occur in narrow valleys or structurally faulted basins. Though these formations have been identified to posses moderate yield potential, the physiography of the terrain, normally restricts exploitation. Under favourable situations, these sedimentaties give rise to flowing conditions as in parts of Godavari valley, Vallar basin, Cambay basin and parts of west coast. Potential semi-consolidated rock aquifers particularly those belonging Gondwanas and Tertiaries in the Peninsula have transmissivity values from 100 to 2270 m2/d and the hydraulic conductivity from 0.5 m to 70 m/day. Generally the well yields in productive areas range from 10 to 40 lps.

Fissured Formation

a. Consolidated Formations:

The consolidated formations occupy almost two thirds of the country. Most consolidated rocks, except vesicular volcanic rocks containing porous layers between successive lava flow sand pyroclastic rocks associated with lave flows, have negligible primary porosity. From the hydrogeological point of view, the fissured rocks are broadly classified into the following four types:

1. Igneous and metamorphic rocks excluding volcanic and cabonate rocks.
2. Volcanic rocks.
3. Consolidated sedimentary rocks excluding carbonate rocks.
4. Carbonate rocks.

The nature, occurance and movement of ground water in them are described below:

The Deccan Trap lava flows are mostly horizontal but occasionally are very gently dipping. Ground water occurance in the Deccan Traps is controlled by the contrasting water bearing properties of different flow units. The topography, nature and extent of weathering, jointing and fracture pattern, thickness and depth of occurrence of vesicular basalts are the important factors which play a major role in the occurance and movement of ground water in these rocks. Basalts of Deccan Traps have usually medium to low permeabilities depending on the presence of primary and secondary porosity. Pumping tests have shown that under favourable conditions, borewells could yield about 250 - 500 m3/day at moderate drawdowns. Transmissivity values of

Deccan Trap aquifers vary from around 25 m2/day and the bulk hydraulic conductivity varies from 0.05 m/day to 25 m/day.

Consolidated Sedimentary Rocks Excluding Carbonate Rocks

Consolidated sedimentary rocks occur in Cuddapah and their equivalents. The formations consists of conglomerates, sandstones, shales, slates, quartzites, apart from limestones, dolomites. Locally they contain phyllites and schists. The Cuddapahs and their equivalents were subjected to low grade metamorphiam in places while the Vindhyans and their equivalent do not show any evidence of metamorphism. The occurrence and movement of water in them is governed by bedding planes, cleavages, fracture, joints, faults, contact zones, degree and magnitude of weathering, topography and climate. They yield limited to moderate supplies wherever favourable conditions exist.

Carbonate Rocks

Carbonate rocks include limestones, marble and dolomite Among the carbonate rocks, limestones have the greatest distribution. In the carbonate rocks solution cavities develop due to circulation of water. This process leads to widely contrasting permeability within short distances. Potential karstified aquifers are found to occur in Rajasthan and Peninsular India in which the yields range from 5 to over 25 lps. large springs exist in the Himalayas region in limestone formations.

Igneous and Metamorphic Rocks excluding Volcanic and Carbonate Rocks

According to their modes of origin these rocks can be divided into igenous rocks and metamorphic rocks. The most common rock types are granite, gncisses, charnockite, khonadite, quartzite, schist, phyllites, slate etc. These rocks posses negligible primary porosity but are rendered porous and permeable due to the formation of secondary openings by fracturing and weathering.

Ground water yield aldo depends on rocks types like granite khondalite and biotite gneiss are better sources than charnockite and possibly upon the grade of metamorphism. The ground water studies carried out in the crystalline rocks revealed the existence, along certain lineaments of deeply weathered and fractured zones, locally forming potential aquifers. These lineament zones are found to be highly productive for construction of borewells. In areas underlain by hard crystallines and metasedimendaries viz. granite, gneiss, schist phyllite, quartzites charannockite etc., occurrence of ground water in the facture system has been identified down to a depth of 60 metres and even upto 200 m locally. In most of the granite gneiss country, the weathered residium, serve as an effective ground water respository. It has been noted that the deeper fracture system are generally hydraulically connected with the weathered saturated residium. The yield potential of the crystalline and metasedimentary rocks show wide variations. Through 10 cm to 15 cm diameter bored wells, the facture system generally yield from less than 1 lps to 5 lps and upto 23 lps in the vicinity of structurally disturbed areas. The transmissivity values of the fractured rock aquifers vary from 25 to 500 m2/day and the bulk hydraulic conductivity varies from 0.1 to 10 m/day.

Chemical quality of Ground Water

The factors adversely affecting the quality of ground water bodies in the country can be divided into the following five major categories apart from local pollution:

1. Aridity is the most important single factor for a very high salinit of ground waters as in arid and semi-arid regions of Gujarat and Rajasthan having rainfall less than 45 cm.

2. Water logging conditions due to canal irrigation is another important factor for development of salinity in the alluvial basin in parts of Haryana, Punjab, Uttar Pradesh and parts of Peninsular India.

3. Influence of sea water influx in coastal facts where salinity stratification is found.

4. Pollution and contamination due to human activities have rendered ground water locally saline.

5. In areas having round water of low salinity, certain specific constituents like fluoride, iron and toxic constituents render it unpotable.

4. Development of Irrigation

Importance and need of irrigation is already explained in para 1 earlier. The planning commission has classified the irrigation schemes as major medium and minor. Before 1978 all projects costing less than Rs. 25 lakhs were classified under minor irrigation. Since April, 1978 the new classification has been done and all projects having Culturable command area (CCA) less than 2000 ha were put under minor irrigation. However, in Planning process the financial allocation are being made under two categories:

i. Major Medium Irrigation and
ii. Minor Irrigation

All groundwater development schemes are included under minor irrigation. Thus, minor irrigation has two components:

i. Surface water and
ii. Ground water schemes.

4.2 Major & Medium Irrigation

Number of major and medium schemes which were actually taken up in various plan period is as under:

Plan Period	Major	Medium
First plan 1951-56	24	212
IInd plan 1956-61	23	116
IIIrd plan 1961-66	27	74
Annual Plan 1966-69	10	38
IV plan 1969-74	33	94
Fifth plan 1974-78	73	331
Annual Plan 1978-80	15	53
Sixth Plan 1980-85	41	141
Seventh Plan 1985-90	18	29
Total	264	1088

4.3 Utilisation of Potential in Major Medium Projects

The position of creation of potential and its utilisation at the end of each plan is as under:

Irrigation Potential in Million ha.

Period	Created	Utilised	Percentage
At the beginning of Ist plan	8.6	8.6	100
At the end of Ist Plan (1951-56)	11.1	9.9	89.2
IInd Plan (1956-61)	13.2	12.0	90.0
Annual Plan (1966-69)	17.0	15.7	92.4
IVth Plan (1969-74)	19.6	17.2	89.8
Vth Plan (1974-78)	23.6	20.1	85.2
Annual Plans (1978-80)	25.5	21.6	84.7
VI Plan (1980-85)	27.6	23.8	86.3
VII Plan (1985-90) (Anticipated	30.8	26.6	86.4

(Source : Working Group on Major Medium Irrigation)

Cause for lag in utilisation of the created potential can be divided into following categories:

i. Over reporting of potential at source.
ii. Data base inaccuracies
iii Inadequate development of land and poor water management.

4.4 Surface Water Minor Irrigation and Ground Water Development

Minor Irrigation Schemes including all ground water schemes and surface water schemes (both flow and lift) which individually have culturable command area upto 2000 ha. These schemes are quick maturing and labour intensive by nature and hence increasing emphasis is made on the development of minor irrigation during the current year.

Private ground water schemes comprise of dug wells, dug cum borewells, bore-wells, filter points, shallow tubewells and individual boring. The culturable command areas of such works varies from 1 to 4 ha on an average. The government assistance in installation of these schemes is confined to technical guidance, custom services, subsidies and arrangement of credit at reasonable rates of interest. The construction, operation and maintenance of deep tubewells with culturable command area varying from 40 to 100 ha are being handled by the state government or minor irrigation tubewells corporations.

Minor surface water flow irrigation projects comprising of storage and diversion works occupy a conspicious place particularly in the undulating areas and hilly regions of the country. These provide the only means of irrigation in the chronically drought affected areas. The storage schemes also help in recharing ground water in the hard rock areas in addition to irrigation. In certain areas where irrigation facilities cannot be provided through flow irrigation schemes due to topographical limitation, the lift irrigation schemes are playing an important role.

Development of minor irrigation is primarily achieved through individual and cooperative efforts with the help of institutional finance or investment by the farmers from their own savings and resources. The bulk of institutional finance is mobilised through the land development banks, Commercial Banks, State Cooperative Banks with refinance from National Bank of Agriculture and Rural Development (NBARD). Public sector outlay are limited to public tubewells, surface water schemes, survey and investigation work and giving subsidy to the farmers for installation of minor irrigation works.

The primary responsibility for planning implementation of minor irrigation programme is that of the State Govts. Centre provides assistance under various Centrally sponsored schemes for accelerating the development of minor irrigation. Generally, a number of departments/organisations are implementing minor irrigation programme under different developmental sectors such as Agriculture, Rural Developments, Welfare, Cooperation etc..

The following table, give the development of minor irrigation potential and ground water structure through various plan periods.

Development of groundwater structures

(000 Nos.)

Plan Periods	Dug wells	Shallow tubewells	Deep Public tubewells -	Electrical pump sets	Diesel pumpsets
1. <u>Ultimate feasible</u> Revised cumulative <u>Progress upto</u>	12200	4076	8.0	12000	5000
2. 1950-51	3860	3	2.4	21	66
3. 1960-61	4540	2	8.9	200	230
4. 1968-69	6100	360	14.7	1090	720
5. 1973-74	6700	1138	22.0	2430	1750
6. 1977-78	7435	1749	30.0	3300	2350
7. 1979-80	7786	2132	33.3	3965	2650
8. 1984-85	8742	2259	48.2	5709	3550
9. 1989-90 (likely)	9487	4754	63.6	8226	4355

Utilisation of Potential

In the case of privately owned works, the standard of irrigated agriculture including land leveling and preparation of fields is usually better since the farmer himself own the source of irrigation. As such, the utilisation of irrigation potential from these private structures is almost immediate and the potential from these structures is fully utilised while in the case of State Minor Irrigation Surface water schemes and Public Tubewells the irrigational potential created from these works is not fully utilised. It has been observed that potential utilisation from water schemes ranges from 50 - 70 and particularly, the utilisation during Kharif season from lift irrigation schemes is negligible. Similarly, in the case of public tubewells the major constraint in utilising the full potential is non-availability of adequate power. Public tubewells are designed to run for about 3000 hours in a year but nearly in all the States due to imposition of power cuts, the performance of tubewell has not been satisfactory. The largest number of public tubewells is in the state of UP where the utilisation is hardly 40%. It will, therefore, be evident from the above, that greater attention is required for stepping up the utilisation from surface water schemes as well as public tubewells.

The potential created and its utilisation figures under minor irrigation were being reported as the same till the end of 6th plan. The public Account Committee in its 141st ( )1982-83) repdort did not accept the practice of reporting 100% utilisation from Minor Irrigation Schemes as the basis of compilation of statistics. The working group on Minor Irrigation for the Formulation of 7th Plan proposals recommended that during 6th plan the utilisation figures may be reported as per the current practice but the base level for the year 1984-85 should be worked out both for potential created and potential utilised and during the 7th plan separate figures for the potential created and utilised should be given. Accordingly, the Planning Commission after having discussions with the State Governments has fixed up the base figures for 1984-85 for the potential created and potential utilised as 37.52 m.ha and 35.25 m.ha thereby showing a gap of 2.27 m.ha at the end of 1984-85. For the subsequent years also, potential created and utilised are being worked out separately.

4.5 Status of Ground Water Surveys and Investigations:

In the country Macro level survey is done by CGWB and the micro level by State Ground Water Organisation (SGWO). The C.G.W.B. carries out following survey work:

- Systematic Hydrogeological Surveys
- Reappraisal of Hydrogeological Surveys
- Water Supply Investigations
- Monitoring of watertable and quality at selected points throughout the country
- Exploratory Drilling
- Construction of production wells
- Pilot projects for artificial recharge like percolation tanks check dams and subsurface dams.
- Preparation of district and state reports
- Hydrogeological atlases of the State.
- Basinwise water balance studies etc.

It may be stated that under programme of hydrogeological surveys an area of 299 million ha (1990) has been covered against geographical area of 329 m.ha and it is hopped to completely cover the entire country very soon. Water table and quality observation are being made regularly on 13,450 places. Finally CGWB has so far drilled 7710 wells and constructed 3330 water supply tubewells. Eleven water balance studies have been completed. SGWO's observe the water table behaviour more closely and carryout the quantitative assessment for each development block annual (there are 5153 such blocks in the country). This forms the basis for future Ground Water Development in the States.

4.6 Type of Ground Water Structures:

The following types of groundwater structures are being constructed in the country.

1. Open dug wells.
2. Repair of wells
3. Boring of wells
4. Deepening of wells
5. Shallow tubewells
6. Borewells
7. Artesian wells
8. Filter points
9. Deep Public Tubewells

However these are grouped in 3 broad based categories:

1. Dugwells

The cost in northern alluvium belt is about Rs.5000 for a 1 m dia and 10-15 m deepwell. The area irrigated is about 1 ha.

In the hard rock areas the well of 1 to 1.5 m dia cost of Rs.15,000 to Rs.20,000 for a 10 to 15 m deep well. The area irrigated is 0.8 ha with indigenous lift and 2.0 ha with a pump. For increasing the discharge the additional boring is done.

2. Shallow Tubewells

In alluvium these are 10 to 15 cm dia and 15 to 20 m deep and would cost Rs.15,000 to Rs.20,000 with pump set. The discharge is about 50 m3/hr. The area irrigated is about 3 to 4 ha. In hard rock areas, these are called borewells and costs about Rs.20,000 to 25,000. The area irrigated is also about 2 to 3 ha only.

3. Deep public Tubewells:

These are about 100 to 150 m deep of 20 cm dia and gravel packed. The discharge varies from 100 to 150 m3/hr. The area irrigated is 40 to 80 ha and the cost is Rs.500,000 to 900,000. These are constructed, operated and maintained by Govt. Departments of Corporation of the Government.

5.0 CONJUNCTIVE USE AND ITS IMPORTANCE

5.1 Surface waters and ground waters are two important sources for irrigation purposes. Both have been extensively used as would be clear from the description given in earlier paras but generally without integrated planning for coordinated development and maximum benefits. The conjunctive use is important because of:

5.2 Meeting the Inadequacy of water in S.W. Irrigation:

Inadequacy of water in the irrigation systems of the country particularly in run off the river schemes is well known. These systems fail in no small measures to provide assured and timely supplies to support high yielding crops. Moreover the concept of protective irrigation has now changed to intensive irrigation. As such in a command of irrigation project, both surface and groundwater are to be used in a planned manner to maximise agricultural production.

5.3 Prevention of the problem of Water Logging and Salinity:

The massive development of surface water resources and the process of intensification of irrigation and meeting the full water requirements of high yielding varieties combined with indiscriminate and unplanned irrigation from canals and high incidence of canal seepage has disturbed the underground hydrological balance through extensive recharging of groundwater aquifers in commands of several irrigation projects. This has resulted in high water table rise resulting in Water Logging, accompanied with Salinity. The Working Group on CAD of Ministry of Water Resources had identified at least 24 major Irrigation Projects in which 865,350 ha. of area has been water-logged and 8,76,350 ha. and 6,73,400 ha. respectively are suffering from the salinity and Alkalinity problems.

It is here that integrated development of the two resources, surface and groundwater and their conjunctive process of use is most effectively brought into play as much to rectify major deficiencies in surface water deliveries as to provide a fundamental safeguard to hold the groundwater table at a safe depth by planned and judicious use of groundwater.

5.4 Checking of the problems of over-exploitation of groundwater

Indiscriminate pumping of groundwater in area not supported by required surface water input has resulted in serious problems of water table lowering accompanied by well going dry, lowering of pump in existing tubewells and their discharge going down and finally resulting in serious water shortage even for drinking and irrigation. Monitoring of groundwater table at 13450 stations all over the country by CGWB has revealed that there are only 13 states where fall of more than 5 m has been recorded. Stationwise trend is given in Appendix IV. However, due to uncontrolled development of groundwater in some areas particularly in the States of Haryana, Punjab, Gujarat, Tamil Nadu, U.P., Maharashtra and Karnataka decline in groundwater level has been observed during the recent past. This is on account of the fact that the amount of resource having exploited in these areas has exceeded the average annual replenishable recharge. According to CGWB, the States and Union Territories where stage of groundwater over-development has reached are given below:

1.	Haryana	-	Karnal, Krukshetra
2.	Punjab	-	Amritsar, Jullundhar, Kapurthala, Ludhiana, Patiala, Sangrur.
3.	Delhi	-	Mehrauli
4.	Chandigarh	-	Chandigarh
5.	Pondicherry	-	Pondicherry

Thus only 10 districts out of 424 districts in India have a true problem of over exploitation. However according to assessment made by SGWOS, about 300 blocks out of 5143 total blocks are approaching to over exploitation and about 400 another blocks are in critical stage. Both these studies present a satisfactory picture as far over exploitation of Ground Water Resources is concerned. However, the author has the opportunity of travelling through-out the country and it has been observed by the another that with in the command of irrigation project, there is no problem of over-exploitation of groundwater resource but only out of commands are there is a general decline of water table and hydrograph show a definite declining trend, which would be clear from the examples given in the next para.

5.5 Examples of the observation of decline of groundwater table

Here the examples have been sited for a few typical States.

MADHYA PRADESH: This is a large state south of Gangetic plane. It is mostly hard rock with patches of alluvium. The State have got big irrigation systems also. Districtwise long term trend of declining of water level from 0.10 m to 1.93 m while the maximum decline varies from 0.55 to 13.05 m.

TAMIL NADU: It is the southern most state of India. Except for coastal area rest is all hard rock and undulating. The state has 1.6 million wells irrigating 1.2 m ha which about 40% of total irrigated area. According to a study made in the state, the groundwater table has depleted from 10 m to 50 m in the last 40-50 years. The area of irrigation by each well has reduced from 1.5 ha to less than 1.0 ha in the last 20-30 years. In many parts of pasumpron district water table has dropped to 20 to 30 m from ground water surface and large number of irrigation water have deep borewells inside to a depth of 60-70 m. Hundreds of wells in Chidambaranar district (Sathankulam block) Madurai district (Chinnamanon and Coimbatore district), Karamedia, Sabar, madukkarai, Avinashi blocks) have been abandoned.

UTTAR PRADESH: This is the most popular state of the country and most of geographical area is fertile alluvium plains, substraining wells and tubewells. It has a maximum groundwater potential of 18 m ha out of 80 m ha for the country according to revised assessment of CGWB.

In this state also several areas serious decline of water table is taking place because of over-exploitation and non-availability of recharge from canals. Observed data from 1975 to 1985 indicates following decline for some districts.

1.	Ghaziabad District	Decline of water table in last 10 years in metres
-	Loni Blocks	0.84 - 3.02
-	Muradnagar	1.78 - 2.48
-	Bhojpur	2.97 - 5.37
-	Dadri	1.56 - 2.48
-	Bisrakh	2.4 - 5.59
-	Thaulare	0.70 - 4.15
-	Hapur	1.74 - 4.15
-	Garhmukteshwar	0.87 - 2.98
2.	Bulandshahr	
-	Bulandshahr Blocks	0.80 - 1.49
-	Lakhavati	4.18 - 5.57
-	Siana	2.37 - 3.07
-	Bibinagar	4.47 - 5.47
-	Gulavathi	1.78 - 3.81
-	Anupahahr	1.84 - 2.86
-	Dhanpur	2.85 - 4.00
-	Dibai	2.46 - 5.90
-	Jahangirabad	1.83 - 3.36
-	Unche gaon	3.41 - 3.36
-	Dankor	0.79 - 4.02
-	Sikarpur	2.05
-	Khurja	3.23
-	Arnia	3.20 - 1.35
-	Pahansu	0.53 - 3.28
3.	Saharanpur	
-	Dechand Blocl	0.40 - 2.34
-	Nagal	1.22 - 2.61
-	Ballakheri	0.45 - 6.65

In addition an study made by the Ground Water Department of UP titled 'Conjunctive use of GW in Ramganga Command of UP in 1987', contour of water table rise and fall from 1972 to 1985 were plotted. It indicates that atleast 20% area show a decline of water table upto 7 metres, naturally outside canal command and with large scale development of GW resource by tubewells. The district most effected are Aligarh, Agra and Mathura. This decline of water table could have been checked if the conjunctive use of surface and groundwater could have been planned before taking up large scale groundwater extraction.

5.6 **Prevention of Sea Water Ingress:**

The groundwater resource, once contaminated, is not prohibitive to restore to its original condition. C Coastal fresh water aquifers need to be managed to ensure that saline water not intrude into them due to heavy withdraws causing sea water to move inwards because of the disturbed hydro-chemical equilibrium. The National Water Policy has laid emphasis on avoiding the over-exploitation of groundwater near the sea coast to prevent ingress of sea water into fresh water aquifers. This problem has already taken place in the coastal Saurashtra area of Gujarat, where the failure of the monsoon to provide normal rainfall during 1974, followed by repeated failures in the following years, lead to the large scale energisation of dug wells in the coastal area, which in turn caused substantial increase in the ground water exploitation. Withdrawal of water in excess of natural recharge lead to intrusion of saline water. Cash crops grown in the area were found to give very poor yields and economy of the coastal area was hardly hit by this salinity problem. The coastal areas of Tamil Nadu, Kerala, Orissa and West Bengal are also threatened with this problem. In all such cases, conjunctive planning is a must.

5.7 **Augmentation of Water Resources:**

It has been observed that in some basins/areas, there is surplus groundwater. Through construction of Augmentation Tubewells this water can be transferred by existing or new canal system to water short basins or areas. This has already been tried in States like Haryana, U.P. etc.

5.8 **Use of Saline Water:**

In some Sates like Haryana, U.P., there are large tracts of land which have saline ground water. Through conjunctive use of mixing this water with fresh canal water in tolerable limits, it can be used for irrigation purposes. Vice-versa in such tracts large scale induction of surface water if possible will help in creating a perched water table of fresh water which can be used for drinking irrigation or through pumping within limits.

6.0 **PRESENT STATUS OF CONJUNCTIVE USE:**

6.1 **Conjunctive Use in Command Area Development:**

CAD Authorities are working since 1973-74 in various States. Although conjunctive use is one of the main objective under CAD, no serious efforts have been made to know the status of conunctive use.

PRESENT STATUS OF CONJUNCTIVE USE

As already described in earlier paras, surface and ground water are being used i isolation and in unplanned way. Data is also not available as to how much supplemented irrigation is provided in commands of S.W. irrigation projects by ground water. In MI causes carried out in 1986-87, an effort has been made in this direction. The statewise position is as below:

Supplements irrigation by GW is S.W. irrigation commands

Area in 1000 ha

Name of State	Utilised potential of SW projects	Area under supplemented irrigation by GW	Percentage
Andhra Pradesh	3094	12	0.4
Gujarat	873	33	4.1
Haryana	1785	400	22.4
Karnataka	1188	42	3.5
Madhya Pradesh	1403	120	8.6
Maharashtra	935	365	39.0
Punjab	2498	1056	42.3
Tamil Nadu	1245	250	20.0
Uttar Pradesh	5703	986	17.3
West Bengal	1524	145	9.5

Conjunctive use in CAD Projects

CAD Authorities are working since 1973-74 in various states. Although conjunctive use is one of the main objective under CAD, no serious efforts have been made to know the status of conjunctive use in commands of these major-medium irrigation projects. Author using districtwise MI census data has made an effort in this direction. The results obtained are given in Table 6.2.

The above table would indicate that large number of GW structures are doing supplemental irrigation in these CAD Projects.

7.3 Status of Conjunctive Use in Tank Irrigation

Irrigation through Surface water tanks plays an important role in Southern State particularly those of A.P., Karnataka, Maharashtra and Tamilnadu. According to M.I. Census (1984) there are bout 500,000 tanks doing irrigation in the country. To meet the inadequacy of water in these tanks, farmers have gone for large scale G.W. extraction structures in the registered ayacut of these tanks. No data in this respect is available. However, in case of Tamilnadu some data has been collected for tanks being modernised under externally aided project of E.E.C. For some tanks the details are given in Table 7.3.

Table 6.2

STATUS OF CONJUNCTIVE USE IN SOME MAJOR IRRIGATION PROJECTS

Sr. No.	Name of Project	C.C.A. in ha.	Ultimate potential Dug wells	Nos. of G.W. in command tubewells	Structures shallow tubewells	Potential by G.W. in ha.
1	2	3	4	5	6	7
	<u>ANDHRA PRADESH</u>					
1.	Nagurjan Sagar	8,95,000	8,95,000	1,45,704	19,992	2,25,672
	<u>GUJARAT</u>					
2.	Mahi	2,00,000	2,74,490	1,41,602	702	1,44,410
3.	UUkai-kakrapar	3,48,000	3,80,910	73,194	1866	80,658
	<u>HARYANA</u>					
4.	J.L.N.Lift Canal	2,50,000	1,55,000	26,459	41,128	1,90,971
	<u>JAMMU & KASHMIR</u>					
5.	Tawi Lift Irrigation	12,880	17,980	51	712	2,899
	<u>KARNATAKA</u>					
6.	Gataprabha	3,17,430	3,17,430	90,900	4,430	1,08,380
7.	Malprabha	2,14,980	2,14,980	98,768	9,426	1,36,380
8.	Tungbabadra	5,29,000	3,49,100	23,557	1,756	30,581
9.	Upper Krishna	4,24,910	4,24,910	55,585	850	58,985
	<u>MADHYA PRADESH</u>					
10.	Chambal	2,20,000	2,73,000	25,990	292	27,158
11.	Tawa	2,47,000	3,33,000	15,699	770	18,779
	<u>MAHARASHTRA</u>					
12.	Jayakwadi	2,27,200	2,27,200	2,66,375	408	2,68,007
13.	Puna	61,500	57,300	58,363	761	61,407
14.	Krishna	74,000	1,11,720	1,10,343	57	1,10,571
	<u>ORISSA</u>					
15.	Hirakund	1,53,240	2,51,150	64,979	1	64,983
16.	Mahanadi	1,79,410	3,00,100	27,205	3,030	28,425
	<u>U.P.</u>					
17.	Gandak	4,11,000	3,08,000	13,254	1,01,899	4,18,550
18.	Ramganga	18,97,000	13,72,000	39,650	3,22,515	13,29,710
19.	Sarda Sahyak	20,00,000	19,23,000	40,669	4,18,359	17,14,005
	<u>WEST BENGAL</u>					
20.	D.V.C.	3,91,970	5,15,000	8,503	73,561	2,92,747
21.	Kangsabati	3,49,750	4,01,460	34,440	80,303	3,55,652
22.	Mauyu Rakshi	2,26,630	2,50,860	1,104	1,04,407	2,18,832

N.B.1 : The figures for G.W. structures have been taken from M.I. Census (1987) on districtwise basis for this purpose whole district has been assumed in the command.

2. Irrigation potential created by G.W. structures has been estimated on the basis of the 1 ha for wells and 4 ha for shallow tubewells.

TABLE 7.3

STATUS OF CONJUNCTIVE USE IN SOME TANK PROJECTS OF TAMILNADU

Sr. No.	Name of Tank	Taluk/ District	Registered Ayacut (ha.)	Irrigation Area (ha.)	Irrigated by Tank only	No.of wells	Area ha.	Percentage of well Irrigation
1.	Latheri	Gudiyatham North Aroot	118.74	115.65	8.56	67	50.58	43.7%
2.	Samudram	Thrumayam Pudu Kottai	124.315	101.89	82.29	36	17.61	13.3%
3.	Periyurkulam	Sankaran Koil Tirunelvdi	196.770	156.230	105.666	90	48064	31.1%
4.	Aliyalmangalam	Pohar Tiruvanna malai	112.88	93.06	70.80	78	22.26	23.9%
5.	Periasadayareri	Sivagiri Tirunelveli	161.25	129.80	99.02	56	30.78	23.7%
6.	Velur	Kulathar Pudukkotkai	131.20	105.32	95.32	81	10.00	9.5%
7.	Manalur Periyakulan	Sanakaran Koil Triunelvi	110.67	92.73	63.390	40	29.34	31.6%
8.	Annamp uthur	Tindivanam South Aroot	107.12	88.09	72.245	24	8.845	10.1%

A study of above table would reveal that anacent area being irrigated both by tanks and wells varies from 9.5% to 43.5%.

6.3 Status of Planned Conjunctive Use:

Very few projects have been taken under this heading, some known examples on cited below:

Augmentation Tubewells in Haryana

In the face of limited surface water resources, tapping of groundwater potential remained the only alternative for augementation of irrigation water supplies. The Irrigation Department of Haryana, therefore chalked out a scheme for the installation of deep tubewells in the year 1969. Originally, it was planned to install 493 deep tubewells with a total capacity of pumping out about 1000 cusec of underground water in the Yamuna Ground Water Basin, extending from Dadupur in Ambala District to Panipat in Karnal District. Later in the year 1970, "The Haryana State Minor Irrigation (Tubewells) Corporation" was formed and the work relating to the exploitation of underground water resources was transferred to this body. As a result of detailed investigations and Ground water studies undertaken by the Minor Irrigation Tubewells Corporation it was revealed that 3,300 cusecs of groundwater could be safely exploited from Yamuna Basin without causing any appreciable fall in the water table in this region. On the basis of these studies.

It was also decided to construct a lined channel from Jagadhri to Munak in order to save absorption losses and augment canal supplies from ground-water resources through deep tubewells. The main objective was to increase water supplies at Munak canal head to the tune of 969 cusecs and thereby improve the supply position of the entire Western Jamuna Canal System. This was envisaged to be achieved through exploitation of 500 cusecs of groundwater by 160 tubewells and saving of absorption losses of 469 cusecs in the lined Augmentation Canal, off-taking from Western Jamuna Canal near Yamuna Nagar and off-taking into it at Munak with a capacity ranging from 3240 cusecs to 3941 cusecs. The work on the installation of deep tubewells and Augmentation Canal project was started in October, 1971 and completed in December, 1972 at a cost of Rs.12.69 crores. The tubewells/canal was commissioned on 31st December, 1972. An evaluation of this project revealed that the objective of increasing canal water supplies at the Munak head of Western Jamuna Canal had almost been achieved. However, the lowering of water table has been observed within 1-2 km from the canal and lowering of pumps in case of private tubewells had to be done. Subsequently, the Haryana Govt. took construction of about 1000 Augmentation tubewells on Western Canal System to directly feed the canal.

Augmentation Tubewells in UP

In Gandak canal CAD Project of UP about 150 augmentation tubewells were drilled about 7 years back. However, due to no demand these have not been used so far.

Augmentation Tubewells in Chambal Command of MP

The Chambal Irrigation System serves areas in the State of Madhya Pradesh and Rajasthan. A series of damd have been constructed on the river and finally at Kota Barrage, the water is diverted into two canals respectively Right Bank Canal serving MP and Left Bank Canal serving Rajasthan. Due to several deficiencies in the system hardly 50% proposed area could be irrigated. As such to augment supplies in the system, a project old one of the distributary namely Ambah Branch canal for intensive development was taken with World Bank assistance in 1982. It includes construction of 175 augmentation tubewells for conjunctive use of ground and canal water. The total installed pumping capacity would be about 47,000 m3/hr. (13m3/sec). It is assumed that power supply limitations will restricted pumping in peak demand periods to 16 hours/day, giving a peak 15 days production of 11.2 m3 at the well heads, equivalent to a continuous discharge of about 8.7 m3/sec. The proposed cropping pattern would required approximately 2,300 hours of groundwater pumping during the period October through March.

The wells will discharge into various parts of the canal conveyance system including the distributaries, minors and subminors down to 6 cusec capacity. They will be distributed through the conveyance system so that the augmentation well head capacity represents approximately half the water supply at full supply level at any point in the system. The project has since been completed. Its performance need evaluation.

6.4 Monsoon Canals in the State of UP

In several regions of the state specially western districts, there is heavy drawl of groundwater th4rough tubewells for Rabi Irrigation. The rivers also do not carry much of discharge. During rainy season, these rivers carry enormous water which can be used for construction of monsoon canals to provide irrigation for paddy and at the same time perform the important function of recharging ground water aquifers. Several such canals have been planned and under construction viz., (i) Eastern Ganga Canal (ii) Madhya Ganga Canal stage I and II, (iii) Parallel lower Ganga canal. These are fine examples of inducting surface water to meet the shortage of ground water.

6.5 Construction of Percolation Tanks

This type of conjunctive use is now being implemented in a planned manner in several south Indian State like Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu. These are very effective in recharging aquifers and increases of yield of wells downstream of tanks. A study of some tanks done in the state of Maharashtra indicates that for five tanks under study 100 new well shave come up and increase in irrigated area in 355 ha.

6.6 Ground Water Dams

A groundwater dam obstructions the flow of groundwater and stores water below the ground surface. It may also serve as a collecting structure that diverts groundwater flow to recharge adjacent aquifers or to raise the ground water table in an aquifer with a limited flow of groundwater, making it accessible for pumping. The need to dam groundwater for water supply purposes is caused basically by erraticity rainfall. In monsoon climate area the total amount of rainfall would generally be sufficient to cater to the needs of people and agriculture, but here the seasonality means that during some part of an year water is not available. Damming groundwater is thus a mean of bridging over the seasonal dry periods. The purpose of the sub-surfaee dam is to arrest the movement of groundwater out of a sub-basin. The method of storing under ground water have reeeived considerable attention during last few year. Damming ground water for conservation purposes is not a new concept - Ground Water Dams were constructed on Islands of Sardinia in Romans times and structures in Tunisia show that damming of groundwater was practised by old civilisation in North Africa. Most reeently various small scale groundwater damming techniques have been developed and adopted in many parts of the world, notably in India, southern and eastern Africa, Brazil and Japan.

Small scale structures constructed for storage of groundwater are presently in practice in various parts of India and oldest one of Ottapalam in Palghat district constructed during 1962-64. The Central Ground Water Board has also constructed two sub-surface dams one at Government Seed Farm, Ananganadi in Palghat district and Ottapalam in Agriculture University Farm, Kerala.

6.7 Development of Micro Watersheds

This program is now being taken up in large measures by State Agriculture and Soil Conservation Departments. In a Micro-Watersheds, the runoff generated from rainfall is checked and stored by construction of small tanks, check dams, contour bunding etc. The surface water stored in the tanks and additional groundwater recharge is used for irrigation in the watersheds. To site a case study, in a small watershed of 8.4 hectares near Agra, the annual runoff out of a total precipitation of 624 mm in 1962 was 54 mm, which represents a percentage of 8.7. This watershed which is situated in the ravines of the Yamuna and is under agriculture to the extent of 80% was rated for soil and water conservation by appropriate physical and biological measures in the early sixteen. Observations made in 1981 showed that a total of 863 mm of precipitation in that year, the runoff amounted to only 8.5 mm which represents a percentage of just about 1. In other words, thanks to effective land management, the amount of runoff was reduced during the intervening years by a factor of 86%.

7.0 METHODOLOGY FOR CONJUNCTIVE USE

7.1 Conjunctive Use of Surface and Ground Waters has not been given the extent of attention and consideration it deserves. None of the States have so far proposed an operational plan for conjunctive use in any of irrigation projects. There is an urgent need for developing it on more scientific lines in order to derive its full benefits. Irrigation supplies from a single source, surface or groundwater are often inadequate to meet the requirements of crops in time and quantity. This is particularly so in case of high yielding varieties of crops which need assured water supply. Both traditional and high yielding variets of crops are being raised in the project commands in the season. On account of their differing base period and critical stages of water requirements from a single source. Both the sources have therefore, to be integrated and used conjunctively in order to meet the irrigation requirements. The National Water Policy has also emphasized the need for conjunctive use. The following paras reproduced here are of great relevance.

Water resource development projects should as far as possible be planned and developed as multipurpose projects. Provision for drinking water should be a primary consideration. The projects should provide for irrigation, flood mitigation, hydro-electric power generation, navigation, pisciculture and recreation wherever possible.

- Integrated and coordinated development of surface water and groundwater and their conjunctive use, should be envisaged right from the project planning stage and should form an essential part of the project. In the planning and operation of systems, water allocation priorities should be broadly as follows:-

- Drinking water
- Irrigation
- Hydro-power
- Navigation
- Industrial and other uses.

However, these priorities might be modified if necessary in particular regions with reference to area specific considerations.

7.2 Keeping in view the National Water Policy

The following methodology for conjunctive use planning is suggested.

i. Water Balance Studies:

Central Water Commission has already divided water of the country into major river basins. As water is a state subject and all the irrigation projects are planned and implemented at the state level, each stage should carry out the complete water balance study for each basin/sub-basin. In such studies, a complete inventory of all water resources surface and ground should be made. For GW Recharge and working out rainfall-runoff relationship the resource should be taken to mathematical modelling techniques.

A strong data base for all type of data i.e. hydrometeorological, hydrological and hydrogeological etc. will have to be built up so that models can give a realistic output and response. Status of consumptive by crops, groundwater pumpage is need to be worked out on a more realistic manner. Since all planning process in the country is based on administrative boundaries like district and community development blocks, the water balance studies carried out on basin/sub-basin wise should be used to work out the district and block wise availability and use of surface and groundwaters.

ii. Agro-Climatic Zoning and Optimal Cropping Pattern

Next step would be to divide the basin/sub-basin into different Agro-climatic zones and for each zone to work out the optimal cropping pattern. Help of Linear Programme Techniques can be taken up in this respect. Several such studies have already been done in the country in this respect.

iii. Master Plan for Integrated Development

Having worked out the Water Resources availability and fixation of optimal cropping pattern master plan for basins sub-basins should be prepared. These will also incorporate the use of water for other purpose like drinking, industry etc. The priority allocated shall be as laid down National Water Policy 7.

These Master Plans should also give break up of all schemes, old and new taking district as a unit also. These plans should include schemes in private sector i.e. individually owned by farmers like dugwells, tubewells, pumpset etc. and in corporate sector owned and maintained by community like surface water life irrigation schemes and deep tubewells.

iv. Credit and Subsidy Requirements

As practically, all the ground water development is in private sector mainly financed by credits from Banks and subsidies for weaker sections from the Govt. Based on the Master Plan, the long term requirement for credit and subsidies districtwise should be worked out as Long Term Credit Planning for conjunctive use of ground water.

v. Operational Plans for Conjunctive use in Surface Water Irrigation Projects

For all existing irrigation projects, the operational plan for conjunctive use should be prepared. As the task is huge and time consuming, to start with, it should be confined firstly to major and medium irrigation projects, which have been included in the centrally sponsored scheme of command area development. In case of junior irrigation project, it should be attempted for Tank projects being implemented through external assistance.

vi. Consideration of Various Alternatives

In respect of groundwater use, the following alternatives can be considered:

i. Dug-wells, dug-cum-bore wells and shallow private tubewells.

ii Direct irrigation deep public tubewells.

iii. Augmentation tubewells for supplementing the canal supplies.

iv. Monsoon canals for the dual purpose of providing Kharif irrigation and recharge to groundwater body for extensive use in Rabi period.

v. Depth at which groundwater table is to be maintained subject to economic and ecological conditions.

vi. Use of Saline Ground Water dug mixing it with canal water.

vii. Induced recharge from the rivers during floods.

These various alternatives are to be considered and one which gives the maximum cost benefit ratio subject to various constraints including the social and political ones, is to be selected for actual execution. Although conventional methods are available but for most optimal solution recourse has to be taken to the modern methods of analog and digital modelling and optimisation procedures.

8.0 IRRIGATION WATER RATES FOR CONJUNCTIVE USE

An important problem associated with conjunctive use of surface and ground water is the matter of irrigation tariffs. Widely divergent patterns of tariffs for canal and tubewell irrigation can complicate matters in no small measure.

Farmers cannot be expected to forego willingly their claims to cheaper surface irrigation though inadequate, for the more expensive volumetric system from State tubewells, even if assured in time and quantity. It is not that cost of tubewell irrigation is so disproportionate that crops cannot sustain the charge as multitudes of farmers are thriving on it - the problem is of a commodity being so drastically cheaper in comparison through inferior in quality, that farmers would automatically choose and adhere to canal irrigation as compared to state tubewells. Yet Indian farmer intelligent and progressive as he generally is and endowed with sound commonsense, can eventually be expected to adopt new systems and techniques. He cannot allow low productivity to persist and must, therefore, orient his operations to maximising his yields and obtaining the best from the holding and improve his economic position.

When suitably educated in the matter of economics of expenditure on the existing canal charges plus that of supplementation from a private tubewell put together to the charges for supplementing irrigation from public tubewell, he would be able to understand that the two bear a close comparison in cost.

In the existing circumstances, therefore, where State tubewells are being constructed to supplement canal water to individual farmers the proposal to charge him for tubewell water by volume in addition to full canal rates or area basis would be reasonable. This would mean having inclusive command for surface and ground water supplies serving the same area. In haryana, however, where batteries of tubewells have been constructed to augment canal supplies the old pattern of irrigation tariffs on area crop basis has not been disturbed.

In any case for an ultimate future pattern of possible irrigation tariffs in areas where canal and ground waters are conjunctively utilised on the same land, a thorough study into all the aspects of the matter may lead to evolving a system best suited to the pattern of combination adopted. In doing so the basic approach of volumetric system being more rational and economical in water use will have to be borne in mind. Side by side it would need special attention to provide adequate safeguards against any further slicing of the financial returns from irrigation projects which have already been strained almost to a breaking point. Presently the water rate in state tubewell ae 15 to 20% of the economic water rates.

To make the concept of integrated development and conjunctive use attractive and acceptable to the farmer, and to achieve a break through his prevailing prejudices against state tubewells, it is of paramount importance that the management of State tubewells, the service against breakdowns and for their repairs, the system of appointment and conveyance of water, uninterrupted supply of electric energy and general assurance of continuous working during periods of demand, must be guaranteed. It is only thus that he farmer will get convinced of the real utility of the system. it should besides be ensured that command areas in such a system is not in excess of a reasonable limit for multiple cropping and for supply of irrigation water at proper time and in adequate quantities from either or both the resources.

9.0 REGULATION AND CONTROL OF GROUNDWATER FOR CONJUNCTIVE USE

During the past three decades, groundwater development has witnessed a massive acceleration. Though on the national scale, there is still considerable potential for future development but when viewed at the micro-level, critical stages appear to have been reached in certain pockets with very high levels of development. Such areas require careful consideration before additional withdrawals are effected. To prevent situation leading to overdrawals and to maintain sustainability of the system and social equity, it is necessary that groundwater development is regulated on scientific lines to permit optimal development.

9.1 Administrative Measures:

The method of control presently for regulating the groundwater development to some extent is in the form of administrative measures, namely, restrictions on flow of institutional finance for groundwater development in areas with high stages of development. Institutional financing agencies require technical clearance for proposed programmes in such areas. However, in the absence of any law, these measures do not necessarily permit the groundwater development on scientific lines to control over-exploitation/indiscriminate exploitation of groundwater. There is also no restriction on private investments.

9.2 Ground Water Legislation

With a view to protecting the groundwater regime, taking safeguards measures against hazards of over-exploitation and ensuring equitable distribution of this vital and finite resources, enactment of suitable legislation to regulate the exploitation of this resources is considered a must, sooner than later. Adverse effects of over-drawl are already being felt in some parts and pose to grave danger in coastal areas.

Anticipating the dangers, in 1970 the Govt. of India had circulated a Model Bill to the State Govts for adoption of suitable legislation keeping in view the prevailing ground water situation in the States. The salient provisions of the Bill were:

1. Creation of a Ground Water Authority to administer the legislation.

2. Empowering the State Govt. to regulate in public interest, the extraction or use of groundwater in any form, in any area so notified, based on a report from the ground water authority of the state.

3. Requiring permission from the state ground water authority for grant of permit for drilling a well in the notified area for any purpose rather than exclusively for domestic use.

4. Registration of the existing users in the notified area.

5. Grant or refusal of permit by the Ground Water Authority based on certain criteria and after providing opportunity to the person concerned to express his views.

6. Regulation of drilling activity in the notified area.

7. Grant of license for sinking wells and tubewells for modification of permit or license cancellation thereof under certain circumstances.

8. Provision for penalty and approval.

While Gujarat had tried to endorse its groundwater legislation in a limited area, the State Govt. of Karnataka, Tamilnadu and Andhra Pradesh have prepared draft legislation for enactment.

Rajasthan and Maharashtra are contemplating similar steps. madhya Pradesh has enacted a law to protect domestic water supplies in scarcity areas. The Govt. of Tamilnadu has also enacted the Madras Metropolitan Area Ground Water Act., 1987. Govt. of Pondicherry has issued a notification on guidelines for Ground Water Development.

10. CONCLUSIONS AND RECOMMENDATIONS

- Out of an ultimate Surface Water irrigation potential of 73 m.ha. already by end of 1989-90, an estimated potential of 44.5 m.ha. has been created. In respect of groundwater, it is 34.5 m.ha. out of present official figure of 40 m.ha.

- In case of groundwater CGWB has reassessed the ultimate potential as 80 m.ha. which has been termed as tentatively revised. Still lot of potential remains to be developed both for SW and GW. It is strongly suggested that in future all irrigation potential should be developed in an integrated manner.

- For feeding country's growing population which has done up from 361 million in 1951 to 945 million in 1991 and estimated as 1970 m in 2001, increased foodgrains production is needed. There is hardly any possibility to increase the net cultivated area of 140 m.ha. However there is a considerable scope increasing the present double cropped area of 180 m.ha. Irrigation, one of the main input for increased agricultural production has to be extended from the present potential of 79 m.ha. (1989-90) and actual gross irrigated area of about 56 m.ha. (1987-88) at an accelerated pace. At the same time, there is urgent need for plug big gap of about m.ha. (difference in irrigation potential and actual irrigation in 87-88) for which conjunctive use can play an important role.

- Water balance studies for all major/minor river basins should be completed expediously preferably within a period of 2 years hence. Using these studies, district and blockwise groundwater balance should be revised and planning of GW development done accordingly in conjunction with surface waters.

- All new SW irrigation projects should include conjunctive planning and an operational plan for the same. CWC, CGWB should issue the necessary guidelines in this respect. Planning Commission should not give clearance to any irrigation projects in future which does not incorporate conjunctive planning.

- Conjunctive use does not merely envisage, canal irrigation to the supplemented by GW but vice-versa also which is of great importance in all drought management programmes. Micro-water shed planning is of great relevance in this respect.

- For effective implementation of conjunctive use of surface and groundwater, there should be an Integrated Organisational Structure for the use of all forms of water not only at the Centre but also in the states, preferably in shape of water resources department/river basin development authorities.

- Presently monitoring and performance evaluation of conjunctive use of grossly inadequate. Data on regular basis in respect of groundwater development structures, basin in respect of ground water development structures, SW lift irrigation, small tanks and the areas irrigated by them is hardly available. Necessary organisational set up at state and central level is urgently needed.

- Regulation and control of groundwater to check the adverse decline in water table and undermining of resources in of prime importance. Suitable GW legislation may be enacted. Till then, it may be controlled through indirect measures like stopping of loam, electric connection etc. In addition artificial recharge measures like construction of monsoon canals, percolation tanks, check dams and GW dams etc. may be taken in areas already suffering from continuous decline of GW table. Use of sprinkler/drip irrigation system may also be encouraged in such areas.

- To give an incentive to farmers for GW development in command area of major-medium irrigation projects liberal subsidies and other facilities should be given. At the same time, in case of public tubewells/augmentation of TW's water rate disparity should be reduced.

- In order to fully achieve the objective of integrated and conjunctive use of surface and ground waters, a comprehensive unified water resource law taking into consideration both the sources should be enacted by each State. A draft already prepared by Tamil nadu conserve as a guide in this respect.

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