Volumes 7 (1981), 8 (1982), and 9 (1983)

FOR LIMITED CIRCULATION

# HYDROLOGY REVIEW

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HIGH LEVEL TECHNICAL COMMITTEE ON HYDROLOGY
NATIONAL INSTITUTE OF HYDROLOGY, ROORKEE

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# PROLOGUE

The 'Hydrology Review' was being brought out as a quarterly journal by erstwhile Indian National Committee for the International Hydrological programme (IHP). During August 1982 a High Level Technical Committee on Hydrology (HILTECH) has been constituted to continue the work being carried out by the Indian National Committee and to provide advice to Central and State Government agencies on the problems referred to the committee. The membership is drawn from various Central and State water resources organisations, academic institutions and experts. The Secretariate of this committee has been functioning as a part of National Institute of Hydrology. During the first meeting of the HILTECH held on 22nd February 1983 it was decided that the publication of Hydrology Review would be continued as part of the HILTECH activities by National Institute of Hydrology. Accordingly, an Editorial Advisory Board has been constituted and its membership approved at the second meeting of HILTECH held on 26 February 1984. In view of these and other unavoidable circumstances the 1981, 1982 and 1983 issues could not be brought out in time. Though some of the events might have lost their news worthiness, it is felt the technical activities of the various Central and State Government Water Resources Organisations and Irrigation Departments during this period have made valuable contribution to the water resources development and utilisation in general and hydrology in particular. It has, therefore, been decided to report important technical activities in the field of hydrology and water resources during 1981, 1982 and 1983 in this issue which is being brought out for limited circulation within the country.

# 2. NATIONAL ACTIVITIES 1981

## 2.1 Indian National Committee for IHP

1. India contributed a report to UNESCO on 'Urban Hydrologic Modelling and Catchment Research' authored by Dr. S. Ramaseshan and Dr. P.B S. Sarma. It happened to be the only report from a developing country, published by UNESCO in 'Research on Urban Hydrology' Vol. II.

2. A report entitled 'Watershed Management in India' was published by the INC for IHP.

3. A report from India was published for presentation at the 'Joint UNESCO-WMO International Conference on Hydrology and Scientific Basis for Rational Management of Water Resources' held in August 1981 at Paris.

The report was in two parts. The first part contains a brief description of geographical location, physiography, drainage, geology, soils, climate, hydrological network, water resources, some major problems of water development, Constitutional and legal framework of water administration etc. The second part of the report contains a brief note on what has been done during the first phase of IHP and general reports from some of the important central agencies and institutions.

4. Water Abstracts (1947-69), containing abstracts of accepted M.Sc./M. Tech. and Ph D. Thesis in Hydrology and Water resources in Indian Universities/Institutes, was published.

5. A short term course on Nuclear Techniques in Ground Water Hydrology, sponsored by the INC for IHP was held at NGRI, Hyderabad on 7-18 September 1981.

6. The International Workshop on Systems Analysis of Irrigation, Drainage and Flood Control Problems cosponsored by the INC for IHP was held in December 1981 at New Delhi.

7. India sent a delegation consisting of Shri M.G. Padhye, Member (WR) in Central Water Commission and S Banerjee, Secretary, INC for IHP to the International Hydrology Conference held at Paris on 18-27, August 1981.

8. The 16th, 17th and 18th meetings of INC for IHP were held on 17 February 1981, 8 July 1981 and 29 September 1981 respectively.

## 2 2 National Institute of Hydrology, Roorkee

The National Institute of Hydrology is an autonomous society under Ministry of Irrigation located at Roorkee. The premier National Research Organisation was established in March 1979 as a UNDP aided project and was entrusted with carrying out systematic scientific research activities in basic, theoretical and applied hydrology which has very great relevance to national planning and developmental activities in the area of water resources.

The governing body has approved a work plan defining the following as priority items of research.

(i) Hydrologic analysis of stream flows in a basin

(ii) Water balance of river basins.

(iii) Watershed models including those for snowfed basins and basins with limited data.

(iv) Method of operation of a system of reservoirs taking into consideration the effect of irrigation, flood control and power generation.

(v) Evolution of mathematical models for storm precipitation for flood estimation.

(vi) Evolution of methodologies for flood estimation, forecasting and control.

(vii) Methodology for ground water estimation and development.

(viii) Study of extreme storms and floods and their implications in hydrologic synthesis.

1. A programme for frequency analysis of seasonal time series data was implemented in the DEC 20 system of University of Roorkee. The programme fits to the given time series data a normal, log normal, square root normal, Pearson and log Pearson distribution by method of moments and tests the goodness of fit by Chi-square test. The programme is being modified to provide for exclusion of the highest or lowest values in a series which do not conform to the general statistical characteristics of the series (and are generally referred to as outliers). A subroutine to compute moving average of the time series for various time periods has been included so that the frequency characteristics of moving averages can also be determined.

The programme has been used to determine the frequency characteristics of rainfall data of seven observatory stations in the Upper Ganga Canal command area and for frequency analysis of annual, monsoon and non-monsoon seasons and monthly rainfall data at Raiwala and Narora in Ganga and at Okhla on Yamuna.

2. Considering the limitations of data availability in India, two simple watershed models are being implemented; one is the Betson rainfall runoff model based on API, rainfall-runoff relationship developed by Tennesse Valley Authority and the USGS model implemented by Carrigon and others. The models are tested with data of Kasurnala in Punjab. It is proposed to implement certain modifications in the programme to take into account environmental and hydrometeorological conditions in India.

3. A simple but extremely versatile programme for simulation of reservoir system has been developed by Texas Water Development Board. The model considers reservoir operating rules and different priorities for uses at different times and for future uses and has been found to be a relatively simple but very useful model for studying reservoir operation. It has been implemented in NIH as first step in the study of reservoir operation for conservation and utilisation.

4. Statistical models including regression models for interpolation of missing data is under preparation. A report on hydrometeorological aspects of estimation of design storm precipitation is also being prepared.

5. A computer programme for unit hydrograph available in the institute has been modified and implemented. The input data consists of hourly recorded rainfall data from a number of stations in a basin. Thiessen weights for the stations are calculated from Thiessen Polygons. The runoff data available in the form of recorded stage values may be converted into discharge data using rating curves The programme aims at using the gauge rainfall runoff data to implement multiple input system model and multistation single input single output system model. The runoff is seperated into its components with baseflow and direct runoff. The parameters N and K of Nash model (gamma function) are calculated for different stations by method of moments. The parameters are then used to calculate unit impulse responses (IUH). Its convolution with input rainfall expresses the open system values of direct runoff. The difference between calculated and observed values of direct runoff are squared and summed up to obtain criteria for effectiveness of the model in simulating observed direct runoff values.

6. Literature in area of flood routing is being reviewed and availabe methodology are critically analysed. A computer programme for flood routing through river reaches taking into account loss or gain in the reaches because of water table conditions and pumping is being implemented.

7. A ground water model based on Tyson Weber approach with two layers has been developed and implemented in the University of Roorkee DEC-20 computer system. It consists of 3 major sub programmes namely GEOM programme which describes the geometric configuration of the polygonal network into which the study area is divided and data for ground surface, aquifer layers, sand percent values and provides for internal consistency checks; Recharge abstraction programme, which uses rainfall and canal cropped area, ground water and the other data to estimate seasonal recharges and abstractions from each of the polygons; and the main ground water simulation model. These are fully operational and have been used to study the surface water ground water interaction in Upper Ganga canal area.

## 2.3 Central Water Commission, New Delhi.

### 2.3.1. Hydrology Directorate I

The Hydrology Directorate I deals with the problems relating to water availability, design flood estimation, evaporation and sedimentation of reservoirs etc. for projects in river basins in India other than Ganga, Brahmaputra and Indus. Hydrological Studies for some projects outside India are also carried out.

1. Hydrology of 30 major projects were examined covering the design floods including design storms, water availability using rainfall and yield series, reservoir losses etc. Further, 42 projects were examined in detail in response to the reviews and revision made by the project authorities. Apart from these, requisite advice was rendered on hydrological aspectsin 19 cases after necessary studies and analysis.

2. Detailed guidelines regarding preparation of hydrology chapter for the feasibility and detailed project report were finalised for the working group set up by the Ministry of Irrigation.

3. Further storm studies for Narmada river basin involving consideration of moving storms, extensive data study and analysis were made.

### 2.3.2 Hydrology Directorate II

The Hydrology Directorate II deals with all major and medium plan projects in Brahmputra, Indus and Ganga basins and North eastern States in the country regarding Hydrological aspects like water availability, design flood, reservoir evaporation etc.

1. Technical Examination of the Hydrological aspects of 36 new projects were carried out covering the scrutiny and review of yield, design flood, sedimentation and evaporation. Replies received from states for 30 projects were reviewed and comments were furnished, 32 special studies on the water availability, yield and design flood aspects were carried out.

2. A status report on sedimentation of reservoirs in India and draft model bill on soil conservation in States of the Indian Union have been prepared for consideration by the committee on Reservoir Sedimentation set up by the Dept of Irrigation in Feb. 1978.

### 2.3.3 Hydrology (Small Catchments) Directorate

As per the main recommendations of the Khosla Committee a suitable methodology for design flood peak estimation with storm rainfall and basin characteristics as parameters was sought to be evolved. The short term plan report has already been brought out and also revised once which is used by the Railways and referred to by the State Agencies. As regards the long term plan, the country is divided into 26 hydrometeorologically homogeneous sub zones and the data on the representative bridge catchments are considered for hydrological analysis of these sub zones. Report for subzone 1-g on Lower Gangetic plains has already been completed and its copies have been sent to the various user departments. Report for the Lower Godavari basin on sub zone 3-f had been completed. The analysis of Mahanadi basin (sub zone 3-d)

and of Krishna Basin (sub zone 3·h) are in progress.

2. Computerisation of the data for safe storage and retrieval for the required information and processing and analysis of the large volume of data already collected has been carried out.

3. In connection with the work of establishing and maintenance of hydrometeorological observation stations at 45 small and medium road bridge catchments on behalf of Ministry of Shipping and Transport, 37 G and D sites have been established and data collection started. Out of 37 road bridge catchments, 16 catchments have also been provided with rain gauges for observing rainfall intensities.

### 2.3 4. Water Resources Utilisation Directorate I

The WRU Directorate I carries out residual work of surface water resources of all river basins of the country excluding Ganga, the Brahmaputra and the Indus; and providing assistance to department of Irrigation with technical studies in connection with resolution of the cauvery waters dispute.

1. The yield of Mahanadi at Tikkarpara Dam site was worked out at various dependabilities after extending the runoff series at Tikkarpara by correlating it with those of U/S site of Basantpur.

2. The yield of the intermediate catchment between Mettur and LCA on river Cauvery was worked out at various dependabilities, namely 50%, 75%, 90%. Hypothetical series of monthly inflow into Mettur reservoir on River Cauvery after making several alternatives of projected upstream utilisation were prepared.

3. Basinwise utilisation for major/medium Projects (existing, under construction and proposed) for Narmada, Mahi, Sabarmati, Tapi, streams of Kathiwar and Kutch, Cauvery and rivers of Kerala and Mahanadi was compiled.

4. Preparation of basinwise maps showing utilisation, gross storage, areas irrigated, deltas and command areas for Mahanadi and Damodar were completed.

5. The following draft papers were prepared on :

(i) 'Water Resources Development and Management'

(ii) 'Water Management for food Production' in connection with a seminar on the subject convened by the Institute of Engineers (India), Mysore.

(iii) 'Conjunctive use of surface and ground water'.

### 2.3.5 Water Resources Utilisation Directorate II

The WRU Directorate II renders technical assistance to the central team on water utilisation constituted to study the operations of selected existing irrigation projects in the country and identify the scope for improving the operational efficiency with the ultimate goal of maximising the benefits. Also technical assistance to the technical committee constituted to examine the feasibility of eastward diversion of west flowing rivers of Kerala and Karnataka is rendered.

1. It is proposed to study the year to year/season to season operational programme of the major irrigation systems.

2. Availability of water resources of four basins of Kerala have been worked out and agreed to by Kerala. Present and future needs of water have been assessed in consultaion with Kerala.

Similarly, Karnataka has agreed to divert waters of Netravaty, Barapole, Mahadayi and Papnashini basins towards east for irrigating drought areas of Karnataka. A study was made to assess the availability of surplus water from Mahadayi basin without affecting power proposals of Karnataka. Similar studies were carried out for Bedti, Aghanashini and Varahi basins and discussions were held with Karnataka for diversion of their waters to east.

3. Crop optimisation study of Bhadra Project was completed. Optimisation study of two more projects is proposed to be taken up.

4. Appraisal reports prepared by Committees on Tungabhadra, Gujarat Medium Projects and Sone were examined.

5. Directorate is assisting Member (WR) to resolve the dispute between Rajasthan and Madhya Pradesh regarding release of Chambal waters from Kota barrage.

6. Assisted West Bengal state government in designs, estimates and project report of Tangan Valley project.

7. Reformulation proposals in respect of Nagarjuna Sagar Project for World Bank loan were prepared.

### 2.3.6 Irrigation Directorate

The Directorate carries out technical scrutiny of Major Irrigation and Multipurpose River Valley Projects on Irrigation aspects and Technical examination of project reports on modernisation of existing system on Irrigation aspects as well as the entire operational programme.

1. During the year, 14 original project reports and 26 follow up cases were examined and comments offered on the irrigation aspects. Seven modernisation schemes in original and 4 follow up cases were examined.

2. Collection and compilation of information on development of irrigation through major and medium projects in the identified tribal areas of 18 States/Union territories remained under progress.

### 2.3.7 Statistics Directorate

The directorate of statistics publishes statistics regarding water resources projects and undertakes technical studies. The Directorate recieves stage and stage-discharge data for central sites and some of the state sites. The data received are scrutinisedfor inconsistencies and corrected wherever possible. The data is coded and punched on cards and finally transferred to magnetic tapes for storage, retrieval and suitable analytical studies.

1. Irrigation statistics of India are proposed to be published for different states.

2. Stage-discharge data of 1200 site years for different river basins except Ganga and Indus have been punched and transferred on tapes.

3. Water year books for 950 site years in respect of different river basins and west flowing rivers between Kanyakumari and Tapi, Tapi, Narmada, Mahi, Sabarmati, Luni and other rivers, Subarnarekha and others, Brahmani, Baitarni, Pennar and Cauvery and rivers between Cauvery and Kanyakumari have been brought out upto Dec. 1980.

4. Software for using Central Water Commission HP 1000 computer were developed for the following jobs in Fortran language :

(i) Scrutiny of Hydrological data,

(ii) Up-dating of Hydrological data,

(iii) Printing of water year book alongwith analysis such as ten daily totals, average monthly totals, monthly average, maximum and minimum discharges alongwith data.

(iv) A system for storing, processing and printing of hydrological data of Indus commission.

(v) Analytical routines for time series analysis of data estimation of missing discharge values.

(vi) Scrutiny of financial statistics.

(vii) Printing of irrigation Statistics

(viii) Printing of financial statistics

(ix) Stage discharge relationship programmes for analytical studies.

5. A proforma for storage of data of project statistics was finalised and several components of information systems were discussed. Basic activities in regard to setting up of a data bank for water resources data have been taken up.

6. It is proposed to prepare basin wise maps for 18 river basins during the year. Basin wise maps for 15 basins except Ganga, Indus, Brahmaputra and Barak showing the hydrological sites for which data are available in the Directorate of Statistics have been prepared upto December 1980.

7. Frequency and trend analysis of stage-discharge data for a number of sites on river Ganga and Jhelum is being done throughout the year. Dependable yields at various sites on river Ganga, Godavari and Krishna will be continued. Study on stability of rating curves is in progress and will be continued.

### 2.3.8 Remote Sensing Directorate

This Directorate is involved in application of remote sensing techniques to water resources development including flood control works.

1. Under the joint experimental programme for water management with Space Application Centre of Indian Space Research Organisation, detailed study of Jalal and Bata catchments of Yamuna basin is proposed to be undertaken with the help of remote sensing techniques. Gauge discharge sites were established in the streams during 1980 with the assistance of Ganga - Brahmputra water resources organisation. The aerial flights were carried out in the Bata watershed during 1979, and Jalal watershed and ground during 1980. Silt observations were also collected.

2. It was proposed to collect information on the extent of saline affected soils on the banks of Hooghly river with the help of remote sensing techniques. The aerial flights have been completed in April 1980 and ground truth data for interpretation has also been collected. Water samples have been collected by Calcutta Port Trust and after analysis, the data has been supplied to National Remote Sensing Agency (NRSA)

3. Proposals are being framed for application of remote sensing techniques for identifying crop prospects, irrigated areas, snow hydrology, estimation of silting in large reservoirs, preparation of flood maps etc. Study of area affected by floods in Sahibi river in year 1977 is being undertaken with the assistance of NRSA.

### 2.3.9 Hydrological Observations and Flood Forecasting Organisation (North), Patna

The Flood Forecasting Organisation and Hydrological Observations Organisation were merged and placed under the charge of two chief Engineers based at Patna for oNrthern region and Hyderabad for Southern region.

1. A study has been initiated in 1978 to collect and analyse water samples from about 41 sites in the Ganga basin for determining the presence of various chemicals and pollutants in the river.

2. A manual on Flood Forecasting has been prepared and is under printing. It is desired to circulate these to the level of Assistant Engineers for reference purposes.

3. During 1980 Flood season, forecasts were issued at 108 sites in various river basins including Ganga, Brahmaputra and Barak basins. During this period, 5382 forecasts were issued of which 4773 were within $\pm$ 15 cm with actual observed levels.

### 2.3.10 Hydrological Observations and Flood Forecasting Organisation (South), Hyderabad,

1. As per the recommendation of Krishna-Godavari Commission, observation of gauge and discharge were continued at 40 stations in Krishna and 44 stations in Godavari River basins.

2. Under national network scheme for hydrological observations in the country in river basins other than Krishna, Godavari, Chenab, Indus and Ganga, gauge and discharge observations are continued.

## 2.4 Central Water and Power Research Station (CWPRS), Khadakwasla.

1. An instrument - Ultrasonic Velocity Meter

has been developed for measurement of discharge in open channels. The instrument is under field trials.

2. The Stream flow Synthesis And Reservoir Regulation (SSARR) model was developed to execute on big computers. Considering its usefulness to CWPRS, the task for modifying this mathematical model to execute on HP 1000 mini computer has been taken up. This required creation of more number of segments to accommodate within available program memory of mini computer. This extended memory area feature of HP 1000 mini computer has been utilised to keep vast amount of data. It is planned to use HP 2648 A display terminal for graphic output from the mathematical model for immediate observations and quick modifications to achieve good match between the observed and synthesised hydrographs.

### 2.5 Central Board of Irrigation & Power, New Delhi.

1. Under the systems planning study for optimal management of water resources in Parambikulam - Aliyar Basin, three types of analysis are envisaged. These are hydrology, agronomy and system analysis of which the first two were taken up during the first phase.

2. A mathematical model formulated as an optimization model with finite element representation of the flow is under development as a part of Prescriptive Regional Ground Water Models project at I.I.T, Madras. The specific aspects under study included.

(i) The unsteady state simulations of a shifting boundary between confined and unconfined zones in a regional aquifer system. The specification of the safe yield/storativity of an interfacial element is being attempted in different ways.

(ii) The facilities available in package programmes for linear programming regarding their capacity to handle large number of equality constraints.

3 Recharge from rainfall being the most vital parameter, studies for the estimation of ground water recharge from rainfall were taken up at U.P. Irrigation Research Institute. In order to estimate ground water recharge in Uttar Pradesh using artificial Tritium, three different geological areas with different intensities of rainfall have been selected. These are Gandak command area, Ganga - Sarda Doab and Roorkee area where there are no artificial sources of recharge nearby.

Soil sampling in these areas is being done periodically with the help of hand auger and the samples are being analysed for Tritium activity with the help of Automatic Liquid Scintillation System using a Dioxan Nepthalene Cocktail.

### 2.6 India Meteorological Department, New Delhi.

1. Rainfall studies were carried out for the evaluation of the Standard Project Storm and Probable Maximum Precipitation for different projects in the country at the request of state Government/project authorities.

2. Isohyetal analysis of past storms of Saurashtra & Kutch region was carried out and maps supplied to the enquiry commission enquiring into the failure of Machhu Dam in Saurashtra and Kutch.

3. Short duration rainfall studies for sub-zones 3-b in Lower Narmada and Tapti basin were completed. Isopluvial maps for various durations and return periods alongwith time distributions and point to areal graphs showing the temporal and spatial variation of storm rainfall for different duration and area were prepared.

4. Isohyetal pattern of storms in and around Thien project on river Ravi were supplied to the Director, Thien Dam Organisation, Chandigarh, alongwith depth-area-duration details for 5 October 1955, 8-10 August 1973 and 15-17 July 1975 storms.

5. IMD participated in Inter Departmental Glacier Expedition to Gor-garang in Himachal Pradesh during July 1981. A meteorological

observatory started functioning from 25 July 1981.

6. Snow survey of upper Beas catchment area was completed by staff of the Hydromet Division for the first time.

7. Two permanent observatories at Tista in Himachal Pradesh and Sama in Uttar Pradesh, two ordinary raingauges at Tharali and Rameshwar in Uttar Pradesh have been installed under Hydrological studies scheme.

8. IMD participated in expedition of Shanne/ Mastang Glacier and snow survey at Manali.

9. Crop yield forecasts of Rabi wheat and Kharif rice based on weather data were sent to Ministry of Agriculture for different meteorological sub-divisions.

10. The following papers were contributed.

(a) Meteorological aspects of the unprecedented Flood at Patna in August 1975 by A. K. Sen, Sharma and K Prasad.

(b) Some interesting meteorological aspects of the floods in northern India during fhe year 1978 by S R Puri and R D Ravishankar.

(c) 'Flash floods and their warning' by S D S Abbi.

(d) 'Variable (API) rainfall intensity unit hydrographs for Flood Forecasting' by DVLN Rao.

(e) 'On the importance of key raingauge station network for operational flood forecasting' by DVL N Rao.

**2.7 Indian Institute of Tropical Meteorology, Poona :**

1. The highest ever recorded floods in the major river basins of the country were catalogued and their space time distribution characteristics analysed. The meteorological situations responsible for these floods were also studied. The years 1973 and 1978 were the worst flood years of the country during the past few decades.

2. The availability of water potential during the monsoon season and its utilisation by existing dams on the selected river basins of the country were studied. Preliminary results showed that most of the existing dams utilise 5 to 15% of the total monsoon rainfall of their respective basins upto the dam sites.

3. The rain storm which caused unprecedented flash floods in the Vamsadhara basin in September 1980 was analysed. The study showed that the rainfall to the left of the depression track was four times more than that on the right side of the track. It is considered that this feature caused devastating flash flood in the basin as it happened to fall on the left side of the track.

4. Trends in the aridity index over Rajasthan desert were determined for south west monsoon months and the year as a whole. The analysis revealed that there is a definite decreasing tendency in aridity in this region.

5. Severe rainstorms numbering about 18 which occurred in the past 70 to 60 years over the Central Indian peninsula lying between lat 12°N to 16°N were analysed, by depth area-duration method. It revealed that rainstorms of 27-29 Sept. 1908 and 28-43 Sept. 1964 were the severe most rainstorms on this region. A generalised PMP chart of 1 day rainfall for the region was prepared which varies from 25 cm to 85 cm.

The following papers were published.

Dhar, O N., P R Rakhecha and B N Mandal. 1983. Influence of tropical disturbances on monthly monsoon rainfall of India. Monthly weather Review Vol. 109. No. 1 pp 188-190.

Rakhecha PR, AK Kulkarni and ON Dhar 1981. Is aridity increasing or decreasing over Rajasthan. Proceedings of National Seminar on Development of Desert and Drought prone Areas', Jaipur, 6-8 March 1981.

Dhar, O N., A K Kulkarni and P R Rakhecha. 1981. Probable maximum point rainfall estimation for the southern half of the Indian peninsula Proceedings of the Indian Academy of Sciences. 90 (A). No. 1 pp 39-46.

Dhar, O N., P R Rakhecha, B N Mandal and R B Sangam. 1981. Rainstorm which caused the Morvi Dam disaster in August 1979. Hydrological Sciences Bulletin. Vol. 26, No. 1. pp 71-81.

### 2.8 Water Resources Development Training Centre (WRDTC), University of Roorkee, Roorkee.

1. The centre is involved in a research project in water resources planning and management which is funded by the Ford Foundation. The following field studies were conducted in the command area bounded by the river Gomti & Kalyani on the three sides and the Sarda Sahayak feeder channel on one side in the state of Uttar Pradesh,

   (a) Assessment of water resources in Gomti Kalyani Doab.

   (b) Identification of subsurface system by inverse method.

   (c) Mathematical modelling of ground water basin with special reference to Gomti Kalyani Doab.

   (d) Surface-Ground Water interaction model for Gomti Kalyani Doab.

   (e) Development of cost function for integrated use of surface and ground water.

   (f) Management tools for optimum utilisation of surface and ground water potential in Gomti Kalyani Doab.

   (g) Study of conveyance losses in channels.

2. Other research studies carried out include.

   (a) performance of pumping units in wells.

   (b) sequential generation of Hydrologic data.

   (c) study of flood problems of Ghaghra basin and mitigation strategies for the same.

   (d) Development of surface drainage in Tawa command area.

   (e) Flood moderation and use of surface water of Ghaghra-Markanda basin.

   (f) Integrated utilisation of surface and ground water at the farm level.

3. A special short term course on 'Water Resources Systems' was organised, during 20 Aug-16 Sept. 1981.

### 2.9 School of Hydrology, University of Roorkee, Roorkee.

The International post graduate course in Hydrology introduced in July 1972, has been imparting advanced education and training in the field of Hydrology to the serving engineers and scientists from developing countries of Asia and Africa, from 1981. Apart from UNESCO, the course has also been sponsored by the WMO.

The training programme of the course has been drawn up to appraise the trainees with the recent developments in the science of hydrology and their application to the field problem The course is oriented to suit the requirements of three main specialisations in the field of hydrology namely the surface water, the ground water and the watershed management.

Besides the teaching and guidance to trainee officers for their special problems, dissertations etc. the faculty is actively engaged in individual research as well as consultancy projects.

1. The following research projects were completed.

   (a) Effect of pollution of surface and ground water in respect of industries in western Uttar Pradesh.

(b). Tritium tracer study in Sarda Sahayak command area.

(c) Geohydrological investigations and water balance study of Mega Alluvial cone of the Ganga river system.

2. Work on two research projects and one research cum consultancy project were in progress. They were.

(a) Application of remote sensing methods to Hydrology.

(b) Assessment of Himalayan water resources for National development and regional cooperation.

(c) Mathematical model studies for induced recharge in Ganga basin.

3. The following consultancy studies were completed.

(a) Hydrological studies of Ramganga Dam project.

(b) Design flood studies for Rajghat Dam project.

(c) Hydrological investigations of Machhu Dam II

(d) Assessment of silting of Jamrani Dam reservoir.

4. Work on the following consultancy projects was in progress.

(a) RC analogue studies in Agra and Varanasi districts

(b) Ground water Studies in Yamuna comand area.

(c) Design of infiltration gallery for drinking water supply scheme for Manila Devi group of villages in Almora district, Uttar Pradesh.

**2 10 Central Soil and Water Conservation Research & Training Institute, Dehradun.**

1. The rainfall data of the rain gauge at the instituties, research station at Vasad was analysed. A simple procedure of frequency analysis of maximum rainfall intensities for various durations was adopted and the rainfall intensities for various durations and frequencies for Vasad were found out. The relationship was found to be

$$I = \frac{7\,506\ F^{0.1393}}{(t+0.5)^{0.3857}}$$

where I = intensity in cm/hr for duration equal to t hrs

t = duration in hours and

F = recurrence interval in years.

2. Five small watersheds, ranging in area from 5 3 ha to 83.4 ha under different land uses i.e. agriculture, forest and mixed land uses were under study to find out the relationship between rainfall, runoff, peak rates of discharge and sediment load.

**2.11 Central Soil Salinity Research Institute, Karnal.**

1. To describe the quantitative hydrologic responses of sodic soil watersheds due to var ous land use treatments, four geometrically identical watersheds were selected at Gudda farm of the institute. Prior to the commencement of rainy season, observation on Ec, pH and infiltration rates of soil in all the catchments were taken to provide the bench mark data. Three observation wells were installed in each of the catchments. Three access tubes upto 1.5m depth, were also installed in each catchement for the periodic soil moisture measurements. During the installation of observation wells, the soil samples taken from the well material were tested for pH and Ec.

The Ec and pH values in June 1981 were nearly uniform through out the soil profile upto 120 cm. depth and varied from 0.5 to 2 micro mhos/cm and 9.9 to 10.3 respectively. However, the October 1981 values taken during installation of observation wells indicated increase in pH values at depth below 120 cm. The water table observations in November 1981

indicates that the water table gradients generally follow the surface topography and that they slope from north east to south west. The water table was in in the range of 4.0 to 4.6. mb.g.l. The Ec. varies from 1000 to 2000 micromhos/cm and pH from 8.0 to 8.8. The runoff hydrograph of 28 July 1981 indicated close identity in respect of hydrologic characteristics of three watersheds without any treatments.

2. The seasonal salt and water balance technique was adopted for evaluating the Hydrologic effects occurring due to saline soil reclamation. The reclamation measures adopted were

(a) Operation of four parallel open sub surface drains.

(b) Effective utilisation of the total rainfall for leaching by providing levelled field surface and bunds.

(c) Continuous cultivation of the area irrigated with saline ground water during rainless period.

The seasonal water balance for reclaimed and unreclaimed area has been compared. The greater amount of ground water out flow from drained area as compared to undrained area favoured the lowering of water table by removing saline water from shallow depths of soils and presented the salinization of soil profile. It was observed that from the drained area more salt is removed along with drainage water as compared to undrained area.

3. Significant hydrologic changes are caused in fhe hydrologic behaviour of sodic soil water sheds due to reclamation. The net effect is that the rain water retention capacity of the watershed is increased particularly because of bunding of the sodic fields and improvement in infiltration rate. A procedure has been developed for extension of SCS curve number technique for calculating the amount of runoff in case of transient watersheds.

4. In order to evaluate and quantify the effect of land surface uniformity on irrigation efficiency and economic parameters, a field study was conducted during rabi 1980-81 on a sodic soil of sandy loam texture. Having average pH of 9.2. The treatments included a range of mean deviations from the desired levels along the field length.

### 2.12 National Environmental Engineering Research Institute (NEERI), Nagpur.

1. Design criteria and operational methodology have been evolved for adoption of slow sand filters in rural water supply systems. The first plant based on Nalgonda technique namely addition of alum to waters containing fluoride was commissioned in 1980. The trial runs have shown a satisfactory performance in bringing down Fluoride levels from above 4.0 mg/l to less than 1.0 mg/l.

2. A number of Research and Development projects were completed.

(a) Infrared (IR) spectroscopic method was studied for the estimation of pesticides in water samples. The precision and accuracy of the method has been evaluated.

(b) Studies were carried out to assess the pollution of the Hoogly and of other water sources in the region. Survey was carried out covering summer and monsoon period at the six sampling stations, in 100 km stretch of Hoogly estuary for chemical, biological as well as bacterial parameters.

3. Some Research & Development projects are under progress

(a) Four village demonstration plants of slow sand filtration were commissioned.

(b) Laboratory model with facilities for preparation of clay suspension was setup

4. A Indian Oil Corporation sponsored project on monitoring of water quality of Yamuna river at Mathura is under progress under the Delhi regional laboratory.

## 2.13 CENTRAL BOARD FOR THE PREVENTION AND CONTROL OF WATER POLLUTION, NEW DELHI

1. The work of evolving national standards which started in August 1977 is proceeding apace and fast nearing completion. To the four documents completed and reported earlier, two more completed documents were added during this year., namely SUGAR and OIL REFINERIES. The six completed documents are now undergoing a final review by experts in preparation for their final publication. Progress on the documents for IRON & STEEL, PETROCHEMICALS and THERMAL POWER PLANT is also very satisfactory and the final draft should be ready by 1981. Due to various difficulties faced in classifying and characterizing the raw materials, products and pollutant loads, the progress on the documents INORGANIC CHEMICALS, PHARMACEUTICALS, PULP and PAPER and PESTICIDES industries has been slower than planned. However, the work is well under control and the basic draft is expected to be ready in 1981-82.

2. Follow up actions to evolve and propogate a national policy for the prevention and control of water pollution caused by the discharge of untreated sewage from major urban sources continued on the basis of the status reports for class I cities and class II towns prepared by the board.

3. To obtain an integrated picture of the role of various human activities and particularly of developmental projects in the maintenance of a desirable water quality in streams and wells, and to evolve policies and programmes for future, inter-state river basin wide pollution potential surveys were initiated by the Board with the close collaboration and help from various state boards involved in the basin. The work on the Yamuna basin was completed and reported. Work on the larger Ganga basin is fast progressing and the draft report should be rady by December 1981. Planning for similar survey for the river Krishna is in Progress.

From the findings and recommendations of the inter state Yamuna basin it is seen that land use Planning and all types of developmental activity in future should devote adequate thought to their implications on water quality right from the beginning This would be even more true for p ojects which abstract, store, discharge or otherwise manipulate large quantities of water such as irrigation and water supply schemes Since the engineers designing and planning irrigation projects are often unaware and unmindful of the water quality implications, the Boa d plans to initiate discussions with a group of design and planning engineers from the river valley projects as water supply and sewerage board to evolve some acceptable policies and procedures.

4. Data from 33 monitoring stations, 24 in various streams and 9 wells in different regions located in 7 states started coming in. The Board is keeping records of all the data in well organised files and is initiating action to analyse and interpret the data on a continuous basis. Under MINARS and Stream Survey Schemes of various state boards significant volumes of date are being collected by the various state boards under general guidance of the Central Board. Attention is now being devoted to compile and interpret thsese data.

5. Due to some reports of ground water in and around Delhi being suspected of containing Cadmium it was decided to carry out an intensive ground water quality survey in the area. Samples from 150 wells & tube wells in Delhi and nearby areas of Uttar Pradesh, Haryana, Rajasthan were collected by the Central Board. All tests except for the heavy metal Cadmium have been completed and when the Atomic absorption Spectrophotometer is installed and commissioned in early July 1981, the analysis for Cadmium would also be completed.

6. To study the effects of mass bathing during religious festivals on stream water quality an intensive survey was undertaken with the help of a mobile laboratory during the Ardh Kumbh Mela at Hardwar in April 1980. Intensive sampling was done in the stretch from Lakshman Jhoola to the Bahadrabad bridge 10 kms down stream of Hari - ki - Pauri on Upper Ganga canal. The study revealed that Ganga water is not as resistant to and safe against bacteriological pollution as is popularly believed. On the basis of the study it appears that Chlorination at some point 20-30 kms upstream of the main bathing points and at regualr intervals of 3 - 4 hrs should be started at least a day before the mass bathing occasion and continued for at least one day after the festive bathing is over.

## 2.14 National Geophysical Research Institute Hyderabad.

1. Water well inventory data of Marvanka basin in Anantapur district of Andhra Pradesh has been analysed considering the geological and structural background of the basin. A number of lineaments identified on landsat have been verified in the field and groundwater potentials in some of the lineament areas have been studied. Pre and post monsoon water level measurements for selected number of observation wells were continued and the fluctuation changes in different hydrogeological and structural settings have been studied.

2. A number of sponsored Geophysical surveys for groundwater and bedrock investigations were carried out.

3. Geohydrological studies of the following two basins in the Deccan trap were initiated with the collaboration of Ground water Survey and Development Agency (GSDA) of Maharashtra state.

   (a) Godavari - Purna basin in Aurangabad districts having an area of 1080 sq km and

   (b) Kukadi basin in Ahmednagar district with an area of 1050 sq. km.

Data on well inventory and pump tests provided by GSDA were analysed and the aquifer parameters were calculated by using the Papadopulos and Cooper method. A field laboratory was set up at Aurangabad and chemical analysis were carried out on 34 representative samples from Godavari Purna and 32 samples from Kukadi basin.

Tritium tracer was injected at 30 sites in Godavari-Purna basin and 25 sites in Kukadi basin and the measurement of Tritium and moisture content and grain size analysis have been completed on some of the soil profiles.

4 In order to keep the discharge from dug wells both constant and low, a device has been fabricated in which a variable fraction of the discharge is returned to the pumped well.

5. Recharge measurements using Tritium injection techniques were initiated during 1979-80 in the following basins.

   (a) Marvanka in Andhra Pradesh

   (b) Noyil and Vatlamalaikarai in Tamil Nadu

   (c) Ponnani in Kerala and Tamil Nadu.

Soil core samples collected previously were analysed for Tritium and moisture content.

6. Aquifer modelling studies were continued in some selected areas employing the available data. A preliminary digital model of the deeper aquifer in Ghazipur district, Uttar Pradesh (north of Ganga) was prepared. The analog model of Tallaguda-Palenkui basin, Andhra Pradesh was further refined and the aquifer response to a few probabilistic input output schemes was studied. Steps were taken for collection of additional data required in Ghazipur and Krishni-Hindon interstream region to validate the assumptions and thereby improve the models which have been constructed earlier.

7. With a view to establish the recharge area for the ground water in confined aquifers and assessing the ground water potential Tritium and radiocarbon measurements have been carried out in Pondicherry and Neyveli Lignite mine area.

**2.15 Address by Shri Rao Birendra Singh, Hon'b-le Union Minister for Agriculture, Rural Construction and Irrigation at the nineteenth congress of the International Association for Hydraulic Research, New Delhi, 1 February 1981.**

RESPECTED RASHTRAPATI JI,HON' BLE ANSARI JI, PROF. KENNEDY, DISTINGUISHED DELEGATES, LADIES AND GENTLEMEN :

It gives me great pleasure to welcome you all to this Nineteenth Cong ress of the International Association for Hydraulic Research. I am extremely grateful to Rashtrapati Ji who has so graciously agreed to inaugurate this Congress. This shows his deep interest in agriculture which is dependent on irrigation, and symbolizes the importance being attached to water development in our country. The Congress would be deliberating on various important subjects such as the design, implementation and operation of water development projects.

We have given high priority to water-supply schemes for domestic uses and have embarked upon a crash programme to provide potable water to all the problem villages in the country. We have undertaken a massive programme of irrigation through major, medium and minor schemes. River valley projects are being planned to provide multipurpose benefits wherever feasible. We have also launched an ambitious programme of hydro-power development for which there is immense potential in our country. Some of the simpler water-resources development projects have already been taken up. We have developed nearly 50 per cent of the potential so far. More and more difficult projects would have to be taken up in future so as to fully exploit the available potential. I am happy to mention that through systematic research and development we have created indigenous expertise for tackling all types of problems whether they pertain to planning, design, implementation or operation of river valley projects. We have an on-going programme of research in the water development sector. A large number of institutions are working on different problems. The Congress would provide a unique opportunity to our engineers and scientists for exchange of data and studies in respect of various problems which must be resolved for economical and speedy implementation of water development programmes.

Irrigation works in our country date back to pre-historic times. At the time we achieved Independence we had an irrigation system capable of irrigating 22.6 million ha. We have increased the potential to 57 million ha by now. Our aim is 150 million ha after the National Plan for water development has been implemented. Although several challenges have been overcome and the experience that we have gained in the last 30 years has given us confidence to embark upon a bigger programme for water development, many more challenges lie ahead. With the experience of performance of projects already implemented and with the modern tools such as mathematical modelling, hydro-dynamic modelling and computer aids it should be possible to solve many complex problems which exist today or are likely to arise in future. Technological advancements in other countries in the field of water would indeed provide a valuable guide in our efforts to find solutions of the problems. In this era of fast developing technology, technical Congresses provide an appropriate forum for transfer of technology and exchange of experience. Certain specific problems would also be posed to international experts. We are, therefore, thankful to the International Association for Hydraulic Research for holding its Congress in India after a peiod of nearly 30 years. In the meantime considerable progress has been achieved in our country in the field of water irrigation and hydro-power. Our experience is available to all, particularly to developing countries. We are in fact, already assisting many countreis in water development and flood control projects through WAPCOS (Water and Power Consultancy Services Ltd.), a public sector undertaking. We

also have a Central Water and Power Research Station at Pune which is recognised as a regional station in the Economic and Social Commisson for Asia and the Pacific region for hydro-dynamic and mathematical modelling of water structures. We also have a chain of sixteen hydraulic research institutes in various States of the country which have been working on important schemes of the States.

In India, the availability of water is highly uneven both in terms of space and time. Nearly a third of the country is drought prone while an eighth is flood prone. Many of the rivers are inter-state in nature and some are also international. Through planning in the context of inter-state and international co-operation by providing optimal storages at appropriate location and inter-linking the various river systems, considerable additional benefits of irrigation, hydro-power, navigation and flood control can be provided for each state, thus removing regional imbalances to the maximum extent feasible. A national perspective plan for water resources development has, therefore, been drawn up for the optimum development and interlinking of the major river systems. This plan envisages construction of about 18 million ha m of storages and a number of interlinks to enable the development of about 35 million ha additional irrigation potential. Apart from this, installation of 40,000 MW of hydro capacity and navigation will be possible. This would be one of the greatest water development projects of the world and engineers and experts will have a vital role to play in this fascinating task.

In the context of the energy crisis high priority is being accorded to the development and utilisation of renewable resources to meet the energy requirement of the future. Since the present day technology to utilise solar energy and power of winds, tides and waves is not yet in a position to meet the massive energy demands in the short term perspective, we have to turn to the other well known renewable enrgy resources, viz., hydro-power especially in view of the fact that the technology for its exploitation is very well established. India is fairly well endowed with hydro-power resources assessed broadly at over 75,000 MW at 60 per cent load factor. The installed hydro capacity rose from 560 MW in 1950 to 10,740 MW at present. The target for the next five years is additional 5,600 MW. We are planning to tap this resource to the fullest extent possible in the near future. Experts in the field of hydraulics have to play a great role in hydro-power development. I am very happy to note that present Congress will deal *inter alia* with various aspects of hydro-power development such as low head hydro-power, pumped storage schemes, etc.

The implementation of water resources development programmes involves not only the efficient utilisation of the available physical resources and harnessing of all the available technical manpower but also means substantial financial investments. The financial resources available are limited. There are competing demands from different sectors of development. It is, therefore essential that the costs of irrigation and hydro-power development schemes are kept at the minimum, and the cost effectiveness of each unit of investment is thereby maximised. It is here that careful planning, investigation, research and development can make the maximum contribution. The help of our research organisations in this direction would be invaluable. I am sure that the present International Congress of Hydraulic Research will act as a catalyst and lead to many innovations of immediate practical importance.

I hope that the delegates from abroad will find some time, amidst their busy schedule, to go round Delhi and also some of the projects which have been undertaken in the country.

I thank you very much for the opportunity given to me to say a few words. May I now request our beloved Rashtrapati Ji to address the gathering and inaugurate the Congress ?

### 2.16 Address by Shri Rao Birendra Singh, Hon'ble Union Minister for Agriculture, Rural Construction, Irrigation and Civil Supplies at the Second Annual General Meeting of the National Institute of Hydrology Society, New Delhi. Ist october 1981,

Friends,

I have great pleasure in welcoming you all to the Second Annual General Meeting of the

National Institute of Hydrology Society. As you are already aware this Institute is the premier national research organisation for carrying out systematic scientific research in basic, theoretical and applied areas of hydrology and water resources which are relevant for various regions of the nation.

As you know hydrology is the basic science dealing with the occurrence and distribution of the water resources and includes the study of the availability of surface and underground water, It also deals with the problems like floods and droughts which are very important for a large developing country like India which depends on agriculture.

We have the second largest population in the world while our land area is only the 7th largest. More than three-fourths of the population of India lives in villages and agriculture is the back bone of our economy. Agriculture depends largely on natural rainfall and river flows during the monsoon months and on surface water reservoirs and groundwater development in the other seasons. The climate, land forms and crops vary from region to region. The rainfall is due to monsoon which is uncertain in distribution.

Streamflows and rainfall vary erratically from place to place and from time to time. With the ever-growing population there is a great need for providing assured supply of water for irrigation. It is estimated that our total irrigation from surface and groundwater will be around 113 million hectares of land out of which 53 percent has been created and the balance is yet to be tapped. There is a considerable emphasis in the Sixth plan for development of new minor and major irrigation schemes besides modernisation of old schemes. While monsoon rainfall is not very dependable because of the uncertainty of monsoons, several regions of India particularly the Indo-Gangetic plains and the coastal alluvial plains have plenty of groundwater. Conjunctive utilisation of surface and groundwater, may tackle the problems arising from undependability of monsoons and it will be helpful for providing assured supply of water for irrigation and other purposes.

Floods are almost an annual feature in our country and they pose serious problems to humanity in terms of damage to life and property, inundation of crops, soil erosion, adverse effects on other several sectors of economy including agriculture, transport, industry etc. The occurrence of floods are governed by laws of chance and there has been significant development in forecasting natural calamities like storms, floods, etc. Using space technology man can follow the movement of cyclones, collect data concerning earlier precipitation, use radars for monitoring storms and floods and using computers he can also forecast floods and decide flood control operation procedures. This procedure may also be used for estimating floods that may occur in future and to design reservoirs, dams, bridges, etc. to alleviate the damage due to floods.

Droughts occur when there is deficiency in precipitation. They are also probabilistic in nature. Even though the effects of floods last for a short duration, those of droughts may extend over a number of years and their space and time implications on the economy of nation is extremely serious. While some parts of the country are reeling under heavy floods, other parts may suffer due to droughts. Actually during the "break-monsoon" period some north Indian rivers would be in floods while the area hardly more than 10 to 15 km. from the river may suffer drought. The supply of water to the cities and the provision of drainage for urban areas and agricultural lands also requires a basic knowledge of hydrology. I am glad to note that the national Institute of hydrology will be dealing with several fundamental and basic problems related to the availability of water for multipurpose use the problems of floods and droughts and for planning of integrated surface and groundwater resources systems. I learn that the Institute has already started its research work in several important fields.

The Institute is completing a study on the interaction of surface water and groundwater for Upper Ganga Canal Command area. They are also associated with the Narmada Flood Estimation studies and the proposed All India Coordinated Project on Droughts of the Indian National Committee for International Hydrological Programme.

In the establishment of the Institute, Government of India is making use of the aid by UNDP under Second India UNDP country programme. The research work to be taken up by NIH involves the use of voluminous data and mathematical modelling. A VAX-11/780 minicomputer system supplied as the equipment under UNDP aid is expected to be installed in the Institute and be operational before the end of this year. The research work of the Institute is then expected to gain momentum.

It is 2½ years since the Institute started functioning from February 1979 and this has been a dynamic period of growth in the number of personnel, in construction of building, procurement of equipment and in the starting of the research activities. The Institute has a very crucial part to play towards reaching national goals in development of water resources.

I am happy to find a number of Hon'ble Ministers of Irrigation of different States participating in this meeting and they will be giving the benefit of their advice to the National Institute of Hydrology Society. It is hoped that the Irrigation Departments of different States under their direction will interact with the National Institute of Hydrology and its research work for optimal development of their water resources and thus help the Institute in carrying out meaningful field oriented research.

Government of India hopes that NIH will fill the long felt need for conducting and coordinating systematic hydrologic research in the country and act as a nucleus for hydroiogic research work and also for transfer of technology to the field engineers. Under your advice and active assistance, I have no doubt that the Institute will be able to contribute significantly not only for hydrologic research in the national and international level, but also towards rational development of the limited water resources of the nation.

### 2.17 Address by Shri Kedar Pandey, Union Minister For Irrigation at the Third Afro-Asian Regional Conference of the International Commission on Irrigation Drainage, New Delhi, 27 October 1980.

Mr. Earves-Bornoz, President, ICID, Shri Framji, Distinguished Delegates and Guests :

It is indeed a pleasure for me to have an opportunity to meet experts in irrigation development who have assembled here on the occasion of the Third Afro-Asian Regional Conference of the International Commission on Irrigation and Drainage. I am glad to note that experts from 15 countries are participating in this conference. This is indeed a happy augury and reflects a wide recognition of the need to pool our experiences and have a free exchange of ideas and knowledge as many of the present day problems in the field of irrigation and drainage are common to the countries of the region.

I am aware the problems relating to Water Resources Management have been receiving critical attention in a number of national and international forums. A few years back on the occasion of the Second World Conference of the Internationl Water Resources Association, we in Delhi, had an apportunity to meet the world's experts dealing with this subject. The United Nations Water Conference held at Mar del Plata, Argentina in 1977 was another major event in this sries. Of course, the International Commission on Irrigation and Drainage has been holding a number of international conferences for detailed study of specific aspects at different centres of the world. Last year's Golden Jubilee Congress of the International Commission on Large Dams, another international organisation dealing with conservation and exploitation of water resources held in New Delhi, has stimulated fresh activity

on safety aspects of water resources development projects. We are now gathered together for the Third Afro-Asian Regional Conference of the ICID.

There are no two opinions on the fact the present and future development of irrigation throughout the world is going to make heavy demands on the available fresh water supplies. According to a survey carried out by the International Commission on Irrigation and Drainage, the irrigated area in the world has increased from about 48 million hectares to over 200 million hectares between 1900 and 1970. By the year 2000 AD the world area under irrigation will need to be about 500 million hectares. The increase in fresh water demand due to this will exceed a million cubic metres annually. The need for the most optimum utilisation of our water resources is, therefore, evident. The activities of the International Commission on Irrigation and Drainage in exchanging experience and pooling of ideas and developing new approaches are therefore of greatest practical importance to humanity.

India is a vast country afflicted by floods and droughts. One-third area in the country is drought affected while one-eighth area is flood prone. A major break through in irrigation development was achieved under the 20-Point Programme initiated in 1974 and the irrigation potential which was being created at a rate of 1 million hectare per year from 1950 to 1974 was stepped up to about 2 million hectares per year in the five year period from 1974 to 1979. A much more ambitious programme of irrigation development is envisaged in the Five-Year Plan 1980—85 when a 15 million hectares target has been fixed which corresponds to a rate of 3 million hectares per year. At present, India is adding 2.5 million hectares to its irrigated area every year. Such a rate of growth has no parallel in the history of the world but our country being dependent on agriculture, there is no other way to step up the economic growth of the masses unless irrigation facilities are stepped up and waters utilised optimally. The Government of India have therefore given high priority to irrigation development. A separate Ministry under a Cabinet Minister has been created and the minor irrigation programmes including ground water development and command area development have been brought under the Ministry of Irrigation. This would certainly help in launching a unified and co-ordinated programme of irrigation development and efficient water utilisation. The total surface water in the country is about 180 million hectare metres out of which about 66 million hectare metres are assessed to be utilisable. The usable ground water resources for irrigation are assessed as 26 million hectare metres. These would enable an irrigation of 113 million hectares. Till March 1980, 57 million hectares of potential has been developed utilising about 27 million hectare metres of surface water and 14 million hectare metres of ground water. The outlay on these programmes from 1951 upto March 1980 was Rs. 125,000 million. A target of 15 million hectares for 1980-85 Plan with an outlay of about Rs. 1,50,000 million is being considered with the objective that the entire potential should be created by the turn of the century. However, the need for water and agricultural production has been growing along with the mounting population. We have therefore to explore all possible avenues of maximum development of the available waters. The Ministry has therefore prepared a National Plan for creating storages and inter-linking various river systems. This would undoubtedly call for co-operation from the States as well as from the neighbouring countries. This National Plan envisages creation of additonal irrigation facilities in a further 35 million hectares of area and generation of additional hydro-power to the extent of 40 million kilowatts besides large benefits of flood control and navigation. All the States and neighbouring countries would stand to benefit by the Plan. The total cost of the National Plan is estimated at Rs. 500,000 million and investigation for the first phase of the scheme is proposed to be taken up shortly.

As is well-known, years of drought are recurrent phenomena in our climate. The drought in 1979 monsoon could be tided over only because of the production from our irrigated

lands and the buffer stock of foodgrains which we were able to carry forward from the earlier years. With our ever-increasing population, notwithstanding our efforts at population control and having brought under cultivation almost all the arable resources, the only way to meet our future food and fibre requirements is to extend irrigation facilities by all possible means by harnessing to the maximum extent feasible, the water resources available by the construction of storages and interlinking rivers. This is the only way to meet the foreseen needs of agricultural production, provide flood control as well as substantial blocks of hydroelectric power.

Flood control and drainage are equally important. Out of 40 million hectares of flood prone area, so far we have been able to provide reasonable protection to an area of 11 million hectares at a cost of roughly Rs. 10,000 million. The problem of floods, like that of droughts, has to be tackled by the overall development of our water resources. We have to create sizable storage reservoirs on our rivers to impound the surplus waters flowing to the sea every year. We have made a start in this direction by the decision to set up the Brahmaputra Board for drawing up a Master Plan for this mighty river. Besides this we have undertaken a big programme of modernisation of flood warning and flood forecasting systems so that timely action is taken for preventing damage to life. We have also taken up new policy initiative for developing the common rivers between India and Nepal.

Perhaps some may ask—are we getting adequate returns on our investments ? Are we fully utilising the irrigation capacity already built-up? Is there any scope for further improvements?

I am afraid, at present, our answers may not satisfy all. Due to various costraints our irrigation projects are not being completed within optimum time schedules. The costs of irrigation projects are on the increase. In a number of projects, the actual irrigation in the field is lagging behind the created irrigation potential in many irrigated areas, especially in the older systems, the irrigation water is applied much in excess of the requirements. Then, there are appreciable losses in the transmission and distribution systems. There is also a need to improve the cropping patterns and make better use of soil, water resources and other available agricultural inputs. In short, what we need is better water management. It is heartening that the theme of your conference 'Managemet of Water in Irrigation Systems including Conjunctive Use of Surface and Ground Waters and Command Area Development aptly covers many of the ills by setting irrigation development in this region. And I sincerely hope that the results of your deliberations would give a fresh impetus to solve these problems and make irrigation projects more remunerative.

The reasons for the lag in the utilisation of irrigation potential created by the new projects have been closely examined by a number of Committees in India. Based on the gaps identified by them to be covered, a command area development programme was initiated in this country in 1973-74. This programme involves the undertaking of a wide range of activities in a co-ordinated manner so as to obtain maximum output. The activities include on-farm development works, adoption of a suitable cropping pattern and rostering system of irrigation, improving the agricultural extension services, supply of required agricultural inputs and development of the necessary infrastructure facilities. Presently a number of command area development authorities are functioning covering over 70 major irrigation projects. This programme is having a good impact in improving the utilisation of irrigation potential created and the integrated development of the rural areas, and I hope that some of the foreign delegates will be able to visit some of them.

I have earlier referred to the need to improve the operating efficiency of irrigation systems. In many of our older irrigation systems where unlined canals are generally prevalent, the transmission loss is quite appreciable in some reaches. Modern irrigated agriculture is often quite exacting in the demand for water. The high yielding varieties of crops, especially when used with

chemical fertilisers, require application of the right quantities of water at the right time. Many of our earlier irrigation systems were not designed to meet these exacting demands. A number of schemes to modernise such irrigation systems have therefore been initiated. Modernisation will, however, include a comprehensive review of the cropping pratterns and crop calendar so as to make the best use of the soil types of the command area, a reappraisal of the irrigation water requirements and the frequency of water application, the conjunctive use of ground water to supplement the canal water supplies, improving the drainage conditions, adequate on-farm development and improvements in water control structures.

Large scale irrigation and drainage works, at times, may cause some changes in environment. Unanticipated, effects have been generated by many projects, especially as they affected aquatic and terrestrial ecosystem. The changes in the life-style of the peole living in project area are also quite considerable. Engineers are themselves aware of the changes in the river regime brought about by modified erosion and sediment transport as a result of the river control structures. Water quality changes are also induced due to chan ges in streamflow and agricultural practices. Ecological balance in the reservoir area and the irrigated lands also get altered. These side effects which are significant have, no doubt, to be considered and allowed for at the planning stage of the irrigation system. Today, there is a tendency on the part of semi-technical writers to paint very gloomy pictures of the disturbing side effects and condemn wholesale these projects as poorly conceived or outright destructive. The more substantial contribution of the p rojects in increasing food production, making available cheap electrical energy for industrial and agricultural development, providing a cheap transportation syst em and general improving the quality of life of the people in the project area and even the beneficial environmental effects are either taken for granted or virtually ignored. Cases are many where different pressure groups have built up a tempo of opposition so as to even negate the development activities to a stop in the name of non-interference in the existing ecosystems. In this context, I would only like to say that we should arrive at a compromise between the conservationists and the practitioners of the development who differ on the emphasis—maintenance on the one hand and production on the other. It has been rightly said that development is more and more a compromise between the technically possible, the economically attractive and the environmentally acceptable. We should always keep in view these criteria in judging our irrigation projects and programmes. In this context the proposed theme "Identification of remedial measures to mitigate the adverse effects of irrigation, drainage and flood control projects" for the special Session at the International Executive Council of ICID to be held in India in 1981 is most appropriate and timely.

Before closing, I would like to extend cordial greetings specially to the foreign participants in this Session and I do hope that their stay in this country will be pleasant, and that they will find some time to go round Delhi and some parts of our country. I am sure that conclusions and recommendations emerging after discussions at this conference will help scientists engineers and technicians in their future work and would be a positive contribution to the effective solution of the problems faced in our attempts to increase agricultural production while preserving the environment we live in.

I have now great pleasure in inaugurating this conference and wishing the Congress participants fruitful discussions and success in their efforts.

### 2.18 Address by Shri Z R Ansari Hon'ble Union Minister for Irrigation at the sixth conference of State Ministers of Irrigation, New Delhi., 30 September 1981,

Hon'ble Union Minister for Irrigation, Hon'ble Ministers from the States and Friends.

It gives me great pleasure to be with you today on the occasion of Sixth Conference of

State Ministers-in-Charge of Irrigation, Flood Control and Command Area Development. The Sixth, Plan provides for an investment of Rs. 11,115 crores for the irrigation sector inciuding the Command Area Development. This is besides the funds to be provided from the institutional finance and private resources of farmers and is against the expenditure of Rs. 10,304 crores from the public funds since the start of the era of planning in our country 30 Years ago. On Flood Control, the provision made in the plan is Rs. 1,045 crores against the expenditure of Rs. 976 crores incurred since the start of planning in our country. This indicates the importance gtven by the Cental and State Goverments to Irrigation anb Flood control sectors. In order the provisions made are fully and fruitfully utilised, it is necessary that planning, design and construction organisations are suitably strengthened. We have also irrigation and flood control projects during the last 3 decades and take appropriate measures in correcting the deficiencies which have come to our notice.

The importance of irrigation in the development of agriculture in our country, which sustains 75 percent of the population and is responsible for nearly 50 percent of the gross national product of the country, hardly needs emphasis. The tempo of irrigation development in the country was about one million hectares per annum upto 1974. During the Fifth plan commencing 1974, this tempo was almost doubled. I am happy to note that from the deliberations of the regional meetings taken by the Secretary, Ministry of Irrigation during June-July this Year and information made available by the States in these meetings 1980-81 was of the order of 2.50 million hectares. All the same, there is no room for complacency, particularly if the entire Irrigation potential of the country is to be achieved by the turn of the century. Let me hasten to add that we have no alternative if we are to be able to feed the growing population which is expected to reach the 900 million mark by then.

The drought conditions in large parts of the country during the last three years have convincingly brought out the importance of irrigation in stabilising the food production in a drought year with the stable production from irrigated areas. We have, therefore, to continue to develop irrigation with increased tempo and achieve the national target.

We should also make the most efficient use of the waters in the existing irrigation systems. The latter is even more important than the former because in terms of unit investment, larger benefits can be achieved and more quickly by efficient use of water. Moreover, with the extension of irrigation facilities and advent of high yielding varieties, the cropping pattern has undergone considerable change in different parts of the country. The demand for water has become more exact in making the efficient management of land and water imperative. High water use efficiency can be achieved by improving the distribution system upto field, making land fit to receive in efficient manner, ensuring the availability of adequate quantity of water to satisfy the crop needs at the right time, designing cropping pattern suitable for local soil and climate to give optimum returns, providing good drainage network to remove excess rain and irrigation water to avoid waterlogging and development of soil salinity, use of sprinklers/drip irrigation system to save water etc.

Primarily, with a view to get the maximum agricultural yield from the irrigation waters provided, Command Area Development Programme was instituted in the country since the beginning of Vth Five year Plan (1974-75) in selected irrigation projects. So far, 76 major and medium irrigation projects, having an ultimate irrigation potential of about 15 million hectares and falling in 16 States and 1 Union Territory, have been covered under this programme. More projects are proposed to be added during the VIth Plan period. I need not elaborate here upon the scope of the programme and its financing which the Honourable Ministers are already familiar with. I would only like to mention that the command area development concept needs to be popularized and made applicable not only to selected major irrigation

projects but also to all the irrigation projects in order to make optimal use of the irrigation provided and to get the maximum yield from per unit of water supplied. I would like to mention here that one of the greatest achievements of the implementation of CAD Programme is that it has created an awareness and appreciation for the need of having a programme beyond the Government outlet among Administrators, Engineers, Economists and the Agricultural Scientists.

We have a bold programme for minor irrigation in the Sixth Plan. In fact, out of the 14 million hectares of additional potential targeted to be achieved during the Sixth Plan, 8 million hectares are to be contributed by minor irrigation. Ground Water Development occupies the pride of place in minor irrigation and out of 8 million hectares, 7 million hectares are from ground water sources. There is considerable scope for development of ground water in Uttar Pradesh, Bihar, West Bengal, Assam and Orissa. Realistic programme should be prepared for drilling tubewells and providing other essential inputs like credit, electrification etc. Supply of electrical power for running tubewells for irrigation has been, no doubt, a constraint, but all out efforts are being made to ensure supply for agricultural purposes on a priority basis. Various State Governments have created Corporations for giving a fillip, to the programme of ground water development. In the Centre, we contemplate strengthening the Central Ground Water Board for supplementing the States' efforts in exploration and exploitation of ground water.

One important aspect which comes to my mind and which I would like to lay stress on is the often heard criticism in the Press as well as in the parliament about the delays in the execution of irrigation projects and cost escalation of such projects. The most important factor contributing to this has been that State Governments have been taking up far too many projects and are, therefore, unable to finance them adequately. We cannot forget that ours is a developing country with limited resources and, therefore, our programme should be such that we can get the maximum benefit with the minimum cost. It, therefore, follows, as a corollary, that strict discipline should be observed in financing of projects, more so in taking up new projects at the cost of on-going ones. In this manner we can complete more projects in a given time with the available resources.

As you are all quite aware, the most efficient use of water can be made when water planning is attempted to benefit the entire region disregarding basin or State limits. This calls for preparation of master plans in each basin taking into account the uses already being made of the water and the realistic needs of future development in the basin. I am rather sad to say that basin plans are not prepared by States so far. Water resources in the country are not unlimited and with the development of irrigation and other water using projects, already the pinch is being felt. I would strongly urge upon the States the need for preparation of master plans for rivers both for the purpose of optimum use of water and for flood control.

I have tried to share with you my thoughts on some important matters. The agenda items on the various subjects are before you. I am confident that with the discussions that we will be having today, it would be possible to take pragmatic decisions on the problems and accelerate the programmes in Irrigation and flood control sectors.

# 3. NATIONAL ACTIVITIES 1982

## 3.1 Indian National Committee for IHP/ High Level Technical Committee on Hydrology (HILTECH)

1. A High Level Technical Committee on Hydrology was constituted by Govt. of India Ministry of Irrigation on 18 August 1982. The constitution of the Committee is given at Appendix I.

2. The proceedings of the International workshop on Ice, Snow and Avalanches held at Manali during 18-30 April 1977 was published.

3. Information was supplied to UNESCO/IHP Rapporteurs and working groups in respect of the following IHP-II Projects.

   (i) Compilation of global sediment yield data

   (ii) To assess possibilities of artificial ground water resources

   (iii) To review the effects of interbasin water transfer

   (iv) Water quality models.

4 Sri H.S. Krishnaswamy, Member (WR), Central Water Commission attended the fifth session of the Intergovernmental Council of IHP held in Paris from 8 to 15 November 1982 as an observer from India.

5. Dr S. Ramaseshan, Director, NIH, Roorkee attended the III meeting of the IHP committee on Training and Education and Technical assistance for developing countries held in Paris during 2-5 November 1982 as an observer from India.

## 3.2 National Institute of Hydrology, Roorkee.

Under its research programme, the institute considers the entire hydrologic cycle and its various components including man's influence on the Water Resources. Accordingly the research activities would concentrate on the evaluation & utilisation of surface and groundwater, their interaction with particular reference to hydrologic synthesis and integrated planning. The research activities could thus be broadly categorised as :

(a) measuring techniques, data collection and processing.

(b) hydrological analysis of surface and/or ground water system and the component processes including precipitation, infiltration evaporation, consumptive use, surface water, soil moisture and ground water.

(c) hydrological synthesis or planning of surface water, ground water and conjunctive utilisation.

1. In order to study the seasonal (temporal) variation of streamflows and also their random variability, frequency analysis, regression analysis, time series analysis and stochastic approach including data generation can be used. The technology used for stream flows can also be applied to study the characteristics of rainfall, ground water, water quality etc. separately and jointly. NIH has developed and/or implemented several approaches for statistical analysis of streamflows. These include

   (i) frequency analysis for fitting different probable distributions which are generally suitable for seasonal, monthly and ten

daily streamflows, rainfalls etc. These methods have been tested with some data of streamflows in river Ganga, Yamuna, Ravi, Beas, Sutlej and Narmada etc.

(ii) Regression and correlation analysis

(iii) Programmes for fitting probable distributions for flood peaks which have been tested with data of Narmada at Garudeshwar.

It is proposed to test these programmes with some more data and also develop general guidelines for frequency analysis of hydrologic data.

2. NIH has taken up to water balance studies one with reference to the Upper Ganga Canal Command area and the other with reference to the river Hindon. Different approaches for estimation of components; the order of errors present in the estimation of components and the resulting water balance are being studied for a simple two seasonal approach which consider the monsoon season and the non-monsoon season. Experience indicated that with available data reasonable two season water balance can be achieved and the major sources of error seem to be rainfall recharge to ground water and actual evapotranspiration in the non-monsoon.

3. Using limited streamflow/data and concurrent hydrological data, it is possible to develop a conceptual mathematical model to define the various interacting component processes of the hydrological cycle in a basin and estimate the rainfall runoff relationship of a basin. Parameters so derived are used for estimating streamflows from generally available longer hydro-meteorological data for use in planning rational utilisation of water resources.

Two simple programmes for watershed simulation namely Tennesse Valley Authority Betson model and the USGS model which are considered suitable for the limited data environment of India, were proposed to be used with data of river Hindon and sub-basins of Narmada. More complicated models including HEC 1 programme for flood estimation in rivers and SSARR model developed by US Army corps of Engineers, North Pacific Division, have been implemented and are used with data for Narmada basin.

4. Complex mathematical models for the operation of reservoir systems have been developed by different world agencies. NIH has implemented a number of programmes including the SIMYLD II of the Texas water Development Board and HEC V of US Army Corps of Engineers on DEC 20 computer system of University of Roorkee. It is proposed to use the data for Ganga between Raiwala and Narora to study the availability of water for meeting the requirements of the existing and contemplated schemes with or without Tehri Dam; to use for the Bhakra Beas system in order to study the integrated operation of reservoirs and diversion and power generation and in the interconnected series of reservoirs of DVC system with particular reference to conservation, use and flood control.

5. Analysis of rainfall for Upper Ganga Canal command area and Narmada basin were completed. Studies on modelling of moving storms were taken up.

6. A study dealing with interaction between surface and ground water in Upper Ganga Canal command area is nearing completion. This study has indicated limitations of an existing model and approaches particularly in terms of the factors.

(a) Rainfall recharge in the monsoon areas with particular reference to the influence of intensity, duration, depth of water table, soil, plant influences.

(b) Actual evapotranspiration in the non-monsoon season.

(c) The estimation, modelling for canal losses and base flow in rivers.

(d) The importance of specific data concerning better estimation, procedures for specific yield of the aquifer in the water table fluctuation zone using technologies developed in NIH and available with NIH or other organisations in India

7. It is necessary and possible to develop criteria or procedures to identify the occurrence of intense storms which may lead to flash floods, perhaps using Radar imagery, remote sensing techniques etc. and also develop design criteria based on considerations of uncertainty and risk to identify and characterise the possibilities of occurrence of floods. Preliminary work with reference to study of some of major and recent flash floods like those of Jaipur, Morvi etc. are in progress.

8. NIH intends to prepare an inventory of water resources data available in India, say for a region in order to demonstrate the methodologies and procedure to be adopted in the preparation of such inventories on national basis. It is also proposed to develop simple programmes for divisional field level vetting of data as and when the data are collected so that the quality of data available for the field organisation can be significantly improved.

### 3.3 Central Water Commission, New Delhi

#### 3.3.1 Hydrology Directorate-I

1. Hydrology of sixteen major projects were examined covering design of hydrologic elements such as water availability analysis including those of rainfall and yield series, inflow design floods including design storm studies, reservoir losses including evaporation and sedimentation.

2. Detailed hydrological studies were conducted and suitable recommendations made for the projects slated for world bank assistance which include Fatewadi Canal system, Bhadar irrigation scheme, Dantiwada project, Machhu I project and Shatraji irrigation scheme all in Gujarat and Jaisamund project, Rajasthan.

3. Detailed studies were carried out in respect of water availability, design flood and sedimentation of reservoir, for Mahanadi Link project and Kola barrage in M.P., Periyar dam in Kerala and Jurala Project in Andhra Pradesh.

#### 3.3.2 Hydrology Directorate—II

Some of the studies carried out include

1. Water availability, Design flood and sediment distribution studies for Dhanuara and Jaspur Barrage scheme in Haryana.

2. Design flood studies of Bagmati in Bihar, flood routing studies of river Bagmati for Ramnagar Barrage site.

3. Silt distribution studies for Kosi High Dam (Nepal), flow duration analysis studies at 16 proposed sites in Chenab basin.

4. Water availability studies on 10 daily, monsoon, non-monsoon and annual basis for river Yamuna at Tajewala and Okhla head works.

5. Design flood and sediment distribution for Renuka Dam, U P.

6. Hydrology of Kanpur barrage on Ganga.

#### 3.3.3 Hydrology (Small catchments) Directorate.

1. Reports on Hydrological analysis of the sub-zones 1-(g) on lower Gangetic plains and 3-(f) on lower Godavari had been completed.

2. Analysis of Mahanadi basin (sub-zone 3d) and of Krishna Basin (sub-zone 3h) have been completed.

3. Flood estimation report of Lower Narmada and Tapti basin prepared by RDSO was reviewed and action to get it printed is in progress.

4. Hydrological and hydrometeorological data on small and medium railway bridge catchments to the extent of about 2265 catchment years

have been collected by the Railway department. About 202 bridge years of data has been transfered to magnetic tapes for computer studies. Documentation of eight computer programmes relating to the hydrology have been developed.

5. The directorate has provided the hydrologic analysis for three specific design flood problems referred to the directorate.

### 3.3.4 Water Resources Utilisation Directorate—I

1. Four basin wise surface water assessment studies, historical flows, withdrawls and weighted rainfalls were determined. These include four sites in Periyar basin, 2 sites in Vaigai, 3 sites in Karuannur basin and one site in Ponnaiyar basin.

2. Collection and compilation of basin wise and site wise data on gross storage and line storage capacities of projects completed, under construction and proposed from available material.

3. Alternative proposals received from the states of Karnataka, Kerala, Tamilnadu and Pondichery for the resolution of Cauvery waters dispute were examined and comments sent.

### 3.3.5 Water Resources Utilisation Directorate—II

The regular weekly bulletin giving water levels and capacities for 23 major reservoirs is being issued by the Directorate.

### 3.3.6 Irrigation Directorate

Six modernisation schemes in original and six follow up cases were examined and comments offered on irrigation aspects.

### 3.3.7 Statistics Directorate

1. Stage discharge data for 900 site years for different river basins have been punched and transferred to magnetic tapes.

2. Computerisation of hourly gauge data for monsoon period of 75 years for 12 sites on Mahanadi basin have been completed.

3. About 32000 programme cards were punched for statistics and other directorates of CWC.

4. Water year books for 1500 site years in respect of different river basins have been brought out and supplied to various users.

5. Software for using CWC computer were developed for the following jobs in Fortran language.

(a) Analysis of rainfall data for drought area study circle.

(b) Estimation of missing data using multiple regression technique.

(c) Coding of raingauge stations and a system for printing the inventory of raingauge stations in India.

(d) Generalised programmes capable of producing water year books for one, two, four months data at a time.

(e) A system of programmes for processing hydrological data for the Indus commission.

(f) Scrutiny programme for hourly gauge data.

6. Studies on stability of rating curves have been taken up for some sites on Mahanadi basin and will be continued.

### 3.3.8 Remote Sensing Directorate

1. Under the remote sensing survey programme of Hoogly river for salinity intrusion studies and soil salinity studies, documentation of water analysis data and drawing relation curves between the various parameters of the analysis is in progress in the directorate. The aerial survey was carried out by National Remote Sensing Agency in April 1980 over the area coinciding with Satellite pass over the area.

2. A photo-interpretation cell is in the process of establishment.

### 3.3.9 Ganga Brahmaputra Water Studies Organisation

1. A compendium of water discharges at 194 discharge sites in the Ganga basin for the period 1960-80 has been brought out. The compendium gives the average annual flow in stream flow order and the minimum average monthly flow during the year.

2. Review, coordination advisory work in respect of investigations, of three key projects namely Jogighopa barrage and Brahmaputra Ganga link, Canal in Assam and West Bengal, Siang (Debang) dam and Subansiri Dam in Arunachal Pradesh was continued.

3. A system study for flood moderation in the Brahmaputra Valley with the help of Indian Institute of Management, Bangalore was completed and final report was received.

4. Studies for development of an estuary model assessment of intrusion in river Hoogly in collaboration with College of Eng., Guindy, Madras were continued.

### 3.3.10 Hydrological observation and Flood Forecasting Organisation (North), Patna.

A number of forecasts were issued as given below :

1. 1987 forecasts for various stations on Ganga and its tributaries, 627 inflow forecasts for Damodar.

3. 1720 forecasts were issued for the river Brahmaputra and its tributaries.

3. 580 forecasts in Tista basin and 44 forecasts in Barak basin were issued.

4. Water samples from about 41 sites in Ganga basin for determining the presence of various chemicals and pollutants in the river were continued.

### 3.3.11 Hydrological observations and Flood Forecasting Organisation (South), Hyderabad

The organisation besides carrying out observations on the peninsular rivers is also entrusted with the responsibility of flood forecasting for the river basins viz. Krishna, Godavari, Narmada, Tapi, Damanganga, west flowing rivers of Gujarat and coastal rivers of Orissa. Flood forecasting was carried out in all the rivers and the forecasts compared well with the actuals. In all there are 122 wireless stations under this organisation and a total of 828 forecasts were issued during the year.

### 3.3.12 System Engineering Unit

Preliminary work in connection with the collection, compilation and processing of the relevant data required for system studies of Mahanadi basin was initiated and is in progress.

### 3.4 Central Water and Power Research Station (CWPRS), Khadakwasla.

1. The conversational mode of SSARR (COSSARR) was being modified for HP 1000 mini computer under the guidance of Mr. Billey Thomas, UN Consultant from US Army Corps of Engineers. The original COSSARR program has been segmented to accommodate in the available programe memory of HP 1000 computer. In addition, the Extended Memory Access (EMA) features of RTEIVB operating system of HP 1000 are being utilised.

2. HEC-4 programme developed by Hydrologic Engineering Centre, USA is used for analysis of monthly stream flows at a number of inter related stations to determine their statistical characteristics and to generate a sequence of hypothetical stream flows of any desired length having these characteristics. Modifications in this HEC-4 program were tried out in order to adopt it on the HP 1000 mini computer system.

### 3.5 Central Board of Irrigation & Power, New Delhi

1. A hydrological model of the catchment of

lower Bhavani Dam to a scale of 1:10,000 horizontal and 1 in 2,500 vertical has been constructed at Bhavanisagar under a project "Conducting Hydrological Model Studies on the Bhavani Catchment for Flood Prediction by simulating surface flow parameters such as infiltration, detention, overland flow and moisture movement by IHH, Poondi. The scheme was commenced in February 1981 and studies in times of concentration of flow were conducted on the model for dry and wet conditions. It is proposed to simulate the rainfall by spraying of water through suitable arrangements over the model and then conduct the different times of concentration studies, under various directions of storm.

2. Theoretical inflow has been worked out based on laminar inflow theory and turbulent inflow theory for hard rock wells under a project on 'Theory of Flow in Hard Rock Aquifers' by I. H. H Poondi. A graph between time and inflow has been drawn and compared with actual pump test data. It is proposed to examine the wells with respect to lithology, location, springs, yield rate, shape and well perimeter and to evolve a well constant based on the laminar inflow theory for regions having more or less same lithology by conducting pump tests.

3. The Tritium tagging method has been employed by the UP Irrigation Research Institute for the "Estimation of Ground Water Recharge by Isotopic Method". Studies on recharge due to rainfall were carried out in the following areas of Uttar Pradesh.

(a) Gandak Command area
(b) Ganga Sarda Doab
(c) Agra Mathura area
(d) Deoband branch command area
(e) Roorkee area.

4. The system planning study for optimal management of water resources in Parambikulam Aliyar basin by College of Engineering, Madras envisages a system approach for the optimal utilisation of the water resources of Parambikulam-Aliyar Project. The study has been divided into three sections :

(a) Hydrometeorological features
(b) Agronomical studies
(c) System study for optimum reservoir operation.

From available catchment runoff and the corresponding rainfalls, the relationship between rainfall and runoff values for 20 years, the estimated yield for each month at 75% dependability using log normal distribution was obtained for the various catchments in the system. These systematically generated flows were used in a simulation model developed for the river basin system. Each trace of inflow sequence was considered as input to the model. The output of the model is the reservoir routed outflows. The simulation program can be run for alternate policies and release patterns and the spills over reservoirs can be analysed to arrive at a conclusion of best operating policy.

### 3.6 India Meteorological Department, New Delhi.

1. Revised isohyetal maps of Krishna basin sub-zone 3 were supplied to Central Water Commission for inclusion in the final technical report.

2. Design storm values of different projects in the country were made available to concerned project authorities.

3. Three ordinary raingauge stations have been established at Salooni in Himachal Pradesh and Bageshwar and Loharket in Uttar Pradesh under glaciological studies scheme.

4. IMD participated in expeditions of Shanne/ Mastang Glacier.

The following papers were presented by officers of IMD at the International Symposium on 'Hydrological aspects of Mountainous Watersheds' held at University of Roorkee during 4-6 Nov. 1982.

(a) Simulation characteristics of rain storms

(b) Flash flood model based on rainfall runoff.

(c) Design storm studies for Beas catchment

### 3.7 Indian Institute of Tropical Meteorology, Pune

1. A generalised 1 day PMP chart for the peninsular region of India (8° N to 20°N latitude) was prepared by using the latest statistical model. Long period data of 800 stations were analysed for this purpose. The study showed that the stations along the east coast of the peninsula and over and near the western ghats can experience one day highest rainfall of the order of 50 to 85 cm while for those located in the central parts of the peninsula the value varies from 30 to 40 cm.

2. Long period 1 day maximum rainfall data for about 100 stations in and around Uttarakhand Himalayan region were analysed to estimate and prepare generalised charts of 10 and 100 yrs. maximum rainfall and PMP for one day duration. The values of 10 and 100 yrs. were found to vary from 10 to 30 cm and 20 to 45 cm respectively. The PMP estimates ranged from 50 to 85 cm.

3. 1 day maximum rainfall for different return periods ranging from 2 to 100 yrs. were estimated for about 232 stations in Tamilnadu. A nomogram was prepared for estimating maximum rainfall of intermediate return periods from 5 to 50 yrs. for any station in the region. One day PMP values for stations in this region were also estimated which were found to vary from 25 to 75 cm.

4. The rain storm of 2 July 1941 over south Gujarat, North Konkan region was found to give the highest one day areal rain depth for different sizes of areas in India. A comparison with similar areal rain depth of tropical rain srorms of USA revealed that the areal rain depths of the July 1941 rain storm were higher in magnitude for practically all the standard areas.

5. A detailed analysis of rainstorms during the monsoon season of 1980 showed that there were only four severemost rainstorms which affected different parts of the country. A comparison with the past severemost rain storms of the respective regions showed that though the flood damage caused by these storms of 1980 was considerably higher, none of them was of unprecedented nature.

6. Depth-area-duration analysis of 24-29 July 1927 rainstorm which caused severe floods over Gujarat region was found to give the highest areal raindepth in India for a duration of 3 days and more.

7. The rainstorm of 17-21 July 1981 which caused unprecedented floods in Rajasthan was studied. Areal rain depths of this rainstorm when compared with the past severe most rainstorms of this region showed that the July 1981, rainstorm gave unprecedented raindepth upto 38,850 sq. Km. (15,000 sq. miles). It was also observed that seven stations in the rainstorm area broke their 80 years record of 1 day rainfall and 2 of these stations equaled their respective estimates of PMP for one day.

8. Rainfall distribution over India was stud ed for those individual monsoon months of June to September which did not experience tropical disturbances during the eighty years period from 1891. The study showed that the absence of these disturbances in the individual monsoon months coupled with certain other meteorological situations can cause considerable deficient rainfall and consequent slight to severe drought conditions. September gets worst affected by the absence of these disturbances so far as rainfall deficiency is concerned.

9. The following papers were published.

(a) Dhar, O. N., B.N. Mandal and P.R. Rakhecha. Absence of Tropical disturbances and rainfall distribution during the summer monsoon months over India. Archiv fur Meteorologie, Geophysik and Bioklimatologie Sr. A 31, 1-2. pp 117-126.

(b) Dhar, O. N., G.C. Ghosh and AK Kulkarni Catalogue of major and devastating floods of India and their space time distribution. Proceedings of International conference on 'Flood disasters' Indian National Science Academy New Delhi, 3-5 December. 1981.

(c) Dhar, O N., PR Rakhecha and BN Mandal Severe most rainstorm of July 1927 which caused devastating floods in Gujarat region Proceedings of international conference on 'Flood disasters' Indian National Science Academy, New Delhi, 3—5 December 1981.

(d) Dhar, O.N. B. N. Mandal and G C. Ghosh, 1981. Vamsadhara flash floods of September 1980-a brief appraisal. Vayu Mandal. Vol. II, 3 and 4, pp 7-11

**3.8 Water Resources Development Training Centre, (WRDTC) Roorkee.**

1. The following field studies were conducted in the Salawa distributory Command of Upper Ganga Canal system in Meerut District, Uttar Pradesh.

(i) Ground Water modelling and
(ii) Water budgeting

2. Other research studies carried out included
(i) Optimum location of augmentation tubewells.
(ii) Case studies of ground water development.

3. A special short term course on reservoir operation, flood control and hydrological data was organised from 19 April to 15 May 1982 under the sponsorship of Tamilnadu Government.

4. A workshop in 'Water distribution practices' was organised from 2 to 3 July 1982 in collaboration with Indian Water Resources Society. On the basis of the experience and in view of the recent developments in agriculture, some modifications in the existing water distribution praictices were recommended.

**3.9 School of Hydrology, University of Roorkee, Roorkee.**

1. The following consultancy projects were completed

(a) Hydrological studies of Ramganga Dam project.

(b) Design flood studies for Rajghat Dam Project.

(c) Hydrological investigations of Machhu Dam—II

(d) Assessment of silting of Jamsari Dam reservoir.

2. The ongoing consultancy projects included

(a) Mathematical model studies for induced recharge in Ganga basin.

(b) R C. Analog studies in Agra and Varanasi Districts.

(c) Ground water studies in Yamuna command area.

(d) Design of infiltration gallery for drinking water supply scheme for Manilla Devi group of villages Dist. Almora.

(e) Special study on sub-surface drainage in command area of Narmada Sagar project.

3. During 4-6 November, 1982 an international symposium on Hydrological aspects of mountainous watersheds was held. The major recommendations of the symposium were as follows :

(i) Adequate systematic studies on mountainous catchments have not been done so far. Design storm and rainfall estimation for mountainous catchments have to be studied and norms for estimation of probable maximum precipitation be developed. Appropriate network design in these regions is to be developed to determine the spatial and temporal rainfall distributions for design purposes.

(ii) Data base is basic for all hydrologic analysis and it needs greater attention. Efforts should, therefore, be made to collect reliable and accurate data which should be consolidated and put in proper formats in the computers and a suitable commonly acceptable retrieval system be worked out. Free flow of data to user organisations without restrictions is essential for development of methodology and proper application to field problems.

(iii) Since investment in water resources projects take large share of a nation's capital, it is desirable that suitable hydrological investigations and appropriate analysis methods be developed to enable planned development with minimum risk. In view of the limited data available simple models and techniques be evolved taking into account the basic physical laws and hydrological processes. There is a need for the development of methodology for flow forecasting suited to the needs of typical climatic and physical characteristics of mountainous watersheds. Adequate emphasis need be placed on statistical methods and necessary regional relationships, correlating hydrological elements and physical characteristics be evolved.

(iv) The data on snow fall measurement and snow melt runoff in mountainous watersheds are usually inadequate. There is an urgent need to evaluate the amount of snow precipitation and snow melt runoff. The runoff prediction models should incorporate snowmelt and glacial melt runoff components for accurate runoff prediction. The watershed have to be instrumented appropriately with automatic and semi-automatisation. Resolute efforts on development of appropriate models, energy and mass balance of the environment should be initiated in a coordinated manner.

To provide adequately trained manpower, one post graduate course in Snow and Glacial Hydrology be introduced at the School of Hydrology in view of the existing hydrology programme and the proximity of Roorkee to field and research areas.

(v) The mountainous watersheds need be studied with a view to understand the interaction of water, flora and fauna, sediment and other factors relating to the ecology of the area. Manipulations of land use, and construction of roads have resulted in considerable erosion of soil. This together with land slides has increased the sediment load in rivers. Appropriate watershed management plans have to be initiated, incorporating the soil and water conservation measures and land use planning. These should have adequate consideration for maintenance of hydrological and sediment stability. Watershed management research units be established in typical land use situations including major forest types to study the effect of management practices on hydrological parameters.

(vi) Recognising the general inadequacy of hydrological information and difficulties in the measurement of hydrological demands in mountainous catchments, there is a pressing need to identify representative and experimental basins & pilot watersheds and studies be initiated to understand the various hydrological processes and the impact of land use changes on these processes.

(vii) The mountainous areas are the recharge zones for the ground water which are the potential source of supply of water. The studies relating to its exploration, feasibility for development and quality aspects be taken up more seriously.

(viii) For integrated water resources development strong multidisciplinary teams are required. The water resources planning

and watershed management organisations should give due emphasis on sociological, economic and ecological aspects to provide optimum benefits to people. The development plans for small and flashy rivulets in mountainous regions have to be evolved as an approach as preparation of these plans have to be different from those of medium and large projects.

(ix) Water resources projects in the mountainous regions are taken up with limited hydrological data to meet the national targets of development without loss of time. Monitoring of projects thus executed and reappraisal of their design criteria would help in formulation of plans in future which could be more economical and safe. Monitoring of projects should thus form its integral part and funds must be earmarked for the purpose.

**3.10 Central Soil and Water Conservation Research & Training Institute, Dehradun and its Centres**

1. A multiplicative stochastic model has been developed which can predict monthly runoff values from Doon valley watersheds.

2. Hypsometric analysis of Mussoorie subwatersheds has been carried out, which gave some clues on their stability. Rainfall and runoff data from five watersheds having areas from 4 to 83.4 ha with three different land uses namely agriculture, forestry and agriculture forestry have been analysed and hydrograph characteristics namely, peak rate and volume of runoff, watershedag times have been determined before and after imposing treatment.

3. Physiographic factors namely raingauge exposure, angle of raingauge and orientation of the gauge which effect the distribution of rainfall in Bhaintam watershed were estimated statistically. The analysis indicated that rainfall in the Himalayas decreases with increasing distances along the prevailing moisture flow line.

4. Standard consumptive use (ET) models based on climatic and crop parameters were developed and compared with actual ET values observed from the weighing type lysimeters (120-120-120 cm.) installed at the institute's research form

5. Based on yearly maximum daily runoff events, the expected maximum daily runoff at various return periods for five typical small watersheds of Doon Valley were calculated.

6. Studies on hydrological analysis of small watersheds under different land uses have been carried out at Dehradun, Ootacamand, Kota and Bellary.

7. To design a suitable parabolic toe drain for the bench terraces in Ooctacmand an experiment was initiated from 1977. The drain dimensions and 3 cultivation practices were tested. Runoff, soil logs and crop yield data were recorded.

8. Frequency analysis of the rainfall data (1959-79) of Agra region for studying its seasonal distribution has shown that at 50% probability level a Kharif crop having not more than 500 mm of water requirement can only be raised.

9. In order to predict annual maximum daily rainfall, probability analysis was carried out with the 18 yrs. (1962-70) raintall data collected at the Research Farm, Chhalesar, Agra. Three commonly used probability distribution functions were fitted to the data. The return period values were obtained using Weibull formula which uses the maximum annual daily rainfall values arranged in descending order of magnitude. The value of probable maximum daily rainfall of 5 yrs. return period was found to be 114.0 mm.

10. Evapotranspiration at Agra was computed by using five methods namely Radiation method, Blaney and Criddle approach, Thornthwaite method, modified Penman's method and pan evaporation method of Christiansen with the climatological data (1962-79) collected at the Chhalesar Research farm of Agra Centre. The results indicated that the ET value of 2387 mm as estimated by the modified Penman's method seem to be accept able for Agra.

11. Weekly rainfall data of 25 years (1956-80) were analysed for computing the percentage chances of expected rainfall during different standard weeks of the year. The analysis indicated the availability of assured weekly rainfall of atleast 10 mm at 70% chance from 27th to 36th meteorological week (2nd July to 9th Sept). Peak rainfall of 16 mm was received in the 30th week.

### 3.11 Central Soil Salinity Research Institute, Karnal

1. Open drains at 20 m spacing and tile drain at 50 m spacing were installed in 1979 at Sampla for evaluating the drainage needs of the saline soils. The higher yields of wheat during 1981-82 in undrained plots in comparison to the previous year indicated the improvement in the plots because of continuous cropping and rainfall leaching.

2. To quantitatively describe the hydrological responses of alkali soil watersheds due to alternate land use treatments, four geometrically identical watersheds were selected at Gudhe farm of the Institute. Each watershed was 0.5 ha with an average slope of 0.15 per cent. The runoff from different storms and periodic moisture content in surface layers, pH, Ec and water table fluctuations were recorded in each watershed. The trend of total runoff, peak runoff and time of peak occurrence was similar for each of the storms. There was a seasonal rainfall of 294.1 mm with four runoff producing storms that produced runoffs of 121.4, 34.0, 120.7 and 92.0 mm from the four watersheds.

3. A management model for an area of 72,500 ha in Karnal and Sonepat districts which is affected by high water table and salinity problems was developed with the objective of determining the optimal land and water use policies for promotion of conjunctive use of canal & saline ground waters ; maintenance of proper salt and hydrologic environment in the crop root zone. Data on different parameters of water balance were collected and analysed. Based on the available information, ground water recharge from different sources has been computed. The results showed that the total ground water recharge is of the order of $183 \times 10^6$ $m^3$/year and is contributed mainly by canal system and the rainfall.

4. The rainfall and runoff data for an alkali watershed of about 287 ha which was in transient state due to reclamation were collected. A procedure was developed for extension of SCS curves number techniques for calculating runoff amounts in such watersheds. In continuation of this a graphical method for determining instantaneous unit hydrograph was developed For the estimation of the peak discharge rate by rational formula from alkali watershed, the runoff coefficient values were calculated from observed data and found to be related with rainfall intensity and the percentage area reclaimed within the watershed.

### 3.12 Central Arid Zone Research Institute, Jodhpur.

1. Geological and hydrogeological survey of Barmer and Jaisalmer districts were taken up.

2. Studies in ground water hydrology using isotope techniques were carried out in Barmer district. Three sites at Siwan-Marwri (Volcanic area), Raike-Ramamiya (Dunal area) and Bhadrajan-Kulthana (older alluvial area) were selected. The radio tracers used consisted of fritiated water and Potassium Cobalt Cyanide.

3. Water resources survey in nearly 55 percent area of Siwana district and Jaisalmer district was carried out.

4. A net work of 240 raingauges was maintained. The studies on rainfall pattern in Luni basin revealed that the year 1982 was the successive hydrological drought year. 32 stream gauging stations were maintained in the Luni basin and data on the highest flow level, peak discharge, total volume and suspended sediment load were collected.

5. A climatological analysis of the drought during the year 1982 over west Rajasthan revealed that except in the Barmer, Jalore and Pali regions, the intensity of drought in Western Rajasthan as a whole was mild in nature The case of the maximum drought intensity over the region was found to prevail in the Sikan region during June which intensified further during July. The case shifted to Barmer and Jalore region in August and to Pali in September.

6. The following papers were published,

(a) Ramana Rao, BV, ASRAS Sastri and YS Rama Krishna 1982. An integrated scheme of drought classification-a case study for Indian Arid Zone-Idogerus Vol. 85 No. 6 pp 317-322.

(b) Sastri ASRAS and Y S Rama Krishna 1982. Drought during 1979 over Western Rajasthan. A climatic perspective Annals of Arid Zone Vol 21, No. 1 pp 41-47

(c) Sastri ASRAS, GCSN Rao and YS Rama Krishna 1982 Climatological analysis of Water harvesting potentials of Jodhpur and Nagpur districts. Indian Journal of Agricultural Engineers Vol 18 No. 2 pp 35-40

(d) Sharma, K.D., N S Vangani, PC Chatterje and Ganga Singh 1982. A severe flood in Luni basin, west Rajasthan during 1979-A case study-mausam-Vol.33 pp. 377-384.

(e) Sharma K.D. and NS Vangani 1982 Flash food of July 1979 in the Luni basin. A rare event in the Indian DesertHydrological Science journal Vol 27, No. 3

(f) Sharma K. D. and N.S. Vangani 1982 Some rainfall features of July 1979 storm over the Luni basin. Annals of Arid Zone Vol 21 pp 29-39.

**3.13 National Geophysical Research Institute (NGRI) Hyderabad**

1. Geological, hydrogeological and hydrochemical data collected earlier for the entire Marvanka basin has been processed. A set of basic hydrological and hydrochemical maps depicting the regional ground flow and hydrochemical variations have been prepared and finalised.

2. Hydrometeorological data on precipitation, evapotranspiration, runoff etc. were collected for 1980-81 in the two basins of Godavari-Purna and Kukadi in the Deccan trap Water table maps for some of the watersheds in the two basins were prepared. Monthly as well as pre and post monsoon epoch samples were collected from observation dug wells and bore wells in the basin during 1980-81. Chemical analysis of 290 samples from 61 wells was completed The predominant anian was bicarbonate. Tritium was injected at 55 sites in the two basins. Analysis of 560 soil case samples was completed and recharge values were computed at all sites. The recharge

during 1981 monsoon to the Kukadi basin was found to vary from 1 cm to 7.2 cm. and that to the Godawari Purna basin from 3.2 cm to 8.4 cm. The new method developed by NGRI for keeping the discharge low and constant during pump test on a dry well was utilised for conducting some more pumping tests on dug wells in Deccan trap. 29 tests in Godawari-Purna and 5 tests in Kukadi have been completed. The transmissivity values of aquifers tapped by dug wells in Deccan trap lava flows varied from 552 $m^2$ to 15$m^2$/dsy.

3. Tritium was injected at 65 sites in Chitravati basin during 1981 and soil cores from these sites have been collected. Pumping tests on wells dug in the phreatic equifer were conducted at 19 sites using the constant discharge devices. 38 dug wells were sampled for chemical analysis.

4. Data on ground water recharge rate collected by NGRI in Silent valley and other information suggested that the ground water potential was inadequate to raise three paddy crops in the command area. The surface water potential of the hydroelectric project was also found to be inadequate for achieving the same objective.

5. The preliminary steady state model developed for Gazipur district in Uttar Pradesh was further refined by assuming Nov. 1977 water level as steady state level. The transmissivity in North Eastern and South Eastern regions were reduced by 6 to 7%. This resulted in a better match of field and model results.

   The steady state model characterised by the transmissivity pattern was taken as the physical frame work for the dynamic calibration. The storativity data available was scanty and a regional pattern of block wise storativity was therefore assumed. Data for the period November 1977 to November 1980 was used for dynamic calibration. Further a study of the time variant behaviour of the digital model was made. Suitable changes were made in the storativity values. The out flow was also gradually adjusted after a few trial runs. The model observations of water levels were compared with those in the field. The calibration was by and large satisfactory.

6. With a view to evolving appropriate exploration schemes in the Dudhi-Shakker interstream region of Madhya Pradesh, a study to prepare a prognostic model was undertaken. In the first phase of modelling, only the deeper alluvial zone which happens to be the major aquifer was taken up. The water level contours for the year 1977 was regarded as the initial water levels for model studies. The flow lines are predominantly towards Narmada river.

   Hydrogeological parameters were estimated through pump tests. The total number of node points representing the entire area was 212. The available values of initial transmissivity and piezometric heads were linearly interpolated and assigned to each node. The model was calibrated for steady state conditions. A number of calibration runs were made and each time the transmissivity pattern was gradually modified to obtain a better match between the field and the model observations.

7. Under the project sponsored by Govt. of Pondichery, a number of lithological sections of deep bore holes were studied and were used to prepare a fence diagram to understand the disposition of various aquifers in the region, their thickness, depths and control of groundwater by major faults etc. Analysis of depth to water table and water levels above m.s.l. as a function of time (1975-80) has indicated that an area of about 10-12 Sq.Km. in the north of Pondichery has high with-

drawl rate with respect to the prevalent recharge rate whereas regions like west of Bahur are less exploited. Formation wise hydrograph analysis on monthly basis carried out from 1975 to 1980 data for 35 dry wells has indicated the potential recharge area for Cuddlalora and this study has also shown correlation with ground water ages determined using environmental tritium and radio carbon. The hydrograph analysis has also thrown light on the areas which are predominantly recharged by the two important lakes. The study of recession of the hydrographs indicates the extent of lakes recharging the ground water in time and space.

8. At the request of CGWB, a plan of action for 'Isotopic studies in ground water of Uttar Pradesh' with special reference to origin, source of recharge and mechanism of replenishment of deep aquifers in Terai and Bhabar belt and further in alluvial plains was prepared 4-5 traverse of sampling and subsequent measurements were proposed.

9. Environmental Tritium and radiocarbon studies were completed in the SIDA assisted CGWB Project area situated in Tamilnadu and Kerala. A report after completion of the measurements and interpretation was handed over to CGWB.

10. Attempts for the first time were made to evaluate specific yield using deep soil moisture profiles. The studies have shown promise for the novel method attempted.

### 3.14 National Environmental Engineering Research Institute, Nagpur.

1. Preliminary investigations and probing studies were started on baseline data on pesticides in Urban water supplies and use of ion-sensitive electrodes for continuous water quality modelling.

2. Some of the research and development projects were completed.

   (a) Under integrated research and demonstration project on 'Slow Sand Filtration' extensive research was carried out on efficiency of slows and filters under different operating conditions and raw water quality, especially turbidity and bacteriological pollution. Guidelines were formulated for cost effective design, construction, operation and maintenance of slow sand filters.

   (b) A critical evaluation of representative rural water supply schemes from different states of India was carried out so as to provide feed back for future planning, designing and implementation of rural water supply programmes.

   (c) A thorough literature search was carried out to know the existing status on the effect of chlorination on cysts of Giardia Lamblia and the possible transmission of infection through piped water supplies.

### 3.15 Address at the Special Meeting of National Institute of Hydrology Society byShri Kedar Pandey, Honble Union Minister of Agriculture, Roorkee, 27th Jan. 1982

Friends,

We are meeting here only about 4 months after the second Annual General Meeting in Delhi held on 1 October 1981. This is because a young fledgeling research organisation in a very vital and sophisticated area needs careful nurturing and monitoring of its progress. I am sure with the benefit of your advice the institute can grow and meet its important national objectives.

India is a very vast country with a large population of 684 million in 1981 which may reach around 1000 million by 2000 A.D. The

food production required for feeding this large population is around 231 million tons which is nearly twice the present level of production. The total culturable area of the nation is around 189 million hectares (Mha). Since nearly the entire area is being cultivated and the area under agricultural production can only be marginally increased, the major increase in agricultural production will have to come from wider adoption of modern agricultural technologies and extensive and intensive irrigation.

The ultimate irrigation potential with integrated optimal utilization of water resources is of the order of 150 Mha. The irrigation potential created by 1980-81 is around 59 Mha which will increase to 113 Mha by the year 2000. The total hydropower potential of India is estimated to be 75000 MW at 60% load factor. The installed capacity has increased from 560 MW in 1950 to 10740 MW in 1981 and this is expected to increase to between 1.1 and 1 3 lakh MW by the year 2000. The domestic water supply requirements may reach 25 MAF and the industrial water reqirements may increase to 45 MAF by the year 2001. The total water utiliz-zation which was around 267 MAF in 1968-69 may go up to about 570 MAF to 650 MAF by the year 2000. Thus it is seen there is nearly a doubling up the different uses of water in the next two decades.

In addition to large increase in demand for water, India is faced with a number of water resources problems They include the seasonality of the monsoon rainfall which occurs intensively during a few cyclonic storms durring the monsoon season and causes floods and drainage problems. During the non-monsoon season the precipitation is very limited and it is hence necessary to store monsoon runoff for use in the non-monsoon season. Furthermore, monsoon precipitation and streamflow are highly erratic in nature and we may have a series of drought years or flood years. Consequently storage reservoirs are to be designed for carrying water over a sequence of dry years. We also have problems of droughts because of low monsoon precipitation, late onset of monsoon, prolonged break in monsoon or early withdrawal of the monsoon. Drainage of water logged areas is also acute in States of Punjab and Haryana and is also present in the alluvial plains of Uttar Pradesh, Madhya Pradesh and coastal plains of West Bengal and Gujarat and in particular in the irrigated areas of the State.

In order to tackle the gigantic problem of optimal water resources development to meet the needs of the nation, Government of India has drawn up a national perspective plan which envisages the construction of reservoirs with a live storage of 145 MAF for the development of 35 Mha additional irrigation potential, 40,000 MW of hydel capacity and also development of navigation system at a cost of Rs. 50,000 crores. You may note that agriculture and irrigation constitute the very first and most important point of the new 20 point programme of Government of India.

In order that the availability and variability of surface water resourcs and the problems like floods and droughts are evaluated quantitatively and for planning, development and operation of water resources systems we have to depend on the use of modern methods of hydrologic analysis and design. The Government of India has accordingly set up the National Institute of Hydrology to develop and implement methodologies for hydrologic analysis and design; to test these methodologies using data for field problems: and disseminate methodology to the various field organisations.

I am happy to note that National Institute of Hydrology has started its research work. They have recently successfully completed a consultation research project sponsored by WAPCOS on the Surface water Ground water Interaction in the Upper Ganga Canal Command area. They have also taken up a consultation research project on Design Flood Studies of Narmada to be completed in about six months. The VAX-11/780 mini computer system which is very necessary for the research work to be taken up by National Institute of Hydrology is expected to be installed in the institute

by March-April 1982. The Administrative Building is also under construction and is expected to be ready before the end of this year.

The institute has to play a very crucial part towards reaching national goals in water resources and economic development. I am happy to find a number of experts participating in this meeting. They will be giving the benefit of their advice to the National Institute of Hydrology. Government of India hopes that National Institute of Hydrology will fill the long felt need of conducting and coordinating systematic hydrologic research in the country and act as a nucleus for hydrologic research work and also for transfer of technology to the field engineers.

### 3.16 Excerpts of speech of Shri Kedar Pandey, Hon'ble Union Minister of Irrigation delivered at the Seventh State Irrigation Ministers' Conference, Madras, December 16, 1982.

Irrigation has received a place of pride in the new 20 point programme of our Prime Minister. This has laid greater responsibilities on all of us who are participating in this conference. We have assembled here to review what we have achieved last year, chalk our course so that achievements are better and prepare programme and plan of action for the next and subsequent years. There are of course, some constraints and inspite of these we have to evolve ways and means and take such decisions which may produce the best results from the available resources for achie ving our objectives.

Though the targets and achievements in the past few years have been commendable, matching to none in the world, the food production in the country been affected by unfavourable weather from time to time. This shows dependence of agriculture on the monsoon and underscores the need to develop water resources expeditiously.

In the Sixth Five Year plan, a target for creating a potential of 5 74 m.ha. from major and medium and 8 m.ha. from minor irrigation works has been fixed. This is against the back drop of achievement of 56.6 million ha. to the end of 1979-80 and a perspective of achievement of 113 m.ha. by the turn of century. The total potential likely to be created by the end of first 3 years of the Sixth plan is estimated to be 2.8 million hectares from major and medium and 4.3 million hectares from minor irrigation, totalling 7.1 million hectares. In the remaining 2 years of the Plan we have, therefore, to create an irrigation potential of the remaining 6.6. million ha. In order to achieve this, a higher priority will have to be given to the irrigation sector by the States and it is ensured that money is utilised in a manner that the rate of the creation of potential is stepped up. When the Sixth Plan commenced, 176 major projects and 447 medium projects were continuing from previous Plans. Of this, 82 were started before 1.4.1976. The number of continuing projects has been mounting from plan. The Sixth plan documents envisages that 65 of the major projects which were started before April 1976 would be completed during the Sixth plan. This is a commitment which should be fulfilled at any cost. Special efforts are necessary to achieve this and special attention will have to be given to these projects by the State Irrigation Departments to remove all the bottlenecks so that this target is fully accomplished.

A number of irrigation schemes which we e constructed in the past are not able to serve their purpose fully. They need not only rehabilitation but also their modernisation to cater to the needs of modern agriculture as also for efficient utilisation of water. Although a sum of about Rs. 1000 crores has been provided in the sixth plan for modernisation works, the progress on modernisation of schemes is not what it should be. It is seen that an expenditure of only about Rs. 275 crores would have been incurred during the first three years of the Plan. It seems that a concerned effort on the part of the States is required to prepare scheme of modernisation. The Central Water Commission

has already prepared and circulated to the State Governments guidelines for preparation of schemes for modernisation of irrigation structure.

Apart from creation of additional facility for irrigation, attention has to be given to its fuller utilisation. It is seen that out of the potential of 61 million ha., utilisation is about 57 million ha. Tnis lag is substantial and needs to be minimised by strenuous efforts. In this, it is necessary that there should be complete co-ordination of the activities of the agricultural Scientists, the extension services and the Irrigation Deptt. engineers. This can be ensured more effectively by creating CAD and water management wings in the State. It may also be appropriate if these wings and the irrigation wing are in the State. It may also be appropriate if these wings and the irrigation wing are in the same Department.

The water available should also be used most efficiently. To achieve this, one must first know, how the existing system is functioning so that its improvement could be considered This will require monitoring of performances of the existing systems on a continuing basis. Plans should also be drawn up to operate the canal systems so that equitable and timely supply of irrigation on water is ensured to each beneficiary and especially the tail ender. Adoption of warabandi system for irrigation management is therefore a must.

Another important measure to improve water management and utilisation is construction of field channels expeditiously. In the Sixth Plan period it is intended to cover an area of 12 lakh ha. by field channels. This has to be achieved. Under the Command Area Development Programme, matching loans and grants for the construction of field channels are being given by the Government of India. I would urge the State Ministers to impress upon their Government to fully avail these facilities and expedite the construction of field channels. There is also need to monitor and review the aspect of productivity due to irrigation as the level of productivity is seen to be about 1.6 to 1.7 T/Ha. As against a potential of 4 to 5T/Ha. This will require looking at the problem of water management in a comprehensive manner as a multi-disciplinary activity.

There is also need to train the personnel incharge of water management in the multidisciplinary approach. The State of Maharashtra, Andhra Pradesh and Gujarat have started such institutions and other states would follow. Adequate funds should also be provided for the proper maintenance and repairs of the canal system to ensure that adequate supply is available from the canals at the time of real need.

Everybody is aware, this year the country had to face both floods in some parts of the country and drought in others. In some States drought has followed floods or vice versa. The Government of India has given increasing importance to flood problems as would be seen from the considerably increased Sixth Plan allocations. As against a total expenditure of of Rs. 976 crores in all the Plans put together, the provision in the Sixth Plan has been placed at Rs. 1045 crores. However, it has been observed that some of the States are providing reduced allocation for flood control works as compared to those approved by the Planning Commission and this needs to be viewed with concern. It has also been observed that most of the States are not providing adequate funds even for maintenance of flood protection works constructed after heavy Investment. Providing adequate funds for maintenance of such works is very assential for continued and assured protection to the areas already protected.

Alongwith this, it is desirable to pay attention to the increasing problem of encroachment in the flood plain areas. The States should take adequate measures for flood plain management and flood plain regulation, as otherwise the beneficial effects of flood control and protection measures will not be fully realised,

Construction of large storages on the rivers-which pose problem of flooding is one of the important methods of flood control and manag-

ement. While tackling the major flood problems which exists in the northern rivers, in cases we may have to depend on cooperation with the neighbouring countries for planning of reservoirs in the country. Storages should be planned for optimal use of available water for multipurpose benefits. It has not been possible to construct storages to store even 10 percent of the total flows of the river. Our effort should be directed to create more storages in our country for multipurpose uses so that alongwith optimal use of water reasonable flood protection is also achieved.

Rashtriya Barh Ayog has made important recommendations after examining the flood problem of the country. These are already available with the States. The State Governments should take appropriate action and implement the valuable recommendations of the Rashtriya Barh Ayog.

In the context of drought-flood syndrome in the country and with a view to making optimum use of available water, Ministry of Irrigation has prepared a National Water Plan which aims at increasing irrigation potential in country by 35 million hectares and development of 40,000 MW of power in addition to affording flood protection. In the National Development Council meeting held on 14th March, 1982 it has been decided to constitute National Water Resources Council with Prime Minister as its Chairman. To make a fesibility report of the Peninsular Component of the National Water Plan, we have constituted a National Water Development Agency in July 1982. The Agency in cooperation with the concerned States is expected to prepare the feasibility report of the National Water Plan in a period of 10 years.

In brief some of the important problems and challenges facing us in the field of irrigation and flood control in the situation prevailing today have been covered. With determination we will be able to achieve the targets set before us and pave the way for accelerating the irrigation development and flood control programme in keeping with the national goals.

# 4. NATIONAL ACTIVITIES 1983

## 4.1 High Level Technical Committee on Hydrology (HILTECH)

1. The second meeting of the Asian Regional Coordinating Committee on Hydrology (ARCCOH) was hosted by India at New Delhi during 10–12 January 1983. The meeting was attended by delegates from Afghanistan, China. India, Iran, Korea, Japan, Malaysia, Mongolia, Nepal, Pakistan, Phillipines, Sri Lanka, Thailand, USSR and representatives of WMO and UNESCO. Shri H S. Krishnaswamy, Member (WR), Central Water Commission was unanimously elected as Chairman for the Meeting. During the meeting, discussions were held on the recommendations of the first ARCCOH meeting and future regional programmes.

2. The first meeting of the High Level Technical Committee on Hydrology was held under the Chairmanship of Shri Pritam Singh, Chairman, Central Water Commission at New Delhi on 22 February 1983. Among other things it was decided that the Publication of Hydrology Review would be continued by National Institute of Hydrology, Roorkee.

3. A meeting of the ARCCOH working group on Major Regional Projects for Asia was hosted by India at New Delhi on 12–13 September 1983. Representatives from China, India, Malaysia, Nepal and UNESCO participated.

4. The first meeting of the ARCCOH Steering Committee was hosted by India on 14 September 1983 in New Delhi. Representatives from India, Malaysia, Nepal and UNESCO were present. A representative from China attended the meeting as an observer. The report of the ARCCOH working group for formulation of a Major Regional Project on Water Resources was discussed among other things at the meeting.

5. On the recommendation of the High Level Technical Committee, India has been elected as a member of UNESCO/IHP Committee on Education and Training at the eleventh session of the IHP Bureau held in Paris in June 1983.

6. A meeting was held with Mr. W.H. Gilbrich, Programme Specialist in Water Sciences, UNESCO, Paris and the Chairman HILTECH and others on 24 November 1983 at New Delhi. Some of the issues concerning UN System, UNESCO General Conference, Inter-governmental Council of IHP etc. were discussed.

7. India had communicated its comments on the Draft Programme on Water Resources and Budget allocation under various IHP–III Projects.

## 4.2 National Institute of Hydrology, Roorkee

1. The 3rd Annual General Meeting of the National Institute of Hydrology Society was held on 27th December 1982 to review the progress and performance of the Institute. It approved the transfer of the International Hydrological Programme activities to National Institute of Hydrology through the High Level Technical Committee on Hydrology set up by Government of India for which National Institute of Hydrology would provide the Secretariate.

2. Dr. David R. Dawdy, formerly Chief (Surface Water Research), US Geological Survey and Professor, Colorado State University and presently working with a private consulting firm visited the Institute as a Consultant during January 1983. Mr. Dawdy has guided some of the scientists in establishing stage discharge rating curves using data for Narmada river and its tributories.

3. Dr. D.H. Pilgrim, Associate Professor, University of New South Wales, Australia visited

NIH in January 1983 for 4 weeks as a Consultant in the area of agricultural and watershed hydrology. Scientists of the Institute interacted with him on Unit Hydrograph studies, flood routing studies and design flood estimation.

4. Mr. Arlen D. Feldman, Chief (Research), Hydrologic Engineering Centre, US Army Corps of Engineers was invited as a Consultant at NIH in February 1983. With the help and guidance of Mr. Feldman, scientists of the Institute had implemented and tested the programmes of HEC particularly HEC 1, HEC 4 and HEC 5 on VAX-11/780 computer of the Institute. A stream net work model for Narmada basin has been formulated under his supervision for use with HEC 1 flood hydrograph package computer programme.

5. One scientist of the Institute has successfully completed the International post graduate course in Hydrology at University, College, Galway, Ireland. Six scientists have completed training under the UNDP Project Fellowship in the areas of Water Resources planning and simulation, Hydrometeorology, Flood Routing, Remote Sensing Applications, Rainfallk-unoff simulation and Time series analysis.

6. The research in the institute is carried out in eight priority areas of research identified by the Governing Body of the institute.

i) Hydrologic Analysis of Stream flows in a basin.

A number of approaches/computer program for statistical analysis of streamflows were implemented and tested.

a) Frequency analysis program for fitting different probability distributions which is suitable for seasonal monthly and ten daily streamflows, rainfalls etc. The prog ram has been further modified to improve its structure to use different number of classes depending on length of data series and to test any of the following fine distributions.

* log normal distribution
* log normal relationship based on the theoretical relationship between original and log domain parameters.
* inverse Pearson type III distribution
* log inverse Pearson Type III distribution
* spuareroot normal distribution.

b) Regression and correlation analysis

c) Programmes for fitting probability distribution for peaks which have been tested with data of Narmada at Garudeshwar.

ii) Water balance of river basins.

Two water balance studies one with reference to the Upper Ganga Canal command area and the other with reference to the Hindon were taken up. It was found that two season water balance could be reasonably achieved with available data and major sources of error were identified to be

a) rainfall recharge to ground water in monsoon and

b) evapotranspiration during non-monsoon season.

iii) Watershed models including those for snowfed basins.

a) The USGS rainfall-runoff model has been implemented on VAX 11/780 system in the institute and has been tested. The model has been calibrated for different combinations of flood events of Kasurnala catchment using storm rainfall and runoff data for the year 1973 and 1975. The peak flow and volume of direct runoff have been simulated quite accurately.

b) Rainfall runoff relationship for a watershed has also been established using Betson model. The model simulates two processes viz, soil moisture accoun-

ting and surface runoff. Betson model is a lumped parameter model and input data needed for this model is daily rainfall. Average rainfall values can be used when the basin has more than one raingauge station. Output from the model consists of simulated daily streamflow and daily antecedent precipitation index. Betson model has also been implemented and tested with data of Kasurnala. The simulated peak value and the recession limb of the runoff hydrograph compare well with the observed value.

c) The tank model is a conceptual non-linear model for simulation of rainfall-runoff relationship of a basin. It can be used for flood analysis and daily analysis for both humid and non-humid basins. Generally, four tanks are considered vertically in series representing discharge from top tank as surface discharge, discharge from second tank as intermediate discharge while discharge from third and fourth tank are taken as base discharge. Each tank has a side outlet and a bottom outlet. Discharges depend on amount of storage and discharge coefficient. Parameters of the model are obtained by trial and error starting from initial set of parameters by subjective comparison of calculated and observed discharge hydrographs till an overall good fit is obtained. Studies heve been made using computer programmes for tank models for flood analysis, daily analysis and 4 × 4 tank model for Jamtara and Belkheri sites in Narmada basin using available rainfall-runoff and evapotranspiration data for 1978-79.

(iv) Method of operation of system of reservoirs taking into consideration effects of Irrigation, flood control and power generation

a) Some of the mathematical approaches for simulation and optimization of operation of reservoir systems developed by various agencies have been implemented on VAX 11/780 system at the institute. These are 'River basin' simulation model 'SIMYLD. developed by Texas Water Development Board, USA and HEC-5 model for reservoir operation for flood control and conservation developed by Hydrologic Engineering Centre of US Army corps of Engineers. Some relevant data for Bhakra - Beas system and Damodar Valley system has been collected and further data collection is in progress.

v) Evolution of Mathematical models for storm precipitation for flood estimation.

Recent developments in hydrometeorological analysis include various approaches for estimation of shorter duration precipitation and snow cover, estimation of design storms from depth - area - frequency relationships, identification of meteorologically homogeneous areas, quantitative precipitation forecasting and modelling of storms. Studies of modelling of moving storm in Narmada basin have been carried out using hourly rainfall data of four storms namely 3-6 Sept. 1970, 28-31 August 1973, 28-30 August 1978 and 8-11 Sept. 1979. Inter-station correlation upto a maximum lag of eighteen hours has been carried out for pairs of stations either way. Lag corresponding to the optimum correlation in each case has been found. Findings of storm movements between stations have been compared with the observations made by IMD.

vi) Evolution of methodo'ogies for flood estimation, forecasting and control.

The different aspects of flood namely estimation, forecasting and control can be grouped under the following categories.

a) Flood estimation
   * Unit hydrograph model
   * rainfall runoff relationships

b) Flood Routing
   * Hydrologic methods of flood routing
   * hydraulic method of flood routing.
   * comprehensive flood routing programs.
   * flood wave modifications due to surface water ground water interaction.

c) Flood forecasting
   * forecast models
   * updating models including filtering algorithm

d) Flood control
   * dam break problem
   * flood bank overlapping and failure.
   * data collection and transmission system

NIH has implemented and tested a number of computer programmes in this research area which include.

(a) loss rate optimisation and unit hydrograph programme developed by Hydrologic Engineering Centre.

(b) Lumped and multiple input system model program based on Nash model of instantaneous unit hydrograph developed by IIT, Kanpur.

(c) Inverse modelling program for estimation of unit hydrograph ordinates.

(d) Constrained Linear System (CLS) model

(e) USGS program for stream flow routing with losses due to bank storage.

(f) HEC 1 flood hydrograph package

(g) Streamflow Synthesis and Reservoir Regulation (SSARR) model.

(h) Muskingum - Cunge method of flood routing.

Studies have been taken up for the application of multiple input and lumped input system program using data of small catchments in Godavari basin, unit hydrograph estimation using loss rate optimisation program of HEC 1 for sub basins in Narmada basin and flood routing studies using HEC 1 and SSARR programme for Narmada river systam.

(vii) Methodology for Groundwater Estimation and Development

The understanding of the interaction between ground water and surface water is a major problem today. A study dealing with interaction between surface and ground water in Upper Ganga Canal (UGC) command area has been completed. The study has indicated limitations in the estimation of some important components of ground water balance namely rainfall recharge, evapotranspiration, seepage losses from canals and base flow.

Tyson-Weber Finite Difference model has been adopted and implemented on VAX-11/780 system for simulating monsoon and non-monsoon water table fluctuations. Using this, model simulation of monthly fluctuation of water table is being carried out for UGC command area.

Fence diagrams for the entire UGC command area and Hindon river basin have also been drawn. Analytical solution for studying interference of canal and shallow water table, distribution of seepage losses from a canal in an aquifer of large depth have been obtained. Estimation of seepage into the aquifer from river bed has been one of the major problems in groundwater hydrology. The seepage from a river of large width to a shallow water table aquifer has been quantified using conformal mapping technique. The seepage from a river is proportional to the

difference in the level of water in the river and in the aquifer in the vicinity of river, the constant of proportionality being known as 'reach transmissivity'. The reach transmissivity has been determined for a river of large width. A critical review on seepage losses from Deoband canal by tracer studies has also been carried out,

### 4.3 Central Water Commission, New Delhi

Following are the main activities of CWC during the year 1982–83 in the field of water Resources and Flood Control.

1. Collection of hydrological and sediment data at 427 stations on various Inter-Sate rivers in the States of Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal was continued. In addition gauge and discharge data at 45 road bridge sites in small and medium catchments was also collected on behalf of Ministry of Transport and Shipping. Rainfall observations in these catchments with 85 self recording gauges and 105 ordinary gauges have been taken up.

2. Hydrology of 20 major projects and 35 medium projects was technically examined and 22 special studies were completed.

3. Report on snow melt-runoff conditions in Chenab basin was prepared.

4. HOMS National reference centre has started functioning for looking after work of Hydrological operational Multi-purpose sub-programme of World Meteorological Organisation.

5. The special unit for Drought Area Investigations and Studies created in 1978 completed the preparation of reports of all the 99 Drought prone Districts by the end of Jan. 1983.

6. Reports of the Committee for assessment of water resources of Southern Tributaries of the Yamuna and rivers flowing into the Arabian Sea and their utilisation were finalised and submitted to the planning Commission.

7. Project report on 'Ganga-Sone Link' was prepared. The project is intended to provide Irrigation to the drought prone districts of Mirzapur and Varanasi in U.P. and Rohtas, Bhojpur, Aurangabad, Gaya and Patna in South Bihar.

8. The status of Sedimentation in some major projects like Maithon, Panchet, Nizam Sagar, Matatila, Shivajisagar, Bhakra, Tungabhadra, Hirakud, Lower Bhawani Mayurakshi, Gandhisagar etc. was examined by the Reservoir Sedimentation Committee and the report was submitted to the Ministry of Irrigation in June 1982.

9. Preliminary water balance studies of Wainganga and Indrawati sub-basins of Godawari were carried out.

10. A water year book for the Narmada Basin has been brought out.

11. A National Seminar on the use of Plastics in lining of canals was organised to promote its use for minimising losses in conveyance of water for irrigation.

12. The report of the High Level Committee on reorganisation of State Irrigation and Command Area Departments was finalised.

13. Technical examination of 42 major irrigation/multipurpose projects and 6 modernisation projects from aspects of Irrigation, water availability, crop water requirements etc. was carried out.

14. The publication 'Birds' eye view of Major and medium irrigation projects' giving upto date information like expenditure, irrigation potential created and utilised for the State of West Bengal, Orissa and Maharashtra has been brought out.

15. The publication containing financial statistics of major and medium Irrigation works in the State of Kerala for the year 1969–70 to 1980–81 has been brought out.

16, (i) Remote sensing of a coastal area for salinity intrusion and soil salinity studies in collaboration with National Remote Sensing Agency was continued and the report is expected to be finalised next year.

(ii) A photo interpretation cell was set up for the Remote Sensing Directorate and the work of photo interpretation in Hasdeo sub-basin in the Mahanadi basin has been taken up.

17. CWC had prepared a Master Plan for water resources utilisation, flood control and drainage in the Sahibi Nadi and Najafgarh Nalla Drainage Basin and all the proposals contained in this Master Plan have been accepted by the concerned authorities.

18. Flood forecasting facilities in almost all the major inter-State rivers prone to flood such as Brahmaputra, Tista, Ganga and its tributories, Subarnrekha, Burhabalang Brahmani, Baitarni, Lower Mahanadi, Godavari, Narmada, Tapi, Mahi, Sabarmati Banas, Raidak and Sankosh have been provided to enable the local civil and engineering authorities for taking adequate advance measures to prevent loss of human lives, cattle and movable property and damage to existing engineering works. The flood forecasting organisations which cover the chronically flood affected basins issued about 5000 forecasts from its 151 forecasting sites during the 1982 monsoon.

19. For the modernisation of the Flood forecasting system, a Pilot project on Yamuna river which was started in April, 1980 with UNDP assistance is under active implementation. During the year, a computer system was installed and various mathematical models are being developed on the computer system. The telemetery equipment is also being obtained and it is expected that the computerised flood forecasting system will be operational by July 1983. Group training course on Hydrological Modelling (under WMO/UNDP scheme) was organised from 10.1.83 to 18.2 83. The Denish Hydraulic Institute (DHI), Central Water Commission collaboration project for development of mathematical models continued this year.

20. The work of regulating the DVC reservoirs for optimum use of water for irrigation, hydropower, industrial and domestic use besides carrying out flood control operations during the monsoon, is entrusted to the Damodar Valley Reservoirs Regulations and Flood Forecasting Circle of the CWC, located at Maithon. Inspite of severe drought conditions in the DVC basin during 1982, the regulation was carried out in such a way that utmost attention was paid for providing much needed waters for agriculture.

21. A report titled 'Status report on Monitoring of Flood Control Projects was prepared.

The detailed monitoring of major flood control and drainage works costing over Rs. 2 crores each has also been taken up. A monitoring report on scheme for improvement of flood spill channel in Kashmir Valley (estimated cost Rs. 1678 lakhs) was prepared and sent to the State authorities.

22. The flood plain zoning surveys undertaken as a part of the flood plain Management measures for reducing the rising trend of flood damage has achieved considerable progress. The surveys started in 1978, through the Survey of India, have covered an area of about 16,000 sq. km upto March 1982.

23. Flood routing studies for Masani Barrage in Haryana, Ajmerpura Dam in Rajasthan and Dhansa Bund in the Union Territory of Delhi corresponding to revised levels were carried

out to decide on the various hydraulic parameters.

Flood discharge studies in respect of Jaspur and Dhanura barrages in Haryana were conducted in connection with the formulation of the project reports by the State authorities.

24. CWC issued 89 flood news bulletins and 17 weekly news letters covering the flood situations in the country during the flood season of 1982 Comprehensive note on the flood situation in the country was prepared for presenting it before the Parliament, during September 1982. The area affected by heavy rains, floods and cyclone during the year was about 259 lakh ha.

25. Comprehensive studies on river Yamuna between Tajeweala and Okhla were carried out and a report entitled "An indepth study of the safety requirements of city of Delhi against flood disaster of river Yamuna as accentuated by construction of upstream embankments by States of Uttar Pradesh, Haryana & Delhi" was prepared.

26. During the year 1982-83, CWC examined 84 schemes submitted by the States for providing central loan assistance and gave its views for consideration of the Screening Committee which held its meeting during December 1982. The state of Assam, Arunachal Pradesh, Bihar, Manipur, Rajasthan, Uttar Pradesh and West Bengal were provided a central loan assistance of Rs. 5 crores for 39 schemes. The monitoring of these schemes has been taken up.

27. An interim report so far as raising the maximum level of Maithon reservoir to RL 500 was prepared and submitted to the Ministry of Energy. On the basis of back water studies made by CWC, the areas which are likely to be submerged when the maximum level of Panchet reservoir reaches RL 445 ft. have been identified.

### 4.4 Central Ground Water Board, New Delhi.

1. Systematic hydrogeological and reappraised surveys were carried out in different states Based on the recommendation of these surveys, 151 exploratory wells, 93 observation wells and 59 slim holes/piezometers were drilled, with an aim to identify the potential aquifers, demarcation of their vertical and lateral extensions, delineation of aquifers with saline water, determination of aquifer parameters, determination of optimum spacing between tubewells etc.

2. The following special ground water projects were in operation.

   (a) Pilot projects on induced recharge studies in Ganga basin.

   (b) Pilot projects on artifical recharge studies in Mehsana and coastal areas of Gujarat.

3. An Atlas containing information on various hydrogeological parameters in respect of Rajasthan was prepared. Similar Atlases for Punjab, Haryana, Bihar, Tripura and Maharahtra were under compilation.

4. Revision of first hydrological map of India has been completed and compilation of the map of South and East Asia is in progress.

### 4.5 Central Board of Irrigation and Power New Delhi.

1. A workshop on dam safety was arranged in collaboration with the Central Water Commission at New Delhi from 27-30 October 1983 and was inaugurated by Sri M. G. Padhye, Secretary (Irrigation).

2. A seminar on Irrigation in Arid lands was arranged at New Delhi on 24-25 November 1983 to discuss the problems faced when irrigation facilities are extended to Arid and Semi Arid areas. The Hon'ble Union

Minister for Irrigation, Sri Ram Nivas Mirdha inaugurated the Seminar. The Hon'ble Chief Minister of Rajasthan, Sri Shivcharan Mathur presided over the inaugural function. The Hon'ble minister for Irrigation of Govt. of Rajasthan also participated and addressed the delegates.

3. During the VI Five year plan upto 1982-83, a total of 127 time bound and result oriented research projects were sanctioned by the Govt. of India. Out of these 46 projects were completed upto 1982-83 and 75 research projects were in progress.

   (a) Under the project at IHH, Poondi for conducting Hydrological model studies on the Bhavani Catchment for flood prediction by simulating surface flow parameters such as infiltration, detention, over land flow and moisture movement etc, a hydrological model of the entire catchment of Lower Bhavani Dam to a scale of 1:10,000 horizontal and 1:2500 vertical has been constructed. The object is to use this physical model for developing a technique for prediucting the floods by simulation of the surface flow.

   (b) Under a project of Rainfall Runoff correlation and hydrological studies of selected catchments of Rajasthan, the following river basins were selected to conduct various hydrological studies for attempting to establish rainfall runoff relationships.

      (i) Jakham river basin
      (ii) Sahibi river basin
      (iii) Berach river basin

      Based on actual rainfall and runoff received in various storage reservoirs ituated in few sdistricts of Rajasthan attempt was made to find out general relationship between rainfall and runoff so as to compare the same with the Stranges table.

   (c) Under a project for field determination of mixing length in rivers and streams by UP Irrigation Research Institute, U.P, the studies conducted in Ganga, Yamuna, Tons, Sona and Alaknanda indicated that the mixing length in mountainous reaches varies linearly with the average water surface width of flow and it was observed that the curvature of bends play an important role in mixing of the tracus.

   (d) In another project on mixing length for determination of discharge in open channels by dilution method at CWPRS, Pune. Studies were carried out in the laboratory flumes for application over a wide range of hydraulic parameters. Literature survey and trials are in progress.

### 4.6 National Water Development Agency, New Delhi.

The National Water Development Agency has been set up for carrying out detailed survey and investigations of the possible storage reservoir sites and interlinks in order to establish feasibility of the proposals of Peninsular rivers development in the National perspective plan.

The Agency has collected some details of investigations carried out by Central Water Commission for Mahanadi Basin, West flowing rivers out falling into the Arabian Sea, Southern tributories of Yamuna, project report of some major schemes proposed by some states and outline plans, toposheets of Mahanadi, Godawari and Krishna basins.

### 4.7 India Meteorological Department, New Delhi.

1. Maps of 20 states showing isopluvials of mean annual rainfall, standard deviation and coefficient of variation of mean annual rainfall were completed.

2. Preparation of generalised dew point temperature maps for state of Maharahtra was in progress to facilitate moisture maximisatation of storms tn the region.

3. Three permanent observatories (snow gauge stations) have been established at Ranikhet in Uttar Pradesh, Hansa and Sumdo in Himachal Predesh under Glaciological studies scheme.

4. Following papers were submitted.

   (a) Hydrometeorological studies of Flash floods in river Vamsadhara.

   (b) Uncommon floods of Grissa in 1982

   (c) A statistical approach to estimate probable maximum precipitation.

   (d) Estimation of probable maximum precipitation depth of Kanhar irrigation project, U.P.

   (e) Estimation of areal rainfall and probable maximisation.

   (f) Estimation of probable maximum precipitation and short duration analysis of Subarnarekha catchment upto Ghatsila Dam site.

   (g) Dynamic approach to quantitative precipitation forecast.

   (h) Desert climatology and its modification.

   (i) Areal rainfall computation by multiquadratic method modification NASH hybrid model for forecast discharge in Narmada catchment.

   (j) Computation of water budget of a snow bound river basin in relation to pollution stress.

### 4.8 Water Resources Development Training Centre (WRDTC), University of Roorkee, Roorkee

1. Field studies on the Ford Foundation aided project on the Left Salawa Distributory command in Meerut District continued during the year. Some of the aspects of water management and related topics studied were :

   (a) Irrigation efficiency
   (b) Ground water modelling
   (c) Evaluation of Irrigation Water management.
   (d) Farm water use pattern
   (e) Improvement in water distribution system.
   (f) Evaluation of water availability and utilisation.

2. Other research studies carried out include

   (a) Operation policy of upper Kolab multipurpose reeervoir.

   (b) Techno-economic feasibilty of improvements in existing pumping sets.

3. A special short term course on 'Ground Water Development and Management' was organised from 2-14 May 1983 in collaboration with Asian Institute of Technology, Bangkok.

4. The centre organised a short term course for inservice Engineers on Reservoir "Operation, Flood Control and Hydrologic Data" during 24th Oct. to 19th Nov. 1983 for engineers from Tamil Nadu Govt.

5. A National Seminar on 'Ground Water Development-A Perspective for the year 2000 AD' was held in Dec. 1983 at Roorkee in collaboration with Indian Water Resources Society.

### 4.9 School of Hydrology, University of Roorkee, Roorkee.

1. Two new subjects, Snow Hydrology and Water quality modelling are being offered as elective subjects.

2. A research project relating to Water Quality and its modelling for Hindon river basin has been sanctioned by Deptt. of Environment to the University of Roorkee as an inter-departmental project and the faculty of the School of Hydrology is actively participating.

3. The following research/consultancy projects were completed.

   (a) Hydrological studies of Ramganga Dam Project.

   (b) Design flood studies for Rajghat Dam Project.

   (c) Hydrological investigations of Machhu Dam II.

   (d) Assessment of silting of Jamrani Dam reservoir

4. The ongoing research consultancy projects are.

   (a) Mathematical model for induced recharge in Ganga basin.

   (b) R.C. Ana'ogue studies in Agra and Varanasi district.

   (c) Ground water studies in Yamuna Command area.

   (d) Special studies on sub-surface drainage in command area of Narmada Sagar project.

   (e) Conjunctive use modeiling for ground and surface water in eastern Yamuna Canal Command area.

   (f) Generation of Stream flow data using generated multistation daily rainfall data and rainfall runoff deterministic models.

### 4.10 Central Soil and Water Conservation Research and Training Institute, Dehradun.

1. In order to predict annual maximum daily rainfall, probability analysis was carried out with 60 years (1899–1958) rainfall data for six stations of Uttar Pradesh Himalayas. Three commonly used probability distribution functions (Gumbel, Log Normal and Log Peason Type III distribution) were used for filling the data of annual maximum daily rainfall. Among the three, Log Pearson type III distribution was found to give the closest fit to the observed values. The value of probable maximum daily rainfall of 5 years return period was found to be 138 mm for Chakrata.

2. Data on rainfall intensity for diiferent durations collected at Chandigarh Centre for 1962–83 (22 years) was analysed for frequency by filling three commonly used probability distribution functions (Gumbel, Log normal and Log Pearson). Using the weibulls formula the maximum intensities of rainfall for selected duration were calculated for different recurrence intervals. The value of maximum intensity rainfall for 30 minutes duration of 5 years return period was found to be 88mm/hr.

3. Analysis of 27 years (1956–82) of rainfall data for seasonal distribution has shown that an assured minimum weekly rainfall of 10 mm at 70% probability chance occurs during the period from 17th–34th Standard weeks (4th week of April – 3rd week of Aug) and highest weekly rainfall of 25 cm is received during 27th week (July 1st week).

The results indicated that the consumptive use requirements of potato crop can be fully met by rainfall in the summer and second season but require supplementary irrigation during winter (Jan.-March).

Similar analysis were also carried out for the period 1959–79 for Agra using 21 years of weekly rainfall data.

4. Rainfall intensity duration frequency relation ship using data of rainfall at Kota centre for the year 1956 to 1980 were analysed and filled in the following equation

$$I = \frac{5.79\ T^{2\cdot3}}{(t+0.5)^{0\cdot85}}$$

where $I$ = intensity in (cm/hr) for duration of t hours and

$T$ = recurrence interval (years),

A rainfall intensity of 6.8 cm/hr was obtained at 50% probability level for 30 minutes rainfall duration for 2 yrs. return period.

5. Aridity index of Kota for monsoon season was worked out using Thornthwaits's Water balance technique.

6. The hydrological behaviour of an agricultural gauged watershed (0.4 ha) under sorghum and pegeon pea crop is being studied. Soil moisture in the watershed is also monitored during crop growth.

### 4.11 Central Soil Salinity Research Institute, Karnal

1. A major part of the area selected for study of conjunctive use of fresh canal saline ground waters in saline soils has problem of saline ground waters with water table fluctua ing between 0.5 to 2 0 m. To evaluate the effect of water resources management policies on ground water behaviour, the whole area was divided into 14 regions. A ground water simulation model, based on finite difference technique, was adopted. The input data for the model were observed for a 5 yrs period from 1976–1980 and has been used for calibration of the model. The calibrated model would be used to predict the ground water behaviour at different periods of time.

2. In the fourth year of the installation of open sub-surface drainage system, the comparative soil salinity status in drained and undrained areas indicated that during the rabi season there was an increase in the salinity status of the soil profile in both the drained and undrained areas but the actual salinity level was much less in the drained area.

3. For estimating the peak discharge from the alkali watersheds in transient state of reclamation, computer analysis was performed for deriving the emperical equations relating rainfall amount, intensity, antecedent precipitation under area, reclamation factor and shape factor of the watershed. The reclamation factor was found to have a dominant role in reducing the peak discharge rate.

4. The hydrologic responses of alkali watersheds (0.5 ha each) to alternate land use treatments were studied. The land use treatments were growing of tree species like Eucalyptus hybrids and Acacia Nilotica and Karnall grass along with a control watershed. The total runoff from the water shed grown with Eucalyptus hybrid was only 136 mm against 261 mm from the control watershed and 198.9 mm from the watershed planted with Acacia Nilotica. The data from the watershed planted with Karnal grass was not considered for analysis as the watershed was under planting during the rainy season.

5. In Haryana, nearly 650,000 ha area has water table within 3 m of ground level and in another 700,000 ha the water table depth is in the range of 3–10 m. In most of these areas, the ground water quality is poor and is leading to secondary salinisation. The provision of sub surface drainage to lower the water table and to facilitate leaching of salts forms a major component in the reclamation of these areas. To undertake techno-economic feasibility studies on surface tile drainage, detailed investigations were conducted in about 10 ha area. The spacing of tile drainage system was computed treating soil profile as layered. Based on rainfall analysis, a drainage coefficient of 10mm/day with watertable depth at 1 m was used for the design, on the basis of which the design spacing was 55 m. Three spacings of 25, 50 and 75 m with a length of 200 m were adopted for the experiment.

### 4.12 Central Board for Prevention and Control of Water Pollution, New Delhi.

1. The board continued the programme of preparation of a comprehensive industry

document to evolve Industry Specific Minimal National Standards (MINAS) as well as policies to control water pollution from industrial sources.

2. River basin wide pollution potential evaluation studies on systematic comprehensive survey of major rivers of the country for evolving a water quality management programme were undertaken. Water quality data of the Yamuna for the subsequent year after preparation of the report in 1978 on the survey programme in Yamuna were analysed to update the information.

3. In cooperation with State Boards of Bihar, Madhya Pradesh, Uttar Pradesh and West Bengal comprehensive surveys for entire Ganga river were initiated in 1979 and has since been completed. The final report on the Ganga basin containing the information from the 4 states has been compiled.

4. The analysis and interpretation of the river water quality data for the four interstate rivers of Gujarat namely Mahi, Sabarmati, Narmada and Tapti were completed and specific recommendations in respect of these rivers were communicated to State Pollution Control board of Gujarat.

5. Revised Water quality monitoring programme for the Yamuna was communicated to all concerned to be made effective from June 1983

6. The Board studied the impact of mass bathing, on water quality on the occasion of Makar Sankranti at Ganga Sagar. For the purpose of sampling the coastal water, five locations were selected at appropriate locations. The studies were started on week before peak bathing day and continued until after one week of the bathing day.

7. Chairman of the board travelled along the river systems of Alakananda to have an on the spot account of the premonsoon water quality of the river. Chemical analysis of water samples indicated that Bhagirathi carries the highest concentration of suspended solids when the river carries only snow melt. It would be desirable to minimise soil erosion in the river which could increase during monsoon.

8. Seven monitoring stations are the east coast covering Tamilnadu and Pondichery were identified for monitoring of various water quality parameters. Water quality survey was conducted along west coast using exclusively the expertise of Central Boards personnel. The reports and maps are under preparation.

9. Water pollution potential due to the oil drilling activities in Assam were found to be high causing ground water pollution and damage to top soil.

10. Pollution monitoring studies were carried out and information on the generation of wastewater (domestic and industrial) was updated.

### 4.13 Department of Civil Engineering, Annamalai University, Tamilnadu.

The department of Civil Engineering has developed a School of Hydrology and conducted the first National Seminar on "Rural Hydrology' in March 1979. The Department runs a post-graduate course on "Water resources engineering and management" the syllabus for which are framed at par with international level in the field.

### 4.14 State Water Investigation Directorate, Department of Irrigation, West Bengal.

The Directorate has been involved in the investigation of both ground water and surface water resources available in the state. To further broadbase the programme the following directives are envisaged.

(a) identification of ground water and surface water resources in terms of major basins.

(b) determination of economic depth of shallow and deep tubewells.

(c) determination of spacings of tube wells for safe and proper utilisation of ground water resources.

1. An area of 3100 $Km^2$ has been surveyed. 187 piezometric wells were installed for water level measurements to study long term behaviour of water table. Monitoring the water leve's in 99 piezometers set up earlier is continuing. The exploratory cum production tube wells were started. 140 samples have been used in chemical analysis.

2. Study of permeability and infiltration rate of storm water through infiltration gallery on Darakeshan river, Ajoy and Daraka river in Bankura, Purulia, Birbhum and Burdwan districts was undertaken.

3. Stream gauging at 4 sites on main and tributory rivers and rainfall data collection were continuing in Darakeshwar river basin

4. Study of soil moisture status in Bankura and Purulia districts was undertaken and col'ection of rainfall data was continuing.

5. Determination af river bed permeability by well point system in Jaypanda, Kangsabati and Sal was undertaken

6. A scheme for evolving construction technique and permeability test of water wells in the foot hills of the Himalayas in the district of Jalpaiguri, Darjeeling was sundertaken.

**4.15 Irrigation Department, Maharashtra.**

The Master Net work approved by Government of Maharashtra for river gauging in all regions of the state except Konkan envisage updating of the existing river gauging stations and establishing some new stations. Similar Master Net work for Konkan region is under preparation.

**4.16 Inaugural Address by Shri Ram Nivas Mirdha, Hon'ble Minister of Irrigation at the Seminar on Assessment, Development and Management of Ground Water Resources held at Vigyan Bhavan, New Delhi, 29 April 1983.**

I am happy to be amongst this distinguished gathering of scientists, engineers and planners who have assembled here to discuss the most vital issues concerning the development and management of ground water resources. Judicious assessment, development and management of ground water is a matter of great concern to the Government and to me personally. This topic is really timely and I am indeed happy that the Central Ground Water Board, the National apex organisation, is organising this Seminar. The importance of this resource as a sustained source of water supply for irrigation, industry and domestic use is well accepted by farmers, industrialists and public health organisations. The Government also lays great importance on this activity and has, therefore, decided to list it as a priority item in the New 20-Point Programme announced by the Hon'ble Prime Minister.

Use of ground water in India has been in vogue from time immemorial. The history of open well construction can be traced back to the Vedic perod Towards the end of the nineteenth century, open wells were an important source of irrigation in the country. The Irrigation Commission (1903) affirmed the importance of irrigation by wells. However, first large scale venture of scientific surveys and development of ground water was taken up in 1934 when a project for construction of about 1500 public (deep) tubewells in the Ganga basin was initiated. Since the middle sixties, there has been increasing realisation of the importance of ground water as a source of irrigation. The events which made the beginning of this realisation were (i) occurrence of recurrent droughts in this country and (ii) arrival of the high yielding varieties of wheat and rice and introduction of an incentive oriented price policy by the Government.

The value of ground water as a source of irrigation lies in the fact that it is widely distributed, can be put to use with ease and speed and is capable of being tapped to a large extent by wells and small capacity tubewells which can be individually or jointly owned by the farmers. In addition, the ground water development schemes have short gestation period and the source is directly under the control of farmers. In Canal Command Areas, ground water wells provide assured supplies of water for raising high yielding varieties of crops in addition to arresting water logging.

The ground water resource has two components—dynamic or replenishable and static. The dynamic component which regenerates every year can be fully developed whereas a part of the static component can be developed during the periods of scarcity and drought. It is this reserve which renders to ground water a higher importance and makes it a fully dependable source.

It has been provisionally assessed that the replenishable ground water resource is sufficient to provide assured irrigation facilities to 40 million hectares The present level of development is estimated as 24.5 million hectares which is about 40 percent of the total irrigation potential so far created in the country.

During the Sixth Plan period, creation of an irrigation potential of 13.741 million hectares is envisaged, of which the contribution from ground water would be 7 million hectares. To realise this, an investment of Rs 3511 crores (Rs. 1811 crores as plan outlay and Rs. 1700 crores as institutional finance) is proposed to be made. This is more than two and a half times the expenditure incurred during the Fifth Plan on ground water schemes.

The sharp expansion in the field of ground water development in recent years has been supported by such factors as an expanded programme of rural electrification, increased indigenous availability of drilling, pumping and other ancillary equipment and development of an institutional structure for making available agricultural credit to individual farmers. The present size of the programme which is gaining momentum from year to year, has made it vitally essential that the development and management of ground water resources is planned in a scientific manner so that hazardous situation is created and there is no infructuous expenditure or over-capitalisation.

Water being a State subject under the Indian Constitution, the responsibility for day-to-day planning and implementation of the ground water development programmes rests with the State Governments. However, since the ground water basins do not restrict themselves to the political boundaries and as the work related to surveys, assessment, development, management and regulation of ground water resources is a job of highly complex nature, it warrants the involvement of the Central Agency in carrying out macro-level investigations, basin-wise assessment and development of the resource and specialised studies in collaboration with the State Ground Water Organisations.

The Central Ground Water Board is an apex body at the National level and is responsible for nation-wide surveys, development, planning and management of the ground water resources and has, therefore, been undertaking various activities in fhe field to provide a data base for planning and development schemes on scientific lines. Under its main activities of regional hydrogeological surveys, ground water exploration and monitoring the behaviour of ground water regime, the Board has undertaken surveys over an area of 17.60 lakh square kilometres in the country. In addition, about 4,500 boreholes of various types have been drilled to establish the ground water worthiness of different areas and determine the aquifer parameters. Under its ground water level monitoring programme, it has established a water level monitoring net work of about 5,000 stations in the country.

A perspective for the development of the entire irrigation potential in the country by 2000 AD has now been laid. To achieve this, it is essential that the basic work connected with the investigation and assessment of the ground

water resources, i.e. hydrogeological surveys and ground water exploration studies are completed well before hand and data made available to the user and planning agencies for preparation of ground water development schemes. Accordingly it is planned that the Central Ground Water Board shall complete the entire hydrogeological survey during the Seventh Plan and the ground water exploration and assessment studies before 1995. The Board is being strengthened and reorganised by adding 30 drilling rigs to its existing fleet and appropriate technical and scientific personnel.

The major inputs in the development of ground water resources of the country are the availability of requisite finance to the individual farmers and providing assured supply of power for operating the lifting devices. Upto early sixties, the Co-operative and Commercial Banks were making loans available to the individual farmers for construction and energization of wells and tubewells. However, significantly larger institutional investments came in with the setting up of the Agricultural Refinance and Development Corporation in 1963 (now merged with National Bank for Agriculture and Rural Development) with a veiw to :

(i) Supplementing the resources of the existing financial institutions, namely, State Co-operative Land Development Banks and Commercial Banks and dispensing medium and long-term loans for agricultural development.

(ii) Re-orienting their operational policies in order to make them responsive to growth oriented lending.

Institutional lending for ground water development was further re-inforced with the availability of loans from World Bank and other sister International Financial Institutions. Since its inception upto June, 1982, ARDC has disbursed loans amounting to Rs. 2808.00 crores out of which Rs. 1647.00 crores were for the development of minor irrigation works including ground water.

For providing the required power for operation of the lifting devices particularly in the rural sections of the country, the Government of India set up the Rural Electrification Corporation in 1969–70. The R.E.C. has evolved a number of loan categories with varied terms and conditions suiting the socio-economic and geographical diversities of the country. It has recently introduced a new programme called the Special Project Agriculture (SPA) envisaging an investment of Rs. 630.00 crores for energization of 8.00 lakh pump-sets during the Sixth Plan period. However since the availability of electric power is limited and diesel oil being costly, it is essential to lay increased emphasis on the development of new and renewable sources of energy such as Solar Energy, Wind Power and Bio-gas. Generation of energy from house-hold wastes i.e. bio-gas is increasingly finding favour with the farmers because of its cheapness, small investment and easy maintenance. I would appeal to the delegates to give special attention to the aspects of further developing the equipment and techniques for harnessing this source of energy.

Since the development of ground water involves a number of agencies such as Central and State Ground Water Organisations, Institutional Finance Agencies and Commercial Banks and the Irrigation, Power generation, Agriculture and Rural Development Departments both at the Central and State levels, it is essential that these organisations work closely with one another and prepare schemes which are economically viable and have low recurring cost. This would ensure a speedier and scientific development of the ground water resource potential.

As mentioned by me earlier, there is a large static ground water component resoruce available in the country. It is desirable that in this gathering of scientists, engineers and research workers, you may put your mind together and evolve a thinking as to what extent the static ground water resource could be developed without having detrimental effect on the system at the same time rendering a valuable assistance

to the farmers in intensifying their efforts for higher food production.

I am informed that in certain parts of Haryana, Tamil Nadu and Gujarat the present draft equals or exceeds the replenishable recharge. Measures to check further development have to be taken up in such areas. Feasibility of undertaking artificial recharge in such areas need to be evaluated.

I would also like you to examine how the development of ground water resource could be regulated and whether appropriate legislation is required, keeping in view the socio-economic structure of the country.

I understand that about 200 papers on various subjects have been received for presentation at this seminar. I am sure the deliberations at the seminar would greatly benefit the scientists, engineers, planners and in turn the farmers in this country. I look forward to receiving useful recommendations emerging out of the seminar.

**4.17 Inaugural Address by Shri. R. Venkataraman, Hon'ble Minister of Defence at the First National Symposium on Seasonal Snow Cover at Vigyan Bhavan, New Delhi, 28 April 1983.**

I am very happy to meet this morning a galaxy of scientists, engineers, foresters, geologists, meteorologists, hydrologists, physicists, space scientists, surveyours, mountaineers, University Professors and also officers of the Defence Services. It is indeed very nice to see that such a multi disciplined expert group has gathered here to take part in the First National Symposium on seasonal snow cover and discuss various aspects of snow and its manifestations.

The Symposium has before it valuable objectives and I am gratified to note that all aspects of snow cover which are of topical interest will be discussed in the next two days

Snow is a fascinating material and a subject of great curiosity. The poet, the philosopher and the mystic are drawn towards snow, towards mountains, because of the splendour and spirituality associated with them from times immemorial. For the sportsman snow clad mountains are places of pilgrimage, where sport does not remain merely a sport. For the scientist in search of the secrets of snow, the problems are more challenging. While he has also to be emotionally drawn to and inspired by the pervasive white blanket perched on the mountain tops his concern is more about the seamy side of snow and the problems it creates whether they are the avalanches, transportation hurdles, destructive floods or other human problems.

It is a common knowledge that some of the most massive avalanches trigger year after year in the Himalayas. Until recently avalanches were a major problem mainly to the mountaineers. Out of the various hazards a mountaineer has to face, avalanche has been the greatest cause of fatalities. We had not paid much heed to the problems of snow and avalanches till we were face to face with them at the time of the 1962 War. For our forces stationed in the snow bound high altitude regions, avalanche is a real threat, indeed a nightmare. For better Defence preparedness, problems of avalanche control have to be tackled on priority. Greater safety and greater mobility will go a long way to raise the morale even of the toughest soldier. He has also to be educated to attune himself to look for the lurking danger. With greater knowledge and know-how in these matters, our expertise of winter warfare will definitely enhance. Scientists working in this field, particularly of the Snow Avalanche Study Establishment (SASE) have an important role to play by applying the results of their research to field problems.

Many of our mountain roads remain closed for traffic during winters for nearly six months. Some of these roads are of strategic importance. A phased programme to tackle the problems of snow and avalanches should be taken up so that we have these roads for winter use also. I am happy to know that the Snow and Avalanche Study Establishment has been doing

pioneering work by mapping major avalanches on important road axes and evolving some protective measures at a few sites. Keeping the defence priorities in mind, economical and durable solutions should now be worked out by speedy implementation. I hope that this symposium will discuss all aspects of this problem so that the available expertise is pooled for a concerted action in this direction.

Every winter, several lives are lost due to avalanches, mostly the victims appear to be the local villagers. Sometimes para-military and military personnel also suffer. I believe the Army is being well served by Avalanche Warning Bulletins of SASE. While the scientists at SASE have evolved norms for forecasting avalanche occurrence for localities where their observatories are situated, they are really handicapped to cover the whole area of Western and Central Himalaya because of lack of real time data. While the resources of SASE should be enhanced to enable them to widen their network of observatories and field stations I hope that the State Government agencies will also come forward to cooperate in this very important task so that the expertise built up at SASE is of benefit to the people living in these far flung areas. Their participation is needed in helping the setting up of a large number of snow and meteorological observatories and providing a communication set up linking the Avalanche Forecast Centre of SASE. Let us not allow the events of March 1979 to be repeated, when more than 300 lives were lost and several heads of cattle, thousands of hectares of forest wealth perished. This is another field where a coordinated approach can yield fruitful results towards greater awareness of the problem and greater safety.

The importance of avalanche forecasting cannot be over emphasised because this is the only economical way to partially tackle the problem. Avalanche control can be resorted to only for vital locations in view of the cost. With a small outlay and efficient system of communication the facility of avalanche forecast warnings can reach even the remotest village. After receiving the warning, where will the villagers go if their village itself is threatened ? Certainly they can go into a community centre if it is designed to withstand the avalanche forces. A partially underground structure properly designed may help in this matter. Our structural engineers should study this aspect of designing one such shelter for bigger villages or a group of small villages affected by avalanches so that on receiving the danger warning they can gather inside and spend out the period of danger.

I am happy to note that you are also devoting sometime to snow hydrology at this symposium. This subject needs special attention as nothing much has been done in our country in this field inspite of the fact that the first snow surveys were initiated in 1974 under the guidance of the US expert Dr. Church. The entire Himalayan range stretching about 2500 Km in length and 250 to 400 Km. in width influences the hydrology of great rivers like Ganga, Indus and Brahmaputra and their tributaries. With snow melt contributing 50 to 70% of the annual run off of these river basins, the importance of studies on estimating snow melt run off rate for better river water management need not be over emphasised.

Speaking of snow and its problems will not be complete without referring to the wanton destruction of our Great National Wealth–the forest. The maniacal, or should I say, suicidal trend of indiscriminate felling of trees has rendered many hill slopes barren, adding to the avalanche problem. I recall the prophetic words of Arnold Toynbee when on seeing the marvel of Himalaya he bemused "May it not now be within man's power to desecrate the Himalayas if he finds this economically profitable and militarily advantageous. We have not yet succeeded in defiling and defacing Himalayas". He wrote these words in 1970. We have certainly proved him wrong and we have to an extent defiled and defaced the Himalayas. It may not be too late even from the limited angle of avalanche safety, to make concerted efforts to restore to the forest its rightful place. I am

glad that we have with us here some leading foresters of the country. I am sure you will concentrate on how to regenerate the forests and what species to try in snow bound areas and the density of the stands required to enhance the snow cover stability. Our Prime Minister herself has taken a personal initiative in reforestation in the Himalayas. Recently she has ordered the constitution of a Committee in the Himachal Pradesh to encourage reforestation in the Kulu Manali region. I understand the SASE is actively associated with this project.

I am happy that the role of the Snow and Avalanche Study Establisment has recently been enlarged to include all problems associated with high altitudes and cold regions and will look forward to its growth as a leading centre of high altitude and cold region research in this part of the world. I wish the Scientists of SASE God speed. I wish you all success in your deliberations.

With these words, I have great pleasure in inaugurating the First National Symposium on Seasonal Snow Cover.

### 4.18 Inaugural Address by Shri Ram Niwas Mirdha Hon'ble Minister of Irrigation at the Seminar on Irrigation in Arid Lands, New Delhi, 24th November 1983.

I am happy to be associated with this Seminar on Irrigation in Arid Lands and at the outset let me thank the organisers of the Seminar for this opportunity of meeting all of you.

The subject of this Seminar is of great importance to the States of Rajasthan, Gujarat, Haryana, etc., which have large areas falling under the category of Arid or Semi-Arid lands. Extending irrigation to such areas to the Maximum extent possible is one of our national objectives.

Effort to increase the irrigation facility throughout the country has been and continues to be one of the important activities in our development plans. The provision of assured irrigation facilities to any area immediately leads to a big quantum jump in the prosperity of that area. There are very large disparities in income and living standards of the people between the dry and drought affected areas on the one hand and the irrigated areas on the other. In the case of arid and semi-arid areas, the improvement in the living conditions of the people is remarkable once irrigation facilities are made available. As for example the introduction of irrigation from canals has transformed parts of Ganganagar District, which was once an intensely arid area into a prosperous agricultural tract. There is, therefore, always a clamour for extending irrigation benefits to more and more areas. However, the water resources as well as the financial resources required for extending irrigation facilities are both limited. We have, therefore, to make a judicious choice when deciding on areas to which irrigation benefits are to be extended. There is always a discussion whether we should go in for extensive irrigation or intensive irrigation.

It has been mentioned that in areas where water resources are in excess of land resources, irrigation should be supplied on an optimum level in order to obtain maximum yield per unit of land. In areas where water resources are deficient as compared to land resources, irrigation scheduling should be done to obtain maximum production per unit of water. The scheduling of water should be tailored to ensure water supply at such stages of crop growth which are critical in their demand for water so that crop growth and quality do not suffer. In arid and semi-arid areas the second condition prevails. The available land area is sometimes so large that it is not possible to even meet the critical requirements of plant growth if irrigation is to be extended on a wide scale. It may become necessary to limit the areas to be served by irrigation facilities. It is reported that experiments have shown that an irrigated field surrounded by other irrigated fields gives a substantially higher yield than one surrounded by unirrigated fields. It has

therefore been suggested that irrigation should be applied in blocks rather than in scattered isolated fields. This means that irrigation facilities get concentrated in some areas while it is denied to adjoining blocks.

The choice of a suitable cropping pattern also becomes important. In arid areas there is need to encourage the cultivation of crops with low water requirements and use of drought resistant varieties so that as large a section of the community as possible is benefited and at the same time the maximum number of farmers are enabled to obtain reasonable yields.

Another factor that has to be borne in mind is the Socio-economic background of the existing population in the area. The transformation of a low level economy sustaining on limited live stock population into a thriving agricultural economy based on extensive growth of different types of food-grains etc , would impose severe stress on the Socio-economic fabric of the area. The existing village population may sometimes prefer extensive pasture cultivation and development of live-stock to switching over suddenly to growing of food-grains based on extensive irrigation.

The above are some of the issues which require consideration and I am sure that you will be discussing these factors during the Seminar.

The second factor that has to be examined is the level of irrigation technology and agricultural technology that are to be introduced in the area newly being brought under irrigation. In the conventional method of irrigation, appreciable loss of water due to deep percolation takes place both in distributaries, water courses and in the field. The seepage losses in the Main canals and the branches are generally controlled by the provision of a suitable lining. How far lining can be extended to distributaries, field channels / water courses requires examination vis-a-vis the cost involved. In many of the lift irrigation schemes lining is being extended to water courses also.

Improved irrigation application methods such as sprinkler irrigation etc., have also been suggested so as to improve the irrigation application efficiency. Sprinkler irrigation is particularly suitable in sandy areas where percolation losses from surface irrigation are high and where frequent light irrigation is preferred because of poor water holding capacity of the soil. Its use where land is undulating or where proper land shaping is not possible due to shallow depth of soil cover is appropriate. However, the capital cost involved is quite high. Estimate of cost varies from Rs 17,000 to 30,000 depending on size of holding, shape etc In spite of this, where soils are highly permeable, lands are highly undulating and would thus require costly land shaping measures and water supply is not adequate even there high cost measures would prove to be economical. The Government of Haryana has introduced a scheme for encouraging the use of sprinklers, by providing a subsidy, giving required technical assistance, providing loan assistance etc. It is gratifying to note that over 10,000 sprinkler sets have been installed in Haryana.

Government of India, through the Ministry of Irrigation, also encourages irrigation through sprinkler and drip irrigation and have the following programme for subsidy :

Sprinkler : Average cost is estimated at Rs. 3,000 to Rs 5,000 per ha and 50 percent subsidy is permissible upto a maximum limit of Rs. 20,000 for small and marginal farmers. 20 percent subsidy upto a maximum limit of Rs. 8,000 is permissible for other category of farmers. As regards drip irrigation, a subsidy of 50 percent subject to a maximum limit of Rs. 20,000 for small and marginal farmers and 20 percent subject to a maximum limit of Rs. 8,000 for other category of farmers.

In a still more sophisticated system viz., the drip irrigation, water is conveyed by suitable tubing and is allowed to drip slowly through nozzles or orifices, at the ground surface so as to keep the soil surface around the plants constantly wet. This however involves laying

on the field a suitable system of feeder lines, laterals etc., along with planting of crops in a well defined pattern so as to be compatible with the drip irrigation system. The Central Arid Zone Research Institute Jodhpur has carried out studies on the efficiency of this system. Subject to financial viability this system also deserves consideration. It is, therefore necessary to clearly establish the financial viability of the system by experimentation on a fairly large scale. More advanced systems involving subsurface irrigation wherein water is delivered directly in the root zone have been used in other countries and further research and development is called for before trying these systems in our country.

Another problem that is encountered in these areas is the strong wind regime obtaining in these places. In addition to increasing evaporation losses, strong winds lead to shifting sands. The formation and movement of sand dunes in the desert areas is well known. Though introduction of irrigation may stabilise the surface by the formation of a thin crust at the top, still the undulating nature of the terrain poses problems. Establishment of tree barriers and other methods for stabilising the dunes can overcome this problem This problem can also be taken advantage of by installing wind mills for harnessing this source of energy for manifold uses.

A number of ecological problems can develop when irrigation is extended extensively in the arid areas which have remained thirsty for long periods. Field studies have shown that in part of the command area of Rajasthan Canal Project Stage–II a shallow hard pan or a cemented alluvial layer is present at depths ranging from 5 to 10 metres below ground level. Deep percolation from intensive irrigation may lead to the development of high water table. Problems of waterlogging and soil salinity could easily develop. The problem of water logging is already reported to be faced in a few areas in Rajasthan Canal Project Stage–I. Our engineers and farm scientists should be forewarned so that the deterioration, if any, detected is arrested in the beginning stages itself and is not allowed to grow into a big problem calling for costly remedial measures. Rajasthan Canal has started delivering water into new areas. It is necessary that by judicious regulation of water use and by regular and continued observations, such situations are not allowed to develop.

Construction of a very big canal network in arid areas itself poses a number of problems. The remoteness and barrenness of the country side and scarcity of water for drinking and construction purposes, non-availability of local construction labour as the canal alignment generally passes through scarcely populated areas, inadequacy of road and rail communication facilities are some of the difficulties faced. These problems may have to be resolved by specific and concerted action.

Before conclusion, I wish to say a few words about the general criticism that is made regarding the long time taken for the completion of the Rajasthan Canal Project. As all of you know the Rajasthan Canal Project is one of the largest irrigation projects of the World. The length of the Main Canal including feeder itself is 650 km. If the length of the distributaries and minors are taken into consideration the length of the channels to be constructed will be more than 6500 km. The work of the project had to be done in rather inhospitable terrain and conditions. The materials of construction had to be transported even longer distances and in the face of shortage. Even for providing construction and drinking water long pipeline or baby canal had to be constructed. The financial constraints have also contributed to this. In spite of all the above difficulties over 500 km of main canal including feeder along with distributary system has been completed and an irrigation potential of nearly 7 lakhs hectares has been created. Earth work and canal lining is in progress in the next 70 km of length and earth work is in progress in the balance length of the canal. This itself is a task of no small magnitude.

Providing irrigation facilities to areas where even drinking water was not available earlier, will be a great boon to the people of the area. Our farmers are highly industrious, well aware of the possibilities for development, and are keen to adopt technologies which are demonstrated to be good and beneficial and I am sure with the assistance of the research staff and agricultural extension workers they would make the best use of the facilities provided to them and contribute to the country's economic prosperity. I am glad to inaugurate this Seminar on Irrigation in Arid Lands.

Jai Hind.

APPENDIX—I

# GOVERNMENT OF INDIA
# MINISTRY OF IRRIGATION

## RESOLUTION

New Delhi, the 18th August 1982

No. 19 (2)/82-P. III : It has been decided to constitute a High Level Technical Committee on Hydrology with the following composition :—

| | | |
|---|---|---|
| (i) | Chairman, Central Water Commission, New Delhi | Chairman |
| (ii) | Director General, Council of Scientific and Industrial Research, New Delhi. | Member |
| (iii) | Chairman, Central Electricity Authority, New Delhi. | " |
| (iv) | Chairman, Central Ground Water Board, New Delhi. | " |
| (v) | Chairman, Central Board of the Prevention & Control of Water Pollution New Delhi. | " |
| (vi) | Director General, Indian Council of Agricultural Research, New Delhi. | " |
| (vii) | Director General, Geological Survey of India, Calcutta. | " |
| (viii) | Director General of Meteorology, New Delhi. | " |
| (ix) | Director, National Institute of Hydrology, Roorkee. | " |
| (x) | President, Forest Research Institute & Colleges, Dehradun. | " |
| (xi) | Director, National Remote Sensing Agency, Hyderabad. | " |
| (xii) | Dr. Subash Chander, Indian Institute of Technology, Hauz Khas, New Delhi. | " |
| (xiii) | Dr. Satish Chandra, School of Hydrology, University of Roorkee, Roorkee. | " |
| (xiv) | Chairman, Narmada Control Authority, New Delhi. | " |
| (xv) | Engineer-in-Chief, Irrigation Department, Uttar Pradesh, Lucknow. | " |
| (xvi) | Chief Engineer, Ground Water Department West Bengal, Calcutta. | " |
| (xvii) | Chief Engineer, Irrigation, Maharashtra, Bombay. | " |
| (xviii) | Chief Engineer, Ground Water Deptt. Tamil Nadu, Madras. | " |
| (xix) | Chairman, Brahmaputra Board, Gauhati. | " |
| (xx) | Senior Scientist, International Hydrological Programme. | Member-Secretary |

2. The functions of the High Level Technical Committee on Hydrology shall be as follows :

(i) To prepare and periodically up date the state of art in the country in different branches of Hydrology by collecting relevant information relating to hydrological work from national organisations and disseminating the same;

(ii) To identify areas in the fields of hydrology and water resources which need immediate attention or in whlch new methods of observation processing and analysis may have to be introduced in order to bring up the level of activity to international standards;

(iii) To encourage the national institutions to take up research studies and developmental activity in the fields which have been identified by the Committee as priority areas. Where necessary the Committee itself should sponsor research/development by providing the necessary funds.

(iv) To appoint special task forces/expert panels to consider special problems for advice to the Committee.

(v) To promote education and training in the field of hydrology and water resources. Special attention may be paid to (a) organising short term courses for professionals and technicians on specialised topics and; (b) organising international training seminars with the assistance of UNESCO/WMO or other international organisations, where required, on topics which are considered by the Committee to be of importance to the Indian professionals and scientists or the region as a whale.

(vi) To foster collaborative studies with other countries under the existing bilateral and aid programmes, if possible, or by special arrangements;

(vii) To co-ordinate effective participation by India in the international hydrological programme of UNESCO and Operational Hydrology Programme of WMO and other Inter-Governmental Programmes of Hydrology in which India may wish to participate.

(viii) To disseminate information and thereby promote improvement in the standards of hydrological activity by (a) publishing (i) a quarterly journal containing research/review papers, notes, news from various centres on their hydrological activities etc. (ii) Annotated Bibliography on hydrology and water resources referring to the research work done in different institutions in India including abstracts of the post-graduate and Ph. D. theses completed at Indian institutions and (iii) Monographs, Guides, Manuals and other publications on Indian Hydrology Series and (b) by organising national and international symposia, seminars, workshops etc. on topics of relevance and interest or supporting such national events.

(ix) To provide advice to Central and State Government agencies on the problems referred to the Committee.

(x) To maintain effective cooperation with other National Committee and Boards.

(xi) To carry out technical scrutiny of individual schemes drawn up by the National Institute of Hydrology for inclusion in the Annual/Five Year Plans/External Assistance.

(xii) To examine the expansion proposal of the National Institute of Hydrology.

(xiii) To carry out technical scrutiny of the research programme of National Institute of Hydrology and to recommend priorities.

3. The recommendations made by the High Level Technical Committee on Hydrology will be considered by the Governing Body of the National Institute of Hydrology.

( C. C. Patel )
Secretary to the Government of India

## ORDER

Ordered that the above Resolution may be published in the Gazette of India.

( C. C. Patel )
Secretary to the Government of India

To

The Manager,
Government of India Press,
Faridabad (Haryana)

Ordered also that this Resolution be communicated to all the State Govts., UTs, the Private and Military Secretaries to the President, Prime Minister's Office, Comptroller & Auditor General of India, the Planning Commission and all Ministries/Deptts of Central Govt, for information.

Ordered also that the Resolution be published in the Gazette of India and the State Govts be requested to publish it in the State Gazettes for General information.

( C. C. Patel )
Secretary to the Government of India