

REPORT
OF
THE KRISHNA GODAVARI COMMISSION

99



X5 (D26) 1.2 RK. NGE
K2
87582



JULY 1962

For Official Use Only

MINISTRY OF IRRIGATION AND POWER



REPORT
OF
THE KRISHNA GODAVARI COMMISSION

JULY 1962

**PRINTED IN INDIA BY THE GENERAL MANAGER,
GOVERNMENT OF INDIA PRESS, NEW DELHI, 1962**

No. 1-61-KGC.

Government of India
MINISTRY OF IRRIGATION AND POWER.

New Delhi, the 21st August, 1962.

To

The Secretary to the Government of India,
Ministry of Irrigation and Power,
New Delhi.

Sir,

We have pleasure in forwarding the report of the Commission appointed by the Government of India *vide* Resolution No. F. (17)/61-Adm. II dated the 1st May, 1961.

2. In dealing with our terms of reference, we felt that it was necessary also to study some other important aspects connected with the water resources development of the Krishna and Godavari basins. The report includes the result of this study.

3. The report is accompanied by 37 Plates and 18 Annexures.

4. The report is unanimous.

Yours faithfully,

N. D. Gulhati
D. D. Jaini
R. C. Hoon

THE KRISHNA GODAVARI COMMISSION

1st May 1961 to 31st July 1962

| | | | | | | | | | | |
|------------------|---|---|---|---|---|---|---|---|---|---------------|
| Chairman | . | . | . | . | . | . | . | . | . | N. D. Gulhati |
| Members | . | . | . | . | . | . | . | . | . | D. D. Jaini |
| | | | | | | | | | | R. C. Hoon |
| Secretary | . | . | . | . | . | . | . | . | . | Bhim Sen |

Officers of the Commission:

| | | | | | | | | | | |
|-----------------------------------------------|---|---|---|---|---|---|---|---|---|-----------------------------------------|
| A. N. Malhotra (Consultant) | . | . | . | . | . | . | . | . | . | (7th July to 6th October 1961) |
| B. S. Johri (Superintending Engineer) | . | . | . | . | . | . | . | . | . | (4th August to 30th December 1961) |
| U. C. Arora (Executive Engineer) | . | . | . | . | . | . | . | . | . | (3rd July to 30th December 1961) |
| K. S. S. Murthy (Deputy Director) | . | . | . | . | . | . | . | . | . | (13th September 1961 to 31st July 1962) |
| S. R. Bhala (Executive Engineer) | . | . | . | . | . | . | . | . | . | (15th July 1961 to 31st July 1962) |
| A. K. Sengupta (Assistant Director) | . | . | . | . | . | . | . | . | . | (15th May 1961 to 31st July 1962) |
| A. S. Ramamoorthy (Assistant Director) | . | . | . | . | . | . | . | . | . | (10th May 1961 to 31st July 1962) |
| K. D. Thite (Extra Assistant Director) | . | . | . | . | . | . | . | . | . | (15th July 1961 to 31st July 1962) |
| T. S. Sohal (Senior Draftsman) | . | . | . | . | . | . | . | . | . | (12th May 1961 to 31st July 1962) |

CONTENTS

| | <i>Page</i> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Definitions and abbreviations | (vii) |
| Units | (xi) |
| CHAPTER I—INTRODUCTORY | |
| Appointment and terms of reference; collection of data and procedure; other sources of data; acknowledgements; accuracy of data; basin-wide survey | 1 |
| CHAPTER II—THE KRISHNA AND GODAVARI BASINS | |
| The basin boundaries; political sub-divisions; political changes since Independence; topo-graphy; geology | 9 |
| CHAPTER III—THE KRISHNA RIVER SYSTEM | |
| The Krishna; the Ghataprabha; the Malaprabha; the Bhima; the Tungabhadra; the Musi; sub-basins | 20 |
| CHAPTER IV—THE GODAVARI RIVER SYSTEM | |
| The Godavari; the Pravara; the Purna; the Manjra; the Pranhita; the Indravati; the Sabari; sub-basins; Krishna and Godavari rivers compared. | 25 |
| CHAPTER V—CLIMATE | |
| Mean temperature; rainfall; rainfall variations; evaporation; evapotranspiration | 31 |
| CHAPTER VI—SOILS | |
| General; principal soil types; drainage characteristics of soils; effect of rainfall on soil formation; behaviour of different soil types under irrigated agriculture; crops grown in relation to soil types; predominant soil types by districts; need for comprehensive scientific soil surveys | 48 |
| CHAPTER VII—LAND USE AND AGRICULTURAL PRACTICES | |
| Introductory; land use; crop pattern in Krishna basin; crop pattern in Godavari basin; crop pattern in Krishna and Godavari basins compared; crop pattern under tanks, canals and wells; recent trends in crop pattern in irrigated areas; crop seasons; preparation of land for irrigation; soil conservation; contour bunding; afforestation; land use statistics required by basins and projects | 63✓ |
| CHAPTER VIII—REGIONAL ECONOMY | |
| General; population; forests and agriculture; power; mineral wealth; industries; scarcity areas; dependence on rainfall and water resources | 99✓ |
| CHAPTER IX—RIVER FLOW | |
| Available flow data; reliability of available data; uneven distribution of discharge sites; general features of river flow; lack of flow data at project sites; estimating river flow for project purposes; proposals for comprehensive system of discharge observations; need for a special organisation; appraisal of the present position; quality of river waters | 109 |

| | <i>Page</i> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| CHAPTER X—GROUND WATER RESOURCES | |
| Nature of sub-soil strata; tubewells; surface wells; possibility of further development; | 145 ^v |
| CHAPTER XI—HYDROLOGIC CHARACTERISTICS | |
| General; rainfall zones; disposal of rain waters; losses by direct evaporation; direct use for sustaining plant life; contribution to ground waters; contribution to stream flow; effect of small tanks on stream flow; transit losses; river gains; valley storage; water balance | 153 |
| CHAPTER XII—WATER RESOURCES DEVELOPMENTS UP TO 1951 | |
| Wells; tanks; diversions; minor schemes; operational statistics of small tanks and diversions and minor schemes; delta canals; other irrigation works; power development; navigation; reservoir losses; drainage | 159 ^v |
| CHAPTER XIII—DEVELOPMENTS SINCE 1951 | |
| General; works in operation in 1951; works which have come into operation since 1951; works under construction; overall magnitude of new developments; reservoir losses; drainage; other uses; change in scope of projects during construction; exclusive developments; main aim of irrigation projects; high costs of projects; full development many years hence | 171 ^v |
| CHAPTER XIV—FURTHER DEVELOPMENTS—PROPOSED AND CONTEMPLATED | |
| General; new projects on the Krishna; new projects on the Godavari; reservoir losses; proposed annual diversions; other uses; regeneration; optimum use of varying river supply; relative merits of various projects; further developments on pre-1951 projects; nature of the proposals for new works; joint projects; assistance needed by one State from another; need for inter-State co-operation and adjustments; need for an integrated basin-wide plan | 194 ^v |
| CHAPTER XV—AVAILABILITY OF WATER SUPPLIES IN RELATION TO EXISTING AND CONTEMPLATED USES | |
| Examination by sub-basins necessary; sub-basin K. 1 to K. 12; sub-basins G. 1 to G. 12; comments on sub-basin studies; hydrologic characteristics of different sub-basins; limitations on estimates of sub-basin flow; need for caution; some general conclusions; integrated project for lower Godavari; Pochampad project | 222 ^v |
| CHAPTER XVI—DIVERSION OF GODAVARI WATERS TO THE KRISHNA | |
| Physical possibilities; Pochampad-Nagarjunasagar Link; Polavarem-Vijayawada Link; Godavari-Pulichintala link; the Penganga-Pochampad link; consequential changes in various projects; overall effect of the proposed diversions | 290 ^v |
| CHAPTER XVII—IRRIGATION PRACTICES, POLICY AND ADMINISTRATION | |
| Important for optimum development; existing legislation; multiplicity of departments dealing with irrigation development; regulation and distribution of water; Government control on crops to be irrigated ; water rates; economic use of water; drainage; method of paddy cultivation | 295 |
| CHAPTER XVIII—SUMMARY AND RECOMMENDATIONS | |
| General; rainfall; evaporation; river flow; ground waters; developments upto 1951; working statistics of canals and distributaries; developments since 1951; new projects and adequacy of river supplies therefor; administration and management; need for a new policy; need for co-operative approach; irrigation extension service | 306 |

(iii)

| | <i>Page</i> |
|----------------|-------------------------------------------------------------------------------------------------------------------------------|
| APPENDIX A | |
| A | Particulars of visits by the Commission to various parts of the Krishna and Godavari basins and adjoining areas 327 |
| B | Statistics of scarcity areas— <i>taluk-wise</i> 331 |
| C | Rough estimate of the yields from some of the Godavari sub-basins 334 |
| PLATE I | |
| I | Physical map of Krishna-Godavari basins and adjoining areas |
| II | Map of Krishna-Godavari basins and adjoining areas showing district and places visited by the Commission |
| III | Geological map of Krishna-Godavari basins and adjoining areas |
| IV | Map of Krishna-Godavari basins and adjoining areas showing annual isohyets |
| V | iso-evaporation lines (annual) |
| VI | classification of soils |
| VII | general distribution of hard and soft rocks |
| VIII | sites for which discharge data have been made available |
| IX | proposed discharge sites |
| X | diversion schemes |
| XI to XXII | maps of sub-basins K. 1 to K. 12 |
| XXIII to XXXIV | maps of sub-basins G. 1 to G. 12 |
| XXXV | Hydrograph of Krishna River at Vijayawada |
| XXXVI | Hydrograph of Godavari River at Dowlaishwaram |
| XXXVII | Longitudinal section of Godavari-Pulichintala Link |
| Map VI | Map of Krishna Godavari basins and adjoining areas showing existing and proposed projects |

(in separate folder)

- ANNEXURE
- I. Rainfall and evaporation data
 - II. Monthly flow data of the Krishna River System
 - III. Ten-daily discharge data of the Krishna River System
 - IV. Withdrawals by canals—Krishna River System
 - V. Monthly flow data of the Godavari River System
 - VI. Ten-daily discharge data of the Godavari River System
 - VII. Withdrawals by canals—Godavari River System
 - VIII. Particulars of irrigation and hydro-electric schemes in operation, as on 31st March 1951—Krishna River System
 - IX. Particulars of irrigation and hydro-electric schemes which came into operation after March 1951—Krishna River System
 - X. Particulars of irrigation and hydro-electric schemes under construction—Krishna River System
 - XI. Particulars of proposed irrigation and hydro-electric schemes—Krishna River System
 - XII. Particulars of irrigation and hydro-electric schemes in operation as on 31st March 1951—Godavari River System
 - XIII. Particulars of irrigation and hydro-electric schemes which came into operation after March 1951—Godavari River System
 - XIV. Particulars of irrigation and hydro-electric schemes under construction—Godavari River System
 - XV. Particulars of proposed irrigation and hydro-electric schemes—Godavari River System
 - XVI. Irrigation practices, policy and administration in Krishna and Godavari basins
 - XVII. Model experiments regarding flow over the Krishna anicut at Vijayawada and the Godavari anicut at Dowlaiswaram
 - XVIII. Maps of Krishna-Godavari basins and adjoining areas showing
 - I. annual isohyets
 - II. seasonal isohyets—Jan. and Feb.
 - III. seasonal isohyets—Mar. to May
 - IV. seasonal isohyets—June to Sep.
 - V. seasonal isohyets—Oct. to Dec.
 - VI. existing and proposed projects

| | <i>Page</i> |
|--------------------------------------------------------------------------------------------------------------------|-------------|
| TABLE I Distribution of various districts in the Krishna and Godavari basins | 10 |
| II Sub-basins of the Krishna river system | 24 |
| III Sub-basins of the Godavari river system | 29 |
| IV Seasonal and annual weighted average rainfall | 34 |
| V Percentage contribution of rainfall in each season | 36 |
| VI Co-efficient of variability | 39 |
| VII Normal potential evaporation—seasonal and annual | 42 |
| VIII Excess of monthly evaporation over monthly rainfall | 43 |
| IX Monthly evaporation from reservoirs, as assumed in different parts of the Krishna and Godavari basins | 45 |
| X Effect of rainfall on soil formation | 55 |
| XI Cropping pattern by soil types | 56 |
| XII Statistics of land use in Krishna basin and adjoining areas | 64 |
| XIII Statistics of land use in Godavari basin | 68 |
| XIV Area under different crops in Krishna basin and adjoining areas | 74 |
| XV Statistics of irrigated crops in Krishna basin and adjoining areas | 78 |
| XVI Area under different crops in Godavari basin | 84 |
| XVII Statistics of irrigated crops in Godavari basin | 88 |
| XVIII Land Revenue suspensions | 104 |
| XIX List of sites on the Krishna river system for which discharge data have been made available | 110 |
| XX List of sites on the Godavari river system for which discharge data have been made available | 114 |
| XXI Krishna River System—list of sites at which discharge observations should be made daily | 131 |
| XXII Godavari River System—list of sites at which discharge observations should be made daily | 133 |
| XXIII Chemical analysis of waters | 141 |
| XXIV District-wise statistics of wells in the Krishna basin | 146 |
| XXV District-wise statistics of wells in the Godavari basin | 148 |
| XXVI Irrigation development from the Krishna river system as of 1951 | 163 |
| XXVII Irrigation development from the Godavari river system as of 1951 | 164 |
| XXVIII Particulars of projects which have come into operation since 1951—Krishna River System | 174 |

| | <i>Page</i> |
|---------------------------------------------------------------------------------------------------------------------|-------------|
| TABLE XXIX Particulars of projects which have come into operation since 1951—Godavari River System | 177 |
| XXX Particulars of projects under construction—Krishna River System | 182 |
| XXXI Particulars of projects under construction—Godavari River System | 186 |
| XXXII Particulars of proposed projects—Krishna River System | 196 |
| XXXIII Particulars of proposed projects—Godavari River System | 202 |
| XXXIV Important hydrologic characteristics | 284 |
| XXXV Review of estimated yield and project requirements as proposed by State Governments | 286 |

DEFINITIONS

Unless otherwise stated, the following terms, as used in this report, have the following meaning

Abi : *Kharif* crop comprising paddy only, term used in Andhra Pradesh.

Acre-foot : Volume of water required to cover an area of one acre to a depth of one foot.

Anicut : A weir; usually applied to weirs across rivers, sometimes also to tank surplus weirs.

Area cropped : This is the area under all crops, that is, net area sown plus area sown more than once.

Area irrigated : This represents the actual geographical area under irrigated crops in a year; areas bearing two irrigated crops in a year are counted only once.

Area not available for cultivation: This includes all lands occupied by buildings, roads and railways or under water, rivers, canals, *etc.*, and all barren and unculturable lands like mountains and deserts. Land which cannot be brought under cultivation except at a high cost is classed as unculturable whether such land is in isolated blocks or within cultivated holdings.

Authorised capacity : Maximum discharge of a canal, as permitted to be run by competent authority.

Ayacut : Area eligible for irrigation and which is normally intended to be irrigated at least once a year, authorised irrigable area. This term is equivalent to C.C.A. if the intensity of irrigation during *Kharif* is 100 per cent.

Bandhara : A weir across a stream to divert water into a channel for irrigation.

Basin : Short for drainage basin, used in its ordinary geographic sense.

Capacity factor : The ratio of the mean supply run in a canal to its authorised full supply or capacity.

Carry-over : That part of the live storage in a reservoir which is reserved, or is proposed to be left over, for utilisation after the 31st of May following the storage season.

Category of projects

A: schemes in operation as on 31st March 1951;

B: schemes which came into operation after March 1951;

C. 1: schemes under construction;

C. 2: schemes referred to in III Plan but not yet approved for execution in III Plan;

C. 3: schemes not referred to in III Plan.

Consumptive use : Consumptive use represents that volume of water which is used by vegetative growth over an area in transpiration and building of plant tissue and that evaporated from adjacent soil or intercepted precipitation. It is the amount of water that is changed from a liquid to a gaseous state within an area because of evaporation and or transpiration.

Crop season : Period of a year from the beginning of sowing to the harvesting of a crop *e.g.*, *kharif* and *rabi*; or *abi* and *tabi*; or *mungari* and *hingarri*; or *kharif*, *rabi* and hot weather, or two-seasonal and perennial.

Culturable area: Gross area as per village papers less the sum total of area under forests and the area not available for cultivation.

Culturable commanded area: Gross area commanded less area of unculturable land included in the gross area, such as area under villages, roads, rivers, tanks, etc.

This term, when used for projects in Maharashtra and Madhya Pradesh implies the area for which distributary system is provided; irrigation water is applied annually to the whole or part of this area. When applied to projects in Andhra Pradesh, Madras, Mysore and Orissa, it implies the area available, on the supposition of unlimited waters being available.

Cusec: Rate of flow of one cubic foot per second.

Delta: Depth of water that would result over the irrigated area from a given water supply *e.g.*, from the supply diverted to grow a particular crop or the supply diverted to grow all the crops in a crop season. Delta may be as at the outlet, or at distributary head or at canal head.

Overall delta: Depth of water that would result from the total volume of water delivered to a canal in a year, spread over the total area of crops raised in that year.

Dry crop: A crop which does not require large quantities of irrigation water. It is used to distinguish crops like wheat, cotton, *jowar*, etc. from *wet crops* like paddy, sugarcane and gardens.

Duty: When applied to a channel it is the area irrigated during a base period divided by the mean supply utilised in cusecs.

Duty may be as at distributary head or as at canal head.

When applied to tank irrigation, it is the number of acres of irrigation per million cubic feet of water.

First crop: A term used in Madras and Andhra region of Andhra Pradesh for the first crop grown on a field during the agricultural year commencing 1st July or 1st June, no matter when the crop is sown whether in August or in January.

Forests: All actually forested areas or lands classed or administered as forests under any legal enactment dealing with forests whether State-owned or private. If any proportion of such land is not actually wooded but put to some agricultural use, that portion is included under the appropriate heading of cultivated or uncultivated land.

Gross commanded area: Area commanded by the whole project; in Andhra Pradesh, Madras, Mysore and Orissa this area is worked out on the supposition that unlimited water is available.

Hot weather: Summer crop season in Maharashtra, lasting from middle of February to middle of June.

Index number of projects: Indicates the State in which the project is situated, the sub-basin of the river Krishna or Godavari from which water is taken and the category of project.

Illustration: 15C. 1-G. 3-M. 10 indicates 15th project in the list of C. 1 category; G. 3 sub-basin *i.e.*, Purna sub-basin of Godavari river and 10th Project in that category in Maharashtra State.

Irrigated cropped area: The gross irrigated area under all crops in any year and is the sum total of area irrigated plus area irrigated more than once.

Kharif: Summer crops harvested in autumn, extending from 15th June to 14th October in Maharashtra and generally from 1st June to 31st December in Andhra Pradesh, Mysore, Madhya Pradesh and Orissa.

Major scheme: One intended for annual irrigation of 50,000 acres or more and all power projects.

Medium scheme: One intended for annual irrigation of less than 50,000 acres but having a C.C.A. or Ayacut of not less than 5,000 acres.

Minor scheme: One having a C.C.A. or Ayacut of less than 5,000 acres but not less than 500 acres.

(ix)

Net area sown: This represents the actual geographical area under the crops, orchards and fodder; areas cropped more than once in a year are counted only once.

One seasonal: Applies to a canal which delivers water during only one crop-season.

Perennial: Applies to a canal which delivers water all the year round, or most of the year, for crops like sugar-cane, gardens, *etc.*, also applies to such crops.

Rabi: Winter crop harvested in spring, extending from 15th October to 14th February in Maharashtra and Madhya Pradesh and generally from 1st January to 31st May in other States.

Second crop: A term used in Madras and Andhra region of Andhra Pradesh for the second crop grown on any area in an agricultural year after the first crop has been harvested.

Small tank or diversion: A scheme having a C.C.A. or Ayacut of less than 500 acres.

Tabi: *Rabi* crop comprising paddy only—term used in Andhra Pradesh.

Two-seasonal: Applies to a canal which delivers water for two crop-seasons; also applies to crops which extend from one crop season to the other.

Wet crop: Crops like paddy, sugarcane and gardens, requiring large supplies of irrigation water.

ABBREVIATIONS

In the Index Number

| | | | |
|---------------|---|---|--------------------------------------------------------------------------------------|
| A. | . | . | stands for Andhra Pradesh |
| Ma. | . | . | stands for Madhya Pradesh |
| Md. | . | . | stands for Madras |
| M. | . | . | stands for Maharashtra |
| My. | . | . | stands for Mysore |
| O. | . | . | stands for Orissa |
| C.C.A. | . | . | Culturable commanded area |
| G.C.A. | . | . | Gross commanded area |
| G. 1 to G. 12 | . | . | sub-basins of the Godavari basin |
| K. 1 to K. 12 | . | . | sub-basins of the Krishna basin |
| kW. | . | . | kiloWatt |
| L.S. Cotton | . | . | Long staple cotton |
| M.A.F. | . | . | Million acre feet |
| M. Cft. | . | . | Million cubic feet |
| N.A. | . | . | Not available |
| pH. | . | . | A measure of the hydrogen ion concentration in water or soil (acidity or alkalinity) |
| R.L. | . | . | Reduced level, referred to mean sea level |
| T.M.C. | . | . | Thousand million cubic feet |

UNITS

(All figures are correct to two places of decimals)

1. Linear

| | | | |
|---------------|-----------------------------------------------------|------------------------|---------------------------|
| 1 inch | =25.4 millimetres | 100 millimetres | =3.94 inches |
| 1 foot | =12 inches =304.8 millimetres | 1 metre | =3.28 feet =1.09 yards |
| 1 mile | =5,280 feet =1,609.34 metres =1.61 kilometres | 1 kilometre | =0.62 mile |

2. Area

| | | | |
|----------------------|--------------------------------------|---------------------|-----------------------------------|
| 1 acre | =4,840 square yards =0.40 hectare | 1 hectare | =2.47 acres |
| | | 100 hectares | =247.1 acres =0.39 square mile |
| 1 square mile | =640 acres =259 hectares | | |

3. Volume

| | | | |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------|---------------------------------------------------------------|
| 1 cubic feet | =0.03 cubic metre =6.23 gallons | 1 cubic metre | =35.32 cubic feet =219.97 gallons |
| 1 million cubic feet | =11.57 cusec-days =22.96 acre-feet =28,316.8 cubic metres =6.23 million gallons | 1 million cubic metres | =35.31 million cubic feet =810.71 acre-feet |
| One thousand million cubic feet. | =28.32 million cubic metres =22,957 acre-feet =385.8 cusec per month (30 days) =6,228.8 million gallons | 1 milliard cubic metres | =0.81 M.A.F. |
| 1 million acre-feet | =43.56 T.M.C. =1.23 milliard cubic metres | | |
| 1 cusec-day | =0.09 million cubic feet =1.98 acre-feet =2,446.57 cubic metres =0.54 million gallons | 1 cubic metre per second for 1 day. | =0.09 million cubic metre =70.05 acre-feet =3.05 M.Cft. |

3. Volume (continued)

1 cusec-month (30 days)
=59.50 acre-feet
=2.59 M.Cft.

1 cubic metre per second for one month (30 days)
=2.59 million cubic metres
=2,101.36 acre-feet
=91.54 M. Cft.

1 cusec-year (365 days)
=723.97 acre-feet
=31.54 M.Cft.

1 cubic metre per second for one year (365 days)
=31.54 million cubic metres
=25,569.79 acre feet
=1.11 T.M.C.

1 million gallons
=160,544 cubic feet
=4,546.09 cubic metres

4. Rates of Flow

1 cubic feet per second
=1.98 acre-feet per day
=0.03 cubic metre per second
=28.32 litres per second
=6.23 gallons per second
=22.424 gallons per hour
=0.54 million gallons per day

1 cubic metre per second
=35.31 cusecs
=70.05 acre-feet per day
=219.97 gallons per second

1 milliard cubic metres per day
=0.41 million cusecs
=0.81 million acre-feet per day

1 acre-foot per day
=0.50 cusecs
=0.015 cubic metre per second
=14.16 litres per second

1 litre per second
=0.04 cusecs
=791.91 gallons per hour

10,000 gallons per hour
=0.45 cusecs
=0.88 acre-feet per day

1 million gallons per day
=1.86 cusecs
=3.69 acre-feet per day

Gallon is imperial gallon=1.20 U.S. gallons
Milliard=1,000 million=1,000,000,000.

CHAPTER I

INTRODUCTORY

Appointment and terms of reference

1-1 The Commission was appointed by the Government of India on the 1st May, 1961, and its composition and terms of reference were set out in the following Resolution:

RESOLUTION

[No. F. 1 (17)/61-Adm. II dated the 1st May, 1961]

“ The Government of India have had under consideration the question of reviewing the position in respect of availability of supplies in the Krishna and Godavari rivers with a view to determining the extent to which further demands on these waters could be met. It has now been decided to set up a Commission for this purpose.

“2. The Commission shall consist of :

- (i) Shri N. D. Gulhati, I.S.E. (Retired)—Chairman
- (ii) Shri D. D. Jaini, I.S.E. (Retired)—Member
- (iii) Dr. R. C. Hoon, Director, Central Water and Power Commission—Member

“3. The terms of reference of the Commission shall be as follows:—

(1) To report on the availability of supplies in the Krishna on the basis of annual flow at Vijayawada and other points taking into account upstream utilisation and allowing for regeneration—

- (i) for 86 per cent dependability as assumed in 1951;
- (ii) for 75 per cent dependability; and
- (iii) for such other criterion of dependability as may be considered appropriate.

(2) To report on the requirements of the projects on the Krishna—

- (i) in operation in 1951;
- (ii) as approved by the Government of India for execution;
- (iii) included in the Plans but not yet approved by the Government of India;
- (iv) further proposed by the States ; and
- (v) such minor schemes as may have been sanctioned up to March 1961.

(3) To report on the availability of supplies in the Godavari on the basis of annual flows at Dowlaishwaram and other points taking into account upstream utilisation and allowing for regeneration—

- (i) for 86 per cent dependability as assumed in 1951;
- (ii) for 75 per cent dependability; and
- (iii) for such other criterion of dependability as may be considered appropriate.

(4) To report on the requirements of the projects on the Godavari—

- (i) in operation in 1951;
- (ii) as approved by the Government of India for execution;
- (iii) included in the Plans but not yet approved by the Government of India;
- (iv) further proposed by the States; and
- (v) such minor schemes as may have been sanctioned upto March 1961.

(5) To report on the feasibility of diverting any surplus supplies in the Godavari to the Krishna indicating the quantity to be diverted and the order of the cost involved.

“4. The Commission shall frame its own rules of business and submit its report by the end of November 1961.

“5. The Commission shall have its headquarters in New Delhi.”

1-2 As the magnitude of the task unfolded itself and it was found that the technical data and other information required by the Commission was not readily available with the State Governments, it became necessary to extend the term of the Commission to 31st July, 1962.

Collection of data and procedure

1-3 As a first step, the Commission visited Hyderabad, Bombay, Bhopal, Bangalore and Bhubaneshwar and held preliminary discussions with the representatives of the Governments of Andhra Pradesh, Maharashtra, Madhya Pradesh, Mysore and Orissa.* At these discussions, the Commission requested for the supply of all available data with regard to river flows, working statistics of canals and reservoirs in operation, project reports of schemes under construction and of those contemplated and other information relevant to its enquiry.

*In January 1962, the Madras Government requested the Commission to take note of their requirements of water from the Krishna and Godavari rivers, both for agricultural purpose and for water supply to Madras city. The procedure outlined in paragraphs 1-3 to 1-14, to the extent it was applicable was also followed with respect to this request.

1-4 It was found that the river flow data had not been printed or even compiled except for some years for the Krishna at Vijayawada and the Godavari at Dowlaishwaram. The data for other sites, to the extent these had been observed, had not been compiled and had to be collected from field officers. In view of the political changes described in paragraphs 2-6 to 2-10 *infra*, this collection, it was found, would take considerable time.

1-5 With regard to the working statistics of canals and reservoirs, the position was equally unsatisfactory. These statistics had never been published, nor even compiled. While some information about major irrigation works was available in the administration reports of the Public Works Departments of the former Madras Presidency and the former Bombay Presidency, no information published or otherwise, was readily available about any irrigation work in the former Hyderabad State, the former Mysore State, the former Central Provinces and Orissa. It was stated that it would be necessary to ask the local officers to trace whatever information was available with them and then to collect and compile it.

As regards statistics for the large number of minor schemes and the still larger number of small tanks and diversions, the State Governments expressed doubt whether any working statistics would at all be available since most of these works were under the control and management not of the Public Works Department but of the revenue officers.

1-6 The Commission was concerned to note the almost complete absence of published statistics relating to the Krishna and Godavari basins and the fact that most of the important data and information relating to water resources development in the two basins were either non-existent or had not been compiled and analysed before. It appeared that one of the important tasks of the Commission would be to get together, compile and analyse whatever data could be obtained within the time available to it.

After discussion with each State Government, lists were drawn up of the data and information which would be collected and furnished to the Commission.

1-7 During the preliminary discussions referred to above, each State Government agreed to the request of the Commission—

- (i) that the data and information furnished to the Commission by one State Government be supplied by the Commission to the other States concerned, on a reciprocal basis;
- (ii) that the State Government would have no objection to representatives of the other concerned States accompanying the Commission on its visit to various works and sites in the State provided that the representatives of the State Government were afforded similar facilities by other States; and
- (iii) that at appropriate stages, joint meetings be convened by the Commission between itself and the representatives of the concerned States.

1-8 The terms of reference of the Commission called for a report on the requirements of projects of various classes. After a preliminary examination, the Commission decided to divide the projects into five categories* as follows:—

| | |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Category A | Schemes in operation as on 31st March, 1951. |
| Category B | Schemes which came into operation after March 1951 (generally limited to the scope as defined in the sanctioned project report) |
| Category C. 1 | Schemes under construction (limited in case of phased schemes to the stages to which financial sanction had been accorded) |
| Category C. 2 | Schemes referred to in III Plan but not yet approved for execution (limited, where necessary, to the scope as defined in the Plan) |
| Category C. 3 | Schemes and projects not referred to in III Plan and later stages of C. 1 schemes to which financial sanction had not yet been accorded. |

Any changes or improvements made in category A schemes after March 1951 have, for convenience, been described along with the particulars of these projects as of March 1951.

1-9 Under each category, the projects were sub-divided into the following four groups:

- (a) major projects, each intended for annual irrigation of 50,000 acres or more and all power projects;
- (b) medium projects, each intended for annual irrigation of less than 50,000 acres but having C.C.A. or Ayacut of not less than 5,000 acres;
- (c) minor schemes, each having C.C.A. or Ayacut of less than 5,000 acres but not less than 500 acres; and
- (d) small tanks and diversions, each having C.C.A. or Ayacut of less than 500 acres.

1-10 For facility of reference, each major and medium project has been given an index number; for instance, 15C. 1-G.3-M. 10 indicates that:

- (a) the project has an overall serial number 15 in the projects of category C. 1;

*During discussions between the Commission and the representatives of the state Governments concerned objections were raised in case of some projects to the category accorded to it by the Commission in accordance with the definition given above. Such objection arose primarily out of a feeling that the categories adopted by the Commission would eventually determine priorities between the various schemes. The Commission made it clear to the representatives of the State Governments that the projects have been divided into these categories as a matter of convenience in presentation and that the category allotted to a particular project did not, by itself imply any priority whatever. These priority, it was affirmed, would be determined in accordance with the usual procedure.

- (b) the project takes its supplies from G. 3 sub-basin *i.e.* Purna sub-basin of Godavari river; and
- (c) the project is 10th in the list of Maharashtra projects in this category.

The overall serial number in each category has been allotted starting with projects from the upstream end of each river to its lower end, followed by projects on tributaries, starting again from their upstream ends.

1-11 Printed Project Reports were available only for a few of the schemes under construction; even these required to be brought up to date because of changes which had been approved during the course of execution. A perusal of these reports also revealed that they did not contain all the information required by the Commission.

As regards the large number of projects, which were contemplated, no project report was generally available.

Accordingly, the Commission proposed special forms, indicating the particulars required for each category of project, and requested the State Governments to fill the relevant forms for each project. Detailed explanatory notes for filling the forms were furnished by the Commission. It took considerable time to obtain the information required as most of it was not readily available with the State Governments, in some cases not even for the projects under construction or those referred to in III Plan. Several discussions were held between the Commission and the representatives of the State Governments, individually and jointly, before the necessary information was compiled, to the extent it could be made available.

1-12 Apart from the visits to the State Capitals for the preliminary discussions referred to in paragraph 1-3 above, the Commission visited various parts of the Krishna and Godavari basins to see irrigation and power projects, discharge sites, areas proposed to be developed and, in general, to acquaint itself with local conditions and problems. Apart from journeys by air, a total length of 6,500 miles in the two basins was covered generally by road and, in most of these visits, the representatives of all the concerned States accompanied the Commission. Plate II shows the places visited and the route taken by the Commission in these visits; other particulars are given in Appendix A.

1-13 The Commission held the following joint meetings with the representatives of all the concerned States:

- | | | |
|----------------------------------------------|-----------|---------|
| (i) 3rd to 10th October, 1961, at New Delhi | | 8 days |
| (ii) 19th to 21st October, 1961, at Bombay | | 3 days |
| (iii) 4th November, 1961 at Hyderabad | | 1 day |
| (iv) 16th to 26th April, 1962, at Ootacamund | | 11 days |

At the first joint meeting held from 3rd to 10th October, 1961, there was a general exchange of views on the following subjects connected with the Commission's enquiry:

- (a) Available gauge and discharge data in the Krishna and Godavari basins;

- (b) Model experiments to determine the discharge co-efficient for Krishna anicut;
- (c) Proposals for establishing a comprehensive system of discharge observations in the Krishna and Godavari basins;
- (d) Rainfall run-off studies;
- (e) Regeneration;
- (f) Evaporation losses in Krishna and Godavari basins;
- (g) Dependability;
- (h) Soil characteristics; existing agricultural and irrigation practices; crops; deltas and duties in different parts of the Krishna and Godavari basins; and
- (i) Diversion of Godavari waters into Krishna.

Working Papers on these subjects, which had been prepared by the Commission, formed the basis of discussion. The views expressed at this meeting by the representatives of various State Governments and those furnished in subsequent notes on these subjects have been very helpful to the Commission.

The discussions at the joint meetings in Bombay, Hyderabad and Ootacamund related mostly to projects and schemes, their scope and requirements and other relevant data.

1-14 The Commission also held several meetings separately with the representatives of each State. These meetings took in all 83 working days, spread over a period of about 10 months, and related mostly to an examination and discussion of the particulars of various projects, referred to in paragraphs 1-8 and 1-9 above. During the course of these discussions, important features of many projects were modified by the representatives of the State Governments.

1-15 During the Commission's visit to various parts of the Krishna and Godavari basins, considerable emphasis was laid on the special requirements and claims of what were called "scarcity areas". In order to assess these requirements, after a discussion with the representatives of all State Governments, special forms were drawn to indicate all the relevant particulars on a common comparable basis. The State Governments were then requested to fill these forms for those *talukas* in the Krishna and Godavari basins which the State Governments regarded as "scarcity areas".

1-16 During the visits referred to above, the Commission had an opportunity to discuss irrigation and power requirements, methods, procedure and technique, with senior officers of the irrigation, electricity, revenue and agriculture departments of the State Governments. The Commission also met a large number of cultivators and received numerous representations. These representations were passed on to the State Government concerned, who were requested to take note of the requirements of the cultivators and let the Commission have the necessary particulars of such schemes as the State Government considered necessary in the light of these representations.

Other sources of data

1-17 Apart from the lack of statistics and the difficulties of collecting and compiling whatever data did exist, as explained in paragraphs 1-4, 1-5 and 1-11 above, another serious difficulty which the Commission had to encounter, at all stages of its work, arose out of the fact that general statistics, collected with the district as a unit, could not be applied directly to hydrologic units—river basins and sub-basins. Again, some of the published statistics were found to be inconsistent and apparently incorrect.

1-18 Some of the maps supplied by different State Governments were, on assembly, found to show dis-continuity of physical features at the State borders, sometimes, even at the boundary between the two basins. The Commission had therefore to seek other sources of information in order to find more reliable and consistent data on which to base its report. These sources are the India Meteorological Department, the Geological Survey of India, the Chief Soil Survey Officer of the Indian Agricultural Research Institute, the Central Water and Power Commission and the publications of the Central Board of Irrigation and Power.

Acknowledgements

1-19 The Commission is particularly grateful to Shri A. K. Mallik, Deputy Director General, India Meteorological Department, Poona, who compiled and made available to the Commission the meteorological data for the Krishna and the Godavari basins, prepared the isohyetal maps, seasonal and annual, and referred the Commission to various technical notes dealing with climatic features in which the Commission was interested. He also examined the draft of Chapter V and made useful suggestions.

1-20 The Commission is grateful to the Director, Map Publication Office of the Survey of India for printing the maps and some of the Plates in the report. Without his willing co-operation and help it would not have been possible to prepare these maps in the time available.

The Commission is also grateful to the Controller of Printing and the Manager, Government of India Press, New Delhi for their assistance in printing the report, a large number of plates and the voluminous annexures.

1-21 The Commission would like to place on record its sense of gratitude for the courtesies and the co-operation extended to it by the State Governments of Andhra Pradesh, Madhya Pradesh, Madras, Maharashtra, Mysore and Orissa and its appreciation of the willing efforts made, at all stages, to collect, compile and furnish the technical data and other information required by the Commission.

The Commission is also grateful to the Chief Engineers, Commissioners and other officers of the States who accompanied the Commission on its visits to various parts of the two basins and furnished the information sought by the Commission.

These visits, in which representatives of all the concerned States also participated, required elaborate arrangements for accommodation and transport *etc.*

The thoroughness and efficiency with which these visits were organised were greatly appreciated by the Commission and all other participants.

Accuracy of data

1-22 As stated above, the report of the Commission is based largely on the technical data and other information supplied by the State Governments concerned. It was not possible for the Commission to carry out any physical verification of these data nor was this considered necessary. The responsibility for the accuracy of these data rests with the State Governments. However, during the course of compilation and study of these data, many discrepancies came to light; these were pointed out to the State Governments and corrections were made where necessary.

Basin-wide survey

1-23 Both for the Krishna and the Godavari basins, this report is the first attempt at a basin-wide survey of the technical information relevant to water resources development. Accordingly, a large part of the time of the Commission was spent in the collection of the requisite data and information from the State Governments and many other sources. Out of a period of 15 months of the life of this Commission, almost 13 months were spent in this collection and compilation of the data.

It may be mentioned here that the basin-wide survey made in this report is not a *Basin-wide plan*, even though a large part of the information contained herein would be of considerable use in the preparation of such a plan.

CHAPTER II

THE KRISHNA AND GODAVARI BASINS

The basin boundaries

2-1 The Krishna and Godavari basins (see Plate I) extend over an area larger than France. They cover about 221,000 square miles, more than one-sixth of the entire area of India. Taken together, the two basins have a maximum width, from north to south, of 532 miles between latitudes 23°41' N and 13° 7' N and a maximum length, from east to west, of 636 miles between longitudes 73° 22' E and 83° 7' E.

2-2 The Krishna and Godavari rivers and their numerous tributaries drain the eastern slopes of the Western Ghats for a length of about 520 miles, from near Mangalore in the south to 32 miles north of Nasik. From the north, the Godavari receives the entire drainage of the southern slopes of the Satmala Hills, the Ajanta Range and the Mahadeo Hills. From the west, the western slopes of the southern half of the Maikala Range of the Eastern Ghats drain into the Godavari, and south of the Krishna lie the Baba Budan Hills, the Erramalai and the Nallamalai ranges. The two rivers and their tributaries, during their course eastwards into the Bay of Bengal, receive the surface flow from a large part of the Deccan plateau.

Political sub-divisions

2-3 Lying in the north of the Deccan plateau, the two basins include (see Plate II) most of Andhra Pradesh, Maharashtra and Mysore and parts of Madhya Pradesh and Orissa. The State-wise distribution of the drainage basins of the two rivers is as follows :

| | <i>Krishna</i> | <i>Godavari</i> | <i>Total</i> |
|--------------------------|------------------------|-----------------|--------------|
| |square miles..... | | |
| Andhra Pradesh | 29,441 | 28,263 | 57,704 |
| Madhya Pradesh | .. | 25,195 | 25,195 |
| Maharashtra | 26,805 | 58,764 | 85,569 |
| Mysore | 43,734 | 1,701 | 45,435 |
| Orissa | .. | 6,854 | 6,854 |
| Total | 99,980 | 120,777 | 220,757 |

TABLE I

DISTRIBUTION OF VARIOUS DISTRICTS IN THE KRISHNA AND GODAVARI BASINS
 [Figures in column 3 are from "India 1961", those in other columns are based on planimeter measurements]

| Serial number | State District | Area (square miles) | Krishna Basin | | Godavari Basin | | Krishna and Godavari Basins | | Outside Krishna Godavari Basins | |
|-----------------------|-------------------|---------------------|---------------|---------------------|----------------|---------------------|-----------------------------|---------------------|---------------------------------|---------------------|
| | | | Percentage | Area (square miles) | Percentage | Area (square miles) | Percentage | Area (square miles) | Percentage | Area (square miles) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| ANDHRA PRADESH | | | | | | | | | | |
| 1 | Adilabad . . . | 6,236 | .. | .. | 100.0 | 6,236 | 100.0 | 6,236 | .. | .. |
| 2 | Anantapur . . . | 7,385 | 23.6 | 1,743 | .. | .. | 23.6 | 1,743 | 76.4 | 5,642 |
| 3 | Chittoor . . . | 5,908 | .. | .. | .. | .. | .. | .. | 100.0 | 5,908 |
| 4 | Cuddapah . . . | 5,924 | .. | .. | .. | .. | .. | .. | 100.0 | 5,924 |
| 5 | East Godavari . . | 5,773 | .. | .. | 66.8 | 3,857 | 66.8 | 3,857 | 33.2 | 1,916 |
| 6 | Guntur . . . | 5,795 | 36.4 | 2,110 | .. | .. | 36.4 | 2,110 | 63.6 | 3,685 |
| 7 | Hyderabad . . . | 2,904 | 98.5 | 2,860 | 1.5 | 44 | 100.0 | 2,904 | .. | .. |
| 8 | Karimnagar . . . | 4,504 | 0.3 | 14 | 99.7 | 4,490 | 100.0 | 4,504 | .. | .. |
| 9 | Khammam . . . | 4,600 | 43.5 | 2,001 | 51.8 | 2,383 | 95.3 | 4,384 | 4.7 | 216 |
| 10 | Krishna . . . | 3,502 | 42.5 | 1,488 | .. | .. | 42.5 | 1,488 | 57.5 | 2,014 |
| 11 | Kurnool . . . | 9,277 | 42.4 | 3,933 | .. | .. | 42.4 | 3,933 | 57.6 | 5,344 |
| 12 | Mahbubnagar . . | 6,833 | 100.0 | 6,833 | .. | .. | 100.0 | 6,833 | .. | .. |
| 13 | Medak . . . | 3,804 | 15.2 | 578 | 84.8 | 3,226 | 100.0 | 3,804 | .. | .. |

| | | | | | | | | | | |
|----|---------------|-------|-------|---------------|-------|---------------|-------|---------------|-------|-------|
| 14 | Nalgonda | 5,351 | 100.0 | 5,351 | .. | .. | 100.0 | 5,351 | .. | .. |
| 15 | Nellore | 7,954 | .. | .. | .. | .. | .. | .. | 100.0 | 7,954 |
| 16 | Nizamabad | 3,203 | .. | .. | 100.0 | 3,203 | 100.0 | 3,203 | .. | .. |
| 17 | Visakhapatnam | 5,200 | .. | .. | 27.5 | 1,430 | 27.5 | 1,430 | 72.5 | 3,770 |
| 18 | Warangal | 5,326 | 47.5 | 2,530 | 52.5 | 2,796 | 100.0 | 5,326 | .. | .. |
| 19 | West Godavari | 2,988 | .. | .. | 20.0 | 598 | 20.0 | 598 | 80.0 | 2,390 |
| | Total | | | 29,441 | | 28,263 | | 57,704 | | |

MADHYA PRADESH

| | | | | | | | | | | |
|---|--------------|--------|----|----|------|---------------|------|---------------|------|-------|
| 1 | Balaghat | 3,573 | .. | .. | 75.8 | 2,708 | 75.8 | 2,708 | 24.2 | 865 |
| 2 | Bastar | 15,124 | .. | .. | 94.4 | 14,277 | 94.4 | 14,277 | 5.6 | 847 |
| 3 | Betul | 3,884 | .. | .. | 22.3 | 866 | 22.3 | 866 | 77.7 | 3,018 |
| 4 | Chhindwara | 4,565 | .. | .. | 75.8 | 3,460 | 75.8 | 3,460 | 24.2 | 1,105 |
| 5 | Durg | 7,576 | .. | .. | 13.2 | 1,000 | 13.3 | 1,000 | 86.8 | 6,576 |
| 6 | Mandla | 5,127 | .. | .. | 6.2 | 318 | 6.2 | 318 | 93.8 | 4,809 |
| 7 | Raipur | 8,214 | .. | .. | 0.5 | 41 | 0.5 | 41 | 99.5 | 8,173 |
| 8 | Seoni | 3,376 | .. | .. | 74.8 | 2,525 | 74.8 | 2,525 | 25.2 | 851 |
| | Total | | | | | 25,195 | | 25,195 | | |

MADRAS

| | | | | | | | | | | |
|---|-------------|-------|----|----|----|----|----|----|-------|-------|
| 1 | Chingleput | 3,065 | .. | .. | .. | .. | .. | .. | 100.0 | 3,065 |
| 2 | South Arcot | 4,204 | .. | .. | .. | .. | .. | .. | 100.0 | 4,204 |

TABLE I—(Continued)

DISTRIBUTION OF VARIOUS DISTRICTS IN THE KRISHNA AND GODAVARI BASINS

(Figures in column 3 are from "India 1961", those in other columns are based on planimeter measurements).

| Serial Number | State District | Area (square miles) | Krishna Basin | | Godavari Basin | | Krishna and Godavari Basins | | Outside Krishna-Godavari Basins | |
|--------------------|-------------------|------------------------|---------------|------------------------|----------------|------------------------|-----------------------------|------------------------|---------------------------------|------------------------|
| | | | Percentage | Area (square miles) | Percentage | Area (square miles) | Percentage | Area (square miles) | Percentage | Area (square miles) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| MAHARASHTRA | | | | | | | | | | |
| 1 | Ahmednagar | 6,591 | 36.2 | 2,386 | 63.8 | 4,205 | 100.0 | 6,591 | .. | .. |
| 2 | Akola | 4,095 | .. | .. | 35.3 | 1,446 | 35.3 | 1,446 | 64.7 | 2,649 |
| 3 | Amravati | 4,723 | .. | .. | 34.3 | 1,620 | 34.3 | 1,620 | 65.7 | 3,103 |
| 4 | Aurangabad | 6,314 | .. | .. | 93.0 | 5,872 | 93.0 | 5,872 | 7.0 | 442 |
| 5 | Bhandara | 3,582 | .. | .. | 100.0 | 3,582 | 100.0 | 3,582 | .. | .. |
| 6 | Bhir | 4,261 | 14.2 | 605 | 85.8 | 3,656 | 100.0 | 4,261 | .. | .. |
| 7 | Buldana | 3,751 | .. | .. | 39.6 | 1,485 | 39.6 | 1,485 | 60.4 | 2,266 |
| 8 | Chanda | 9,972 | .. | .. | 99.0 | 9,872 | 99.0 | 9,872 | 1.0 | 100 |
| 9 | Jalgaon | 4,575 | .. | .. | 0.5 | 23 | 0.5 | 23 | 99.5 | 4,552 |
| 10 | Kolhapur | 3,205 | 91.4 | 2,929 | .. | .. | 91.4 | 2,929 | 8.6 | 276 |
| 11 | Nagpur | 3,842 | .. | .. | 100.0 | 3,842 | 100.0 | 3,842 | .. | .. |
| 12 | Nanded | 3,918 | .. | .. | 100.0 | 3,918 | 100.0 | 3,918 | .. | .. |
| 13 | Nasik | 6,021 | .. | .. | 47.2 | 2,842 | 47.2 | 2,842 | 52.8 | 3,179 |

| | | | | | | | | | | |
|----|-----------------------|-------|-------|---------------|-------|---------------|-------|---------------|------|-------|
| 14 | Osmanabad | 5,532 | 31.8 | 1,759 | 68.2 | 3,773 | 100.0 | 5,532 | .. | .. |
| 15 | Parbhani | 4,853 | .. | .. | 100.0 | 4,853 | 100.0 | 4,853 | .. | .. |
| 16 | Poona | 6,032 | 99.1 | 5,978 | 0.9 | 54 | 100.0 | 6,032 | .. | .. |
| 17 | Ratnagiri | 5,013 | 0.9 | 45 | .. | .. | 0.9 | 45 | 99.1 | 4,968 |
| 18 | Sangli (South Satara) | 3,297 | 100.0 | 3,297 | .. | .. | 100.0 | 3,297 | .. | .. |
| 19 | Satara | 4,041 | 100.0 | 4,041 | .. | .. | 100.0 | 4,041 | .. | .. |
| 20 | Sholapur | 5,811 | 99.2 | 5,765 | 0.8 | 46 | 100.0 | 5,811 | .. | .. |
| 21 | Wardha | 2,429 | .. | .. | 100.0 | 2,429 | 100.0 | 2,429 | .. | .. |
| 22 | Yeotmal | 5,246 | .. | .. | 100.0 | 5,246 | 100.0 | 5,246 | .. | .. |
| | <i>Total</i> | | | 26,805 | | 58,764 | | 85,569 | | |

MYSORE

| | | | | | | | | | | |
|----|-------------|-------|-------|-------|------|-------|-------|-------|------|-------|
| 1 | Belgaum | 5,091 | 90.8 | 4,623 | .. | .. | 90.8 | 4,623 | 9.2 | 468 |
| 2 | Bellary | 3,825 | 100.0 | 3,825 | .. | .. | 100.0 | 3,825 | .. | .. |
| 3 | Bidar | 2,072 | 17.9 | 371 | 82.1 | 1,701 | 100.0 | 2,072 | .. | .. |
| 4 | Bijapur | 6,590 | 100.0 | 6,590 | .. | .. | 100.0 | 6,590 | .. | .. |
| 5 | Chikmagalur | 2,787 | 86.0 | 2,397 | .. | .. | 86.0 | 2,397 | 14.0 | 390 |
| 6 | Chitradurga | 4,185 | 100.0 | 4,185 | .. | .. | 100.0 | 4,185 | .. | .. |
| 7 | Dharwar | 5,303 | 86.5 | 4,587 | .. | .. | 86.5 | 4,587 | 13.5 | 716 |
| 8 | Gulbarga | 6,348 | 100.0 | 6,348 | .. | .. | 100.0 | 6,348 | .. | .. |
| 9 | Hassan | 2,638 | 19.3 | 509 | .. | .. | 19.3 | 509 | 80.7 | 2,129 |
| 10 | Kanara | 3,965 | 6.2 | 246 | .. | .. | 6.2 | 246 | 93.8 | 3,719 |
| 11 | Raichur | 5,508 | 100.0 | 5,508 | .. | .. | 100.0 | 5,508 | .. | .. |

TABLE I—(Concluded).

DISTRIBUTION OF VARIOUS DISTRICTS IN THE KRISHNA AND GODAVARI BASINS

(Figures in column 8 are from "India 1961", those in other columns are based on planimeter measurements).

| Serial number | State District | Area (square miles) | Krishna Basin | | Godavari Basin | | Krishna and Godavari Basins | | Outside Krishna-Godavari Basins | |
|--------------------------|--------------------|------------------------|---------------|------------------------|----------------|------------------------|-----------------------------|------------------------|---------------------------------|------------------------|
| | | | Percentage | Area (square miles) | Percentage | Area (square miles) | Percentage | Area (square miles) | Percentage | Area (square miles) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| MYSORE—continued. | | | | | | | | | | |
| 12 | Shimoga | 4,066 | 74.4 | 3,025 | .. | .. | 74.4 | 3,025 | 25.6 | 1,041 |
| 13 | Tumkur | 4,096 | 37.1 | 1,520 | .. | .. | 37.1 | 1,520 | 62.9 | 2,576 |
| | Total | | | 43,734 | | 1,701 | | 45,435 | | |
| ORISSA | | | | | | | | | | |
| 1 | Kalahandi | 5,099 | .. | .. | 11.0 | 561 | 11.0 | 561 | 89.0 | 4,538 |
| 2 | Koraput | 9,864 | .. | .. | 63.8 | 6,293 | 63.8 | 6,293 | 36.2 | 3,571 |
| | Total | | | | | 6,854 | | 6,854 | | |
| | Grand Total | | | 99,980 | .. | 120,777 | .. | 220,757 | .. | .. |

2-4 Table I shows the total area of each district lying wholly or partly in the Krishna and Godavari basins. The percentage and extent of the area of each district which lies within either of the two basins is also indicated.

As the benefits from the waters of the two rivers extend to, and are claimed for, some districts outside the two basins, these districts have also been included in Table I.

2-5 In the States mentioned above, there are a few well-defined regions. As these will sometimes be referred to in the report, it is necessary to define them here.

Andhra Pradesh broadly comprises two regions, Telengana and Andhra. The regional classification of the districts of Andhra Pradesh, shown in Table I, is as follows :

| Telengana | | Andhra | |
|----------------|--------------|------------------|--------------------|
| 1. Adilabad | 6. Medak | 1. Anantapur | 6. Krishna |
| 2. Hyderabad | 7. Nalgonda | 2. Chittoor | 7. Kurnool |
| 3. Karimnagar | 8. Nizamabad | 3. Cuddapah | 8. Nellore |
| 4. Khammam | 9. Warangal | 4. East Godavari | 9. Visakhapatnam |
| 5. Mahbubnagar | | 5. Guntur | 10. West Godavari. |

The districts of Anantapur, Chittoor, Cuddapah and Kurnool, together with the Bellary district in Mysore, are sometimes also called Rayalaseema or Ceded Districts, and the districts of Visakhapatnam, East Godavari, West Godavari and Krishna as the Circars.

The region-wise classification of the Maharashtra districts, shown in Table I, is as follows :

| Western Maharashtra | Marathwada | Vidarbha |
|---------------------|---------------|-------------|
| 1. Ahmednagar | 1. Aurangabad | 1. Akola |
| 2. Jalgaon | 2. Bhir | 2. Amravati |
| 3. Kolhapur | 3. Nanded | 3. Bhandara |
| 4. Nasik | 4. Osmanabad | 4. Buldana |
| 5. Poona | 5. Parbhani | 5. Chanda |
| 6. Ratnagiri | | 6. Nagpur |
| 7. Sangli | | 7. Wardha |
| 8. Satara | | 8. Yeotmal |
| 9. Sholapur | | |

Similarly, some of the districts of Mysore are known as Bombay-Karnatak region and Hyderabad-Karnatak region respectively as follows :

| Bombay-Karnatak | Hyderabad-Karnatak |
|-----------------|--------------------|
| 1. Belgaum | 1. Bidar |
| 2. Bijapur | 2. Gulbarga |
| 3. Dharwar | 3. Raichur |
| 4. Kanara | |

Political changes since Independence

2-6 The political distribution of the drainage basins, as described above came into effect only from 1st November 1956, when the former State of Hyderabad was split* into three parts and merged with the then existing Andhra State, Bombay and Mysore. From that date, Andhra State came to be called Andhra Pradesh. At the same time, Buldana, Akola, Amravati, Yeotmal, Wardha, Nagpur, Bhandara and Chanda districts, formerly in Madhya Pradesh, were transferred to Bombay and the districts of Bijapur, Dharwar, Kanara and Belgaum (except Chandgad Taluk) were transferred from Bombay to Mysore. The State of Bombay, as constituted on 1st November, 1956, was split on 1st May, 1960, into Maharashtra and Gujarat and all the districts in the Krishna and Godavari basins shown in Table I came to lie in Maharashtra.

2-7 Andhra State, as existing on 1st November, 1956, had come into being only three years earlier, in October 1953, when the districts of Anantapur, Chittoor, Cuddapah, East Godavari, Guntur, Krishna, Kurnool, Nellore, Visakhapatnam and West Godavari were separated from the then Madras State and formed into Andhra State. At the same time, Bellary District of Madras was transferred to Mysore except Alur, Adoni and Rayadurg talukas which were transferred to Andhra State.

2-8 Apart from the re-organisation of States, as described above, soon after Independence, in 1947-48, a large number of former princely States had come to be merged in different districts and provinces of what was formerly British India. The

**The districts of Hyderabad, Medak, Nizamabad, Karimnagar, Warangal, Khammam, Nalgonda and Mahbubnagar were added to the then existing Andhra State and the districts of Aurangabad, Parbhani, Bhir and Osmanabad to the then existing Bombay State. In addition, the following districts were split between various States as follows :—*

Raichur—Alampur and Gadwal Taluks to Andhra Pradesh and the rest to Mysore.

Gulbarga—Kodangal Taluk and Tandur Taluk to Andhra Pradesh and the rest to Mysore.

Bidar—Zahirabad Taluk (except Nirna Circle), Narayankhed Taluk and Nyalkal Circle of Bidar Taluk to Andhra Pradesh ; Nilanga and Udgir Taluks to Bombay and the rest to Mysore.

Nanded—Bichkonda and Jukkal Circles of Deglur Taluk and Mudhol, Bhiansa and Kuber Circles of Mudhol Taluk to Andhra Pradesh and the rest to Bombay.

Adilabad—Kimwat Taluk, Rajura Taluk and Islapur Circle of Boath Taluk to Bombay and the rest to Andhra Pradesh.

particulars of these States in the Krishna and Godavari basins are :

| Serial Number | Name of State | Area (square miles) | Name of district with which merged | Name of State |
|-----------------------------------|----------------------------|---------------------|------------------------------------|--------------------------------------------|
| Kolhapur and Deccan States | | | | |
| 1. | Kolhapur | 3,217 | Kolhapur | Bombay, now in Maharashtra |
| 2. | Akalkot | 498 | Sholapur | " |
| 3. | Bhor | 910 | Satara | " |
| 4. | Phaltan | 397 | " | " |
| 5. | Aundh | 501 | Sangli | " |
| 6. | Jath | 981 | " | " |
| 7. | Kurundwad (senior) | 183 | " | " |
| 8. | Kurundwad (junior) | 116 | " | " |
| 9. | Miraj (senior) | 342 | " | " |
| 10. | Miraj (junior) | 196 | " | " |
| 11. | Sangli | 1,136 | " | " |
| 12. | Jankhandi | 524 | Bijapur | Formerly in Bombay now in Mysore; |
| 13. | Mudhol | 368 | " | " |
| 14. | Ramfurg | 169 | Belgaum | " |
| 15. | Sivapur | 73 | Dharwar | " |
| 16. | Wadi | 12 | Gulbarga | Mysore |
| Mysore Agency | | | | |
| 17. | Sandur | 167 | Bellary | Formerly in Madras, now in Mysore. |
| 18. | Banganpalle | 275 | Kurnool | Formerly in Madras, now in Andhra Pradesh. |
| Chattisgarh States Agency | | | | |
| 19. | Kalahandi | 3,745* | Kalahandi | Orissa |
| 20. | Bastar | 13,062* | Bastar | Madhya Pradesh. |

*Partly in Krishna Godavari basin, partly outside.

It will thus be seen that above 20,000 square miles of the Krishna and Godavari basins, were until about 1948 under the control of several princes whose technical and financial capacity for development was extremely limited.

2-9 Apart from the above, in the former Hyderabad State as also in several districts of former British India, there were large *jagirs* in which, except for the administration of law and order, the *jagirdar* or *zamindar* was in overall charge of the

area and was nominally responsible for all development work including the provision of irrigation facilities. The largest of these *jagirs* was the Jeypore estate in Koraput District of Orissa, more than a thousand square miles in area. There were numerous other *jagirs*, large and small, all of which have been abolished during the last few years.

Thus, so far as irrigation and hydro-electric developments were concerned, large parts of the Krishna and Godavari basins were, until recently, under the management and control of princes, *jagirdars* and *zamindars*. In all these parts, there was little irrigation, no hydrological observations and no one in nominal authority ever knew the available potential of the water resources available to them.

2-10 Briefly stated, the portion of the Krishna and Godavari basins now in Andhra Pradesh was, prior to Independence, under the control variously of the former Madras Presidency, the erstwhile Hyderabad State, a former princely state and a number of *jagirdars*. That in Madhya Pradesh was under the former Central Provinces and erstwhile Bastar State. The areas now in Maharashtra were, prior to Independence, distributed between the former Bombay Presidency, the former Central Provinces erstwhile Hyderabad State and a number of now defunct princely States. The portion of the Krishna and the Godavari basins now in Mysore was, 15 years ago, distributed between the former Madras Presidency, the erstwhile State, the former Bombay Presidency, the former Mysore State and some defunct Hyderabad princely States. The areas in Orissa were largely in the erstwhile Kalahandi State and in the now defunct Jeypore estate.

Topography

2-11 Except for the hills forming the water shed around the two basins (see Plate I), the entire drainage basin of the two rivers comprises rolling and undulating country—a series of ridges and valleys interspersed with low hill ranges. Large flat areas of the type one sees in the Indo-Gangetic plains are scarce except in the two deltas.

2-12 The western edge of the two basins is an almost unbroken line, formed by the Sahyadri range of the Western Ghats, from 2,000 to 7,000 feet high. It is the seat of the heaviest rainfall and the dampest atmosphere in the two basins. One has, however, only to proceed eastward and, in the course of only 30 to 40 miles from their crest, one passes from the ever-green forests and torrential rainfall of the Sahyadri range to the sparsely cultivated and undulating plains and dry atmosphere of the Deccan.

2-13 The interior of the basin is a plateau, the greater part of which is at an elevation of 1,000 to 2,000 feet. Its general slope is eastward. The Godavari, the Bhima, the Krishna, the Tungabhadra and many of their tributaries rise on the east of the Sahyadri range and flow eastwards. Great undulating plains, divided from each other by flat-topped ranges of hills, is the chief characteristic of this plateau. The hill-sides are marked by conspicuous wide terraces except in the southern part of the plateau where the hills are frequently crowned with great tors or rounded hummocks of bare rock, the result of ages of atmospheric action.

2-14 The Eastern Ghats which form the eastern boundary of the peninsula are by no means so well-defined or continuous as the Sahyadri range on the west. To the north of the Godavari, these Ghats rise from the plains of East Godavari and Visakhapatnam to the level of the table land of Jeypore and are fairly well-defined. To the south of the Krishna, the Ghats comprise parallel ranges, the successive outcrops of an ancient series of stratified rocks.

2-15 The northern boundary of the Godavari basin comprises a series of table lands varying from 2,000 to 4,000 feet in elevation, which have withstood the effect of ages of denudation better than the country to their north and south. To their south, lie great stretches of plains at an elevation of about 1,000 feet, interspersed and surrounded by hill ranges, some bare and rocky, but more generally covered with forests or with scrub jungle.

2-16 The deltas of the Krishna and the Godavari, formed by deposits at the mouths of the two rivers over the ages past, consist of a wide belt of river borne alluvium. The process of silt deposit at the mouth of the two rivers is still continuing and the deltas are gradually extending into the sea.

Geology

2-17 Like the rest of the Peninsula, the Krishna and Godavari basins represent a continental fragment of the earth's surface which, since the dawn of geological history, has never been submerged beneath the sea, except temporarily and locally. No considerable marine sediment of a later age than Cambrian was ever deposited in the interior of this land mass.

2-18 The geological structure of these basins (see Plate III), like the rest of the Deccan Plateau, forms a single crust block, the rigidity of which is not weakened by any overloading of large and deep belt of deposits. The two basins consist largely of Archaean formations, parts of which are covered over by Deccan trap lavas, Cuddapah and Vindhyan basins and faulted blocks of the Gondwanas, e.g., the Godavari valley is all bounded by faults which have helped to preserve the Gondwana strata. The Gondwana sediments in long narrow basins and the large mass of plateau basalts are the only examples of post-Purana loadings.

2-19 The sub-structure of the two basins is composed in great part of generally horizontally reposing rock beds that stand on a firm and immovable foundation and have remained so for ages. Lateral thrusts and mountain building forces have had but little effect in folding or displacing its originally horizontal strata.

2-20 The physiography of the two basins is also similar to the rest of the Plateau. While the mountains are more outstanding portions of the old plateau that have escaped the weathering of ages, the rivers have flat shallow valleys with relatively low gradients, the channels having approached the base level of erosion. The river systems are all of great antiquity and consequently, by the ceaseless degradation of ages, their channels have approached the last stage of river development, viz. the base-levelling of a continent. The valleys are characteristic of the regions where vertical erosion has almost ceased and the lateral erosion of the banks by winds, rain and streams is of greater moment. The rivers have some characteristic falls which bear evidence to some minor disturbances in a late geological age.

CHAPTER III

THE KRISHNA RIVER SYSTEM

The Krishna

3-1 The River Krishna (see Plate I) rises in the Western Ghats, at an altitude of 4,385 feet, just north of Mahabaleshwar, about 40 miles from the Arabian Sea, and flows across the whole width of the peninsula, from west to east, for a length of about 870 miles, through Maharashtra, Mysore and Andhra Pradesh.

3-2 About 85 miles from its source, the Krishna receives the waters of the river Koyna, from the western side of the Mahabaleshwar hills. Lower down, the Yerla falls into the Krishna from the left and then the Varna, the Panchganga and the Dudhganga from the right; the last three draining about 90 miles length of the Western Ghats.

3-3 Just near its confluence with the Dudhganga and about 190 miles from its source, the Krishna enters Mysore. At this point the river has come down to an altitude of about 1,750 feet and has emerged from the heavy rainfall zone along and near the Western Ghats. After entering Mysore, there is no major contribution to river flow for about 125 miles until the Krishna receives, from its right, the waters of the river Ghataprabha and, 22 miles lower down, the waters of the river Malaprabha; both of which rise in the Western Ghats.

3-4 A short distance below the junction of the Malaprabha, the Krishna drops from the table-land of the Deccan proper, about 400 feet down, to the alluvial lands of Raichur. Before the river enters Andhra Pradesh, at an altitude of about 1,125 feet and about 490 miles from its source, it receives from its left the waters of the river Bhima which brings down the drainage of Ahmednagar, Poona, Sholapur and Gulbarga. The Tungabhadra river falls into the Krishna about 80 miles further down, near Kurnool. Both the Bhima and the Tungabhadra drain large areas of the Western Ghats and each is a major river in its own right.

3-5 From a short distance below its confluence with the Tungabhadra, the Krishna runs in a deep gorge through a series of hills, for nearly 180 miles, before emerging into the coastal belt at Pulichintala, at an elevation of about 120 feet above sea level. Beyond this point, the river flows for about 50 miles before it spreads out into the delta.

Two tributaries, the Dindi and the Musi join the Krishna, from its left, between Kurnool and Pulichintala and two more tributaries, the Palleru and the Muneru, also from the left, fall into the Krishna between Pulichintala and the head of the delta near Vijayawada.

3-6 The Krishna has a drainage area of about 100,000 square miles. Together with its tributaries, it drains about 440 miles length of the Western Ghats, the chief source of the Krishna waters.

The Ghataprabha

3-7 The river Ghataprabha rises in the Western Ghats at an altitude of 2,900 feet and flows eastwards for a length of 176 miles before joining the Krishna at Kudli-sangam, about 22 miles north-east of Kaladgi, at an elevation of 1,640 feet.

3-8 The river flows for about 37 miles in Ratnagiri and Kolhapur Districts of Maharashtra, before entering Belgaum District of Mysore. Two of its tributaries the Hiranyakeshi and the Markandeya, also rise in the Western Ghats and flow through Maharashtra and Mysore.

3-9 The total catchment area of the river and its tributaries is 3,409 square miles in Maharashtra and Mysore, but their principal source of supply is about 40 miles length of the Western Ghats and about 40 miles width on the east of these hills; within this area the annual rainfall drops from about 120 inches to about 40 inches.

The Malaprabha

3-10 The river Malaprabha rises in the Western Ghats, at an altitude of 2,600 feet, about 10 miles west of Jamboti in Belgaum District of Mysore. The river flows first in an easterly and then in a north-easterly direction and joins the Krishna at an elevation of about 1,600 feet, about 190 miles from its source.

3-11 Its principal tributaries are the Bennihalla, the Hirehalla and the Tas Nadi, all of which drain an area of relatively low rainfall.

3-12 The total catchment area of the Malaprabha and its tributaries is 4,459 square miles, wholly in Mysore. Its principal source of supply is, however, only about 20 miles length of the Western Ghats and a small area east of it, drained by the Malaprabha itself.

The Bhima

3-13 The river Bhima rises in the Western Ghats, at an altitude of about 3,100 feet and flows south-eastwards through Maharashtra and Mysore. It has a total length of 535 miles and falls into the Krishna about 16 miles north of Raichur at an altitude of about 1,125 feet.

3-14 About 85 miles from its source, the Bhima receives, from its right, the combined waters of the Mula and the Mutha from Poona and, about 18 miles lower, the Ghod joins the Bhima from the left. At this point the Bhima flows at an elevation of about 1,685 feet and is well out of the heavy rainfall zone along and near the Western Ghats. Lower down, it is joined on its right bank by the Nira, which also rises in the Western Ghats, and then by the Man. For a length of 46 miles, the Bhima runs along the boundary between Maharashtra and Mysore. In this reach it receives the waters of the Sina, which rises near Ahmednagar.

3-15 For the last 186 miles of its course, the Bhima flows in Mysore. No major tributary falls into the Bhima in this reach.

3-16 The Bhima has a drainage area of 27,264 square miles but its principal source of supply is about 100 miles length of Western Ghats.

The Tungabhadra

3-17 The Tungabhadra, an important tributary of the Krishna, is formed north of Shimoga at an elevation of about 2,000 feet by the union of the twin rivers Tunga and Bhadra, which rise together in the Western Ghats at Gangamula at an elevation of about 3,930 feet. The united river Tungabhadra flows for about 330 miles in a general north-easterly direction, through Mysore and Andhra Pradesh, and joins the Krishna, beyond Kurnool, at an elevation of about 865 feet.

3-18 Among the tributaries of the Tungabhadra may be mentioned the Varada river which drains a large area of the Western Ghats and falls into the Tungabhadra, at an elevation of about 1,670 feet, about 100 miles below the junctions of the Tunga and the Bhadra. Another important tributary is the Hagari, called Vedavati in its lower reach, which joins the Tungabhadra about 105 miles above its junction with the Krishna.

3-19 The Tungabhadra has a drainage area of 27,574 square miles and, like the Bhima, drains about 128 miles length of the Western Ghats.

The Musi

3-20 The river Musi rises at an altitude of about 2,168 feet in Medak district, of Andhra Pradesh. It flows through Hyderabad city and runs mostly west to east until it is joined by the Aleru. It then flows due south to drop into the Krishna, near Wazirabad, at an elevation of about 200 feet. In all, the river has a course of about 166 miles and has three important tributaries, the Musa, the Aleru and the Paler.

3-21 The river Musi and its tributaries drain a catchment area of 4,329 square miles, lying wholly in Andhra Pradesh. They traverse a low rainfall area having an annual rainfall of 25 to 32 inches.

Sub-Basins

3-22 For the purpose of this report, the Krishna drainage basin has been divided (see Plate II) into 12 sub-basins as follows:—

K. 1. Upper Krishna:—The river Krishna from source to the confluence with it of the Dudhganga; the sub-basin includes the catchment area of the river Krishna and of all its tributaries which fall into the Krishna in this reach upto and including the Dudhganga.

- K. 2 Middle Krishna*:—The river Krishna, from its confluence with the Dudhganga to its confluence with the Bhima; the sub-basin includes the direct catchment of the Krishna in this reach as well as of all its tributaries outfalling in this reach, except that of the Ghataprabha and of the Malaprabha (K. 3 and K. 4 below).
- K. 3 Ghataprabha*:—The entire catchment of the Ghataprabha from source to its confluence with the Krishna, including the catchment areas of the Hiranyakeshi, the Markandeya and other tributaries of the Ghataprabha.
- K. 4 Malaprabha*:—The river Malaprabha, from source to its confluence with the Krishna; the sub-basin includes the entire catchment of the Malaprabha and of all its tributaries.
- K. 5 Upper Bhima*:—The river Bhima, from source to the confluence with it of the Sina; the sub-basin includes the catchment area of the Bhima in this reach as well as of all its tributaries which fall into it in this reach including the Sina.
- K. 6 Lower Bhima*:—The lower part of the river Bhima from its confluence with the Sina to the point where the Bhima falls into the Krishna; the sub-basin includes the direct catchment of the lower part of the Bhima as well as of all its tributaries which fall into it in this reach.
- K. 7 Lower Krishna*:—The lower part of the river Krishna from its confluence with the Bhima to the sea; the sub-basin includes the direct catchment of the Krishna in this reach and of all its tributaries which fall into it in this reach, except the area covered by sub-basins K. 8 to K. 12, described below.
- K. 8 Tungabhadra*:—This sub-basin includes the entire catchment of the Tungabhadra and of all its tributaries, except that of the Vedavati (K. 9 below).
- K. 9 Vedavati*:—The river Vedavati, from source to its out-fall into the Tungabhadra; the sub-basin includes the catchment area of the Vedavati (also called Hagari in its upper reach) and of all its tributaries.
- K. 10 Musi*:—This sub-basin includes the entire catchment of the Musi and of all its tributaries.
- K. 11 Palleru*:—This sub-basin includes the entire catchment of the Palleru and of all its tributaries.
- K. 12 Muneru*:—This sub-basin includes the entire catchment of the Muneru as well as of all its tributaries.

3-23 The area of each sub-basin and the percentage it represents of the total catchment area of the Krishna are shown in Table II.

TABLE II

SUB-BASINS OF THE KRISHNA RIVER SYSTEM

| <i>Sub basin number</i> | <i>Name of the sub-basin</i> | <i>Area (Square miles)</i> | <i>Percentage of Krishna basin</i> |
|-------------------------|------------------------------|----------------------------|------------------------------------|
| K. 1 | Upper Krishna | 6,939 | 6.94 |
| K. 2 | Middle Krishna | 6,779 | 6.78 |
| K. 3 | Ghataprabha | 3,409 | 3.41 |
| K. 4 | Malaprabha | 4,459 | 4.46 |
| K. 5 | Upper Bhima | 17,786 | 17.79 |
| K. 6 | Lower Bhima | 9,478 | 9.48 |
| K. 7 | Lower Krishna | 13,948 | 13.95 |
| K. 8 | Tungabhadra | 18,466 | 18.47 |
| K. 9 | Vedavati | 9,108 | 9.11 |
| K. 10 | Musi | 4,329 | 4.33 |
| K. 11 | Palleru | 1,260 | 1.26 |
| K. 12 | Muneru | 4,019 | 4.02 |
| | TOTAL | 99,980 | 100.00 |

CHAPTER IV

THE GODAVARI RIVER SYSTEM

The Godavari

4-1 The river Godavari (see Plate I) flows across the Deccan plateau, from the Western to the Eastern Ghats. It rises in the Nasik District of Maharashtra, about 50 miles from the shore of the Arabian Sea, at an elevation of 3,500 feet. After flowing for about 910 miles in a general south-easterly direction, through Maharashtra and Andhra Pradesh, Godavari falls into the Bay of Bengal, about 60 miles below Rajamundry.

4-2 About 40 miles from its source, the Godavari receives, from its right bank, the waters of the Darna ; a short distance lower down the Kadwa joins the Godavari from its left. The river has already got out of the high rainfall zone near the Western Ghats and there is no further significant contribution to river flow until, about 135 miles from its source, it receives the combined waters of the Pravara and the Mula which rise in the hills of Akola. About 210 miles lower, while still in Maharashtra, the Godavari receives the combined waters of the Purna and Dudna rivers from the north and 86 miles lower, just at the border between Maharashtra and Andhra Pradesh, the waters of the Manjra river from the south. At this point, the Godavari runs at an elevation of about 1,080 feet and has again entered a rainfall zone of about 40 inches and more.

4-3 The river Pranhita, conveying the united waters of the Penganga, the Wardha and the Wainganga, which drain Nagpur and the southern slopes of the Satpura Range, falls into the Godavari about 190 miles below the Manjra confluence and about 285 miles above its outfall in the Bay of Bengal. Thirty miles lower, the Godavari receives the waters of the Indravati river from the erstwhile Bastar State. Both the Pranhita and the Indravati are major rivers in their own right. The last major tributary of the Godavari is the Sabari from Orissa which falls into the Godavari 62 miles above Rajamundry.

4-4 The Godavari has a drainage area of about 121,000 square miles. Its principal sources of supply, are, in its upper reach, the relatively small catchment in the Western Ghats and, at its lower end, the Mahadeo Hills, the Maikal Range and the hills in the south of Orissa.

The Pravara

4-5 The river Pravara rises in the Western Ghats at an altitude of about 3,500 feet and flows in an easterly direction for about 130 miles before falling into the Godavari, about 6 miles north of Newasa, at an altitude of about 1,500 feet.

4-6 About 110 miles from its source, the Pravara receives from its right the waters of the Mula river, which also rises in the Western Ghats south of the Pravara.

4-7 The Pravara has a drainage area of 2,524 square miles, lying entirely in Maharashtra, but its principal source of supply is only about 20 miles length of the Western Ghats.

The Purna

4-8 The Purna river rises in the Ajanta Range of hills at an altitude of 2,750 feet and flows in a south-easterly direction before joining the Godavari at an elevation of about 1,150 feet, 40 miles upstream of Nanded.

4-9 The total length of the Purna is 232 miles. It has a number of tributaries, the longest being the Dudna, 142 miles.

4-10 The total catchment area of the Purna and its tributaries is 6,015 square miles, lying entirely in Maharashtra, in a relatively low rainfall zone, 28 inches to 35 inches (annual).

The Manjra

4-11 The river Manjra rises in the Balaghat Range of hills in the Bhir District of Maharashtra at an altitude of about 2,700 feet.

4-12 The river flows in a general east and south-easterly direction for 320 miles through the Osmanabad District of Maharashtra, the Bidar District of Mysore and the Medak District of Andhra Pradesh until it changes its direction northward near Sangaredipet. After flowing for 47 miles further, it enters the Nizamabad District of Andhra Pradesh and, from 64 miles lower down, it forms the boundary between Maharashtra and Andhra Pradesh. The total length of the river from source to its confluence with the Godavari, at an altitude of 1,060 feet, is about 450 miles.

4-13 The principal tributaries of the Manjra are the Tirna, the Karanja and the Haldi which join from its right and the Lendi and the Manar from its left.

4-14 The Manjra and its tributaries have a total catchment area of 11,900 square miles (nearly one-tenth of the Godavari catchment) lying in Maharashtra, Mysore and Andhra Pradesh. It lies in a rainfall zone of about 25 inches (annual) in the upper reaches of the river gradually increasing to about 40 inches (annual) towards the lower end of its catchment.

The Pranhita

4-15 The Pranhita, with its three principal branches, the Penganga, the Wardha and the Wainganga, is by far the most important tributary of the Godavari.

4-16 The river Penganga rises at an altitude of 2,250 feet in the Buldana Range in Maharashtra and, after flowing for a length of 420 miles in a general south-easterly and easterly direction, joins the river Wardha at an elevation of 570 feet. Except in its uppermost reach of about 100 miles, which is mostly barren and hilly, the river passes through dense forests of Yeotmal and Nanded Districts.

The river Kiadoh joins the Penganga from the right at miles 189 and the Pus, the Arna, the Aran and the Waghari join from the left.

The catchment area of the Penganga river with all its tributaries is 9,227 square miles and it lies mostly in Maharashtra.

4-17 The river Wardha rises at an altitude of 2,550 feet in the Betul District of Madhya Pradesh and enters Maharashtra about 20 miles from its source. After flowing further for a distance of 300 miles, in a general south-easterly direction, it joins the Wainganga at an elevation of 480 feet. For the last 26 miles of its course, it forms the boundary between Maharashtra and Andhra Pradesh.

The major tributaries of the Wardha are the Wunna from its left and the Bembla and the Penganga from the right.

The catchment area of the Wardha is 9,300 square miles lying mostly in Maharashtra. Throughout its course the river flows through dense forests.

4-18 The river Wainganga rises at an altitude of 2,100 feet in the Seoni District of Madhya Pradesh and after flowing north for a short length it takes a turn towards east and then south forming a great loop. After flowing for a total length of 170 miles in Madhya Pradesh, it forms the boundary between Madhya Pradesh and Maharashtra for about 20 miles. It then continues to flow due south for another 188 miles to join the Wardha.

4-19 The combined waters of the Wainganga and the Wardha, now called Pranhita, flow for 70 miles along the border between Maharashtra and Andhra Pradesh before falling into the Godavari at an elevation of 350 feet.

The major tributaries of the Wainganga are the PENCH and the Kanhan from its right and Bagh and the Andhari from the left.

The catchment area of the Wainganga is 23,588 square miles lying partly in Madhya Pradesh and partly in Maharashtra. The river passes through the thick forests of Central India.

4-20 The catchment area of the Pranhita and of all its branches is 42,115 square miles, a little more than one third of the entire Godavari river system. It lies mainly in Madhya Pradesh and Maharashtra in a medium rainfall zone of 35 inches to 63 inches (annual).

The Indravati

4-21 The river Indravati rises at an altitude of 3,000 feet in the Kalahandi District of Orissa on the western slopes of the Eastern Ghats. It flows westward through Koraput and Bastar Districts; turns south and, about 330 miles from its source, joins the Godavari, at an elevation of about 270 feet.

4-22 The important tributaries of the Indravati are the Narangi, the Baordhig, the Kotri and the Bandia from its right and the Nandira (Berudi) from its left.

4-23 The total catchment area of the Indravati is 16,087 square miles, lying in Orissa and Madhya Pradesh, in a relatively high rainfall zone of about 60 inches (annual).

The Sabari

4-24 The Sabari, also known as the Kolab, is the last important tributary of the Godavari. The Sabari rises at an altitude of 4,500 feet in the Sinkaram hill range of the Eastern Ghats. After flowing for a short distance in a north, north-westerly and westerly direction it turns south and joins the Godavari, about 260 miles from its source, at an altitude of 83 feet, about 60 miles upstream of Rajamundry.

4-25 The Sileru (also known as Machkund river) is the most important tributary of Sabari river. The Sileru rises at an elevation of 4,000 feet and flows for a length of about 190 miles before joining the Sabari, at an elevation of 134 feet, 21 miles above the Sabari confluence with the Godavari.

4-26 The total catchment area of the Sabari and of its tributaries is 7,887 square miles, most of it in Orissa, in a relatively high rainfall zone of about 55 inches to 70 inches (annual).

Sub-Basins

4-27 For the purpose of this report, the Godavari Drainage Basin has been divided into 12 sub-basins as follows:—

- G.1 *Upper Godavari*.—The river Godavari from its source to its confluence with the Manjra; the sub-basin excludes the catchment area of the Pravara, the Purna and the Manjra tributaries but includes that of all other tributaries which fall into the Godavari in this reach.
- G.2 *Pravara*.—This sub-basin includes the entire catchment of the Pravara from source to its confluence with the Godavari including the catchment area of Mula and other tributaries of the Pravara.
- G.3 *Purna*.—The river Purna from source to its confluence with the Godavari; the sub-basin includes the entire catchment of the Purna and of all its tributaries.
- G.4 *Manjra*.—This sub-basin includes the entire catchment of the Manjra from its source to its confluence with the Godavari including the catchment areas of Maner and other tributaries of the Manjra.
- G.5 *Middle Godavari*.—The river Godavari from its confluence with the Manjra to its confluence with the Pranhita; the sub-basin includes the direct catchment of the Godavari in this reach as well as of its tributaries outfalling in this reach except the Maner and the Pranhita.
- G.6 *Maner*.—This sub-basin includes the entire catchment of the Maner from its source to its confluence with the Godavari.

- G.7 *Penganga*.—This sub-basin includes the entire catchment of the Penganga from its source to its confluence with the Wardha.
- G.8 *Wardha*.—The river Wardha from its source to its confluence with the Wainganga, excluding the catchment of the Penganga (G. 7 above).
- G.9 *Pranhita*.—The river Wainganga from its source to its confluence with the Wardha and the Pranhita up to its confluence with the Godavari; the sub-basin includes all the tributaries of the Wainganga and the Pranhita except the Penganga and the Wardha (G.7 and G.8 above).
- G.10 *Lower Godavari*.—The lower part of the river Godavari from its confluence with the Pranhita to the sea; the sub-basin includes the direct catchment of the Godavari in this reach and of all its tributaries which fall into it in this reach except the area covered by the sub-basins of the Indravati and the Sabari (G.11 and G. 12 below).
- G.11 *Indravati*.—The river Indravati from its source to its confluence with the Godavari; the sub-basin includes the catchment area of the Indravati and of all its tributaries.
- G.12 *Sabari*.—This sub-basin includes the entire catchment of the Sabari river from its source to its confluence with the Godavari.

4-28 The area of each sub-basin and the percentage it represents of the total catchment area of the Godavari are shown in Table III.

TABLE III
SUB-BASINS OF THE GODAVARI RIVER SYSTEM

| <i>Sub-basin number</i> | <i>Name of the sub-basin</i> | <i>Area (square miles)</i> | <i>Percentage of Godavari basin</i> |
|-------------------------|------------------------------|----------------------------|-------------------------------------|
| G.1 | Upper Godavari | 12,935 | 10·71 |
| G.2 | Pravara | 2,524 | 2·09 |
| G.3 | Purna | 6,015 | 4·98 |
| G.4 | Manjra | 11,909 | 9·86 |
| G.5 | Middle Godavari | 6,643 | 5·50 |
| G.6 | Maner | 5,060 | 4·19 |
| G.7 | Penganga | 9,227 | 7·64 |
| G.8 | Wardha | 9,300 | 7·70 |
| G.9 | Pranhita | 23,588 | 19·53 |
| G.10 | Lower Godavari | 9,602 | 7·95 |
| G.11 | Indravati | 16,087 | 13·32 |
| G.12 | Sabari | 7,887 | 6·53 |
| Total | | 120,777 | 100·00 |

Krishna and Godavari rivers compared

4-29 The catchment area of the river Godavari is about 121,000 square miles against about 100,000 square miles of the Krishna. The length of the Godavari is 910 miles, that of the Krishna 870 miles.

4-30 The configuration of the two basins is very different. The Krishna basin is roughly triangular in shape with its base along the Western Ghats, the apex at Vijayawada and the Krishna itself forming the median. All the major tributaries, draining the base of the triangle, fall into the river in its upper two-third length. The Godavari basin is also roughly triangular in shape but the main river itself runs practically along the base of the triangle. Almost two third of the catchment of the Godavari drains into the river in the lowest one third of its length.

4-31 While the principal source of water of the Krishna and its tributaries is the heavy rainfall, along and near the Western Ghats for a length of 440 miles, the Godavari drains only a short length, about 80 miles, of these Ghats. The Godavari has, however, a large catchment of medium to high rainfall in the north-east of its basin; a large part of this comprises dense forests.

4-32 The valley of the Godavari in its upper reach is considerably lower than the valley of the Krishna. In their lower reaches, however, the two rivers run at about the same elevation. At the confluence of the Bhima and the Krishna, about 490 miles from its source, the Krishna flows at an elevation of 1,125 feet and, almost due north of this point, the river Godavari about 431 miles from its source, at its confluence with the Manjra, is about 50 feet lower.

4-33 Both the rivers have large and fertile deltas at their mouths and fall into the Bay of Bengal.

CHAPTER V

CLIMATE

Mean Temperature

5-1 As will be seen from Plate I, the Krishna and Godavari basins lie mainly between latitudes 16° and 20° , though a part protrudes south-ward upto $13^{\circ} 7' N.$ and another northward upto $23^{\circ} 41' N.$ The entire area of the two basins is thus subject to tropical climate.

5-2 The mean annual surface temperature in the Western Ghat area, *i.e.* at the western end of the two basins, is about $24^{\circ}C.$ ($75^{\circ}F.$); it increases gradually towards the east and attains a maximum of $29.4^{\circ}C.$ ($85^{\circ}F.$) on the east coast.

5-3 During January, which may be taken as representative of the winter months, the mean daily minimum temperature increases from west to east, from $15^{\circ}C.$ ($59^{\circ}F.$) in the Western Ghats to about $18^{\circ}C.$ ($64^{\circ}F.$) at the east coast; the mean daily maximum temperature generally exceeds $30^{\circ}C.$ ($86^{\circ}F.$) in the western part of the two basins and is only slightly less than $30^{\circ}C.$ in the eastern part. Both the daily maximum and the daily minimum temperatures in this month are considerably higher in the Krishna and Godavari basins than in northern India. While the daily maximum temperature in the two basins is also about the highest in southern India, the daily minimum temperature in the two basins is exceeded on the south-east coast and in the southern most part of the peninsula.

5-4 During April, which may be taken as representative of the summer months, preceding the monsoon, the mean daily minimum temperature is about $22^{\circ}C.$ ($72^{\circ}F.$) in the western end and it increases eastward to a maximum of about $26^{\circ}C.$ ($79^{\circ}F.$) near the east coast; the mean daily maximum temperature, which is about $35^{\circ}C.$ ($95^{\circ}F.$) in the western end, increases to about $40^{\circ}C.$ ($104^{\circ}F.$) in the middle of the plateau and then falls to about $35^{\circ}C.$ near the east coast. During this month the temperatures in the Krishna and Godavari basins are about the highest any where in the country.

5-5 During July, which may be taken as representative of the monsoon months, the mean daily minimum temperature in the Western Ghats area is about; $20^{\circ}C.$ ($68^{\circ}F.$) and it increases eastward to about $26^{\circ}C.$ ($79^{\circ}F.$) near the east-coast; the mean daily maximum temperature is about $27^{\circ}C.$ ($81^{\circ}F.$) in the Western Ghats area and it increases eastward to about $33^{\circ}C.$ ($91^{\circ}F.$) near the east coast.

5-6 During October, which may be taken as representative of the post-monsoon months, the mean daily minimum temperature is about $20^{\circ}C.$ ($68^{\circ}F.$) in most parts of the Krishna and Godavari basins but increases to about $23^{\circ}C.$ ($74^{\circ}F.$) on the east coast ; the mean daily maximum temperature is a little more than $39^{\circ}C.$ ($86^{\circ}F.$) in the entire area of the two basins.

Rainfall

5-7 Like most other parts of India, the Krishna and Godavari basins receive their maximum rainfall during the south-west monsoon. The monsoon winds strike the west coast of the Indian peninsula from the west south-west and meet the Western Ghats or Sahyadri Range which present an almost uninterrupted barrier, ranging from 2,000 to 7,000 feet high. After surmounting this barrier and depositing most of the moisture on the wind ward side, the monsoon currents sweep across the interior peninsula on a course which is mainly west.

The amount of rainfall on the *ghats*, at any place, is governed largely by the orographic features there. This factor introduces considerable spatial variation in the rainfall amounts. In crossing the *ghats*, the monsoon winds lose a large part of the moisture.

As the crest of the *ghats* forms the general watershed of the peninsula and the average slope of the country therefrom is towards the east coast, which slope is followed by the monsoon winds, the conditions in the interior are somewhat unfavourable for heavy precipitation except in association with the depressions from the Bay of Bengal.

The north-east part of the Godavari basin also receives some rain in association with monsoon depressions which move west north-west across the Orissa Coast.

5-8 Data* of seasonal and annual rainfall at all rain gauge stations in the Krishna and Godavari basins and adjoining areas is given in Part I of Annexure I to this Report. The seasons, for this purpose are as adopted by the India Meteorological Department, viz., January and February, March to May, June to September and October to December.

5-9 Plate IV and Map I show the extent and the distribution of annual rainfall in the Krishna and the Godavari basins. It will be seen therefrom that the high rainfall zone along the Western Ghats forms the western boundary of the Krishna basin for a distance of about 440 miles, and many channels, big and small, carry the drainage of this area into the Krishna. Likewise, the Godavari river receives the drainage of this high rainfall zone but only from a length of about 80 miles. The width of this high rainfall zone (with an annual rainfall from about 3,000 mm. or about 120 inches to 1,000 mm. or about 40 inches) within the Krishna and the Godavari basins, varies from almost nil to a maximum of about 35 miles.

East of the Western Ghats and all along these hills, the annual rainfall decreases rapidly until it is less than 600 mm (about 24 inches) along a line running approximately from Chitradurga to Sangli to Poona to a point about 12 miles east of Nasik. North and east of a line connecting Kurnool, Raichur, Bijapur, Ahmednagar to a point about 25 miles west of Aurangabad, the annual rainfall again begins to increase gradually from about 600 mm. until it is about 900 mm. (about 35 inches) along line roughly joining Amravati, Nanded, Bidar, Khammam and Guntur. East and north of this last line, the annual rainfall increases rapidly to a maximum of about 1600 mm (about 64 inches) in the Koraput, Jagdalpur and Balaghat areas.

* Made available to the Commission by the India Meteorological Department, Poona.

5-10 There is thus a large belt, a short distance east of the Western Ghats and varying in width from about 160 miles in the south of the Krishna basin to about 60 miles in the north of the Godavari basin, where the normal annual rainfall is less than 600 mm. (about 24 inches). This belt, about 45,000 square miles in area (about one fifth of the total area of the two basins), includes portions of the Anantapur and Kurnool Districts of Andhra Pradesh ; Raichur, Bellary, Chitradurga, Dharwar, Belgaum, Bijapur and Gulbarga Districts of Mysore ; and Satara, Sholapur, Poona, Ahmednagar and Aurangabad Districts of Maharashtra.

Except for a narrow strip along the Western Ghats and a small portion at the lower end of the river Krishna in the districts of Krishna, West Godavari and Khammam, the rest of the Krishna basin has an annual normal rainfall of less than 800 mm. or about 30 inches. On the other hand, except for the districts of Aurangabad, Ahmednagar and portions of Nasik and Bhir, the rest of the Godavari basin has an annual normal rainfall of more than 30 inches, the north-eastern portion having a large zone of relatively heavy rainfall. With regard to the latter, it is stated :

“.....the conclusion is almost irresistible that, the increased rainfall of the north and north-east of the great plateau of the peninsula is in some measure due to an influx of vapour from the east coast, and mainly up the valley of the Godavari. To the north of this river the high table-land of Jeypore opposes a certain barrier to the direct passage of the vapour-laden winds from the Bay. But there is another source of vapour which is probably not unimportant. This is local evaporation, which must be much more considerable in the comparatively fertile, and in great part forest-clad drainage basin of the Godavari and its tributaries, than in the basin, and in part rocky tract, drained by the Kistna and its affluents. The extent to which this is operative, cannot, of course, be estimated, but it can hardly be doubted that evaporation from vegetation, from irrigation, and from the general land surface wetted by rainfall is more considerable in the basin of Godavari, especially the eastern half, than from the bare rolling plains dotted with rocky tors and equally bare hills, which constitute so large a portion of the Kistna basin.....”*

5-11 From the point of view of agriculture, however, a study of the normal annual rainfall, although an important indication, is not sufficient, one has to study the incidence and distribution of rainfall in different seasons and the rainfall variation and dependability from year to year.

Maps II to V show the seasonal distribution of rainfall over the Krishna and the Godavari basins and adjoining areas.

5-12 It will be seen from Map II, that January and February are almost entirely dry months in the Krishna and Godavari basins. The total rainfall during these two months is less than 15 mm. or half an inch except in the north-eastern part of the area and near the two deltas. Even in these portions, the rainfall during these two months does not exceed 25 mm. or one inch except north of a line roughly joining, Jagdalpur, Adilabad and Amravati where it is just over an inch.

*Blanford H.F., *Indian Meteorological Memoirs Vol. III*, page 31, 1886—1888.

A perusal of Map III will show that during the three months from March to May, the rainfall in most parts of the Krishna and Godavari basins varies from 20 mm. or 0·8 inch to about 50 mm. or two inches, except in the Rajamundry—Koraput—Jagdalpur area and in the south-western corner bounded by a line drawn from Kurnool through Bijapur to Satara where it ranges from 50 mm. (2 inches) to 150 mm. (6 inches).

5-13 June to September are the four months of south-west monsoon during which all parts of the Krishna and Godavari basins receive their maximum rainfall. It will be seen from Map IV, however, that the rainfall, in these four months, does not exceed 800 mm. or 32 inches ; the only exception being the Western Ghats (60—120 inches), the north-eastern portion of the Godavari basin in Orissa and Madhya Pradesh (up to 60 inches) and, to a lesser extent, the districts of Nizamabad and Adilabad in Andhra Pradesh and Yeotmal, Wardha, Betul and Chindwara in Maharashtra (up to 40 inches). On the other hand, there are large blocks of area where the rainfall during these four months is less than 400 mm. (about 16 inches) and in the Anantapur, Bellary and Chitradurga areas, it is even less than 300 mm. or 12 inches. The last three districts, however, receive rainfall of 150 mm. or 6 inches during October to December.

TABLE IV

SEASONAL AND ANNUAL WEIGHTED AVERAGE RAINFALL

| Serial number | Name of sub-basin | Rainfall (millimetres) | | | | | |
|----------------------|-------------------|------------------------|----------|-----------|----------|-----------------------|-----------------------|
| | | Jan.-Feb. | Mar.-May | June-Sep. | Oct-Dec. | Annual | |
| | | | | | | Total of Cols. 3 to 6 | As per Isohyets Map I |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| KRISHNA BASIN | | | | | | | |
| K. 1 | Upper Krishna | 5 | 65 | 1,286 | 152 | 1,508 | 1,481 |
| K. 2 | Middle Krishna . | 7 | 62 | 366 | 130 | 565 | 553 |
| K. 3 | Ghataprabha . | 5 | 92 | 671 | 153 | 921 | 985 |
| K. 4 | Malaprabha . | 4 | 93 | 431 | 147 | 675 | 717 |
| K. 5 | Upper Bhima . | 8 | 36 | 527 | 105 | 676 | 702 |
| K. 6 | Lower Bhima . | 12 | 51 | 499 | 99 | 661 | 676 |
| K. 7 | Lower Krishna . | 12 | 60 | 508 | 141 | 721 | 724 |
| K. 8 | Tungabhadra . | 8 | 95 | 622 | 159 | 884 | 904 |
| K. 9 | Vedavati . | 9 | 103 | 288 | 168 | 568 | 602 |
| K. 10 | Musi . | 14 | 65 | 546 | 124 | 749 | 730 |
| K. 11 | Palleru . | 14 | 55 | 605 | 136 | 810 | 308 |
| K. 12 | Muneru . | 19 | 78 | 723 | 134 | 954 | 956 |
| | Krishna basin . | 9 | 69 | 570 | 136 | 784 | 798 |

TABLE IV (Concluded)
SEASONAL AND ANNUAL WEIGHTED AVERAGE RAINFALL

| Serial number | Name of sub-basin | Rainfall (millimetres) | | | | | |
|-----------------------|-------------------|------------------------|----------|-----------|-----------|----------------------|-----------------------|
| | | Jan.-Feb. | Mar.-May | June-Sep. | Oct.-Dec. | Annual | |
| | | | | | | Total of Cols 3 to 6 | As per Isohyets-Map I |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| GODAVARI BASIN | | | | | | | |
| G. 1 | Upper Godavari | 12 | 28 | 645 | 85 | 770 | 765 |
| G. 2 | Pravara . . . | 6 | 26 | 476 | 98 | 606 | 615 |
| G. 3 | Purna . . . | 15 | 32 | 660 | 90 | 797 | 811 |
| G. 4 | Manjra . . . | 16 | 47 | 696 | 87 | 846 | 892 |
| G. 5 | Middle Godavari | 25 | 45 | 809 | 76 | 955 | 993 |
| G. 6 | Maner . . . | 24 | 56 | 762 | 90 | 932 | 935 |
| G. 7 | Penganga . . . | 25 | 39 | 819 | 77 | 960 | 965 |
| G. 8 | Wardha . . . | 31 | 40 | 907 | 77 | 1,055 | 1,116 |
| G. 9 | Pranhita . . . | 41 | 45 | 1,196 | 81 | 1,363 | 1,360 |
| G. 10 | Lower Godavari | 20 | 88 | 929 | 171 | 1,208 | 1,232 |
| G. 11 | Indravati . . . | 27 | 85 | 1,366 | 110 | 1,588 | 1,567 |
| G. 12 | Sabari . . . | 14 | 125 | 1,137 | 157 | 1,433 | 1,532 |
| Godavari basin . . . | | 25 | 56 | 953 | 98 | 1,132 | 1,149 |

5-14 During the months of October to December, see Map V, most parts of the Krishna and Godavari basins receive a rainfall of less than 150 mm. (about 6 inches). This is exceeded at a few stations on the Western Ghats but more so all along the east coast. In the interior the rainfall during these three months is much less than 150 mm., the lowest is about 80 mm. (about 3 inches).

5-15 Table IV shows the seasonal and annual weighted average rainfall in millimetres for each sub-basin, the Krishna basin as a whole and the Godavari basin as a whole. The figures in columns 3, 4, 5, 6 and 8 have been worked out from the isohyets drawn on the respective maps (Map II—Map V) by planimetry the area between the respective isohyets and taking a weighted average*.

5-16 Table V shows the seasonal rainfall expressed as a percentage of the total annual rainfall for each of the sub-basins, the Krishna basin and the Godavari basin.

5-17 Tables IV and V provide an interesting study of the rainfall distribution, by seasons and by sub-basins.

The weighted average annual rainfall (Col. 7, Table IV) of the Krishna basin is 784 mm. (30.9 inches) of which almost three-fourths (72.7 per cent) falls during the four months, June to September. Within the basin, the Upper Krishna sub-basin has the highest rainfall and the Ghataprabha sub-basin, the Tungabhadra sub-basin and the Muneru sub-basin have a rainfall considerably in excess of the weighted average of the entire Krishna basin.

*The small difference in columns 7 and 8 of Table IV can be attributed to the system of calculation to the distribution of rainfall stations and the varying period for which data are available at each of the stations; by and large the figures in these two columns for each sub-basin support each other.

TABLE V

PERCENTAGE CONTRIBUTION OF RAINFALL IN EACH SEASON

| Serial number | Name of sub-basin | Percentage contribution during | | | |
|---------------|-------------------|--------------------------------|----------|-----------|-----------|
| | | Jan.-Feb. | Mar.-May | June-Sep. | Oct.-Dec. |
| 1 | 2 | 3 | 4 | 5 | 6 |

KRISHNA BASIN

| | | | | | |
|-------|--------------------------|-----|------|------|------|
| K. 1 | Upper Krishna | 0.3 | 4.3 | 85.3 | 10.1 |
| K. 2 | Middle Krishna | 1.2 | 11.0 | 64.8 | 23.0 |
| K. 3 | Ghataprabha | 0.5 | 10.0 | 72.9 | 16.6 |
| K. 4 | Malaprabha | 0.6 | 13.8 | 63.8 | 21.8 |
| K. 5 | Upper Bhima | 1.2 | 5.3 | 78.0 | 15.5 |
| K. 6 | Lower Bhima | 1.8 | 7.7 | 75.5 | 15.0 |
| K. 7 | Lower Krishna | 1.7 | 8.3 | 70.1 | 19.6 |
| K. 8 | Tungabhadra | 0.9 | 10.8 | 70.3 | 18.0 |
| K. 9 | Vedavati | 1.6 | 18.1 | 30.7 | 29.6 |
| K. 10 | Musi | 1.9 | 8.7 | 72.9 | 16.5 |
| K. 11 | Paleru | 1.7 | 6.8 | 74.7 | 16.8 |
| K. 12 | Muneru | 2.0 | 8.2 | 75.8 | 14.0 |
| | Krishna basin | 1.1 | 8.8 | 72.7 | 17.4 |

GODAVARI BASIN

| | | | | | |
|-------|---------------------------|-----|-----|------|------|
| G. 1 | Upper Godavari | 1.6 | 3.6 | 83.8 | 11.0 |
| G. 2 | Pravara | 1.0 | 4.3 | 78.5 | 16.2 |
| G. 3 | Purna | 1.9 | 4.0 | 82.8 | 11.8 |
| G. 4 | Manjra | 1.9 | 5.6 | 82.2 | 10.3 |
| G. 5 | Middle Godavari | 2.6 | 4.7 | 84.7 | 8.0 |
| G. 6 | Maner | 2.6 | 6.0 | 81.7 | 9.7 |
| G. 7 | Penganga | 2.6 | 4.1 | 85.3 | 8.0 |
| G. 8 | Wardha | 3.0 | 3.8 | 85.9 | 7.3 |
| G. 9 | Pranhita | 3.0 | 3.3 | 87.8 | 5.9 |
| G. 10 | Lower Godavari | 1.7 | 7.3 | 76.8 | 14.2 |
| G. 11 | Indravati | 1.7 | 5.4 | 86.0 | 6.9 |
| G. 12 | Sabari | 1.0 | 8.7 | 79.3 | 11.0 |
| | Godavari basin | 2.2 | 5.0 | 84.2 | 8.6 |

The weighted average annual rainfall of the Godavari basin is 1,132 mm. (44.6 inches), of which as much as 84.2 per cent falls in the four months, June to September. Within the basin, the Indravati sub-basin, the Sabari sub-basin and the Pranhita sub-basin each contribute much in excess of the weighted average for the entire basin.

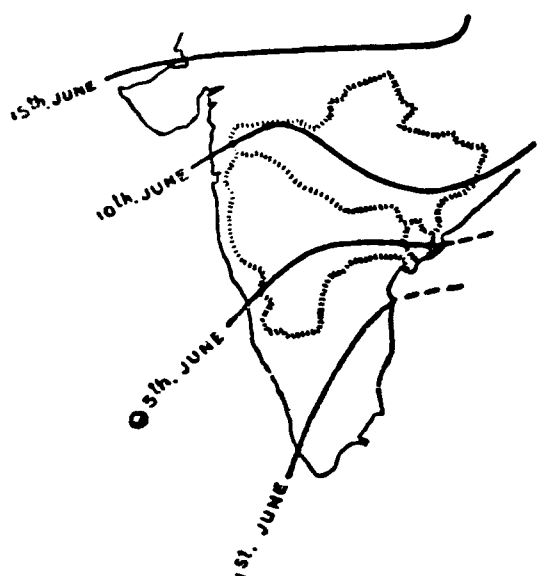
From October to December, the Lower Godavari sub-basin and the Sabari sub-basin have a rainfall much in excess of the average for this period for the entire basin.

It may also be noted (see Table V) that October to December rainfall represents 17.4 per cent of the annual rainfall in the Krishna basin, but only 8.6 per cent in the Godavari basin.

Rainfall Variations

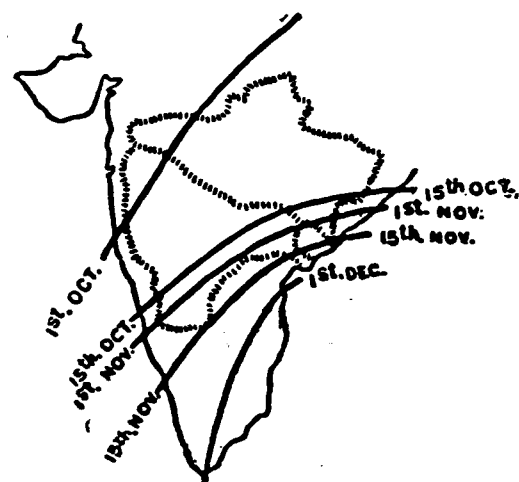
5-18 The above discussion has been confined to what is called normal annual rainfall and its normal distribution in time (seasons) and space (different parts of the Krishna and Godavari basins). The actual rainfall, however, varies widely from year to year. There are variations in the total annual rainfall ; there are also variation in its incidence and distribution in time and space. These variations have an important bearing on agricultural operations and river flow and may now be examined.

5-19 In view of the long dry period preceding the onset of the south-west monsoon, the actual date of this onset is important, both from the point of view of crop sowing operations as well as of the availability of river supplies. Figures 1 and 2 show respectively the dates of the onset of the south-west monsoon in different



NORMAL DATES OF ONSET OF
SOUTH-WEST MONSOON

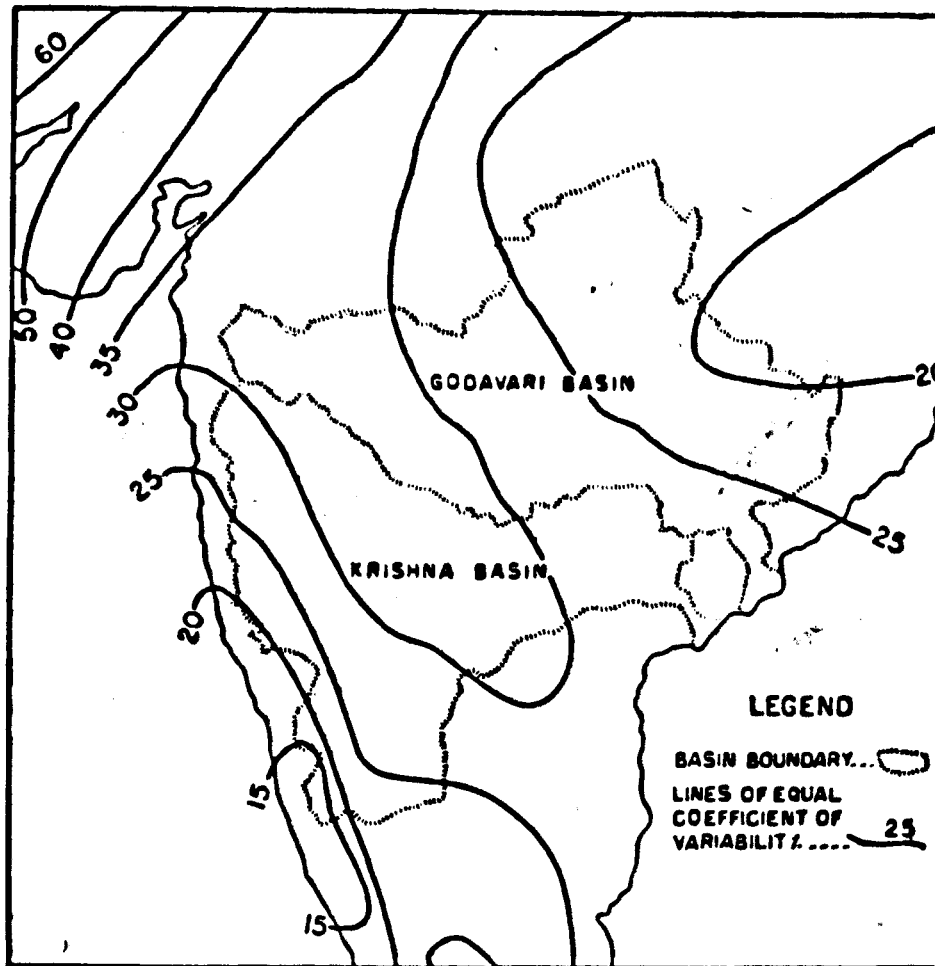
FIGURE 1



NORMAL DATES OF WITHDRAWAL OF
SOUTH-WEST MONSOON

FIGURE 2

parts of the Krishna and Godavari basins and of the normal dates of its withdrawal*. There is, however, a considerable variation not only in these dates but also in the speed with which the monsoon currents move from Kerala towards Bombay and across the peninsula. The standard deviation @ from these dates, in so far as they relate to the west coast, is about 5 to 6 days ; in individual years, however, the monsoon has been known to break on the west coast as many as 19 days earlier or 13 days later than the mean date.



COEFFICIENT OF VARIABILITY OF ANNUAL RAINFALL

FIGURE 3

*L.A. Ramdas ; "Rainfall of India—A brief review" ; *The Indian Journal of Agricultural Science*, March 1949.

@The "standard deviation" of a given set of values is the root mean square of the deviations of individual values from their arithmetic mean. If S.D. denotes "standard deviation" for n values of x and \bar{x} is their arithmetic mean, then

$$\text{S.D.} = \frac{\sqrt{\sum (x - \bar{x})^2}}{n}$$

In other words, "standard deviation" is an overall measure of the dispersion of individual values on both sides of the arithmetic mean ; the more compact the cluster, the smaller the standard deviation and the more frequent the deviations of a large magnitude, the larger the standard deviation.

5-20 There are various methods of analysing and studying rainfall variations; the best measure of variation is given by the "co-efficient of variability"*, which can be worked out for any given area. Figure 3 shows the co-efficient of variability of annual rainfall in southern India. It will be seen that except for the north-eastern part of the Godavari basin, where the co-efficient of variability is between 25 ; and 20, the co-efficient of variability for the rest of the Krishna and Godavari basins exceeds 25; in a significant portion, this co-efficient even exceeds 30.

5-21 It will be noticed by a comparison of Figure 3 and Plate IV that the area of low rainfall is also the area of relatively high co-efficient of variability. In other words, areas subject to low rainfall are also the areas subject to large variations of rainfall.

5-22 It has not been possible for the Commission to obtain maps showing the co-efficient of variability of seasonal and monthly rainfall. Such a study is necessary to get a proper appreciation of the hydrology of each sub-basin as well as of the irrigation requirements of crops in that sub-basin. In general, the co-efficient of variability for seasonal rainfall would be larger than that for annual rainfall and the co-efficient of variability for monthly rainfall would be still larger.

The following information** available about the co-efficient of variability of monthly rainfall in the Krishna and Godavari basins, arranged by sub-divisions of India, as formerly adopted by the India Meteorological Department, is highly instructive :—

TABLE VI
COEFFICIENT OF VARIABILITY

| Name of sub-basin | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec |
|---------------------------------------|------|------|------|------|-----|------|------|------|------|------|------|-----|
| Bombay Deccan | 215 | 175 | 144 | 71 | 76 | 33 | 30 | 37 | 39 | 61 | 101 | 200 |
| Berar | 173 | 170 | 203 | 169 | 143 | 43 | 34 | 46 | 53 | 108 | 140 | 267 |
| Central Provinces (East) | 111 | 99 | 138 | 137 | 110 | 73 | 38 | 37 | 58 | 126 | 161 | 191 |
| Hyderabad (North) | 251 | 167 | 163 | 61 | 97 | 35 | 25 | 41 | 40 | 71 | 120 | 204 |
| Hyderabad (South) | 294 | 102 | 218 | 87 | 70 | 37 | 33 | 41 | 43 | 82 | 106 | 168 |
| Rayalaseema | 207 | 241 | 221 | 81 | 61 | 41 | 52 | 63 | 45 | 56 | 83 | 172 |
| Andhradesa | 134 | 161 | 184 | 103 | 77 | 40 | 27 | 29 | 32 | 50 | 70 | 142 |

*When considering rainfall variations, a knowledge of "standard deviation" does not give a complete picture. A standard deviation of, say, 10 in an area with an annual mean rainfall of 20 inches would have very different significance to the same standard deviation in an area with an annual mean rainfall of 50 inches. A measure of variation or dispersion should, therefore be related to the size of the mean about which it is measured. The "co-efficient of variability" relates the "standard deviation" to the arithmetic mean and is obtained by dividing the standard deviation by the arithmetic mean, converting the ratio into a percentage. Thus, the co-efficient of variability is equal to $\frac{S.D.}{x} \times 100$.

**Govindaswamy, T.S: "Rainfall abnormalities" week by week, in India during 1908 to 1950 Journal of the Central Board of Irrigation and Power, April and July, 1953.

It will be noticed that in the months, when rainfall is low, the co-efficient of variability is high.

A co-efficient of variability of 294 during the month of January for Hyderabad (South) indicates that the magnitude of standard deviation would be about three times as large as the mean rainfall of the month. Such a situation arises from the fact that it rains in this area during January only on one day in three years. Likewise, a co-efficient of variability of 25 in the month of July for Hyderabad (North) indicates that the standard deviation would be one-fourth of the mean rainfall of the month.

5-23 A closer examination of the figures in Table VI would show that the co-efficient of variability for the north-east monsoon (October to December) is considerably larger than that for the south-west monsoon (June to September). This confirms the view expressed by some people that the north-east monsoon is much less dependable than the south-west monsoon and any agriculture as also, river flow dependent on the former would be more precarious than the latter. It will be noticed, also, that the rainfall during December to May is, in general, not at all dependable for agricultural operations.

As between different sub-divisions shown in Table VI, it will be seen that during the south-west monsoon period, taken as a whole, the rainfall is more dependable in Andhradesa and Bombay Deccan and least dependable in Rayalaseema and Central Provinces (East). Taking the two months of July and August only, the rainfall dependability is least in Rayalaseema and maximum in Andhradesa.

5-24 As indicated in paragraph 5-14 above, the areas lying towards the south-east of the Krishna basin receive a large proportion of their annual rainfall during the north-east monsoon.

A comparative study of the rainfall of Madras State (as it existed prior to the separation of Andhra) was published* in 1953. This study relates *inter alia* to the rainfall conditions in the following districts in which the waters of the Krishna and Godavari are proposed to be utilised by various State Governments :

| | | |
|--------------------|---------|---------------------------------------------------------|
| Coastal Andhradesa | • • | Visakhapatnam, West Godavari, Krishna, Guntur, Nellore. |
| Rayalaseema | • • • • | Kurnool, Bellary, Anantapur, Cuddapah, Chittoor. |
| Tamilnad | • • • • | Chingleput, South Arcot. |

The outstanding points which emerge from the study are:

- “(i) The north-east monsoon rainfall of the whole State and the south-west monsoon rainfall of Rayalaseema are highly variable and undependable. The rainfall of Rayalaseema, specially in the north-east monsoon period,

*P. R. Krishna Rao, “Rainfall of Madras State with special reference to Tamilnad and Rayalseema” *Memoirs of the India Meteorological Department Vol. XXX, Part 3.*

is the most variable in the whole State. In Tamilnad, the north-east monsoon rainfall is more variable in the coastal districts than in the interior districts because an appreciable percentage of coastal rainfall is 'cyclonic'.

- “(ii) The areas most liable to droughts in the north-east monsoon season are Rayalaseema (specially Anantapur, Bellary and Cuddapah districts) and the coastal districts of Tamilnad (specially Chingleput, South Arcot, Tanjore, Tirunelveli and North Arcot). The area most liable to droughts in the south-west monsoon is Rayalaseema, specially the Anantapur and Cuddapah districts.
- “(iii) The area least liable to droughts is Malabar where the rainfall is least variable specially in the south-west monsoon.
- “(iv) There is an indication that good north-east monsoons in Tamilnad are associated with deficient or normal south-west monsoons in that region in the same year and that deficient north-east monsoons are associated with excessive or normal south-west monsoon. This relationship requires further detailed examination and confirmation.”

This study was confined to the Madras State as it existed in 1953. The areas immediately adjoining the various sub-divisions of the former Madras State would, obviously, have similar rainfall characteristics.

Evaporation

5-25 Next to rainfall and its variations, evaporation is the most important climatic factor bearing on agriculture and water resource development. It influences the disposal of water in the upper layers of the soil, received from rain or from irrigation. It determines the major part of the losses from reservoirs and from river flows. It influences transit losses in canals of all types. The quantum of transpiration from plants, depending primarily on the physical processes of the plant, is at all times also controlled by the prevailing evaporation rate.

5-26 Efforts made by the Commission to obtain observed evaporation data for the Krishna and Godavari basins have yielded but poor results. Such observed data as have been made available by the State Governments have been presented in Statement 1 of Part II of Annexure I to this Report. These data comprise *ad hoc* observations for one or more years at only six stations within the two drainage basins and three stations south of the Krishna basin; the method of observation is not always known. As such, these data are not of much help to the Commission.

5-27 Enquiries made from the India Meteorological Department show that evaporation observations with U.S.A. Class A type open pans have been made, since about 1952, at a net-work of stations in India. On scrutiny of the data collected, however, it has been found that these data have, to some extent, been vitiated due to interference by birds and animals. To eliminate this source of error, further experiments have been undertaken to evolve suitable relationship between these observa-

tions and fresh observations made from pans provided with standardized wire mesh covers. Until such time as these relationships are evolved, the observations already made cannot be put to any use.

5-28 The only systematic information available at present on evaporation in India is based on calculations made, many years ago, from other meteorological factors, like pressure, temperature, vapour pressure, wind velocity, *etc.*

TABLE VII
NORMAL POTENTIAL EVAPORATION—SEASONAL AND ANNUAL

| Serial number ₁ | Name of station | Sub-basin | Mean potential evaporation | | | | | Annual |
|--------------------------------------------------------------|-------------------|-----------|----------------------------|--------------|---------------|---------------|-------|--------|
| | | | Jan.- Feb. | Mar.— May | June— Sep. | Oct.— Dec. | | |
| | | |millimetres..... | | | | | inches |
| A. Stations in the Krishna Basin and adjoining areas | | | | | | | | |
| 1 | Belgaum . . . | K. 3 | 478 | 934 | 351 | 574 | 2,337 | 92.0 |
| 2 | Poona . . . | K. 5 | 427 | 1,135 | 589 | 503 | 2,654 | 104.5 |
| 3 | Ahmednagar . . . | K. 5 | 556 | 1,440 | 693 | 605 | 3,294 | 129.7 |
| 4 | Sholapur . . . | K. 5 | 838 | 1,778 | 927 | 897 | 4,440 | 174.8 |
| 5 | Gulbarga . . . | K. 6 | 559 | 1,499 | 851 | 683 | 3,592 | 141.4 |
| 6 | Raichur . . . | K. 7 | 569 | 1,410 | 996 | 678 | 3,653 | 143.8 |
| 7 | Kurnool . . . | K. 8 | 363 | 1,196 | 927 | 406 | 2,892 | 113.9 |
| 8 | Chitradurga . . . | K. 9 | 546 | 889 | 577 | 518 | 2,530 | 99.6 |
| 9 | Hyderabad . . . | K. 10 | 287 | 1,046 | 653 | 376 | 2,362 | 93.0 |
| 10 | Hassan . . . | * | 216 | 455 | 1,282 | 261 | 1,214 | 47.8 |
| 11 | Bangalore . . . | * | 287 | 602 | 442 | 325 | 1,656 | 65.2 |
| 12 | Bombay . . . | * | 379 | 640 | 579 | 503 | 2,101 | 82.7 |
| 13 | Marmagoa . . . | * | 183 | 528 | 282 | 257 | 1,250 | 49.2 |
| 14 | Mangalore . . . | * | 262 | 437 | 201 | 285 | 1,184 | 46.6 |
| B. Stations in the Godavari Basin and adjoining areas | | | | | | | | |
| 1 | Aurangabad . . . | G. 3 | 765 | 1,877 | 704 | 858 | 4,204 | 165.5 |
| 2 | Hanamkonda . . . | G. 6 | 386 | 1,067 | 907 | 521 | 2,881 | 113.3 |
| 3 | Chanda . . . | G. 8 | 261 | 1,156 | 643 | 292 | 2,352 | 92.6 |
| 4 | Seoni . . . | G. 9 | 292 | 1,186 | 498 | 439 | 2,415 | 95.1 |
| 5 | Nagpur . . . | G. 9 | 330 | 1,351 | 615 | 457 | 2,753 | 108.4 |
| 6 | Amravati . . . | * | 462 | 1,395 | 592 | 645 | 3,094 | 121.8 |
| 7 | Raipur . . . | * | 274 | 1,275 | 592 | 358 | 2,489 | 98.0 |
| 8 | Khandwa . . . | * | 350 | 1,308 | 732 | 478 | 2,868 | 112.9 |
| 9 | Angul . . . | * | 269 | 823 | 546 | 325 | 1,963 | 77.3 |
| 10 | Gopalpur . . . | * | 381 | 864 | 602 | 427 | 2,274 | 89.5 |
| 11 | Cocanada . . . | * | 231 | 394 | 442 | 429 | 1,496 | 58.9 |

*designates stations outside the Krishna and Godavari basins,

Evaporation is essentially a physical phenomenon and a close relation exists between it and a number of other climatic factors, mainly (a) the gradient of vapour pressure close to the evaporating water surface and (b) the velocity of the air close to the water surface. Based on this relationship, Raman and Satakopan calculated* monthly rates of normal potential evaporation for 80 stations in India, 25 of which are located in the Krishna and Godavari basins and adjoining areas. The calculated evaporation rates for these 25 stations have been reproduced in Statement 2 of part II of Annexure I to this report. They represent theoretical *normal* values of potential† monthly evaporation from a water surface one foot above ground; the actual values from year to year would vary with variation of relevant climatic factors.

5-29 Table VII shows for each of the 25 stations, referred to above, the normal potential evaporation for each of the rainfall seasons referred to in paragraph 5-8 and for the year as a whole.

5-30 Raman and Satakopan prepared charts showing lines of equal evaporation (Iso-lines) for each month and for the year.

TABLE VIII
EXCESS OF MONTHLY EVAPORATION OVER MONTHLY RAINFALL

| Serial number | Name of station | Sub-basin | Excess of monthly evaporation over monthly rainfall | | | | | Annual |
|-------------------------------------------------------------|-------------------|-----------|-----------------------------------------------------|----------|-----------|-----------|--------|--------|
| | | | Jan.-Feb. | Mar.-May | June-Sep. | Oct.-Dec. | | |
| | | |millimetres..... | | | | | inches |
| A. Stations in the Krishna Basin and adjoining areas | | | | | | | | |
| 1 | Belgaum . . . | K. 3 | 472 | 813 | -666 | 412 | 1,031 | 40.6 |
| 2 | Poona . . . | K. 5 | 423 | 1,091 | 85 | 393 | 1,992 | 78.4 |
| 3 | Ahmednagar . . . | K. 5 | 546 | 1,406 | 217 | 501 | 2,670 | 105.1 |
| 4 | Sholapur . . . | K. 5 | 829 | 1,737 | 411 | 786 | 3,763 | 148.2 |
| 5 | Gulbarga . . . | K. 6 | 546 | 1,442 | 290 | 583 | 2,861 | 112.6 |
| 6 | Raichur . . . | K. 7 | 558 | 1,363 | 507 | 561 | 2,989 | 117.7 |
| 7 | Kurnool . . . | K. 8 | 351 | 1,146 | 497 | 291 | 2,285 | 90.0 |
| 8 | Chitradurga . . . | K. 9 | 535 | 785 | 250 | 322 | 1,892 | 74.5 |
| 9 | Hyderabad . . . | K. 10 | 267 | 977 | 77 | 265 | 1,586 | 62.4 |
| 10 | Hassan . . . | * | 203 | 276 | -151 | 8 | 336 | 13.2 |
| 11 | Bangalore . . . | * | 271 | 438 | -40 | 98 | 767 | 30.2 |
| 12 | Bombay . . . | ** | 373 | 618 | -1,114 | 420 | 297 | 11.7 |
| 13 | Marmagoa . . . | ** | 182 | 414 | -1,958 | 52 | -1,310 | -51.6 |
| 14 | Mangalore . . . | ** | 254 | 215 | -2,664 | -19 | -2,214 | -87.2 |

*P.X. Raman and V. Satakopan; "Evaporation in India calculated from other meteorological actors"; India Meteorological Department, Scientific Notes, Volume VI No. 61 (1935).

†i.e., if a water surface were available, the water would evaporate at this rate.

TABLE VIII—(concluded)
EXCESS OF MONTHLY EVAPORATION OVER MONTHLY RAINFALL

| Serial number | Name of station | Sub-basin | Excess of monthly evaporation over monthly rainfall | | | | | Annual |
|--------------------------------------------------------------|-----------------|-----------|-----------------------------------------------------|----------|-----------|-----------|-------|--------|
| | | | Jan.-Feb. | Mar.—May | June—Sep. | Oct.—Dec. | | |
| B. Stations in the Godavari Basin and adjoining areas | | | | | | | | |
| 1 | Aurangabad | G. 3 | 753 | 1,851 | 103 | 771 | 3,478 | 136.9 |
| 2 | Hanamkonda | G. 6 | 363 | 1,002 | 169 | 420 | 1,954 | 76.9 |
| 3 | Chanda | G. 8 | 228 | 1,109 | -468 | 216 | 1,085 | 42.7 |
| 4 | Seoni | G. 9 | 246 | 1,125 | -697 | 343 | 1,017 | 40.0 |
| 5 | Nagpur | G. 9 | 295 | 1,297 | -454 | 373 | 1,511 | 59.5 |
| 6 | Amravati | * | 433 | 1,363 | -151 | 569 | 2,214 | 87.2 |
| 7 | Raipur | * | 232 | 1,220 | -613 | 286 | 1,125 | 44.3 |
| 8 | Khandwa | * | 336 | 1,292 | 14 | 404 | 2,046 | 80.6 |
| 9 | Angul | * | 250 | 763 | 194 | -86 | 1,121 | 44.1 |
| 10 | Gopalpur | * | 345 | 780 | -91 | 92 | 1,126 | 44.3 |
| 11 | Cocanada | * | 215 | 319 | -168 | 36 | 402 | 15.8 |

*Designates stations outside the Krishna and Godavari basins.

Note : The minus sign indicates that the rainfall is in excess of evaporation.

Plate V shows these Iso-lines of annual evaporation (the charts of monthly evaporation lines have not been reproduced). In using these charts, it has to be borne in mind that these lines are based on computed values of evaporation for only 25 stations. These lines should, therefore, be taken as indicating the general trend and not the exact magnitude of evaporation. In drawing their lines, Raman and Satakopan considered it preferable to smoothen the lines instead of giving them the kinks necessary to fit them with the values, as computed by them; it seems they took note also of orography and other local features.

5-31 A perusal of the monthly charts prepared by Raman and Satakopan shows that during each of the six months from November to April, the western and middle parts of the Krishna basin and the north-western part of the Godavari basin lie in the zone of highest evaporation in the country. This high evaporation is reflected in the annual evaporation rates shown in Plate V.

5-32 Table VIII shows for each of the 25 stations referred to above the cumulative, seasonal and annual, excess of monthly evaporation over monthly rainfall. This excess furnishes a rough** measure of the relative aridity of various parts of the Krishna and Godavari basins. It will be seen that, except during the monsoon season, June to September, the normal potential (calculated) evaporation is always in excess of the normal rainfall and, for some stations, this excess persists even in the monsoon season. Ahmednagar, Sholapur, Gulbarga, Raichur, Aurangabad and Kurnool appear to be the most arid of the stations in the Krishna and Godavari basins for which this information is available.

**A more accurate measure would be provided by a comparison of daily evaporation (if available) and daily rainfall.

5-33 As stated in paragraph 5-28, the evaporation rates computed by Raman and Satakopan and shown in Table VII and Plate V represent the power of the air layer, one foot above the ground, to carry away water vapour from a water surface at that level. It has been estimated* that if E represents evaporation rate from a water surface, one foot above the ground, then the evaporation rate E_o from a water surface, flush with the ground, would be

$$E_o = 0.845E$$

During rainy spells, when the whole country-side is saturated with water, E_o will represent the evaporation from a large area of water but during the dry season E_o will represent only the evaporation from isolated water surfaces, four feet** in diameter and flush with the ground. It has further been estimated† that the evaporation E_w from a large water surface, during the dry season, would be

$$E_w = 0.7E_o = 0.6E \text{ approximately}$$

5-34 It would appear from the above that, for calculating losses from storage reservoirs and other collections of water, one would have to adopt E_o for the rainy days and E_w for the dry period of the year. It would not, however, be possible to check these results with actual field conditions as little reliable data are available of the quantity of water lost by evaporation from existing storage reservoirs in the Krishna and Godavari basins. For preparing water accounts, wherever such accounts are being maintained, the actual evaporation loss is either taken as an assumed figure or where actual losses are calculated from reservoir levels the inflow into the reservoir is not observed and not accounted for.

TABLE IX.

MONTHLY EVAPORATION FROM RESERVOIRS AS ASSUMED IN DIFFERENT PARTS OF THE KRISHNA AND GODAVARI BASINS

| Particulars of area or works | Evaporation (inches) | | | | | | | | | | | | Annual |
|-------------------------------------------|----------------------|------|------|------|-----|------|------|------|------|------|------|------|--------|
| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | |
| Andhra Pradesh | | | | | | | | | | | | | |
| Small reserv- oirs in Andhra region | 4 | 4 | 7 | 9 | 10 | 7 | 6 | 6 | 6 | 5 | 4 | 4 | 72 |
| Tungabhadra reservoir | 9 | 9 | 12 | 12 | 12 | 9 | 3 | 3 | 3 | 3 | 6 | 6 | 87 |

*Ramdas L.A. Bulletin of the National Institute of Sciences, India, 1962.

**The size of a U.S.A. class A type open pan.

†Venkateshwaran S.P., Jagannathan P. and Ramakrishnan S.S.; Indian Journal of Meteorology and Geophysics, Vol. 10, No. 1, page 30, 1959.

TABLE IX (continued)

MONTHLY EVAPORATION FROM RESERVOIRS AS ASSUMED IN DIFFERENT PARTS OF THE KRISHNA AND GODAVARI BASINS

| Particulars of area or works | Evaporation (inches) | | | | | | | | | | | | |
|-----------------------------------------|-----------------------------------------------------------------------------|------|------|------|-----|------|------|------|------|------|------|------|--------|
| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
| Proposed reservoirs at— | | | | | | | | | | | | | |
| Ippur . . . | 4 | 4 | 9 | 12 | 12 | 9 | 6 | 6 | 6 | 6 | 4 | 4 | 82 |
| Inchampalli . | 4 | 4 | 7 | 9 | 10 | 7 | 6 | 6 | 6 | 6 | 4 | 4 | 73 |
| Nagarjunasagar | 4 | 4 | 9 | 12 | 12 | 9 | 6 | 6 | 6 | 6 | 4 | 4 | 82 |
| Pulichintala . | 4 | 4 | 9 | 12 | 12 | 9 | 6 | 6 | 6 | 6 | 4 | 4 | 82 |
| Srisaïlam . | 4 | 5 | 6 | 7 | 7 | 6 | 3 | 4 | 3 | 3 | 3 | 3 | 54 |
| Small reservoirs in Tel- angana area | Raman and Satakopan's figures (Plate..V..) with a reduction factor of 0.72. | | | | | | | | | | | | |
| Nizamsagar reservoir (existing) | 5 | 4 | 5 | 6 | 8 | 6 | 7 | 7 | 8 | 6 | 6 | 3 | 71 |
| Pochampad (proposed) | 4 | 4 | 9 | 12 | 12 | 9 | 6 | 6 | 6 | 6 | 4 | 4 | 82 |
| Madhya Pradesh | | | | | | | | | | | | | |
| All work | 5 | 6 | 7 | 10 | 12 | 10 | 2 | 2 | 2 | 6 | 5 | 5 | 72 |
| Maharashtra | | | | | | | | | | | | | |
| Western Ma- harashtra. | | | | | | | | | | | | | |
| Ghat areas . . . | Monthly distribution not available. | | | | | | | | | | | | 84 |
| Other areas . . . |x.....48.....x.....18.....x.....30..... | | | | | | | | | | | | 84 |
| Marathwada | 4 | 7 | 10 | 12 | 11 | 7 | 6 | 6 | 6 | 5 | 4 | 4 | 82 |
| Vidharba— | | | | | | | | | | | | | |
| Two seasonal projects |Monthly distribution not available..... | | | | | | | | | | | | 48 |
| Perennial pro- jects |Monthly distribution not available..... | | | | | | | | | | | | 96 |

TABLE IX (concluded)

MONTHLY EVAPORATION FROM RESERVOIRS AS ASSUMED IN DIFFERENT PARTS OF THE KRISHNA AND GODAVARI BASINS

| Particulars of area or works | Evaporation (inches) | | | | | | | | | | | | |
|------------------------------------|----------------------|------|------|------|-----|------|------|------|------|------|------|------|--------|
| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
| Mysore | | | | | | | | | | | | | |
| Proposed re- servoires at | | | | | | | | | | | | | |
| Bhadra . | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 7 | 8 | 52 |
| Malaprabha . | 9 | 9 | 12 | 12 | 12 | 9 | 6 | 6 | 6 | 6 | 6 | 6 | 99 |
| Upper Krishna | 4 | 5 | 9 | 12 | 11 | 9 | 6 | 6 | 6 | 6 | 4 | 4 | 82 |
| Ghataprabha . | 6 | 6 | 9 | 9 | 9 | 9 | 3 | 3 | 3 | 6 | 6 | 6 | 75 |
| Other works | Not available | | | | | | | | | | | | |
| Orissa | | | | | | | | | | | | | |
| All works . | 4 | 4 | 7 | 9 | 10 | 7 | 6 | 6 | 6 | 5 | 4 | 4 | 72 |

5-35 The evaporation losses, as assumed in various States, are given in Table IX. It would appear from a comparison of the figures shown therein with Plate V that the assumed evaporation rates for many reservoirs are less than would be indicated by the general meteorological conditions at the site.

Evapo-transpiration

5-36 Preliminary investigations show that the evaporation from a large surface E_w , referred to above, provides an approximate estimate of the combined loss of moisture by transpiration from a crop and evaporation from the soil under *continuous* irrigation. No reliable and systematic data are, however, available of observed values of evapo-transpiration in the Krishna and Godavari basins. These values would, of course, vary for different crops and different soil moisture conditions. Since evapo-transpiration is a correct measure of the water requirements of crops, the lack of observed data of evapo-transpiration is a serious lacuna for the optimum development of the water resources of the two basins.

CHAPTER VI

SOILS

General

6-1 Soils differ in their capacity for crop production and suitability for irrigated agriculture. Their physical and chemical properties, which determine this capacity and suitability, are governed by several factors, operating singly and collectively, e.g., geological, topographical, climatic, agronomic and biological. The behaviour of sub-soil waters also plays an important part. Under natural conditions, there is a soil-water-crop relationship peculiar to each area. When man interferes with this relationship, he must do so in full knowledge of the complex and of the likely effect of his actions.

6-2 Introduction of irrigated agriculture in an area under forests or scrub jungle or rain-fed crops is a major interference in the *status-quo* and must therefore be preceded by detailed field and laboratory investigations aimed at classification of the soils of the area and assessment of their suitability or otherwise for irrigation. This information makes it possible for agronomists and irrigation engineers to determine appropriate pattern of cropping, intensities of irrigation and the quantity of water to be diverted into the fields.

6-3 Some pre-irrigation surveys with limited objectives have been made in connection with the Nagarjunasagar project in Andhra Pradesh, irrigation projects in Madhya Pradesh, several projects in Maharashtra and Tungabhadra and Ghataprabha projects in Mysore. Soil survey reports are also available for small experimental blocks under different research stations engaged on agro-irrigational problems. This chapter is based on the information obtained from these sources and on the information about the soils of the country compiled by the Chief Soil Survey Officer, Indian Agricultural Research Institute.

6-4 As stated in Chapter II, the basins of the Krishna and the Godavari rivers consist largely of undulated land, forming alternate ridges and relatively narrow valleys, which go on getting wide from west to east. The plateau land in these basins is, therefore, liable to serious erosion by rain. Under such conditions, the soils in these basins are, in general, relatively shallow especially where they have formed in situ. Deep soils are found mainly along the banks of streams and rivers where they have been formed by eroded material brought by, and deposited during floods. Deep soils are also to be found in broad valleys where the surface drainage is often impeded by ridges. This facilitates deposition of dis-integrated soil material carried by surface drainage. While the climatic conditions favour soil formation, the topographical features facilitate continued soil erosion. Thus the existing soils represent a balance between the soil formation and the soil erosion processes.

The soils of the two basins have, in general, attained a high degree of maturity as they represent products of weathering over long ages.

Principal Soil Type

6-5 The principal soil types in the Krishna and Godavari basins and adjoining areas are shown in Plate VI.* These are (a) black soils (*regur*), (b) red soils, (c) laterites and lateritic soils, (d) alluvium, (e) mixed red and black soils and red and yellow soils, and (f) saline and alkaline soils.

6-6 The salient features, occurrence, texture, physical properties, *etc.*; of each of the principal soil types are briefly given below.

6-7 *Black soils* cover the largest area in the two basins. They are generally found in areas of low rainfall (20 to 30 inches, annual). The most characteristic black soils cap the volcanic plateau of the Deccan traps and thus form a mantle of rich residual soil of varying depths, shallow, medium and deep but by no means as deep as alluvial soils. The area of black soil is not co-terminous with the boundary of the Deccan trap formation as these soils are also found over the surrounding granite and basic gneissic rock formations and other geological formations such as Vindhyan or Cuddapah sand-stones and slates rich in lime and soda felspar. The lime and soda felspars weather more quickly than potash felspars. While prolonged weathering results in a fine consistency of clay or silt in the early stages of weathering, the undecomposed finer particles of felspars may be present along with the weathered particles. There are also large tracts of transported black soil.

The depth of black soil varies from place to place in the Krishna and Godavari basins. In the valleys, these soils are darker, deeper and richer and are constantly enriched by the washings from land at higher elevations. Thus deep black soils have mainly developed as alluvial material along the courses of the Krishna, Godavari, Bhima, *etc.*, in low-lying areas with flat topography. The deeper soil horizons along the profile, although highly clayey, are usually somewhat light in colour, black to yellowish grey, and at times manifest irregular foliations in which case clay lumps present lustrous surfaces along the plane of fracture.

The medium black soils are generally 3 to 5 feet in depth, comparatively less clayey and have greater calcium carbonate content. Other characteristics are in between those of the deep and the shallow soils of this type.

The shallow black soils are residual soils and are found on hill slopes and plateaus. They are light in colour; the light yellow sub-soil is not so well developed.

Black soils are classified into deep, medium and shallow depending on the effective depth of soil overlying parent material, the exact depth for each type varies in different States.

*The soil map shown in Plate VI has been obtained from the Chief Soil Survey Officer, Indian Agricultural Research Institute.

6-8 Black soils often contain *kankar* nodules and occasionally crystals of gypsum in the lower layers. Very often, the yellow clay horizon, which is a conspicuous feature of the gypsum-bearing soil, may be absent in soils without gypsum, particularly in shallow soils. When gypsum is present in the soil profile, as generally happens between third to fifth foot of its effective depth, it is followed by a zone of salt accumulation, the percentage of salts going upto 1—1.5 percent in some cases. Deep black soil with gypsum has generally the highest salt concentration, the next in descending order of soluble salt content being the shallow soil with gypsum, shallow soil without gypsum and deep black soil without gypsum respectively.

6-9 In texture, black soils vary from heavy loams to light clay loams, to heavy clay loams and clays. They are usually clayey with clay content ranging from 40 to 70 percent and can therefore be designated as heavy texturally. The preponderating clay minerals in these soils are those of the montmorillonite-beidellite groups as are known to have the silica sesquioxide ratio of 3 or even higher. These soils exhibit high expansion and shrinkage characteristics, high hygroscopicity and high pore space. They have neutral to alkaline reaction. Their base exchange capacity is fairly high throughout the profile depth and they are well supplied with replaceable bases, in particular, calcium. While they are generally ill-supplied with humus, available nitrogen and phosphates but are sufficient in potash.

6-10 *Kankar* and other accumulations consisting of gypsum, sodium sulphate and other salts, disposed at different depths and in varying concentrations along the profile, are not the decomposed products of the parent rock, from which black soil is formed, but are mostly products of the secondary decomposition of soda-lime felspar. The soluble salts manifest a tendency to accumulate in soils if they are not leached out. The black soils have large quantities of replaceable calcium ; the high lime status minimizes the ill-effects on crop growth of the soluble salts, if present. Moreover, these soils have high fertility status and moisture retentivity.

6-11 The cause of the dense black colour of these soils is not definitely known. The theories put forth attribute the black colour of soil to the presence of titaniferrous magnetite, colour of clay and its humus complex, topographical positions and degree of hydration of iron oxide, derivation from rock having predominance of calcium, *etc.* The majority of black soils, however, contain little organic matter.

6-12 *Red Soils* occur over large parts of the two basins; the extent of their occurrence is only next to that of black soils. The regions occupied by acid granites, gneisses, quartzite and felpathic, with only subordinate rock types rich in iron and magnesium bearing minerals, give rise particularly to red soil but at places to yellow, grey or even black-coloured soils. The ancient sedimentary sandstones and clays of the Cuddapah and Vindhyan systems have contributed secondarily to the formation of these soils. Distinct from the red soils formed from the above mentioned rocks, some red coloured soils are of different constitution having been derived from the surface capping of laterized rocks or from limestone formations.

This type of soil, though frequently red in colour, is not always necessarily so and the colour is not due to a high percentage of the iron content. It is noteworthy that the granites and gneisses also serve as a source of black soils described above.

6-13 Texturally, red soils comprise coarse sandy loams, medium fine sandy loams, fine sandy loams and loams. They vary from the poor thin gravelly light-coloured soils of the uplands, by intermediate stages, to the rich-coloured fertile soil of the low-level lands. The deep red soils exhibit a sandy loamy texture at the surface with a loamy composition in the deeper layers. The shallow red soils have characteristics similar to those of the deep red soils except for the depth which may be from 18 inches to even 6 inches. Red soil can also be present mixed with a high percentage of coarse gravel and quartz pebbles with disintegrated rock or *moorum* of varying depths underlain by bed rock.

6-14 In contrast to black soils, red soils are more friable and light-textured, sufficiently permeable to be well-drained, have a low water retentivity, negligible salt content seldom exceeding 0.2 percent, a low base-status and are almost free from lime concretions and carbonates, *etc.*

The clay fraction of red soils is rich in kaolinitic type of minerals. Sometimes iron and manganese concretions are contained in the soil at the surface or in the upper layers. Often the presence of colloidal iron makes the soil sticky when moistened. The silica alumina ratio usually exceeds 2.0, thus differing from both the lateritic soil and laterites, which, though also of reddish colour, have a silica alumina ratio of less than 2.0. Generally speaking, these soils are deficient in exchangeable bases.

Red soils are deficient in nitrogen and organic matter but have sufficient potash and lime. The content of available phosphates is generally low to sufficient.

The depth of these soils varies from a few inches to several feet. Because of their being friable, well-drained, and easily manageable, they are capable of withstanding a heavy moisture saturation without detriment to crop growth.

6-15 *Laterites and lateritic soils.* The laterite soil group in its best development forms a belt of variable width, capping the hills and plateaus in the two basins. Laterites are derived from a variety of parent materials principally igneous formations under conditions of high humidity, high temperature and alternate periods of wetting and drying. Most of the laterites in the form of massive beds are found capping hills at altitudes ranging from 2,000 to 5,000 feet. Although the laterite cap on the top of plateaus in the Deccan trap area varies considerably in thickness, extending to a hundred or two hundred feet, generally the laterite soils have a thickness of two to three feet. The laterites occurring at low levels, in many cases, are secondary (detrital), having been derived from high level (primary) and cemented on the valleys and plains. Primary laterite can be found at all altitudes if the conditions are favourable. On the whole, while the primary laterite is compact and fairly uniform in composition, the detrital laterite is heterogeneous and seldom compact.

Although the laterite itself is something in the nature of a soil cap passing down by clear gradations into subjacent rock, the pedogenic processes have stopped short at a stage such that the resulting product, ferruginous, porous and vesicular, soft when fresh but hardening on exposure, is not in the true sense a soil. However, further modification and the action of biological and other soil forming agencies, convert laterites into a red to yellow coloured soil, not very deep and composed of disintegrated loam charged either with segregated iron nodules or at times having an iron pan.

6-16 Laterites being largely a product of the higher rainfall regions, with their alternate dry and moist conditions, the constant leaching action in these soils particularly in up-ghat areas, renders these soils poor in respect of their colloidal and plant nutrient contents. This brings about conditions of deficiency of lime and other bases, leading to somewhat acid reaction in this soil type. The primary individual particles in the clay and silt fractions tend to get cemented into secondary sand-like particles and therefore fail to manifest such typical properties of clays as swelling on wetting, plasticity and pronounced base exchange capacity. The silica alumina ratio is low in natural laterites; in true laterites, the combined silica being almost totally absent.

Because of the intensive leaching and the low base exchange capacity, typical laterite soils are lacking in elements of fertility and are of little value for crop production. While in some parts of the Krishna and Godavari basins, tillage and secondary changes result in producing soils acquiring enough potash, nitrogen and phosphates, the laterite soils developed on the summits of the plateaus of Madhya Pradesh, Eastern *Ghats* and Orissa are generally deficient in these constituents.

6-17 *Alluvial soils* are, as a rule, of sedimentary type and are found in the deltaic areas and on the coastal belt. They are formed by the annual deposition of rich silts brought down by the rivers. On the basis of the textural characteristics, these soils can be silty loams, silts, silty clayey loams, silty clays, clayey loams, clays and rarely sandy loams. They are generally well-drained and being inherently fertile, they respond well to irrigation and generally give high crop yields.

The alluvial soil in the upper Krishna valley, 60 to 80 feet above the present river bed, comprises gravels, sandy silts and calcareous conglomerates of pleistocene age. There are also thick deposits of alluvium along the upper Godavari basin composed of brown clay and sandy silts with nodules of kankar and beds of gravel, the later composed of pebbles derived from the Deccan trap, agate and chalcedony.

6-18 *Mixed soils* In addition to the distinct soil types described above, combinations of these types are also met with in the two basins, e.g., mixed red and black soils, red and yellow soils, etc. The properties of such soils are those of the constituent soil types.

6-19 *Saline* soils are found near the west coast and *alkaline* in some parts of the two basins. The coastal soil, subject to inundation by sea tides, contains high concentration of soluble salts, mainly sodium and magnesium chlorides, with a slightly alkaline reaction, low lime reserve and a fair to poor amount of manurial constituents, nitrogen, phosphates and potash. The alkaline soils are developed in arid and semi-arid areas on account of the nature of the parent rock, basin-shaped topography, excessive irrigation and consequent rise of water table under defective drainage conditions and salinity of irrigation water and are not only characterised by the presence of a high content of soluble salts but also of high exchangeable sodium. These soils in some canal-irrigated areas manifest a zone of salt accumulation and a high degree of sodium saturation, the soil structure getting worse with increasing sodium in the exchange complex.

Saline and alkaline soils are amenable to reclamation and or the use of soil amendments like gypsum, sulphur, molasses and can thus be made to yield good crops.

6-20 It would have been clear from the above description of the principal soil types in the Krishna and Godavari basins and the general topographical feature of the basins described earlier in Chapter II that these soil types would also occur mixed with each other. In fact, the soil map in Plate VI indicates only the dominant soils in different parts of the two basins and within each of the dominant soil belts shown therein would occur also patches of some of the other soil types described above.

6-21 It should also be noted that the principal soil types described above are primarily classifications of the top soil only. From the point of view of agriculture, the behaviour of these soils under irrigation and the general hydrology of the two basins, one needs to know not only the characteristics of the top soil and how these characteristics would be modified by some influencing factors (e.g. excessive content of soluble salts and high alkalinity resulting from sodiumisation) but also the structure and the drainage characteristics of the sub-grade.

Drainage characteristics of soils

6-22 The high content of clay in black soils and at times in alluvial soils confers on them characteristic physical properties such as low permeability and a high moisture holding capacity, conditions which are conducive to lowering their capacity for sub-soil drainage but favouring a high capacity for surface drainage. The presence of gypsum and nodular kankar in these soil types render them more pervious to water and thus liable to be easily drained. In other types of soils viz., red, lateritic and some mixed soils, the top soil is generally light texturally and, therefore, it rarely presents any drainage problem, except when the sub-grade happens to be of an impervious type.

6-23 The sub-grade may be *moorum*, with good drainage properties; it may be trap rock and impervious to flow or its structure may be such as would give it a permeability in between these two extremes. When the sub-grade has good drainage characteristics, there are little complications under irrigated

conditions except that excessive seepage, in the absence of a good outfall into a river, may bring about a rise in the sub-soil water table and consequent water logging. When the sub-grade happens to be impervious, then any water percolating down through the top soil is blocked by the sub-grade and, therefore, tends to flow in a lateral direction, thus bringing about conditions of perched water table or appearance of water at the surface in the adjoining lower fields. Several instances of this phenomenon have been noticed in the two basins and adjoining areas.

6-24 As a result of soil profile studies in the black soil areas of some canal systems in the former Bombay State, viz., Nira Right and Left Bank Canals, and the Pravara Right and Left Bank Canals, these soils have been divided* into two major groups according to the soil forming processes operating there.

In group one are included soils developed under conditions of restricted drainage which exhibit the presence of appreciable amount of soluble salts in their profiles, the soils becoming cloddy and attaining a high degree of sodiumisation of clay complex. While the deposition of salts in this group is normally low at the surface, first increasing with depth and then decreasing, in some types the salt content goes on increasing with depth without the formation of a salt accumulation zone.

The soils included in the second group are developed under conditions of free drainage and manifest considerable variation in their free lime content.

In some irrigated areas, type of black soil overlies a practically impervious sub-grade locally known as *Chopan*. The *Chopan* black soil found in valleys is deep, heavy and highly retentive ; similarly reddish yellow or grey soil is found at the surface of denuded areas and is impermeable and clayey, 4 to 6 feet in depth, overlying *Chopan*. At places 2 to 3 feet depth of black stiff soil occurs above that sub-grade. Such *Chopan* soils in Maharashtra have been reclaimed by cutting through the impermeable sub-grade by a system of drains.

Effect of rainfall on soil formation

6-25 It will have been seen from the preceding paragraphs that one particular type of soil is not formed solely from any one type of parent rock. For instance, while the black soil is derived mainly from the Deccan trap, it is by no means confined to the trap areas but is met with also in areas where the parent rock consists of gneisses, charnokites, cretaceous sediment, etc. Likewise, while the red soils are derived mainly from granites and gneisses, there are instances where those very parent rocks serve as a source of black soil. This would suggest that apart from the chemical composition of the parent rock other factors, such as climate, also play an important part in the formation of soils.

6-26 An examination of the soils in the two basins, taken together, in relation to the annual rainfall isohyets shown in Plate IV reveals the following dominant features :

* Basu J.K. & Sirur, S.S. (1933) *Ind. Jour. Agri. Sci.* VIII, 1:637-97

TABLE X
EFFECT OF RAINFALL ON SOIL FORMATION

| Annual rain- fall | Northern parts | | Southern parts | | Deviation, if any, from the predominant soil types |
|-------------------------------------|-----------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------|
| | Predominant parent rock | Predominant soil type | Predominant parent rock | Predominant soil type | |
| 2,000 mm. (80 inches) | Basalt | Red soil (gravelly) | Gretaceous and tertiary. | Laterite | |
| 2,000-1,000 mm. (80-40 inches) | Basalt, archæan gneiss and schist, etc. | Red and yellow soils, red gr- avelly soil (shallow to medium). | Basalt, archæan gneiss and schist etc. | Red soil | Skeletal soil |
| 1,000-600 mm. (40-24 inches) | Basalt | Black soil (medium). | Archæan, etc. | Laterite soil red, soil. | Skeletal soil and deep black soil along rivers. |
| 600 mm. (24 inches) and below | Basalt | Black soil (medium to deep). | Archæan, etc. | Red soil, mixed red and black soil and black soil (deep). | |

It is thus seen that in areas of high rainfall (2,000 mm. and above) the climate is conducive to the formation of laterites and lateritic soils. With decreased rainfall (1,000—600 mm.), the black soils generally predominate. With slightly less rainfall, the types of soil formed show variation due to the variety of parent rocks.

Behaviour of different soil types under irrigated agriculture

6-27 Shallow black soils overlying well-drained open-textured bed rock can, under irrigation and good management practice, be highly productive. When black soils formed from soda-lime felspars are subjected to heavy irrigation they are likely to undergo changes due to continued hydration and decomposition liberating lime and soda. In the absence of leaching through drainage, this would lead to the development of salinity. In such cases, the soda liberated may lead to sodiumization of clay. The latter being highly impervious swell heavily on the application of water and shrink on drying to form a hard mass, thus leading to development of deep cracks. Under irrigated conditions, even if the pH is somewhat high, *i.e.*, from 8.5 to 9.5, and the degree of alkalization is less than 25 percent, the crop yields are not affected appreciably. This is contrary to the experience with the alluvial soils of north India.

6-28 In black soils, under irrigation, the general distinctive profile characteristics which are noticeable under un-irrigated conditions are apt to be obliterated, largely due to the leaching of salts. These soils are likely to give trouble if care is not taken to avoid promiscuous or indiscriminate irrigation of land or if water is applied in such manner as to maintain soil in over-moist condition. It is helpful in such soils to restrict wet and perennial cultivation to low lying areas provided drainage is good*. Heavy black soils are, therefore, essentially suitable for cropping in the post-monsoon period but, if shallow and overlying a well-drained subsoil, as already stated, black soils are known to be highly productive under irrigation and good management practice.

6-29 Red and mixed soils, because of their permeability and low water-holding capacity, react favourably to the application of irrigation water and do not give trouble. They are friable, well-drained and easily managed. As such, their behaviour is normal and good crop yields can be obtained from them with application of irrigation and fertilizers.

6-30 The laterites and lateritic soils, which are normally met with in high rainfall areas, have conspicuous good drainage capacity. They are mostly covered with forest or scrub jungle and, where not under scrub jungle or grass, bear dry rain-fed crops.

6-31 The saline and alkaline soils need reclamation before normal cropping can be ensured.

Crops grown in relation to soil types

6-32 Table XI gives a general analysis of cropping under rain-fed and irrigated conditions for each of the four main soil types viz., black, red, lateritic and alluvial. The names of crops have been arranged in the descending order of acreage covered by each.

TABLE XI
CROPPING PATTERN BY SOIL TYPES

| <i>Soil type</i> | <i>Rain-fed cultivation</i> | <i>Irrigated agriculture</i> |
|------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Black soil | <i>Jowar, cotton, wheat, pulses oil-seeds, gram, millet and ground-nut.</i> | <i>Paddy, vegetables, chillies, cotton, jowar, wheat, fruit crops, sugarcane and onions.</i> |
| | <i>Also grown are ginger, paddy (if rainfall is high), linseed, tobacco, niger, kulthi and chillies.</i> | <i>Also grown are pulses, ginger, linseed, potatoes, maize, banana and tobacco.</i> |

*At the Nandyal Agricultural Farm, where the soil is stiff deep black clay extending to a depth of seven feet and has a pH of about 9.0, in seasons of heavy rainfall, crops have been noted to suffer for want of drainage.

TABLE XI (concluded)
CROP PATTERN BY SOIL TYPES

| <i>Soil type</i> | <i>Rain-fed cultivation</i> | <i>Irrigated agriculture</i> |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Red soils | <i>Jowar</i> , ground-nut, pulses, <i>ragi</i> , oil-seeds and millets. Also grown are cotton, paddy (if rainfall is high) coconut, ginger, chillies, and castor. | Paddy, vegetables, ground-nut, sugarcane, banana, fruit crops and areca. Also grown are chillies, betel, <i>ragi</i> , coconut and onions. |
| Laterite and Lateritic soils | Paddy, <i>jowar</i> , ground-nut, pulses, oil-seeds, miller, cardomum. Also grown are niger, saf-flower, linseed, coconut, pepper, sugarcane, banana, and areca. | Paddy, sugarcane, vegetables, banana, chillies and areca. Also grown are wheat, fruit crops, turmeric, ginger, onion, cardomum and potatoes. |
| Alluvial soils | <i>Jowar</i> , chillies, cotton, pulses, paddy, wheat and sugarcane. Also grown is coconut. | Same as under rain-fed conditions, paddy is also grown in Andhra Pradesh. |

It is seen that paddy, sugarcane, vegetables, chillies, areca, banana and fruit crops are grown under irrigated conditions on laterite and lateritic, black and red soils. *Jowar*, ground-nut, pulses, oil-seeds, millets and paddy are grown under rain-fed conditions on black and red loamy soils. *Ragi* is grown under both rain-fed and irrigated conditions mostly on light type of soil, principally the red loamy soil. Wheat and fruit crops are grown on laterites and lateritic and black soils under irrigated conditions. Cotton and fruit crops are grown mostly under irrigated and rain-fed conditions on black and alluvial soils while tobacco is grown under both irrigated and rain-fed conditions on black soils.

6-33 Deep black soils are regarded as good for wheat and a variety of other crops, particularly *rabi* crops ; medium black soils for wheat, cotton, sugarcane, *jowar*, ground-nut *etc.*, for both *kharif* and *rabi* crops : shallow black soils for a variety of crops depending on their clay content ; clays and loamy soils are generally put under paddy.

6-34 Red sandy soils derived from sand-stones and lime-stones are more suitable for *kharif* crops.

The mixed red and black soils differ widely in depth and fertility and, although these soils are deficient in nitrogen, phosphoric acid, organic matter and lime, they produce a large variety of crops under irrigation.

The gravelly soils are generally poor and grow inferior millets and oil-seeds. When such soils occur in association with black soil, crops like paddy and wheat are possible.

Predominant soil types by districts

6-35 The following information with regard to the predominant soils, district-wise, has been summarized from the data (not yet published) compiled by the Division of Soil Survey and Land Use of the Indian Agriculture Research Institute. The suffix (K) or (G) indicate whether the district lies in the Krishna or the Godavari basin respectively.

Andhra Pradesh

Adilabad (G), Medium black soil in the northern half of the district, deep black soil in areas near banks of the Godavari, the rest of the area has red soil.

Anantapur (K), Majority of the area has red soil ; black and alluvial soils are also present. While the non-calcareous red soils have loose structure, are poor in organic matter content and neutral, the calcareous soils are fairly deep and poor in organic matter content. The black soils are clayey. Alluvial soils are sandy at top with salts in sub-soil layers.

Cuddapah (K), Both red and black soil, the latter of calcareous and non-calcareous types. The organic matter content of soils is low and they are well drained.

East Godavari (G), Black soil, clayey, pH about 8·7, nitrogen content high in Amalapuram and Mandapeta taluks. Loamy to clayey soils in the Peddapuram and Ramchandrapuram taluks ; the soils of the former taluk are better drained. The lime, nitrogen and available phosphate contents are low.

Guntur (K), Black soils, heavy clays with good supply of lime, pH about 8·8, nitrogen content medium, phosphates low but potash well supplied.

Hyderabad (G & K), Both shallow black soils and red soils are met with.

Karimnagar (G & K) : Same as for Adilabad District.

Khammam (G & K) : Soils in the area are sandy loam, clayey loam and loam. The red sandy loam is known as *chalkas*. At a few places, soil is highly coarse-textured and known as *dubbas*; it is permeable and subject to intensive leaching, of low fertility and has low organic matter content. The clay loams are black or grey occurring near the river banks and lowlying areas. They have a high calcium carbonate content.

Krishna (K), Valley land along the river has deep black soil ; the remaining area has predominantly red sandy soil with small portions having red and black soils. Soils from two areas near Vijayawada have been described as saline, having sandy loam texture, appreciable sodium chloride, low total and available phosphates and poor nitrogen.

Kurnool (K), Major portion of this district has black soil, well supplied with plant materials and lime content is over 2·5 per cent. In the dry part of the district, the soil is of chocolate clay loam type, overlying stiff yellow clay.

Mahbubnagar (K), The district has both deep and shallow black soils and also red soil of sandy loam type. Deep black clayey soils are present on northern side of the Krishna river.

Medak (G & K):—Same as for Hyderabad district.

Nalgonda (K):—Same as for Khammam district.

Nizamabad (G):—Clay loam to clayey soil with low nitrogen and phosphates but fair potash content. The content of exchangeable calcium is high.

Visakhapatnam (G):—Soils loamy to sandy in texture, low soluble salts, pH about 7·5; well drained, rich in phosphates but poor in nitrogen.

Warangal (G & K):—Soils show great variation in texture and have low nitrogen, phosphates and potassium content.

West Godavari (G):—Alluvial soils, clayey to silty clay to clay loam. The red ferruginous soils are loamy to sandy loam in texture. The black and alluvial soils contain high amounts of soluble salts, decreasing with depth along the profile; pH about 8·0.

Madhya Pradesh

Bastar (G):—Mixed red and yellow soils predominate in the district; skeletal (gravelly) soil is also met with. Calcium carbonate content of soil is low, pH ranges from 6·6 to 8·4, nitrogen is low and exchangeable calcium high.

Chhindwara and Seoni (G):—The variations in soils are indicated by local names *e.g.* *kali*, *morand*, *khardi* and *mutabara* (*sehra* and *bardi*).

Durg (G):—Same as for the Chhindwara district.

Maharashtra

Ahmednagar (G & K):—Three types of soils, black, red and grey or white are present. The soils along the river banks are deep and rich and gradually grow poorer as they approach the hills.

Osmanabad (G & K):—Mainly medium black soil; some shallow reddish brown soils are present in hilly areas.

Poona (G & K):—Three types of soils, black or medium black, red and coarse grey are met with. Soils in the western part of the district are lighter than those in its eastern part. Soils in the hilly areas of the district are sandy.

Ratnagiri (K):—Laterites occupy the largest area of the district. Soils of the remaining area are of four types, (i) yellowish to reddish brown in colour, generally put under rice cultivation, (ii) garden soil preferred for garden crops, (iii) alluvial soil and (iv) poor quality soil, locally known as *verkas* having lime content ranging from 1 to 3.3 per cent.

Satara (K):—The important soil groups are (i) lateritic soil, reddish to light brown in colour, (ii) deep black to dark brown soils (iii) brown to dark brown soil of medium depth and rich in lime. The soluble salts are low at the surface but increase down the profile.

Sangli (K):—The western part of the district receiving very heavy rainfall has lateritic soil growing paddy and hill millets; (ii) the portion of moderate rainfall has deep black soil of alluvial origin which is inherently fertile; (iii) the eastern part of the district is comparatively drier and has a mixture of medium black and poor shallow sandy soils.

Sholapur (G & K):—Three types of soils are met with in the district (i) black soil having a fair content of lime, (ii) coarse grey soils on gently sloping land and (iii) reddish soils along the ridges and near low hills.

Mysore

Belgaum (K):—The district has red, laterite and black soils.

Bellary (K):—While the main soil type is red loam, black soils are found towards the eastern and western sides of the district.

Bijapur (K):—The major part of the district has heavy and deep black soil, sometimes more than 20 feet in depth. In the Don valley and that of Bhima and along the Krishna river, there is deep rich soil, at some places soil contains soluble salts. The deep black soils are relatively more clayey and contain appreciable lime content than the shallow black soils. The red soils are relatively poor.

Chikmagalur (K):—The red and laterite soil types are more predominant. While the red soil areas have rolling topography, those having lateritic soil near the western side of the district are under forest. The red soils are relatively richer in the manurial constituents than the lateritic soils.

Chitradurga (K):—The predominant soil in the district is of red type with low manurial constituents and exchangeable calcium.

Dharwar (K):—Red, black and brown soils occur in the district. The red soil is shallow and gravelly. Medium black soil has high clay and lime contents. The brown soil has relatively less clay and more sand.

Gulbarga (K):—Like the Bijapur district, the predominant soil in this district is black.

Hassan (K):—Loamy soil, neutral to slightly acidic in reaction, low in nitrogen and phosphate contents but potash content is variable.

Kanara (K):—Mostly lateritic soil, coarse, poor in lime and phosphates, but having fair content of humus, nitrogen and potash. The red soils, which are also present, are loamy to sandy in texture.

Raichur (K):—The predominant soils in the district are black and red earths.

Shimoga (K):—Red, black and alluvial soils of loamy texture containing fair calcium content. The sub-soils in all these cases are highly gravelly.

Tumkur (K):—Mainly red soils, ranging in texture from loamy to sandy.

Orissa

Koraput (G):—The soils are red, sandy to loamy, particularly for the first and second foot depths.

Need for comprehensive scientific soil surveys

6-36 The necessity of scientific soil surveys of an area to be put under irrigated agriculture has been stressed in paragraphs 6-1 and 6-2 above. Such a survey must aim at obtaining:

- (a) information with respect to geology, nature of parent rock or sub-grade, effective depth of soil, presence or otherwise of hard pan;
- (b) surface and sub-surface drainage characteristics, knowledge of water-table and the nature of its fluctuations during the year;
- (c) physical and chemical characteristics, for example, texture, contents of each of the soluble salts, calcium carbonate, exchangeable bases and manurial constituents, *etc.*, exchange capacity, pH; and
- (d) analysis of sub-soil water to determine whether its fluctuations would tend to aggravate any undesirable features in the soil.

6-37 These soil surveys must not be limited to plough depth but should be extended to a depth of 8 to 10 feet below ground level or to hard sub-grade, if the latter is nearer.

The area to be surveyed should first be divided into a broad grid depending on the extent of the area and variations in important soil features, as indicated by preliminary reconnaissance of the area. If as a result of a somewhat broad-base survey, certain objectionable salt contents or pH indicates prevalence of deteriorate soil conditions, then the entire area or the part concerned should be re-surveyed on more intensive basis. This helps to demarcate areas requiring special attention or treatment, before starting irrigation or later on.

6-38. After the introduction of irrigation, at suitable intervals of time, it will be necessary to repeat similar soil surveys to determine the changes, if any, which have been brought about in the soil characteristics by irrigation. This will indicate tendency, if any, towards development of deteriorated soil conditions, which require attention.

CHAPTER VII

LAND USE AND AGRICULTURAL PRACTICES

Introductory

7-1. Considerable difficulty has been experienced in presenting a picture of land use in the Krishna and the Godavari basins. No basin-wise statistics are available. The annual Agricultural Statistics published by the Government of India give information only by districts. To get some idea of land use within the Krishna and the Godavari basins, the relevant figures available in the Agricultural Statistics for the districts in each basin have been reduced in the proportion, given in Table I, of the area of the district in each basin to the total area of the district. The results must, therefore, be regarded as only approximate.

Land Use

7-2. Tables XII and XIII give for the Krishna basin and the Godavari basin, respectively, the figures of land use, district-wise and State-wise. As in Statement I, figures have also been included for some of the districts outside the Krishna drainage basin in which the waters of the Krishna are actually in use or are proposed to be used, but these figures are not included in the total areas given for the basin. The area at present irrigated from the Krishna and the Godavari outside its drainage basin is, however, included in the figures of irrigated area shown in Tables XII and XIII.

TABLE
STATISTICS OF LAND USE IN KRISHINA BASIN

| Serial number | State/District | Normal weighted annual rainfall | Percentage area of district | Gross area as per village papers | Forests | Not available for cultivation | Culturable area (5-6-7) | Net area sown |
|-----------------------|----------------------------|---------------------------------|-----------------------------|----------------------------------|--------------|-------------------------------|---------------------------|---------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | <i>Inches</i> | | | | | Thousand acres..... | |
| ANDHRA PRADESH | | | | | | | | |
| 1 | Anantapur . . . | 21.7 | 23.6 | 1,116 | 113 | 169 | 834 | 587 |
| 2 | Chittoor* . . . | 35.4 | 100.0 | 3,782 | 858 | 832 | 2,092 | 975 |
| 3 | Cuddapah* . . . | 27.6 | 100.0 | 3,799 | 1,157 | 365 | 2,277 | 1,002 |
| 4 | Guntur . . . | 32.5 | 36.4 | 1,373 | 170 | 146 | 1,057 | 773 |
| 5 | Hyderabad . . . | 27.6 | 98.5 | 1,839 | 194 | 290 | 1,355 | 836 |
| 6 | Karimnagar . . . | 38.4 | 0.3 | 9 | 2 | 1 | 6 | 4 |
| 7 | Khamam . . . | 41.3 | 43.5 | 1,109 | 435 | 124 | 550 | 359 |
| 8 | Krishna . . . | 37.4 | 42.5 | 1,376 | 94 | 177 | 1,105 | 541 |
| 9 | Kurnool . . . | 26.6 | 42.4 | 2,499 | 721 | 237 | 1,541 | 1,200 |
| 10 | Mahbub nagar . . . | 27.6 | 100.0 | 4,560 | 738 | 447 | 3,375 | 2,376 |
| 11 | Medak . . . | 33.5 | 15.2 | 381 | 32 | 52 | 297 | 172 |
| 12 | Nalgonda . . . | 28.5 | 100.0 | 3,443 | 250 | 401 | 2,792 | 1,724 |
| 13 | Nellore* . . . | 39.4 | 100.0 | 4,872 | 460 | 1,471 | 2,941 | 1,492 |
| 14 | Warrangal . . . | 41.3 | 47.5 | 1,552 | 394 | 273 | 885 | 523 |
| | Total | | | 19,257 | 3,143 | 2,317 | 13,797 | 9,095 |
| MADRAS | | | | | | | | |
| 1 | Chingleput . . . | | 100.0 | 1,959 | 121 | 558 | 8,280 | 656 |
| 2 | South Arcot* . . . | | 100.0 | 2,693 | 159 | 632 | 1,902 | 1,281 |
| | Total | | | 4,652 | 280 | 1,190 | 3,182 | 1,937 |
| MAHARASHTRA | | | | | | | | |
| 1 | Ahmednagar . . . | 25.6 | 36.2 | 1,522 | 178 | 134 | 1,210 | 1,116 |
| 2 | Bhir . . . | 27.6 | 14.2 | 392 | 5 | 14 | 373 | 280 |
| 3 | Kolhapur . . . | 78.7 | 91.4 | 1,846 | 346 | 154 | 1,346 | 912 |
| 4 | Osmanabad . . . | 33.5 | 31.8 | 1,102 | 1 | 30 | 1,071 | 785 |
| 5 | Poona . . . | 51.2 | 99.1 | 3,809 | 466 | 512 | 2,831 | 2,378 |
| 6 | Ratnagiri . . . | 118.1 | 0.9 | 28 | .. | 9 | 19 | 8 |
| 7 | Sangli (South Satara). . . | 29.5 | 100.0 | 2,129 | 116 | 106 | 1,907 | 1,595 |
| 8 | Satara . . . | 49.2 | 100.0 | 2,607 | 367 | 258 | 1,982 | 1,690 |
| 9 | Sholapur . . . | 23.6 | 99.2 | 3,675 | 98 | 184 | 3,393 | 2,876 |
| | Total | | | 17,110 | 1,577 | 1,401 | 14,132 | 11,640 |

XII
AND ADJOINING AREAS

| Area sown more than once | Area cropped (9+10) | Uncultivated culturable area (8-9) | Area Irrigated | | | Total 13 to 15 | Irrigated cropped area | Percentage of irrigated cropped area to total cropped area | Serial number |
|--------------------------|---------------------|------------------------------------|----------------|----------|----------------------------|----------------|------------------------|------------------------------------------------------------|---------------|
| | | | by Canals | by Tanks | by wells and other sources | | | | |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|Thousand acres..... | | | | | | | | | |
| 20 | 607 | 247 | 10 | 20 | 20 | 50 | 63 | 10.4 | 1 |
| 128 | 1,103 | 1,117 | 13 | 200 | 112 | 325 | 569 | 51.6 | 2 |
| 78 | 1,080 | 1,275 | 67 | 65 | 87 | 219 | 282 | 26.1 | 3 |
| 97 | 870 | 284 | (474) | 18 | 3 | (495) | (712) | .. | 4 |
| 19 | 855 | 519 | 9 | 46 | 64 | 119 | 119 | 13.9 | 5 |
| .. | 4 | 2 | .. | .. | .. | .. | .. | .. | 6 |
| 2 | 361 | 191 | 1 | 54 | 3 | 58 | 58 | 16.0 | 7 |
| 97 | 638 | 564 | (628) | 48 | 14 | (690) | (756) | .. | 8 |
| 68 | 1,268 | 341 | (68) | 25 | 10 | (103) | (112) | .. | 9 |
| 32 | 2,408 | 999 | 18 | 151 | 51 | 220 | 249 | 10.3 | 10 |
| 10 | 182 | 125 | 2 | 25 | 6 | 33 | 37 | 20.3 | 11 |
| 112 | 1,836 | 1,068 | 37 | 116 | 66 | 219 | 298 | 16.3 | 12 |
| 158 | 1,650 | 1,449 | 146 | 310 | 113 | 569 | 659 | 39.9 | 13 |
| 27 | 550 | 362 | 7 | 96 | 18 | 121 | 138 | 25.1 | 14 |
| 484 | 9,579 | 4,702 | 1,254 | 599 | 255 | 2,108 | 2,542 | 26.6 | 15 |
| 239 | 895 | 624 | 12 | 391 | 40 | 443 | 672 | 75.1 | 16 |
| 410 | 1,691 | 621 | 189 | 255 | 138 | 582 | 801 | 47.4 | 17 |
| 649 | 2,586 | 1,245 | 201 | 646 | 178 | 1,025 | 1,473 | 56.8 | 18 |
| 64 | 1,180 | 94 | .. | .. | 59 | 59 | 69 | 5.8 | 19 |
| 13 | 293 | 93 | .. | 1 | 9 | 10 | 13 | 4.4 | 20 |
| 20 | 932 | 434 | 35 | 1 | 33 | 69 | 70 | 7.5 | 21 |
| 21 | 806 | 286 | 2 | .. | 27 | 29 | 32 | 4.0 | 22 |
| 214 | 2,592 | 453 | 105 | .. | 75 | 180 | 221 | 8.5 | 23 |
| 1 | 9 | 11 | .. | .. | .. | .. | .. | .. | 24 |
| 40 | 1,635 | 312 | 6 | .. | 72 | 78 | 94 | 5.7 | 25 |
| 131 | 1,821 | 292 | 87 | 1 | 75 | 163 | 217 | 11.9 | 26 |
| 58 | 2,944 | 517 | 57 | 3 | 172 | 232 | 286 | 9.7 | 27 |
| 572 | 12,212 | 2,492 | 292 | 6 | 522 | 820 | 1,002 | 8.2 | 28 |

TABLE
STATISTICS OF LAND USE IN

| Serial number | State/District | Normal weighted annual rainfall | Percentage area of district | Gross area as per village papers | Forests | Not available for cultivations | Culturable area (5-6-7) | Net area sown |
|---------------|----------------------------------|---------------------------------|-----------------------------|----------------------------------|--------------|--------------------------------|---------------------------|---------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | <i>Inches</i> | | | | | Thousand acres..... | |
| MYSORE | | | | | | | | |
| 1 | Belgaum . . . | 39.4 | 90.8 | 3,004 | 440 | 140 | 2,424 | 2,095 |
| 2 | Bellary . . . | 22.6 | 100.0 | 2,451 | 379 | 318 | 1,754 | 1,443 |
| 3 | Bidar . . . | 35.4 | 17.9 | 239 | 3 | 15 | 221 | 161 |
| 4 | Bijapur . . . | 23.6 | 100.0 | 4,231 | 208 | 156 | 3,867 | 3,557 |
| 5 | Chikmagalur . . . | 88.6 | 86.0 | 1,502 | 296 | 151 | 1,055 | 402 |
| 6 | Chitradurga . . . | 21.7 | 100.0 | 2,649 | 214 | 217 | 2,218 | 1,318 |
| 7 | Dharwar . . . | 27.6 | 86.5 | 2,944 | 241 | 142 | 2,561 | 2,349 |
| 8 | Gulbarga . . . | 26.6 | 100.0 | 3,930 | 78 | 192 | 3,660 | 3,144 |
| 9 | Hassan . . . | 39.4 | 19.3 | 309 | 12 | 35 | 262 | 122 |
| 10 | Kanara . . . | 108.3 | 6.2 | 157 | 128 | 5 | 24 | 18 |
| 11 | Raichur . . . | 23.6 | 100.0 | 3,438 | 348 | 274 | 2,816 | 2,651 |
| 12 | Shimoga . . . | 78.7 | 74.4 | 1,894 | 273 | 263 | 1,358 | 470 |
| 13 | Tumkur . . . | 27.6 | 37.1 | 971 | 43 | 118 | 810 | 449 |
| | Total . . . | | | 27,719 | 2,663 | 2,026 | 23,030 | 18,179 |
| | GRAND TOTAL FOR THE BASIN | | | 64,086 | 7,383 | 5,744 | 50,959 | 38,914 |

Notes :

- (1) The figures in columns 5 to 18 are based on the Agricultural Statistics for the year 1957-58 and the
- (2) The "percentage area of district" shown in column 4 represents the percentage area of the district lying asterisk which lie wholly outside the basin and for which 100 percent of the area is taken; but the
- (3) The figures within brackets in column 13 against Guntur and Krishna Districts represent the total canal basin of the Krishna, is based on the waters of the Krishna river. The figure in column 13 for Kurnool
- (4) Since practically the entire irrigation in the Ahmednagar District is from the Godavari river system,
- (5) The figures within brackets in column 17 are based on the figures in column 13 and the total irrigated

XII (concluded)
KRISHNA BASIN AND ADJOINING AREAS

| Area sown more than once | Area cropped (9+10) | Uncultivated culturable area (8-9) | Area Irrigated | | | Total 13 to 15 | Irrigated cropped area | Percentage of irrigated cropped area to total cropped area | Serial number |
|--------------------------|---------------------|------------------------------------|----------------|----------|--------------------------|----------------|------------------------|------------------------------------------------------------|---------------|
| | | | by Canals | by Tanks | by wells & other sources | | | | |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|Thousand acre..... | | | | | | | | | |
| 55 | 2,150 | 329 | 35 | 19 | 70 | 124 | 132 | 6.1 | 1 |
| 66 | 1,509 | 311 | 32 | 14 | 5 | 51 | 55 | 3.6 | 2 |
| 12 | 173 | 60 | .. | .. | 4 | 4 | 5 | 2.9 | 3 |
| 69 | 3,626 | 310 | 2 | 2 | 61 | 65 | 69 | 1.9 | 4 |
| 14 | 416 | 653 | 18 | 41 | 71 | 130 | 134 | 32.2 | 5 |
| 72 | 1,380 | 900 | 20 | 42 | 35 | 97 | 103 | 7.4 | 6 |
| 80 | 2,429 | 212 | 8 | 97 | 12 | 117 | 117 | 4.8 | 7 |
| 2 | 3,146 | 516 | .. | 14 | 30 | 44 | 45 | 1.4 | 8 |
| 3 | 125 | 140 | 3 | 12 | 3 | 18 | 20 | 16.0 | 9 |
| 1 | 19 | 6 | .. | 2 | 1 | 3 | 4 | 21.0 | 10 |
| .. | 2,651 | 165 | 11 | 10 | 10 | 31 | 31 | 1.2 | 11 |
| 14 | 484 | 888 | 35 | 121 | 39 | 195 | 199 | 41.1 | 12 |
| 8 | 457 | 361 | .. | 32 | 11 | 43 | 45 | 9.9 | 13 |
| 396 | 18,575 | 4,851 | 164 | 406 | 352 | 922 | 959 | 5.16 | |
| 1,452 | 40,366 | 12,045 | 1,710 | 1,011 | 1,129 | 3,850 | 4,503 | 11.3 | |

"percentage area of District" shown in column 4.

within the boundaries of the Krishna drainage basin, except in the case of districts marked with an figures for these districts are not included in the totals.

irrigation in each of the two districts as this irrigation, even though lying partly outside the drainage District is the estimated irrigation in that district from the K.C. Canal.

the figure in column 13 for Ahmednagar District is taken as nil.

cropped area of the district.

TABLE
STATISTICS OF LAND USE

| Serial number | State District | Normal weighted annual rainfall | Percentage area of district | Gross area as per village papers | Forests | Not avail- able for cultivation | Culturable area (5-6-7) | Net area sown |
|-----------------------|---------------------|------------------------------------------|-----------------------------------|-------------------------------------------|--------------|---------------------------------------|-------------------------------|------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| ANDHRA PRADESH | | <i>inches</i> |Thousand acres..... | | | | | |
| 1 | Adilabad . . . | 39.4 | 100.0 | 4,130 | 1,572 | 522 | 2,036 | 1,299 |
| 2 | East Godavari . . . | 43.3 | 66.8 | 2,430 | 898 | 275 | 1,257 | 691 |
| 3 | Hyderabad . . . | 27.6 | 1.5 | 28 | 3 | 4 | 21 | 13 |
| 4 | Karimnagar . . . | 38.4 | 99.7 | 2,928 | 630 | 375 | 1,923 | 1,307 |
| 5 | Khammam . . . | 41.3 | 51.8 | 1,320 | 517 | 147 | 656 | 427 |
| 6 | Medak . . . | 33.5 | 84.8 | 2,124 | 177 | 288 | 1,659 | 959 |
| 7 | Nizamabad . . . | 39.4 | 100.0 | 1,908 | 386 | 328 | 1,194 | 709 |
| 8 | Visakhapatnam . . . | 45.3 | 27.5 | 912 | 398 | 201 | 313 | 224 |
| 9 | Warangal . . . | 41.3 | 52.5 | 1,715 | 435 | 302 | 978 | 578 |
| 10 | West Godavari . . . | 43.3 | 20.0 | 386 | 39 | 65 | 282 | 191 |
| Total | | | | 17,881 | 5,055 | 2,507 | 10,319 | 6,398 |
| MADHYA PRADESH | | | | | | | | |
| 1 | Balaghat . . . | 63.0 | 75.8 | 1,704 | 798 | 169 | 737 | 475 |
| 2 | Bastar . . . | 59.1 | 94.4 | 9,140 | 6,581 | 270 | 2,289 | 1,353 |
| 3 | Betul . . . | 43.3 | 22.3 | 555 | 180 | 29 | 346 | 198 |
| 4 | Chhindwara . . . | 45.3 | 75.8 | 1,897 | 818 | 138 | 941 | 832 |
| 5 | Durg . . . | 51.2 | 13.2 | 634 | 164 | 42 | 428 | 326 |
| 6 | Mandla . . . | 59.1 | 6.2 | 203 | 90 | 13 | 100 | 50 |
| 7 | Raipur . . . | 55.1 | 0.5 | 27 | 11 | 2 | 14 | 10 |
| 8 | Seoni . . . | 55.1 | 74.8 | 1,609 | 539 | 91 | 979 | 565 |
| Total | | | | 15,769 | 9,181 | 754 | 5,834 | 3,809 |
| MAHARASHTRA | | | | | | | | |
| 1 | Ahmednagar . . . | 25.6 | 63.8 | 2,683 | 315 | 235 | 2,133 | 1,968 |
| 2 | Akola . . . | 33.5 | 35.3 | 921 | 76 | 64 | 781 | 666 |
| 3 | Amravati . . . | 35.4 | 34.3 | 1,034 | 298 | 32 | 704 | 568 |
| 4 | Aurangabad . . . | 27.6 | 93.0 | 3,740 | 189 | 154 | 3,397 | 2,880 |

XIII

IN GODAVARI BASIN

| Area sown more than once | Area cropped (9+10) | Uncultivated culturable area (8-9) | Area irrigated | | | Total (13 to 15) | Irrigated cropped area | Percentage of irrigated cropped area to total cropped area Col. No. 17 ----- Col. No. 11 ×100 | Serial number |
|--------------------------|---------------------|------------------------------------|----------------|----------|----------------------------|------------------|------------------------|-----------------------------------------------------------------------------------------------------------|---------------|
| | | | By canals | By tanks | By wells and other sources | | | | |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|Thousand acres..... | | | | | | | | | |
| 19 | 1,318 | 737 | 11 | 47 | 3 | 61 | 74 | 5.6 | 1 |
| 164 | 855 | 566 | (477) | 89 | 4 | (570) | (687) | .. | 2 |
| .. | 13 | 8 | .. | 1 | 1 | 2 | 2 | 15.4 | 3 |
| 20 | 1,327 | 616 | 35 | 204 | 73 | 312 | 338 | 25.5 | 4 |
| 2 | 429 | 229 | 2 | 64 | 4 | 70 | 70 | 16.3 | 5 |
| 58 | 1,017 | 700 | 12 | 139 | 31 | 182 | 216 | 21.3 | 6 |
| 82 | 791 | 485 | 134 | 113 | 17 | 264 | 325 | 41.1 | 7 |
| 54 | 278 | 89 | 36 | 56 | 15 | 107 | 141 | 50.6 | 8 |
| 31 | 609 | 400 | 8 | 107 | 20 | 135 | 153 | 25.2 | 9 |
| 49 | 240 | 91 | (533) | 25 | 6 | (564) | (732) | .. | 10 |
| 479 | 6,877 | 3,921 | 1,248 | 845 | 174 | 2,267 | 2,738 | 39.8 | |
| 158 | 633 | 262 | 79 | 83 | 6 | 168 | 168 | 26.5 | 1 |
| 59 | 1,412 | 936 | .. | 25 | 11 | 36 | 38 | 2.7 | 2 |
| 15 | 213 | 148 | .. | .. | 9 | 9 | 10 | 4.5 | 3 |
| 34 | 866 | 109 | .. | .. | 26 | 26 | 26 | 3.0 | 4 |
| 80 | 406 | 102 | 25 | 7 | 2 | 34 | 34 | 8.4 | 5 |
| 3 | 53 | 50 | .. | .. | .. | .. | .. | .. | 6 |
| 3 | 13 | 4 | 1 | 1 | .. | 2 | 2 | 16.1 | 7 |
| 28 | 593 | 414 | 21 | 13 | 7 | 41 | 40 | 6.7 | 8 |
| 380 | 4,189 | 2,025 | 126 | 129 | 61 | 316 | 318 | 7.6 | |
| 112 | 2,080 | 165 | (123) | .. | 104 | (227) | (267) | 12.8 | 1 |
| 4 | 670 | 115 | .. | .. | 2 | 2 | 2 | 0.3 | 2 |
| 2 | 570 | 136 | .. | .. | 5 | 5 | 6 | 1.0 | 3 |
| 120 | 3,000 | 517 | .. | .. | 88 | 88 | 118 | 3.9 | 4 |

TABLE:
STATISTICS OF LAND USE

| Serial number | State District | Normal weighted Annual rainfall | Percentage area of district | Gross area as per village papers | Forests | Not available for cultivation | Culturable area (5-6-7) | Net area sown |
|----------------------------------|------------------------|---------------------------------|-----------------------------|----------------------------------|---------------|-------------------------------|-------------------------|---------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| MAHARASHTRA—Continued. | | | | | | | | |
| | | <i>inches</i> | | | | <i>Thousand</i> | <i>acres</i> | |
| 5 | Bhandara | 59.1 | 100.0 | 2,283 | 649 | 223 | 1,411 | 921 |
| 6 | Bhir | 27.6 | 85.8 | 2,368 | 28 | 84 | 2,256 | 1,694 |
| 7 | Buldana | 33.5 | 39.6 | 956 | 120 | 52 | 784 | 659 |
| 8 | Chanda | 55.1 | 99.0 | 5,923 | 3,511 | 305 | 2,107 | 1,226 |
| 9 | Jalgaon | 23.5 | 0.5 | 14 | 2 | 1 | 11 | 10 |
| 10 | Nagpur | 46.3 | 100.0 | 2,443 | 266 | 181 | 2,006 | 1,301 |
| 11 | Nanded | 39.4 | 100.0 | 2,990 | 224 | 281 | 2,485 | 1,930 |
| 12 | Nasik | 39.4 | 47.2 | 1,819 | 397 | 177 | 1,245 | 1,087 |
| 13 | Osmanabad | 33.5 | 68.2 | 2,364 | 2 | 64 | 2,298 | 1,682 |
| 14 | Parbhani | 33.5 | 100.0 | 3,090 | 63 | 118 | 2,909 | 2,216 |
| 15 | Poona | 51.2 | 0.9 | 35 | 5 | 5 | 25 | 22 |
| 16 | Sholapur | 23.6 | 0.8 | 30 | 1 | 1 | 28 | 23 |
| 17 | Wardha | 43.3 | 100.0 | 1,554 | 162 | 105 | 1,287 | 1,000 |
| 18 | Yeotmal | 39.4 | 100.0 | 3,341 | 768 | 290 | 2,283 | 1,804 |
| | Total | | | 37,588 | 7,066 | 2,372 | 28,150 | 21,657 |
| MYSORE : | | | | | | | | |
| 1 | Bidar | 35.4 | 82.1 | 1,096 | 11 | 96 | 989 | 739 |
| ORISSA: | | | | | | | | |
| 1 | Kalahandi | 55.1 | 11.0 | 357 | 140 | 28 | 189 | 110 |
| 2 | Koraput | 59.1 | 63.8 | 4,032 | 497 | 1,195 | 2,340 | 1,521 |
| | Total | | | 4,389 | 637 | 1,223 | 2,529 | 1,631 |
| Grand Total for the basin | | | | 76,723 | 21,950 | 6,952 | 47,821 | 34,234 |

Notes:—(1) The figures in columns 5 to 18 are based on the latest available Agricultural Statistics (of 1952-53 for Orissa) and the "percentage area of district" shown in column 4.

(2) The "percentage area of district" shown in column 4 represents the percentage area of the

(3) The figures within brackets in column 13 against East Godavari and West Godavari though lying partly outside the drainage basin of Godavari, is

(4) Since practically the entire canal irrigation in the Ahmednagar and Nasik districts is districts represent the entire canal irrigation in those districts.

(5) The figures within brackets in column 17 are based on the figures in column 13 and the total

XIII (concluded)
IN GODAVRI BASIN

| Area sown more than once | Area cropped (9+10) | Uncultivated culturable area (8-9) | Area irrigated | | | Total (13 to 15) | Irrigated cropped area | Percentage of irrigated cropped area to total cropped area (Col. 17 $\frac{\text{Col. 17}}{\text{Col. 11}} \times 100$) | Serial number |
|----------------------------|---------------------|------------------------------------|----------------|----------|----------------------------|------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------|
| | | | By canals | By tanks | By wells and other sources | | | | |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Thousand acres | | | | | | | | | |
| 243 | 1,164 | 490 | 53 | 254 | 13 | 320 | 320 | 27.5 | 5 |
| 78 | 1,772 | 562 | .. | 7 | 57 | 64 | 80 | 4.5 | 6 |
| 16 | 675 | 125 | .. | .. | 8 | 8 | 8 | 1.2 | 7 |
| 99 | 1,325 | 881 | 37 | 189 | 13 | 239 | 240 | 18.1 | 8 |
| .. | 10 | 1 | .. | .. | .. | .. | .. | .. | 9 |
| 16 | 1,317 | 705 | 10 | 15 | 40 | 65 | 65 | 4.8 | 10 |
| 18 | 1,948 | 555 | .. | 2 | 12 | 14 | 17 | 0.9 | 11 |
| 48 | 1,135 | 158 | (39) | .. | 26 | (65) | (100) | 8.8 | 12 |
| 46 | 1,728 | 616 | 4 | .. | 57 | 61 | 69 | 4.0 | 13 |
| 62 | 2,278 | 693 | .. | .. | 38 | 38 | 38 | 1.7 | 14 |
| 2 | 24 | 3 | 1 | .. | .. | 1 | 2 | 8.3 | 15 |
| 1 | 24 | 5 | 1 | .. | 1 | 2 | 2 | 8.3 | 16 |
| 5 | 1,005 | 287 | .. | .. | 11 | 11 | 11 | 1.1 | 17 |
| 11 | 1,815 | 479 | .. | .. | 6 | 6 | 6 | 0.3 | 18 |
| 883 | 22,540 | 6,493 | 268 | 467 | 481 | 1,216 | 1,351 | 6.0 | |
| 52 | 791 | 250 | .. | 1 | 19 | 20 | 24 | 3.0 | 1 |
| 4 | 114 | 79 | .. | 6 | .. | 6 | 6 | 5.6 | 1 |
| 1,521 | 1,521 | 819 | 1 | 17 | 19 | 37 | 37 | 2.4 | 2 |
| 1,635 | 1,635 | 898 | 1 | 23 | 19 | 43 | 43 | 2.6 | |
| 1,798 | 36,032 | 13,587 | 1,643 | 1,465 | 754 | 3,862 | 4,474 | 12.4 | |

the year 1957-58 for Andhra Pradesh, Madhya Pradesh, Maharashtra and Mysore and of the year

district lying within the boundaries of the Godavari drainage basin.

districts represent the total canal irrigation in each of the two districts as this irrigation, even based on the waters of the Godavari river.

from the Godavari river system, the figures in column 13 for Ahmednagar and Nasik

area of the district

7-3 The salient features of land use in each of the two basins, State-wise, are as follows :—

KRISHNA BASIN

| | <i>Andhra Pradesh</i> | <i>Maharashtra</i> | <i>Mysore</i> | <i>Total</i> |
|----------------------------------------------------|-----------------------|--------------------|---------------|--------------|
| Gross area as per village papers (Million acres) | 19.3 | 17.1 | 27.7 | 64.1 |
| Forests | 3.1 | 1.6 | 2.7 | 7.4 |
| Culturable area | 13.8 | 14.1 | 23.0 | 50.9 |
| Net area sown | 9.1 | 11.6 | 18.2 | 38.9 |
| Uncultivated culturable area | 4.7 | 2.5 | 4.8 | 12.0 |
| Area cropped | 9.6 | 12.2 | 18.6 | 40.4 |
| Irrigated cropped area | 2.5* | 1.0 | 1.0 | 4.5* |
| Percentage of area sown to cultivable area | 66.0 | 82.4 | 79.1 | 76.5 |
| Percentage of irrigated area to total cropped area | 26.6 | 8.2 | 5.2 | 11.3 |

GODAVARI BASIN

| | <i>Andhra Pradesh</i> | <i>Madhya Pradesh</i> | <i>Maharashtra</i> | <i>Mysore</i> | <i>Orissa</i> | <i>Total</i> |
|----------------------------------------------------|-----------------------|-----------------------|--------------------|---------------|---------------|--------------|
|Million acres..... | | | | | | |
| Gross area as per village papers | 17.9 | 15.8 | 37.6 | 1.1 | 4.4 | 76.8 |
| Forests | 5.1 | 9.2 | 7.1 | 0.01 | 0.6 | 22.0 |
| Culturable area | 10.3 | 5.8 | 28.2 | 1.0 | 2.5 | 47.8 |
| Net area sown | 6.4 | 3.8 | 21.7 | 0.7 | 1.6 | 34.2 |
| Uncultivated culturable area | 3.9 | 2.0 | 6.5 | 0.3 | 0.9 | 13.6 |
| Area cropped | 6.9 | 4.2 | 22.5 | 0.8 | 1.6 | 36.0 |
| Irrigated cropped area | 2.7* | 0.3 | 1.4 | 0.02 | 0.04 | 4.5* |
| Percentage of area sown to cultivable area | 62.0 | 65.2 | 77.2 | 74.7 | 64.5 | 71.7 |
| Percentage of irrigated area to total cropped area | 39.8 | 7.6 | 6.0 | 3.0 | 2.6 | 12.4 |

*Includes irrigation from the river outside its drainage basin.

The area shown under forests in the two basins is not necessarily all wooded as some areas classed as forests were denuded and not re-planted. The original classification, however, continues. Some de-forestation is now going on in the Dandakarnya area in Madhya Pradesh and Orissa to develop the land for resettlement of refugees from East Pakistan.

7-4 Roughly speaking, there are about 50 million acres of culturable land in each of the two basins which account for 21 per cent of the total culturable area of India. Of the culturable land in the two basins, there are 12 million acres uncultivated in the Krishna basin and about 14 million acres uncultivated in the Godavari basin.

7-5 The net area sown in the two basins is 73 million acres which represents almost one fourth (23 per cent) of the net area sown in the whole of India. The total cropped area is 76.4 million acres against 359 million acres for the whole country.

7-6 Irrigated crops are raised over 4.5 million acres from each of the two river systems, representing 11.3 per cent of the cropped area in the Krishna basin and 2.4 per cent of the cropped area in the Godavari basin. The classification of irrigated area in the two basins is as follows :—

| Name of State | Area irrigated | | | Total | Irrigated cropped area |
|--------------------------|----------------|-------------|----------------------------|-------------|------------------------|
| | by canals | by tanks | by wells and other sources | | |
|million acres..... | | | | | |
| KRISHNA BASIN | | | | | |
| Andhra Pradesh | 1.25* | 0.60 | 0.26 | 2.11 | 2.54* |
| Maharashtra | 0.29 | 0.01 | 0.52 | 0.82 | 1.00 |
| Mysore | 0.16 | 0.41 | 0.35 | 0.92 | 0.96 |
| Total | 1.70* | 1.02 | 1.13 | 3.85 | 4.50* |
| GODAVARI BASIN | | | | | |
| Andhra Pradesh | 1.24† | 0.85 | 0.17 | 2.26 | 2.74† |
| Madhya Pradesh | 0.13 | 0.13 | 0.06 | 0.32 | 0.32 |
| Maharashtra | 0.27 | 0.47 | 0.48 | 1.22 | 1.35 |
| Mysore | .. | .. | 0.02 | 0.02 | 0.02 |
| Orissa | .. | 0.02 | 0.02 | 0.04 | 0.04 |
| Total | 1.64† | 1.47 | 0.75 | 3.86 | 4.47† |

*Including 1.11 million acres irrigated from the Krishna outside its drainage basin.

†Including 0.79 million acres irrigated from the Godavari outside its drainage basin.

TABLE
AREA UNDER DIFFERENT CROPS IN KRISHINA

| Serial number | State/District | Percentage area of district | Food Crops | | | | | | | | |
|--------------------------|-----------------------|-----------------------------|--------------|--------------|--------------|-----------|--------------|--------------|------------|--------------|-------|
| | | | Kharif | | | | | | Total | Paddy | Jowar |
| | | | Paddy | Jowar | Bajra | Maize | Others | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|Thousand acres..... | | | | | | | | | | | |
| ANDHRA PRADESH | | | | | | | | | | | |
| 1 | Anantapur | 23.6 | 21 | 65 | 43 | .. | 203 | 332 | 13 | 27 | |
| 2 | Chittoor* | 100.0 | 176 | 32 | 129 | .. | 244 | 581 | 101 | 5 | |
| 3 | Cuddappah* | 100.0 | 112 | 250 | 95 | .. | 200 | 657 | 32 | 19 | |
| 4 | Guntur | 36.4 | 185 | 160 | 47 | 2 | 93 | 487 | 3 | 38 | |
| 5 | Hyderabad | 18.5 | 86 | 141 | 24 | 16 | 226 | 493 | 38 | 98 | |
| 6 | Karimnagar | 0.3 | 1 | 1 | .. | .. | 1 | 3 | .. | .. | |
| 7 | Khammam | 43.5 | 62 | 7 | 5 | 6 | 50 | 130 | .. | 140 | |
| 8 | Krishna | 42.5 | 315 | 92 | 4 | 2 | 43 | 456 | 28 | 12 | |
| 9 | Kurnool | 42.4 | 54 | 331 | 34 | 9 | 384 | 812 | 7 | 69 | |
| 10 | Mahbubnagar | 100.0 | 211 | 481 | 118 | .. | 636 | 1446 | 60 | 193 | |
| 11 | Medak | 15.2 | 29 | 21 | 1 | 15 | 52 | 118 | 12 | 25 | |
| 12 | Nalgonda | 100.0 | 190 | 254 | 320 | 5 | 183 | 952 | 101 | 248 | |
| 13 | Nellore* | 100.0 | 436 | 229 | 106 | .. | 345 | 1116 | 46 | 210 | |
| 14 | Warangal | 47.5 | 102 | 74 | 20 | 39 | 76 | 311 | 23 | 80 | |
| | Total | | 1,256 | 1,627 | 616 | 94 | 1,947 | 5,540 | 285 | 930 | |
| MADRAS | | | | | | | | | | | |
| 1 | Chingelput* | 100.0 | 493 | 1 | 8 | .. | 94 | 596 | 183 | | |
| 2 | South Arcot* | 100.0 | 534 | 75 | 131 | .. | 230 | 970 | 115 | 3 | |
| | Total | | 1,027 | 76 | 139 | .. | 324 | 1,566 | 298 | 39 | |
| MAHARASHTRA | | | | | | | | | | | |
| 1 | Ahmednagar | 36.2 | 8 | .. | 273 | 1 | 55 | 337 | .. | 505 | |
| 2 | Bhir | 14.2 | 3 | 29 | 34 | 1 | 12 | 79 | .. | 79 | |
| 3 | Kolhapur | 91.4 | 201 | 127 | 6 | 9 | 201 | 544 | .. | 6 | |
| 4 | Osmanabad | 31.8 | 24 | 118 | 17 | 1 | 91 | 251 | .. | 158 | |
| 5 | Poona | 99.1 | 120 | 42 | 474 | 2 | 116 | 754 | .. | 915 | |
| 6 | Ratnagiri | 0.9 | 3 | .. | .. | .. | 4 | 7 | .. | .. | |
| 7 | Sangli (South Satara) | 100.0 | 27 | 373 | 342 | 5 | 238 | 985 | .. | 234 | |
| 8 | Satara | 100.0 | 59 | 152 | 407 | 4 | 261 | 883 | .. | 334 | |
| 9 | Sholapur | 99.2 | 22 | 5 | 237 | 10 | 35 | 309 | .. | 1,798 | |
| | Total | .. | 467 | 846 | 1,790 | 33 | 1,013 | 4,149 | .. | 4,029 | |

XIV

BASIN AND ADJOINING AREAS

| <i>Rabi</i> | | | Non-food crops | | | | Perennial | | | <i>Grand Total</i> | <i>Serial number</i> |
|--------------------------|-----|-------|----------------|---------------|--------------|---------------|------------------|---------------|--------------|--------------------|----------------------|
| | | | <i>Wheat</i> | <i>Others</i> | <i>Total</i> | <i>Cotton</i> | <i>Groundnut</i> | <i>Others</i> | <i>Total</i> | | |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|Thousand Acres..... | | | | | | | | | | | |
| .. | 14 | 54 | 41 | 150 | 22 | 213 | 2 | 6 | 8 | 607 | 1 |
| 1 | 21 | 128 | .. | 311 | 20 | 331 | 24 | 39 | 63 | 1,103 | 2 |
| 1 | 46 | 98 | 55 | 213 | 15 | 283 | 2 | 40 | 42 | 1,080 | 3 |
| .. | 135 | 176 | 9 | 44 | 147 | 200 | .. | 7 | 7 | 870 | 4 |
| 2 | 43 | 181 | 2 | 17 | 138 | 157 | 2 | 22 | 24 | 855 | 5 |
| .. | .. | .. | .. | .. | 1 | 1 | .. | .. | .. | 4 | 6 |
| .. | 23 | 163 | .. | 37 | 29 | 66 | .. | 2 | 2 | 361 | 7 |
| .. | 39 | 79 | 1 | 41 | 38 | 80 | 5 | 18 | 23 | 638 | 8 |
| 2 | 14 | 92 | 136 | 195 | 26 | 357 | .. | 7 | 7 | 1,268 | 9 |
| 4 | 70 | 327 | 9 | 411 | 209 | 629 | .. | 6 | 6 | 2,408 | 10 |
| 1 | 15 | 53 | 1 | 4 | 4 | 9 | 1 | 1 | 2 | 182 | 11 |
| .. | 61 | 410 | 4 | 223 | 243 | 470 | .. | 4 | 4 | 1,836 | 12 |
| .. | 103 | 359 | 24 | 18 | 117 | 159 | .. | 16 | 16 | 1,650 | 13 |
| .. | 26 | 129 | 1 | 74 | 33 | 108 | .. | 2 | 2 | 550 | 14 |
| 9 | 440 | 1,664 | 204 | 1,196 | 890 | 2,290 | 10 | 75 | 85 | 9,579 | |
| .. | 7 | 192 | .. | 60 | 34 | 94 | .. | 13 | 13 | 895 | 1 |
| .. | 29 | 181 | 7 | 314 | 139 | 460 | 24 | 56 | 80 | 1,691 | 2 |
| .. | 36 | 373 | 7 | 374 | 173 | 554 | 24 | 69 | 93 | 2,586 | |
| 43 | 80 | 628 | 34 | 37 | 111 | 182 | 26 | 7 | 33 | 1,180 | 1 |
| 16 | 46 | 141 | 25 | 24 | 23 | 72 | .. | 1 | 1 | 293 | 2 |
| 4 | .. | 10 | .. | 107 | 204 | 320 | 53 | 5 | 58 | 932 | 3 |
| 39 | 106 | 303 | 48 | 84 | 114 | 246 | 4 | 2 | 6 | 806 | 4 |
| 55 | 190 | 1,160 | 11 | 52 | 549 | 612 | 26 | 40 | 66 | 2,592 | 5 |
| .. | .. | .. | .. | .. | 2 | 2 | .. | .. | .. | .. | 6 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 7 |
| 35 | .. | 269 | 17 | 202 | 143 | 362 | 11 | 8 | 19 | 1,635 | |
| 34 | .. | 368 | 5 | 148 | 379 | 532 | 15 | 23 | 38 | 1,821 | 8 |
| 58 | 247 | 2103 | 37 | 217 | 247 | 501 | 21 | 10 | 31 | 2,944 | 9 |
| 234 | 669 | 4,982 | 186 | 871 | 1,772 | 2,829 | 156 | 96 | 252 | 12,212 | |

TABLE
AREAS UNDER DIFFERENT CROPS IN

| Serial number | Stat District | Percentage area of district | Food Crops | | | | | | | | |
|--------------------|----------------------------------------|-----------------------------|----------------------------|--------------|--------------|------------|--------------|---------------|------------|--------------|-------|
| | | | Kharif | | | | | | | Paddy | Jowar |
| | | | Paddy | Jowar | Bajra | Maize | Others | Total | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| MYSORE | | | Thousand acres | | | | | | | | |
| 1 | Belgaum . . . | 90.8 | 144 | 413 | 194 | 17 | 276 | 1,044 | .. | 236 | |
| 2 | Bellary . . . | 100.0 | 27 | 328 | 66 | .. | 329 | 750 | 3 | 101 | |
| 3 | Bidar . . . | 17.9 | 8 | 27 | 7 | .. | 49 | 91 | .. | 26 | |
| 4 | Bijapur . . . | 100.0 | 12 | 292 | 496 | 5 | 168 | 973 | 3 | 1,272 | |
| 5 | Chikmagalur . . . | 86.0 | 89 | 29 | 1 | .. | 158 | 277 | 3 | 4 | |
| 6 | Chitradurga . . . | 100.0 | 31 | 237 | 89 | .. | 594 | 951 | 19 | 70 | |
| 7 | Dharwar . . . | 86.5 | 165 | 515 | 5 | .. | 344 | 1,029 | 21 | 104 | |
| 8 | Gulbarga . . . | 100.0 | 55 | 159 | 178 | 1 | 273 | 666 | 3 | 1,314 | |
| 9 | Hassan . . . | 19.3 | 19 | 2 | .. | .. | 62 | 83 | .. | .. | |
| 10 | Kanara . . . | 6.2 | 12 | .. | .. | .. | 3 | 15 | .. | .. | |
| 11 | Raichur . . . | 100.0 | 30 | 389 | 119 | 1 | 399 | 938 | 1 | 417 | |
| 12 | Shimoga . . . | 74.4 | 206 | 53 | .. | .. | 154 | 413 | 5 | 1 | |
| 13 | Tumkur . . . | 37.1 | 25 | 22 | 3 | .. | 287 | 337 | 13 | 1 | |
| | Total . . . | | 823 | 2,466 | 1,158 | 24 | 3,096 | 7,567 | 71 | 3,546 | |
| PONDICHERRY | | | | | | | | | | | |
| 1 | Pondicherry* . . . | | Not available . | | | | | | | | |
| | Grand Total for the basin . . . | | 2,546 | 4,939 | 3,564 | 151 | 6,056 | 17,256 | 356 | 8,505 | |

Notes :—(1) The figures given above are based on the agricultural Statistics for the year 1957-58 and the

(2) The "percentage area of district" i.e., shown in column 3 represents the percentage area of the which i.e., wholly outside the basin and for which 100 per cent of the area is considered but

(3) In the Agricultural Statistics, the area irrigated by paddy is not shown separately for Kharif Commission from the classification given in the Agricultural Statistics.

XIV (concluded)

KRISHNA BASIN AND ADJOINING AREAS

| | | | Non-food crops | | | | Perennial | | | | |
|----------------------------|--------|--------|----------------|-----------|--------|--------|-----------|--------|-------|-------------|---------------|
| Rabi | | | | | | | | | | | |
| Wheat | Others | Total | Cotton | Groundnut | Others | Total | Sugarcane | Others | Total | Grand Total | Serial number |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Thousand acres. | | | | | | | | | | | |
| 107 | 57 | 400 | 193 | 295 | 176 | 664 | 30 | 12 | 42 | 2,150 | 1 |
| 2 | 28 | 134 | 305 | 269 | 32 | 606 | 13 | 6 | 19 | 1,509 | 2 |
| 4 | 15 | 45 | 4 | 13 | 17 | 34 | 2 | 1 | 3 | 173 | 3 |
| 212 | 90 | 1,577 | 473 | 465 | 125 | 1,063 | 2 | 11 | 13 | 3,626 | 4 |
| .. | 2 | 9 | 2 | 5 | 104 | 111 | 2 | 17 | 19 | 416 | 5 |
| 1 | 10 | 100 | 130 | 104 | 85 | 319 | 2 | 18 | 20 | 1,390 | 6 |
| 221 | 105 | 451 | 569 | 232 | 133 | 934 | 2 | 13 | 15 | 2,429 | 7 |
| 79 | 285 | 1,681 | 140 | 289 | 361 | 790 | 2 | 7 | 9 | 3,146 | 8 |
| .. | .. | .. | 2 | 1 | 34 | 37 | 1 | 4 | 5 | 125 | 9 |
| .. | .. | .. | .. | .. | 4 | 4 | .. | .. | .. | 19 | 10 |
| 78 | 67 | 563 | 718 | 321 | 103 | 1,142 | 6 | 2 | 8 | 2,651 | 11 |
| .. | 8 | 14 | 10 | 20 | 10 | 40 | 7 | 10 | 17 | 484 | 12 |
| .. | 13 | 27 | 3 | 35 | 50 | 88 | 1 | 4 | 5 | 457 | 13 |
| 704 | 680 | 5,001 | 2,549 | 2,049 | 1,234 | 5,832 | 70 | 105 | 175 | 18,575 | |
| 997 | 1,789 | 11,647 | 2,939 | 4,116 | 3,896 | 10,951 | 236 | 276 | 512 | 40,366 | |

"percentage area of district" as shown in column 3.

district in the Krishna drainage basin except in the case of districts marked with an asterisk the figures for these districts are not included in the totals.

and Rabi. The areas shown above for paddy in columns 4 and 10 have been estimated by the

TABLE
STATISTICS OF IRRIGATED CROPS

| Serial number | State/District | Percentage area of district | Food Crops | | | | | | | | |
|--------------------------|-----------------------|-----------------------------|--------------|-----------|-----------|------------|--------------|------------|------------|--|--|
| | | | Kharif | | | | | | | | |
| | | | Paddy | Jowar | Bajra | Others | Total | Paddy | Jowar | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
|Thousand acres..... | | | | | | | | | | | |
| ANDHRA PRADESH | | | | | | | | | | | |
| 1 | Anantapur | 23.6 | 21 | 2 | .. | 23 | 46 | 13 | 1 | | |
| 2 | Chittoor* | 100.0 | 170 | 13 | 69 | 89 | 341 | 100 | 2 | | |
| 3 | Cuddapah* | 100.0 | 107 | 2 | 24 | 94 | 227 | 32 | 1 | | |
| 4 | Guntur | (93.0) | 448 | 87 | 14 | 86 | 635 | 8 | 1 | | |
| 5 | Hyderabad | 98.5 | 55 | .. | .. | 21 | 76 | 38 | .. | | |
| 6 | Karimnagar | 0.3 | .. | .. | .. | .. | .. | .. | .. | | |
| 7 | Khammam | 43.5 | 55 | .. | .. | 2 | 57 | .. | .. | | |
| 8 | Krishna | (89.2) | 647 | .. | .. | 11 | 658 | 59 | .. | | |
| 9 | Kurnool | (61.5) | 61 | 1 | 6 | 22 | 90 | 6 | 2 | | |
| 10 | Mahbubnagar | 100.0 | 181 | .. | .. | 5 | 186 | 60 | 1 | | |
| 11 | Medak | 15.2 | 23 | .. | .. | 1 | 24 | 12 | .. | | |
| 12 | Nalgonda | 100.0 | 190 | .. | .. | 5 | 195 | 101 | 1 | | |
| 13 | Nellore* | 100.0 | 427 | 7 | 66 | 97 | 597 | 44 | 1 | | |
| 14 | Warangal | 47.5 | 95 | .. | .. | 19 | 114 | 23 | .. | | |
| | Total | | 1,776 | 90 | 20 | 195 | 2,081 | 320 | 6 | | |
| MADRAS | | | | | | | | | | | |
| 1 | Chingleput* | 100.0 | 390 | .. | 1 | 67 | 458 | 177 | .. | | |
| 2 | South Arcot* | 100.0 | 497 | 4 | 4 | 79 | 584 | 115 | 1 | | |
| | Total | | 887 | 4 | 5 | 146 | 1,042 | 292 | 1 | | |
| MAHARASHTRA | | | | | | | | | | | |
| 1 | Ahmednagar | 20.5 | .. | .. | 4 | 1 | 5 | .. | 25 | | |
| 2 | Bhir | 14.2 | .. | .. | .. | .. | .. | .. | 7 | | |
| 3 | Kolhapur | 91.4 | 5 | .. | .. | 8 | 13 | .. | .. | | |
| 4 | Osmanabad | 31.8 | .. | .. | .. | .. | .. | .. | 13 | | |
| 5 | Poona | 99.1 | 7 | .. | 20 | 9 | 36 | .. | 77 | | |
| 6 | Ratnagiri | 0.9 | .. | .. | .. | .. | .. | .. | .. | | |
| 7 | Sangli (South Satara) | 100.0 | 5 | 5 | 1 | 11 | 22 | .. | 9 | | |
| 8 | Satara | 100.0 | 22 | 3 | 15 | 11 | 51 | .. | 166 | | |
| 9 | Sholapur | 99.2 | 6 | 2 | 11 | 14 | 33 | .. | 134 | | |
| | Total | | 45 | 10 | 51 | 54 | 160 | .. | 331 | | |

XV

IN KRISHNA BASIN AND ADJOINING AREAS

| <i>Rabi</i> | | | <i>Non-food Crops</i> | | | | <i>Perennial Sugar cane</i> | <i>Grand Total same as col. 17 of Table XII</i> | <i>Serial num- ber</i> |
|----------------------------|---------------|--------------|-----------------------|------------------|---------------|--------------|-------------------------------------|-----------------------------------------------------------------|--------------------------------|
| <i>Wheat</i> | <i>Others</i> | <i>Total</i> | <i>Cotton</i> | <i>Groundnut</i> | <i>Others</i> | <i>Total</i> | | | |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Thousand acres | | | | | | | | | |
| .. | 1 | 15 | .. | .. | .. | .. | 2 | 63 | 1 |
| 1 | .. | 103 | .. | 91 | 10 | 101 | 24 | 569 | 2 |
| .. | 6 | 39 | 1 | 6 | 7 | 14 | 2 | 282 | 3 |
| .. | 5 | 14 | 1 | 25 | 36 | 62 | 1 | (712) | 4 |
| .. | .. | 38 | .. | .. | 3 | 3 | 2 | 119 | 5 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | 6 |
| .. | .. | .. | .. | .. | 1 | 1 | .. | 58 | 7 |
| .. | 1 | 60 | .. | 9 | 19 | 28 | 10 | (756) | 8 |
| .. | 2 | 10 | 1 | 9 | 1 | 11 | 1 | (112) | 9 |
| .. | .. | 61 | .. | 1 | 1 | 2 | .. | 249 | 10 |
| .. | .. | 12 | .. | .. | .. | .. | 1 | 37 | 11 |
| .. | .. | 102 | .. | .. | 1 | 1 | .. | 298 | 2 |
| .. | 1 | 46 | .. | 1 | 15 | 16 | .. | 659 | 13 |
| .. | .. | 23 | .. | .. | 1 | 1 | .. | 138 | 14 |
| .. | 9 | 335 | 2 | 44 | 63 | 109 | 17 | 2,542 | |
| .. | .. | 177 | .. | 26 | 11 | 37 | .. | 672 | 1 |
| .. | .. | 116 | 1 | 69 | 7 | 77 | 24 | 801 | 2 |
| .. | .. | 293 | 1 | 95 | 18 | 114 | 24 | 1,473 | |
| 8 | 9 | 42 | 2 | 2 | 4 | 8 | 14 | (69) | 1 |
| 2 | 4 | 13 | .. | .. | .. | .. | .. | 13 | 2 |
| 3 | 1 | 4 | .. | .. | 1 | 1 | 52 | 70 | 3 |
| 7 | 7 | 27 | .. | .. | 1 | 1 | 4 | 32 | 4 |
| 20 | 35 | 132 | 9 | 4 | 14 | 27 | 26 | 221 | 5 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | |
| 16 | 24 | 49 | 3 | 1 | 8 | 12 | 11 | 94 | 7 |
| 27 | 43 | 136 | 5 | 2 | 8 | 15 | 15 | 217 | 8 |
| 34 | 23 | 191 | 13 | 7 | 21 | 41 | 21 | 286 | 9 |
| 117 | 146 | 594 | 32 | 16 | 57 | 105 | 143 | 1,002 | |

TABLE
STATISTICS OF IRRIGATED CROPS

| Serial number | State/District | Percentage area of district | Food Crops | | | | | | | |
|----------------------------------|-------------------|-----------------------------------|---------------------|------------|-----------|------------|--------------|------------|------------|--|
| | | | Kharif | | | | | Paddy | Jowar | |
| | | | Paddy | Jowar | Bajra | Others | Total | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|Thousand acres..... | | | | | | | | | | |
| MYSORE | | | | | | | | | | |
| 1 | Belgaum . . . | 90.8 | 26 | 12 | .. | 25 | 63 | .. | 4 | |
| 2 | Bellary . . . | 100.0 | 22 | 3 | .. | 7 | 32 | 3 | .. | |
| 3 | Bidar . . . | 17.9 | .. | .. | .. | .. | .. | .. | .. | |
| 4 | Bijapur . . . | 100.0 | 4 | 1 | .. | 8 | 13 | .. | 24 | |
| 5 | Chikmagalur . . . | 86.0 | 89 | .. | .. | 7 | 96 | 2 | .. | |
| 6 | Chitradurga . . . | 100.0 | 31 | 4 | .. | 33 | 68 | 19 | .. | |
| 7 | Dharwar . . . | 86.5 | 88 | .. | .. | 4 | 92 | 21 | .. | |
| 8 | Gulbarga . . . | 100.0 | 21 | 1 | .. | 11 | 33 | 3 | 1 | |
| 9 | Hassan . . . | 19.3 | 19 | .. | .. | .. | 19 | .. | .. | |
| 10 | Kanara . . . | 6.2 | 3 | .. | .. | 1 | 4 | .. | .. | |
| 11 | Raichur . . . | 100.0 | 20 | 1 | .. | 2 | 23 | 1 | .. | |
| 12 | Shimoga . . . | 74.4 | 174 | 1 | .. | 10 | 185 | 4 | .. | |
| 13 | Tumkur . . . | 37.1 | 20 | 1 | .. | 9 | 30 | 12 | .. | |
| | Total | | 517 | 24 | .. | 117 | 653 | 65 | 29 | |
| PONDICHERRY | | | | | | | | | | |
| Pondicherry* | | | Data not available. | | | | | | | |
| GRAND TOTAL FOR THE BASIN | | | 2,338 | 124 | 71 | 366 | 2,899 | 335 | 356 | |

NOTE :

The figures given above have been worked out from the Agricultural Statistics for the year 1957-58 the ratio of the figures in column 9 bear to the total irrigated cropped areas of the

XV—concluded

IN KRISHNA BASIN AND ADJOINING AREAS

| | | | Non-food Crops | | | | Perennial Sugar- cane | Grand Total same as col. 17 of Table XII | Serial Num- ber |
|-------|--------|-------|----------------|-----------|--------|-------|-----------------------------|------------------------------------------------------|-----------------------|
| Rabi | | | Cotton | Groundnut | Others | Total | | | |
| Wheat | Others | Total | | | | | | | |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

..... Thousand acres

| | | | | | | | | | |
|----|----|-----|----|----|----|-----|----|-----|----|
| 7 | 5 | 16 | 8 | .. | 16 | 24 | 29 | 132 | 1 |
| .. | .. | 3 | 1 | .. | 6 | 7 | 13 | 55 | 2 |
| 2 | 1 | 3 | .. | .. | .. | .. | 2 | 5 | 3 |
| 2 | 14 | 40 | 9 | .. | 5 | 14 | 2 | 69 | 4 |
| .. | .. | 2 | .. | .. | 34 | 34 | 2 | 134 | 5 |
| .. | .. | 19 | .. | .. | 14 | 14 | 2 | 103 | 6 |
| .. | .. | 21 | .. | .. | 2 | 2 | 2 | 117 | 7 |
| 4 | 2 | 10 | .. | .. | .. | .. | 2 | 45 | 8 |
| .. | .. | .. | .. | .. | .. | .. | 1 | 20 | 9 |
| .. | .. | .. | .. | .. | .. | .. | .. | 4 | 10 |
| .. | .. | 1 | .. | .. | 1 | 1 | 6 | 31 | 11 |
| .. | .. | 4 | 1 | .. | 2 | .. | 7 | 199 | 12 |
| .. | .. | 12 | .. | .. | 2 | 2 | 1 | 45 | 13 |
| 15 | 22 | 131 | 19 | .. | 82 | 101 | 69 | 959 | |

Data not available.

| | | | | | | | | |
|-----|-----|-------|----|----|-----|-----|-----|-------|
| 132 | 177 | 1,060 | 53 | 60 | 202 | 315 | 229 | 4,503 |
|-----|-----|-------|----|----|-----|-----|-----|-------|

on the lines followed in Table XII except that the figures within brackets in column 3 represent districts.

The figures given above show the large area irrigated by tanks, wells and other sources in relation to the total irrigated area. Canal irrigation is largely confined to the two deltas.

About 17 per cent of the area under irrigation, from each river, bears a second crop.

Crop pattern in Krishna basin

7-7 Table XIV shows the overall crop pattern of irrigated and un-irrigated crops, taken together, in the Krishna basin and Table XV shows the pattern of irrigated crops only. A study of these Tables reveals the following general picture :

Andhra Pradesh :

- (a) Total cropped area within the drainage basin of the Krishna is 9·6 million acres; total irrigated area about 1·43 million acres. In addition, an area of about 1·11 million acres, outside the drainage basin of the Krishna, is irrigated from the Krishna waters.
- (b) *Jowar*, *bajra* and other food-crops (excluding paddy), in *kharif*, and *jowar* and other food-crops (excluding paddy), in *rabi* account for 59 per cent of the total cropped area of 9·6 million acres. Of these about 95 per cent are un-irrigated and the *kharif rabi* ratio is 3:1.
- (c) Paddy, all irrigated, accounts for 16 per cent of the total cropped area (*abi* 13 per cent and *tabi* 3 per cent).
- (d) Non-food crops represent 24 per cent of the cropped area; of these, cotton is 2·1 per cent and ground-nut 12·5 per cent. About 95 per cent of the non-food crops are un-irrigated.
- (e) 10,000 acres of sugarcane are grown, all irrigated.
- (f) Of the irrigated area of 2·5 million acres, 82 per cent is under paddy (69·8 per cent *abi* and 12·6 per cent *tabi*).

Maharashtra :

- (a) Total cropped area within the drainage basin of the Krishna is 12·2 million acres; total irrigated area is 1·0 million acres.
- (b) *bajra*, *jowar* and other food-crops (excluding paddy), in *kharif* and *jowar* and other food-crops (excluding paddy), in *rabi*, account for 71 per cent of the cropped area. Of these about 92 per cent are un-irrigated and the *kharif rabi* ratio is 1:1·3.
- (c) Paddy accounts for about 4 per cent of the cropped area, of which only about 10 per cent is irrigated. There is no *rabi* paddy.

- (d) Non-food crops (96 per cent un-irrigated) represent 23 per cent of the cropped area; of these, cotton is 1·5 per cent and ground-nut 7·1 per cent.
- (e) About 150,000 acres of sugarcane are grown, all irrigated.
- (f) Of the irrigated area, *jowar*, wheat and other food-crops in *rabi* account for about 59 per cent, *kharif* paddy only 4·5 per cent, sugarcane 14·2 per cent and cotton 3·2 per cent.

Mysore :

- (a) Total cropped area within the drainage basin of the Krishna is 18·6 million acres; total irrigated area almost a million acre.
- (b) *Jowar*, *bajra* and other food-crops (excluding paddy), in *kharif* and *jowar* and other food-crops (excluding paddy), in *rabi*, account for about 63 per cent of the cropped area. Of these about 98 per cent are un-irrigated and the *kharif rabi* ratio is 1·3 :1.
- (c) Paddy accounts for about 5 per cent (*kharif* 4·4 per cent and *rabi* 0·4 per cent) of the cropped area and 65 per cent of the crop is irrigated.
- (d) Non-food crops (98 per cent un-irrigated) represent 31 per cent of the cropped area; of these cotton is 13·7 per cent and ground-nut 11·0 per cent.
- (e) 70,000 acres of sugarcane are grown, all irrigated.
- (f) Of the irrigated area, paddy accounts for 61 per cent (53·8 per cent in *kharif* and 6·9 per cent in *rabi*) and sugarcane 7·2 per cent.

7-8 For the basin, as a whole, of the irrigated area, 51·9 per cent is *kharif* paddy, 8·6 per cent is *rabi* paddy, 8·1 per cent is *rabi jowar*, 5·1 per cent is sugarcane and the rest are miscellaneous crops.

Crop pattern in Godavari basin

7-9 Table XVI shows the overall crop pattern of irrigated and un-irrigated crops, taken together, in the Godavari basin and Table XVII shows the pattern of irrigated crops only. A study of these Tables reveals the following general picture :

Andhra Pradesh :

- (a) Total cropped area in the Godavari basin is 6·9 million acres; that irrigated is 1·95 million acres. In addition, an area of about 0·79 million acres, outside the drainage basin of the Godavari, is irrigated from the Godavari waters.

TABLE
AREA UNDER DIFFERENT CROPS

| Serial number | State District | Per-centage area of dis- trict | Food-Crops | | | | | | | |
|----------------------------|-------------------|-----------------------------------------|--------------|------------|------------|------------|--------------|--------------|------------|------------|
| | | | Kharif | | | | | | Rabi | |
| | | | Paddy | Jowar | Bajra | Maize | Others | Total | Paddy | Jowar |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Thousand acres | | | | | | | | | | |
| ANDHRA PRADESH | | | | | | | | | | |
| 1 | Adilabad . | 100.0 | 101 | 231 | .. | 42 | 134 | 508 | 13 | 278 |
| 2 | East Godavari | 66.8 | 414 | 31 | 27 | 1 | 60 | 533 | 89 | 15 |
| 3 | Hyderabad . | 1.5 | 1 | 2 | .. | .. | 6 | 9 | 1 | 1 |
| 4 | Karimnagar . | 99.7 | 216 | 194 | 1 | 147 | 186 | 744 | 87 | 103 |
| 5 | Khammam . | 51.8 | 74 | 8 | 6 | 7 | 55 | 150 | .. | 167 |
| 6 | Medak . | 84.8 | 161 | 115 | 8 | 85 | 222 | 591 | 68 | 139 |
| 7 | Nizamabad . | 100.0 | 216 | 57 | .. | 53 | 138 | 464 | 71 | 103 |
| 8 | Visakhapatnam | 27.5 | 79 | 9 | 39 | .. | 64 | 191 | 2 | 1 |
| 9 | Warangal . | 52.5 | 111 | 82 | 22 | 43 | 96 | 354 | 27 | 89 |
| 10 | West Godavari | 20.0 | 135 | 6 | 1 | .. | 20 | 162 | 35 | 4 |
| | Total . | | 1,508 | 735 | 104 | 378 | 981 | 3,706 | 393 | 960 |
| MADHYA PRADESH | | | | | | | | | | |
| 1 | Balaghat . | 75.8 | 379 | 5 | .. | 7 | 55 | 446 | .. | .. |
| 2 | Bastar . | 94.4 | 826 | 8 | .. | 48 | 427 | 1,309 | .. | 4 |
| 3 | Betul . | 22.3 | 9 | 38 | .. | 6 | 82 | 135 | .. | .. |
| 4 | Chhindwara . | 75.8 | 20 | 245 | .. | 26 | 249 | 540 | .. | 1 |
| 5 | Durg . | 13.2 | 164 | .. | .. | .. | 88 | 252 | .. | .. |
| 6 | Mandla . | 6.2 | 14 | .. | .. | 3 | 22 | 39 | .. | .. |
| 7 | Raipur . | 0.5 | 8 | .. | .. | .. | 4 | 12 | .. | .. |
| 8 | Seoni . | 74.8 | 124 | 21 | .. | 10 | 153 | 308 | .. | 1 |
| | Total . | | 1,544 | 317 | .. | 160 | 1,080 | 3,041 | .. | 6 |
| MAHARASHTRA | | | | | | | | | | |
| 1 | Ahmednagar . | 63.8 | 13 | .. | 480 | 1 | 124 | 618 | .. | 891 |
| 2 | Akola . | 35.3 | 6 | 206 | 5 | .. | 77 | 294 | .. | .. |
| 3 | Amravati . | 34.3 | 4 | 154 | 4 | .. | 52 | 214 | .. | .. |
| 4 | Aurangabad . | 93.0 | 11 | 214 | 395 | 4 | 293 | 917 | .. | 600 |
| 5 | Bhandara . | 100.0 | 624 | 14 | 14 | 3 | 203 | 844 | .. | 82 |
| 6 | Bhir . | 85.8 | 17 | 172 | 207 | 1 | 175 | 572 | .. | 477 |
| 7 | Buldana . | 39.6 | 2 | 226 | 6 | .. | 78 | 312 | .. | .. |

XVI

IN GODAVARI BASIN

| | | | <i>Non-food Crops</i> | | | | <i>Perennial</i> | | | <i>Grand Total</i> | <i>Serial No.</i> |
|--------------------------|---------------|--------------|-----------------------|-------------------|---------------|--------------|------------------|---------------|--------------|--------------------|-------------------|
| <i>Wheat</i> | <i>Others</i> | <i>Total</i> | <i>Cotton</i> | <i>Ground nut</i> | <i>Others</i> | <i>Total</i> | <i>Sugarcane</i> | <i>Others</i> | <i>Total</i> | | |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|Thousand acres..... | | | | | | | | | | | |
| 11 | 104 | 406 | 190 | .. | 212 | 402 | .. | 2 | 2 | 1,318 | 1 |
| .. | 40 | 144 | 80 | 4 | 38 | 122 | 15 | 41 | 56 | 855 | 2 |
| .. | .. | 2 | .. | .. | 2 | 2 | .. | .. | .. | 13 | 3 |
| 1 | 50 | 241 | 6 | 163 | 168 | 337 | .. | 5 | 5 | 1,327 | 4 |
| .. | 30 | 197 | .. | 45 | 34 | 79 | .. | 3 | 3 | 429 | 5 |
| 7 | 64 | 278 | 5 | 19 | 110 | 134 | 8 | 6 | 14 | 1,017 | 6 |
| 6 | 25 | 205 | 12 | 25 | 44 | 81 | 38 | 3 | 41 | 791 | 7 |
| .. | 8 | 11 | .. | 22 | 39 | 61 | 9 | 6 | 15 | 278 | 8 |
| 1 | 16 | 133 | 2 | 81 | 36 | 119 | .. | 3 | 3 | 609 | 9 |
| .. | 2 | 41 | .. | 3 | 22 | 25 | 4 | 8 | 12 | 240 | 10 |
| 26 | 339 | 1,658 | 295 | 362 | 705 | 1,362 | 74 | 77 | 151 | 6,877 | |
| 19 | 95 | 114 | .. | .. | 68 | 68 | 2 | 3 | 5 | 633 | 1 |
| 5 | .. | 9 | .. | .. | 84 | 84 | 1 | 9 | 10 | 1,412 | 2 |
| 31 | 20 | 51 | 2 | 10 | 13 | 25 | 1 | 1 | 2 | 213 | 3 |
| 107 | 59 | 167 | 23 | 31 | 94 | 148 | 3 | 8 | 11 | 866 | 4 |
| 15 | 103 | 118 | .. | .. | 33 | 33 | .. | 3 | 3 | 406 | 5 |
| 5 | 3 | 8 | .. | .. | 6 | 6 | .. | .. | .. | 53 | 6 |
| .. | .. | .. | .. | .. | 1 | 1 | .. | .. | .. | 13 | 7 |
| 123 | 83 | 207 | 1 | 1 | 74 | 76 | 1 | 1 | 2 | 593 | 8 |
| 305 | 363 | 674 | 26 | 42 | 373 | 441 | 8 | 25 | 33 | 4,189 | |
| 75 | 114 | 1,080 | 61 | 65 | 198 | 324 | 45 | 13 | 58 | 2,080 | 1 |
| 44 | 1 | 45 | 279 | 39 | 12 | 330 | .. | 1 | 1 | 670 | 2 |
| 33 | 10 | 43 | 277 | 16 | 17 | 310 | .. | 3 | 3 | 570 | 3 |
| 193 | 341 | 1,134 | 490 | 179 | 254 | 923 | 15 | 11 | 26 | 3,000 | 4 |
| 73 | 50 | 205 | .. | 2 | 104 | 106 | 2 | 7 | 9 | 1,164 | 5 |
| 95 | 180 | 752 | 148 | 142 | 150 | 440 | 3 | 5 | 8 | 1,772 | 6 |
| 40 | 13 | 53 | 246 | 38 | 24 | 308 | .. | 2 | 2 | 675 | 7 |

TABLE
AREA UNDER DIFFERENT CROPS

| Serial number | State District | Per-centage area of district | Food-Crops | | | | | | | | |
|----------------------------------------|-------------------|------------------------------------|--------------|--------------|--------------|------------|--------------|---------------|------------|--------------|--|
| | | | Kharif | | | | | | | Rabi | |
| | | | Paddy | Jowar | Bajra | Maize | Others | Total | Paddy | Jowar | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|Thousand acres..... | | | | | | | | | | | |
| MAHARASHTRA—continued. | | | | | | | | | | | |
| 8 | Chanda . . . | 99·0 | 450 | 51 | .. | 5 | 114 | 620 | .. | 327 | |
| 9 | Jalgaon . . . | 0·5 | .. | 2 | 1 | .. | 3 | 6 | .. | .. | |
| 10 | Nagpur . . . | 100·0 | 48 | 444 | 1 | 1 | 138 | 632 | .. | 103 | |
| 11 | Nanded . . . | 100·0 | 48 | 601 | 3 | 1 | 306 | 959 | .. | 143 | |
| 12 | Nasik . . . | 47·2 | 43 | 10 | 426 | 2 | 158 | 639 | .. | 69 | |
| 13 | Osmanabad . . . | 68·2 | 51 | 254 | 37 | 3 | 180 | 525 | .. | 338 | |
| 14 | Parbhani . . . | 100·0 | 29 | 370 | 7 | 1 | 160 | 567 | .. | 520 | |
| 15 | Poona . . . | 0·9 | 2 | .. | 5 | .. | 1 | 8 | .. | 8 | |
| 16 | Sholapur . . . | 0·8 | .. | .. | 2 | .. | .. | 2 | .. | 15 | |
| 17 | Wardha . . . | 100·0 | 4 | 309 | .. | .. | 100 | 413 | .. | 1 | |
| 18 | Yeotmal . . . | 100·0 | 24 | 661 | 25 | .. | 216 | 926 | .. | .. | |
| | Total | | 1,376 | 3,688 | 1,604 | 22 | 2,378 | 9,068 | .. | 3,574 | |
| MYSORE | | | | | | | | | | | |
| 1 | Bidar . . . | 82·1 | 35 | 121 | 30 | 1 | 226 | 413 | .. | 116 | |
| ORISSA | | | | | | | | | | | |
| 1 | Kalahandi . . . | 11·0 | 59 | 1 | 1 | .. | 15 | 76 | .. | .. | |
| 2 | Koraput . . . | 63·8 | 780 | 16 | 4 | 12 | 462 | 1,274 | .. | 9 | |
| | Total | | 839 | 17 | 5 | 12 | 477 | 1,350 | .. | 9 | |
| Grand Total for the basin . . . | | | 5,302 | 4,878 | 1,743 | 513 | 5,142 | 17,578 | 393 | 4,605 | |

Notes:

- (1) The figures given above are based on the latest available Agricultural Statistics (of the year 1952-53 for Orissa) and the "percentage area of the district", as shown in column 3.
- (2) The "percentage area of district" shown in column 3 represents the percentage area of the
- (3) In the Agricultural Statistics, the area irrigated by paddy is not shown separately for Kharif the Commission from the classification given in the Agricultural Statistics.

XVI—concluded.

IN GODAVARI BASIN

| | | | Non-food Crops | | | | Perennial | | | Grand Total | Serial number |
|--------------------------|--------------|--------------|----------------|--------------|--------------|--------------|------------|------------|------------|---------------|---------------|
| Wheat | Others | Total | Cotton | Ground nut | Others | Total | Sugarcane | Others | Total | | |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|Thousand acres..... | | | | | | | | | | | |
| 77 | 92 | 496 | 39 | 1 | 164 | 204 | 1 | 4 | 5 | 1,325 | 8 |
| .. | .. | .. | 2 | 2 | .. | 4 | .. | .. | .. | 10 | 9 |
| 184 | 81 | 368 | 165 | 15 | 108 | 288 | .. | 29 | 29 | 1,317 | 10 |
| 50 | 103 | 296 | 509 | 57 | 117 | 683 | 4 | 6 | 10 | 1,948 | 11 |
| 110 | 62 | 241 | 5 | 88 | 133 | 226 | 11 | 18 | 29 | 1,135 | 12 |
| 83 | 242 | 663 | 103 | 179 | 245 | 527 | 8 | 5 | 13 | 1,728 | 13 |
| 139 | 252 | 911 | 504 | 104 | 180 | 788 | 4 | 8 | 12 | 2,278 | 14 |
| 1 | 1 | 10 | .. | 1 | 5 | 6 | .. | .. | .. | 24 | 15 |
| .. | 3 | 18 | .. | 2 | 2 | 4 | .. | .. | .. | 24 | 16 |
| 103 | 32 | 136 | 393 | 4 | 52 | 449 | .. | 7 | 7 | 1,005 | 17 |
| 46 | 14 | 60 | 697 | 76 | 50 | 823 | 1 | 5 | 6 | 1,815 | 18 |
| 1,346 | 1,591 | 6,511 | 3,918 | 1,010 | 1,815 | 6,743 | 94 | 124 | 218 | 22,540 | |
| 19 | 71 | 206 | 18 | 57 | 82 | 157 | 12 | 3 | 15 | 791 | 1 |
| .. | 12 | 12 | .. | .. | 25 | 25 | .. | 1 | 1 | 114 | 1 |
| 2 | 25 | 36 | .. | 2 | 195 | 197 | 8 | 6 | 14 | 1,521 | 2 |
| 2 | 37 | 48 | .. | 2 | 220 | 222 | 8 | 7 | 15 | 1,635 | |
| 1,698 | 2,401 | 9,097 | 4,257 | 1,473 | 3,195 | 8,925 | 196 | 236 | 432 | 36,032 | |

1957-58 for Andhra Pradesh, Madhya Pradesh, Maharashtra and Mysore and of the year

district in the Godavari drainage basin.

and rabi. The areas shown above for paddy in column 4 and 10 above have been estimated by

TABLE
STATISTICS OF IRRIGATED

| Serial number | State District | Percentage area of district | Food | | | | | |
|-----------------------|-------------------|-----------------------------------|--------------|-----------|-----------|------------|--------------|-------|
| | | | Kharif | | | | Total | |
| | | | Paddy | Jowar | Bajra | Others | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| ANDHRA PRADESH | | | | | | | Thousand | acres |
| 1 | Adilabad | 100.0 | 57 | .. | .. | 4 | 61 | |
| 2 | East Godavari | (92.5) | 512 | .. | .. | 14 | 526 | |
| 3 | Hyderabad | 1.5 | 1 | .. | .. | 1 | 2 | |
| 4 | Karimnagar | 99.7 | 208 | .. | .. | 41 | 249 | |
| 5 | Khammam | 51.8 | 65 | .. | .. | 2 | 67 | |
| 6 | Medak | 84.8 | 128 | .. | .. | 10 | 138 | |
| 7 | Nizamabad | 100.0 | 203 | .. | .. | 13 | 216 | |
| 8 | Visakhapatnam | 27.5 | 79 | 1 | 9 | 19 | 108 | |
| 9 | Warangal | 52.5 | 104 | .. | .. | 22 | 126 | |
| 10 | West Godavari | (82.0) | 514 | .. | . | 11 | 525 | |
| Total | | | 1,871 | 1 | 9 | 137 | 2,018 | |
| MADHYA PRADESH | | | | | | | | |
| 1 | Balaghat | 75.8 | 163 | . | . | . | 163 | |
| 2 | Bastar | 94.4 | 35 | .. | .. | .. | 35 | |
| 3 | Betul | 22.3 | .. | .. | .. | .. | .. | |
| 4 | Chhindwara | 75.8 | . | . | . | . | . | |
| 5 | Durg | 13.2 | 34 | . | . | . | 34 | |
| 6 | Mandla | 6.2 | .. | .. | .. | .. | .. | |
| 7 | Raipur | 0.5 | 2 | .. | .. | .. | 2 | |
| 8 | Seoni | 74.8 | 37 | .. | .. | .. | 37 | |
| Total | | | 271 | .. | .. | .. | 271 | |

XVII

CROPS IN GODAVARI BASIN

| <i>Crops</i> | | | | | <i>Non-food Crops</i> | | | | <i>Perennial Sugar cane</i> | <i>Grand Total same as Col. 17 of Table XIII</i> | <i>Serial number</i> |
|-----------------------------------|--------------|--------------|---------------|--------------|-----------------------|-----------------------|---------------|--------------|-------------------------------------|--------------------------------------------------------------------------|--------------------------|
| <i>Rabi</i> | | | | | <i>Cotton</i> | <i>Ground nut</i> | <i>Others</i> | <i>Total</i> | | | |
| <i>Paddy</i> | <i>Jowar</i> | <i>Wheat</i> | <i>Others</i> | <i>Total</i> | | | | | | | |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Thousand acres. | | | | | | | | | | | |
| 13 | .. | .. | .. | 13 | .. | .. | .. | .. | .. | 74 | 1 |
| 120 | .. | .. | .. | 120 | .. | 1 | 21 | 22 | 19 | (687) | 2 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | 3 |
| 87 | .. | 1 | .. | 88 | .. | .. | 1 | 1 | .. | 338 | 4 |
| — | .. | .. | 1 | 1 | .. | .. | 2 | 2 | .. | 70 | 5 |
| 68 | .. | 2 | .. | 70 | .. | .. | .. | .. | 8 | 216 | 6 |
| 71 | .. | .. | .. | 71 | .. | .. | .. | .. | 38 | 325 | 7 |
| 2 | .. | .. | .. | 2 | .. | 9 | 13 | 22 | 9 | 141 | 8 |
| 27 | .. | .. | .. | 27 | .. | .. | .. | .. | .. | 153 | 9 |
| 145 | .. | .. | .. | 145 | .. | 8 | 40 | 48 | 74 | (732) | 10 |
| 533 | .. | 3 | 1 | 537 | .. | 18 | 77 | 95 | 88 | 2,738 | |
| .. | .. | .. | .. | .. | .. | .. | 3 | 3 | 2 | 168 | 1 |
| .. | .. | .. | .. | .. | .. | .. | 2 | 2 | 1 | 38 | 2 |
| .. | .. | 6 | 3 | 9 | .. | .. | .. | .. | 1 | 10 | 3 |
| .. | .. | 11 | 3 | 14 | .. | .. | 9 | 9 | 3 | 26 | 4 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 34 | 5 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 6 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | 7 |
| .. | .. | 1 | .. | 1 | .. | .. | 1 | 1 | 1 | 40 | 8 |
| .. | .. | 18 | 6 | 24 | .. | .. | 15 | 15 | 8 | 318 | |

TABLE
STATISTICS OF IRRIGATED

| Serial number | State District | Percentage area of district | Food | | | | |
|--------------------|----------------------------------|-----------------------------|--------------|-----------|-----------|------------|--------------|
| | | | Kharif | | | | |
| | | | Paddy | Jowar | Bajra | Others | Total |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| MAHARASHTRA | | | | | | | |
| 1 | Ahmednagar | (79.5) | .. | .. | 15 | 5 | 20 |
| 2 | Akola | 35.3 | .. | .. | .. | .. | .. |
| 3 | Amravati | 34.3 | .. | .. | .. | .. | .. |
| 4 | Aurangabad | 93.0 | 1 | .. | 1 | 3 | 5 |
| 5 | Bhandara | 100.0 | 308 | .. | .. | 10 | 318 |
| 6 | Bhir | 85.5 | 4 | .. | 4 | 3 | 11 |
| 7 | Buldana | 39.6 | .. | .. | .. | .. | .. |
| 8 | Chanda | 99.0 | 232 | .. | .. | 7 | 239 |
| 9 | Jalgaon | 0.5 | .. | .. | .. | .. | .. |
| 10 | Nagpur | 100.0 | 26 | .. | .. | 22 | 48 |
| 11 | Nanded | 100.0 | 3 | .. | .. | 7 | 10 |
| 12 | Nasik | 69.8 | 7 | .. | 1 | 8 | 16 |
| 13 | Osmanabad | 68.2 | 2 | .. | .. | 2 | 4 |
| 14 | Parbhani | 100.0 | 3 | 2 | .. | 3 | 8 |
| 15 | Poona | 0.9 | .. | .. | .. | 1 | 1 |
| 16 | Sholapur | 0.8 | .. | .. | .. | .. | .. |
| 17 | Wardha | 100.0 | .. | .. | .. | .. | .. |
| 18 | Yeotmal | 100.0 | .. | .. | .. | .. | .. |
| | TOTAL | | 586 | 2 | 21 | 71 | 680 |
| MYSORE | | | | | | | |
| 1 | Bidar | 82.1 | .. | .. | .. | .. | .. |
| ORISSA | | | | | | | |
| 1 | Kalahandi | 11.0 | 4 | .. | .. | 2 | 6 |
| 2 | Koraput | 63.8 | 31 | .. | .. | 6 | 37 |
| | TOTAL | | 35 | .. | .. | 8 | 43 |
| | GRAND TOTAL for the Basin | | 2,763 | 3 | 30 | 216 | 3,012 |

Note : The figures given above have been worked out from the latest available agricultural statistics of the year 1952-53 for Orissa, on the lines followed in Table XIII except that the figures in of the districts.)

XVII (concluded)

CROPS IN GODAVARI BASIN

| Crops | | | | Non-food Crops | | | | Perennial Sugar cane | Grand Total same as Col. 17 of Table XIII | Serial number | |
|-------|-------|-------|--------|----------------|----------------|-------|-------|----------------------------|----------------------------------------------------------|------------------|----|
| Rabi | | | | Cotton | Ground- nut | Other | Total | | | | |
| Paddy | Jowar | Wheat | Others | | | | | Total | 14 | 15 | 16 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| .. | 97 | 31 | 30 | 158 | 7 | 9 | 16 | 32 | 57 | (267) | 1 |
| .. | .. | .. | 2 | 2 | .. | .. | .. | .. | .. | 2 | 2 |
| .. | .. | .. | 6 | 6 | .. | .. | .. | .. | .. | 6 | 3 |
| .. | 36 | 26 | 29 | 91 | 2 | .. | 6 | 8 | 14 | (118) | 4 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | 320 | 5 |
| .. | 34 | 14 | 15 | 63 | .. | 1 | 2 | 3 | 3 | 80 | 6 |
| .. | .. | 3 | 5 | 8 | .. | .. | .. | .. | .. | 8 | 7 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 240 | 8 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 9 |
| .. | .. | 6 | 9 | 15 | 1 | .. | 1 | 2 | .. | 65 | 10 |
| .. | .. | 1 | 2 | 3 | .. | .. | .. | .. | 4 | 17 | 11 |
| .. | .. | 24 | 27 | 51 | 2 | 2 | 12 | 16 | 17 | (100) | 12 |
| .. | 27 | 14 | 13 | 54 | .. | .. | 4 | 4 | 7 | 69 | 13 |
| .. | 5 | 11 | 7 | 23 | .. | .. | 3 | 3 | 4 | 38 | 14 |
| .. | 1 | .. | .. | 1 | .. | .. | .. | .. | .. | 2 | 15 |
| .. | .. | .. | 2 | 2 | .. | .. | .. | .. | .. | 2 | 16 |
| .. | .. | 1 | 10 | 11 | .. | .. | .. | .. | .. | 11 | 17 |
| .. | .. | 1 | 5 | 6 | .. | .. | .. | .. | .. | 6 | 18 |
| ☐.. | 200 | 132 | 162 | 494 | 12 | 12 | 44 | 68 | 109 | 1,351 | |
| .. | 1 | 6 | 4 | 11 | .. | .. | 1 | 1 | 12 | 24 | 1 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 6 | 1 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 37 | 2 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 43 | |
| 533 | 201 | 159 | 173 | 1,066 | 12 | 30 | 137 | 179 | 217 | 4,474 | |

(of the year 1957-58 for Andhra Pradesh, Madhya Pradesh and Maharashtra and Mysore and column 3 represent the ratio the figures in column 19 bear to the total irrigated cropped areas

- (b) *Jowar*, maize and other food-crops (excluding paddy), in *kharif*, and *jowar* and other food-crops (excluding paddy), in *rabi*, account for 50 per cent of the total cropped area. Of these 96 per cent are un-irrigated and the *kharif rabi* ratio is 1·7 : 1.
- (c) Paddy, all irrigated, accounts for about 28 per cent of the cropped area (*abi* 21·9 per cent and *rabi* 5·7 per cent).
- (d) Non-food crops (93 per cent un-irrigated) represent about 20 per cent of the cropped area. Of these, cotton is 4·2 per cent and ground-nut 5·3 per cent.
- (e) About 90,000 acres of sugarcane are grown, all irrigated.
- (f) Of the irrigated area, about 88 per cent is paddy (68·3 per cent *abi* and 19·5 per cent *tabi*); sugarcane 3·2 per cent.

Madhya Pradesh :

- (a) Total cropped area in the Godavari basin is 4·2 million acres, of which only 318,000 acres are irrigated.
- (b) *Jowar* and other food-crops (excluding paddy), in *kharif* and wheat and other crops (excluding paddy), in *rabi*, all un-irrigated, represent 52 per cent of the cropped area. *Kharif rabi* ratio is 2·2 : 1.
- (c) Paddy, of which only about 18 per cent is irrigated, represents 37 per cent of the cropped area, all in *kharif*.
- (d) Non-food crops, mostly un-irrigated, represent 10·5 per cent of the cropped area.
- (e) Only 8,000 acres of sugarcane are grown, all irrigated.
- (f) Of the irrigated area, 85 per cent represents *kharif* paddy and 2·5 per cent sugarcane.

Maharashtra :

- (a) Total cropped area in the Godavari basin is 22·5 million acres, of which about 1·4 million acres are irrigated.
- (b) *Jowar*, *bajra* and other food-crops (excluding paddy), in *kharif* and *jowar*, wheat and other food-crops (excluding paddy), in *rabi*, account for 63 per cent of the cropped area. Of these 96 per cent is un-irrigated and the *kharif rabi* ratio is 1·2 : 1.
- (c) *Kharif* paddy, of which 43 per cent is irrigated, represents only 6·1 per cent of the cropped area.
- (d) Non-food crops (99 per cent un-irrigated) represent 30 per cent of the cropped area, of which cotton is 17·4 per cent and ground-nut 4·5 per cent.
- (e) About 100,000 acres of sugarcane are grown, all irrigated.

- (f) Of the irrigated area, 43·4 per cent is *kharif* paddy and 36·6 per cent is *rabi* food crops (other than paddy). Sugarcane represents 8·1 per cent of the irrigated area.

Mysore :

- (a) Total cropped area in the Godavari basin is only 0·8 million acres. Of this, 74 per cent is *kharif* and *rabi* food-crops (other than paddy) and 4·4 per cent is *kharif* paddy.
- (b) Non-food crops represents 20 per cent of the cropped area.
- (c) The irrigated area is 24,000 acres of which 12,000 acres are sugarcane and the rest *rabi* food-crops other than paddy.

Orissa :

- (a) Total cropped area in the Godavari basin is 1·6 million acres, of which only 43,000 acres are irrigated.
- (b) *Kharif* paddy represents 51 per cent of the cropped area ; 31 per cent is taken by other food-crops in *kharif*; non-food crops represent about 14 per cent of the cropped area.
- (c) Of the irrigated area, 81·4 per cent is under *Kharif* paddy, the rest under *kharif* food crops.

7-10 For the basin as a whole, the pattern of irrigated crops is *kharif* paddy 61·7 per cent ; *rabi* paddy 12·0 per cent, sugarcane 4·9 per cent, *rabi* food-crops (other than paddy) 11·8 per cent and the rest are miscellaneous crops.

Crop pattern in Krishna and Godavari basins compared

7-11 The overall crop pattern in the Krishna and Godavari basins may now be examined :

| Name of crop | Krishna Basin | | | Godavari Basin | | |
|--------------------------------|---------------|-----------|-------|----------------|-----------|-------|
| | Un-irrigated | Irrigated | Total | Un-irrigated | Irrigated | Total |
|percentages | | | | | | |
| Jowar | 32·1 | 1·2 | 33·3 | 25·8 | 0·6 | 26·4 |
| Paddy | 0·4 | 6·8 | 7·2 | 6·7 | 9·1 | 15·8 |
| Bajra | 8·6 | 0·2 | 8·8 | 4·7 | 0·1 | 4·8 |
| Wheat | 2·2 | 0·3 | 2·5 | 4·3 | 0·4 | 4·7 |
| Other food crops | 19·2 | 1·3 | 20·5 | 21·9 | 1·1 | 23·0 |
| Sugarcane | .. | 0·6 | 0·6 | .. | 0·5 | 0·5 |
| Cotton | 7·2 | 0·1 | 7·3 | 11·8 | .. | 11·8 |
| Ground-nut | 10·1 | 0·1 | 10·2 | 4·0 | 0·1 | 4·1 |
| Other non-food crops | 9·1 | 0·5 | 9·6 | 8·5 | 0·4 | 8·9 |
| Total | 88·8 | 11·2 | 100·0 | 87·7 | 12·3 | 100·0 |

It would be seen that :

- (a) under irrigated conditions, paddy is the principal crop in each of the two basins, followed by *jowar*, sugarcane, wheat and *bajra* in descending order; and
- (b) under un-irrigated conditions, in the Krishna basin, *jowar* tops the list followed by ground-nut, *bajra*, cotton and wheat. In the Godavari basin, the order is *jowar*, cotton, paddy, *bajra*, wheat and ground-nut.

Crop pattern under tanks, canals and wells

7-12 The remarks in paragraphs 7-6 to 7-10 above, concerning crop in irrigated areas, relate to the entire irrigated area, whether by canals or tanks or wells. Statistical information regarding the crop pattern, separately, under each of these classes of irrigation works is not available; but the position can be stated in general terms.

7-13 Under all tanks in the Krishna and Godavari basins, with perhaps the only exception of Mhaswad tank in Maharashtra, the aim is to grow the maximum possible area of paddy in *kharif*. Such quantity of water as may be left in any tank at the end of the *kharif* season is utilised for a second crop of paddy.

7-14 Except in Western Maharashtra and on the Gokak canals in Mysore, irrigation from canals is also almost entirely for paddy cultivation, mainly in *kharif*, and, on some canals, for sugarcane. There has always been a small area under second crop of paddy under the Godavari Delta Canals and since the construction of the Tungabhadra Dam in 1953, a significant area of second crop paddy and some sugarcane has been introduced in the Krishna Delta. Except on some canals where sugarcane is grown, the emphasis mainly is on paddy. A notable example is of the Dindi Canal in Andhra Pradesh. Originally intended for irrigation of dry crops (*rabi jowar* 15,000 acres; *kharif jowar* 15,000 acres), the only crop actually grown is paddy in about 15,000 acres (about 2/3rd *abi* and 1/3 rd *tabi*); the *ayacut* had to be reduced to 10,000 acres.

7-15 In Western Maharashtra, the canals cater for a mixed crop pattern, dry crops in *kharif* and *rabi*, with an emphasis on sugarcane.

7-16 The pattern of irrigation from wells is mixed; there is hardly any area under paddy. The crops mostly grown are *jowar*, small millets, sugarcane, chillies, vegetables and fruit gardens.

In Maharashtra, on some canals, wells are used to supplement canal supplies during the post-monsoon season for the irrigation of sugarcane and other perennial crops.

Recent trends in crop pattern in irrigated areas

7-17 On the Palair and Muneru Canals, in Andhra Pradesh and the Mhaswad Tank in Maharashtra, there is a growing tendency to introduce second crop of ground-nut after paddy.

7-18 On the Nira canals in Maharashtra and to a lesser extent on the Godava and Pravara Canals, long staple cotton is now being introduced as an irrigated crop

7-19 There is also a tendency to grow wheat as a second crop after paddy and some of the irrigation works in Madhya Pradesh and the Vidarbha region of Maharashtra.

Crop seasons

7-20 Because of the relatively equable temperatures in the Krishna and Godava basins, as described in paragraphs 5-1 to 5-6, crop seasons are not so well defined in northern India. By and large, the sowing of crops and other agricultural operations are determined by the timing of rainfall and the availability of river water which, in turn, also depend on the incidence of rainfall.

7-21 In Western Maharashtra and the Bombay Karnatak areas of Mysore, there are three official irrigation seasons ; *kharif*, 15th June to 14th October, *rabi*, 15 October to 14th February and Hot weather, 15th February to 14th June. Major crops, however, extend from one season to the other ; *jowar* is grown both in *kharif* and *rabi* and cotton and ground-nut can be grown in all three seasons, if irrigational supplies were available.

7-22 In Vidarbha, Madhya Pradesh and Orissa, there is generally one crop on which is sown about the beginning of July immediately after the rains begin. The un-irrigated areas generally bear a short-term crop which is harvested by October and in the irrigated areas a long-term crop which is harvested in November-December. In some areas, a *rabi* crop follows.

7-23 In Andhra Pradesh and most of Mysore, crop season begins on the advent of rains in June. The un-irrigated crops are harvested in October but the irrigated paddy is not harvested until about December. Wherever irrigation waters are available, another paddy crop follows which is sown in January-February and harvested in April-May. Paddy can, however, be grown practically any time during the year. Paddy, in all stages of growth, can be seen at the same time in one and the same locality. Such fields as cannot be sown in July and August, are sown with the September rains.

7-24 In general, paddy, cotton and ground-nut can be grown throughout the year in the two basins, provided irrigation supplies could be made available.

It will be seen from paragraph 7-11 that cotton is almost entirely an un-irrigated crop in the Krishna and Godavari basins; the short staple variety is grown. Cotton requires sufficient moisture during early stages of its growth and comparatively dry conditions during the flowering and maturing stages; rainfall during the boll opening and harvesting period is definitely harmful. Long staple varieties of cotton have relatively longer crop period and need, therefore, some irrigation supplies in addition to rainfall. These varieties have a relatively large yield and, in suitable soil with sufficient drainage, long staple cotton can be a good cash crop.

Like Cotton, groundnut is also grown mainly as a rain-fed crop in the two basins. The average yield of the 'spreading' varieties grown under these conditions is 1200-1400 pounds per acre and that of the 'bunch' varieties 800-1000 pounds per acre. With a relatively small quantity of irrigation water, ground-nut can be grown to give 3,000 pounds or more per acre—a valuable cash crop.

Preparation of Land for Irrigation

7-25 Because of the nature of the terrain, most of the uplands to be put under irrigation require some levelling and terracing for efficient distribution of water over the whole field. Only a beginning has been made in this direction.

In Andhra Pradesh, the work of terracing irrigated fields, during II Plan and the first year of III Plan, in the districts of Kurnool, Nizamabad, Karimnagar, Nalgonda and Adilabad, has covered an area of about 27,000 acres.

In Mysore, the contour border strip irrigation methods is being introduced. In the Tungabhadra areas, 21 demonstration plots were laid out in 1961-62 and the cultivators are being encouraged to take to this method of irrigation. The total area so treated up-to-date is not available.

7-26 During its visits to various project areas in the two basins, the Commission noticed that, unlike the irrigated areas in the Indo-gangetic plains, most of the tracts to be irrigated in the Krishna and Godavari basins by the projects, which have recently come into operation or are under construction, would require to be prepared for receiving irrigation supplies. The Commission felt that this aspect was not so far receiving the attention necessary for efficient irrigation practice.

Soil Conservation

7-27 It has been stated in Chapter II that the Krishna and Godavari basins largely comprise ridges and valleys. In the upper reaches of the rivers and of their tributaries, land slopes are relatively steep and there is considerable soil erosion during rainfall of high intensity. Accordingly, for some years past, efforts are being made to conserve soil by contour bunding and afforestation. Efforts so far made in this direction are described below.

Contour Bunding

7-28 In Andhra Pradesh, about 3,200 acres were taken up for contour bunding during I Plan in the districts of Anantapur, Adilabad and Kurnool. In II Plan, the total area protected by contour bunding was about 35,600 acres in the districts named above and in the districts of Cuddapah, Hyderabad, Medak, Nizamabad, Mahbubnagar, Karimnagar, Warangal, Nalgonda and Khammam. During III Plan, about 19,000 acres are proposed to be protected in the districts named above. The total area to be protected by contour bunding by the end of III Plan would be about 58,000 acres.

7-29 In the Godavari basin, in Madhya Pradesh, about 1,700 acres in Chhindwara district were taken up for contour bunding in 1961-62. During 1962-63, it is proposed to protect about 142,000 acres in the districts of Seoni, Chhindwara, Balaghat and Bastar.

7-30 In Maharashtra, the work of contour bunding has been in progress for some time past, on a relatively large scale, in the districts of Poona, Satara, Sangli, Kolhapur, Sholapur and Ahmednagar in the Krishna basin and in the districts of Nanded, Parbhani, Aurangabad, Bhir, Osmanabad, Ahmednagar and Nasik in the Godavari basin. The progress to-date is as follows :

| Name of Basin | I Plan | II Plan | 1961-62 | Total |
|--------------------|-------------------------|--------------|--------------|--------------|
| |million acres..... | | | |
| Krishna | 0.483 | 0.595 | 0.267 | 1.345 |
| Godavari | 0.086 | 0.208 | 0.140 | 0.434 |
| Total | 0.569 | 0.803 | 0.407 | 1.779 |

7-31 The total area which has been contour banded by the end of 1961-62 in the Bombay Karnatak area of Mysore is 0.374 million acres, out of which 0.225 million acres are in Bijapur District alone. In addition, about 18,000 acres have been provided with contour bunds in the Gulbarga, Raichur, Chitradurga and Tumkur districts.

7-32 In the Koraput District, the area provided with contour bunding since the beginning of I Plan upto 1960-61 is about 56,000 acres in the Godavari basin; about 2,000 acres have been similarly protected in the Kalahandi district.

7-33 The contour bunding described above has been carried out entirely in un-irrigated areas and generally where the rainfall is less than 20 inches (annual). Although the black cotton soil areas have not responded well to contour bunding in Mysore, the overall results are promising, particularly in Maharashtra where the farmers' associations have taken to this work enthusiastically.

Afforestation

7-34 Whereas the less steep areas are being provided with contour bunds, the relatively steep areas in various states are being planted with trees. In Andhra Pradesh, about 4,000 acres have been afforested in the Krishna basin in the districts of Kurnool, Nalgonda and Guntur. Likewise, about 2,500 acres have been afforested in the Godavari basin in the districts of East Godavari, Warangal and Khammam.

7-35 While no work has been done in Maharashtra on afforestation as a part of soil conservation, in Mysore such measures have covered 33,550 acres in the districts of Chitradurga, Dharwar, Belgaum, Bijapur, Bellary, Gulbarga and Raichur in the Krishna basin where trees have been planted after staggered trenching, *nallah bunding* and gully plugging, where necessary. During III Plan, it is proposed to take up a further area of about 46,000 acres.

7-36 As part of the Tungabhadra Project, about 2,300 acres have been afforested since 1956-57. Some more area is expected to be covered in its catchment.

7-37 About 20,000 acres of land in the Godavari basin in the Koraput district of Orissa have been covered under the afforestation programme and about 700 acres in the Seoni, Bastar and Chhindwara districts of Madhya Pradesh.

Land use statistics required by basins and projects

7-38 For optimum development of the land and water resources of the Krishna and Godavari basins, it would appear desirable to examine whether it is not possible to collect and compile land use statistics by sub-basins and basins in addition to the present practice of compiling these statistics by political and administrative units.

In any case, it is important to have these statistics for each project area. These are not available at present. In general, the project reports of works already sanctioned during the First Plan and Second Plan and now proposed in the Krishna and Godavari basins do not contain results of any surveys of land use in the project areas. When the Commission requested for such statistics, the State Governments could only furnish rough figures of the cropping pattern in the areas proposed to be irrigated, based on the district-wise or *taluk*-wise data already collected.

CHAPTER VIII

REGIONAL ECONOMY

General

8-1 A study of regional economy is not included in the terms of reference of the Commission nor does this chapter purport to be one. A brief reference to some of the important aspects of the economy of the two basins is, however, necessary in any survey relating to the development of water resources.

Population

8-2 On the basis of the 1961 Census and the percentages, given in Table I, of the area of each district within the Krishna and Godavari basins to the district as a whole, the total population of the two basins is about 60 million. About 80 per cent of this population live in rural areas.

Of the total population of the Krishna and the Godavari basins, about 20 million is in Andhra Pradesh, 3 million in Madhya Pradesh, 24 million in Maharashtra, 12 million in Mysore and 1 million in Orissa.

Forests and agriculture

8-3 Forests and agriculture are the main stay of the people.

8-4 A large part of the Godavari basin consists of forests, 22 million acres out of a total area of about 77 million acres. In the Krishna basin forests extend over 7 million acres. The north-eastern part of the Godavari basin in Andhra Pradesh, Madhya Pradesh and Orissa is particularly rich in forests and forest potential but this potential is largely undeveloped. Lack of communications in the area is one reason for a low level of exploitation of the forest wealth. The Godavari has no bridge across it for a length of over 400 miles from the sea. From Jagdalpur, the headquarters of Bastar district, the nearest rail head is 200 miles away. One road bridge is now being built at Bhadrachalam on the lower Godavari and a railway line is under construction from Kottavalasa to Bailadilla. These will help in opening up part of this area but a considerable further effort is necessary in this direction.

8-5 The area annually cropped in the Krishna basin is about 40 million acres and that in the Godavari basin is about 36 million acres. Agriculture is largely rain-fed with relatively low yields except in about 9 million acres of irrigated area, of which six million acres grow paddy.

Under un-irrigated agriculture, *jowar* has the pride of place with 23 million acres grown partly in *Kharif* and partly in *Rabi*, 5 million acres are under *bajra*, 3 million acres under wheat and 19 million acres under other food crops. Cotton extends over 7 million acres and ground-nut over about 6 million acres. Other oil-seeds and pulses are also important crops.

Under irrigated agriculture, apart from the large areas under paddy, sugarcane extends over about 430,000 acres. Some of the best sugarcane in the country is grown in this area.

8-6 Banana cultivation, growing of mangoes, citrus and, more recently, grapes are important activities in the two basins. Chillies and tobacco are grown over large areas. Melons are grown in the river beds in the hot weather before the monsoon.

Power

8-7 The development of power in the Krishna and the Godavari basins has so far been poor. The total installed capacity of hydro-electric generating plants in the two basins, as on March, 1961, was about 500,000 kW. The installed capacity of thermal generating plants was about 100,000 kW.

The total energy produced during 1958-59 was about 2,200 million kWh about half of which was exported out of the basin, mainly into the Bombay area. The per-capita annual consumption, within the two basins, would be of the order of 18 units.

Mineral wealth

8-8 The Krishna and Godavari basins have a rich variety of mineral wealth spread over their vast areas. The occurrence of these minerals is intimately connected with the geologic formations of the areas. Since most part of the two basins is covered by Deccan trap, important minerals like bauxite, manganese, asbestos, copper and chromite, associated with that type of formation are found in these basins. Deposits of iron, manganese, gold, copper, barytes, chromite, asbestos, and graphite are associated with the Archaean schists and gneiss formations in the two basins. The Cuddapahs contain iron, barytes and chromite; mica and graphite are important minerals associated with the Pleistocene and recent formations. Coal-fields are found in the areas covered by Upper and Lower Gondwanas. The largest concentration of ore mines are to be found in the Mysore plateau and in the eastern part of the Godavari basin.

Several coal mines are to be found in the Chhindwara district of Madhya Pradesh and in Khammam district of Andhra Pradesh. Many manganese mines are located in these basins. Balaghat District in Madhya Pradesh and Nagpur District in Maharashtra, both in the Godavari basin, are the two chief manganese producing centres in India. Iron ore is found mostly in Mysore State, which has the second largest number of iron ore mines in India. The iron ores found in Sandur hills in Bellary district and in the Bababudan hills of Chikmagalur districts are well-known for their quality.

8-9 The district-wise distribution of the principal minerals found in the Krishna and Godavari basins is as under :

Bauxite is found in Balaghat district of Madhya Pradesh and Kolhapur district of Maharashtra.

Manganese is found in Visakhapatnam district of Andhra Pradesh, Bhandara district of Maharashtra, Bellary, Chitradurga, Shimoga and Tumkur districts of Mysore and Koraput district of Orissa.

Iron Ore occurs in the districts of Khammam, Krishna and Kurnool of Andhra Pradesh and Bellary and Chikmagalur of Mysore.

Copper occurs in the Anantapur district of Andhra Pradesh.

Gold occurs at Hatti in Raichur district of Mysore and in river beds.

Coal is found in the Khammam district of Andhra Pradesh, Chhindwara district of Madhya Pradesh and Chanda district of Maharashtra.

Limestone deposits are found in Gulbarga and Shimoga districts of Mysore.

Other minerals like lead, zinc, corundum, ilmenite, refractory minerals and kaolin are also found in small quantities in different parts of the two basins.

Industries

8-10 Rich in forests, agricultural and mineral resources, the industrial potential of the Krishna and Godavari basins is higher than of many other parts of India. There is also a large hydro-power potential awaiting development in these two basins. The present developments are a modest indication of the large potential which remains to be developed in this area.

8-11 A small part of the enormous forest wealth of the two basins is at present utilised as timber and in the manufacture of paper and other timber products in the districts of Adilabad and East Godavari of Andhra Pradesh, Bastar of Madhya Pradesh, Chanda of Maharashtra and Shimoga of Mysore.

8-12 Of the industries based on agricultural produce may be mentioned the processing of agricultural commodities like rice milling, cotton ginning, pressing, spinning and weaving, manufacture of sugar, manufacture of textiles, extraction of oil from ground-nut and other oil-seeds and *bidi* manufacture.

8-13 Mining of manganese, coal and other ores are important activities in the districts rich in minerals. Most of the ores are at present exported.

Iron and steel are manufactured only in one place in the Krishna basin at Bhadravati in Shimoga District. Small engineering industries are spread all over the area.

8-14 Cement is manufactured at a number of places in the two basins; in the districts of Adilabad, Guntur and Krishna in Andhra Pradesh and of Bijapur, Gulbarga and Shimoga in Mysore.

Scarcity areas

8-15 As indicated in paragraph 1-15, considerable stress was laid, at various stages of the Commission's work on the special requirements or claims of "scarcity areas". The basis of these claims and the criteria for "scarcity" which were put forward varied and appeared sometimes to be rather vague. A close study of the problem appeared to be necessary, particularly in view of the fact that agriculture is the main stay of the people in the two basins, specially in the rural areas.

8-16 Whenever an area is declared 'scarcity area', the collection of land revenue in that area is suspended in whole or in part and if scarcity conditions continue over a number of successive years, the land revenue previously suspended, is remitted. Relief works are also started to provide employment for the people. While these practices are pretty well known throughout the country, the rules and regulations for suspension and remission of land revenue and for opening relief works vary a great deal not only from State to State but even from district to district in the same State.

8-17 The Commission was unable to ascertain any set of well-defined conditions under which an area should be declared as "scarcity area". The Bombay Fact Finding Committee, for the economic and administrative survey of scarcity areas, has in its Report (1960) divided these areas into three categories ; a total or almost total failure of crops in an area

once every three years,
once every six years, or
once every ten years.

This failure would be reflected in the amount of land revenue suspended in different areas when compared with the total annual dry assessment for the area.

8-18 After discussion with the representatives of the State Governments on 4th November, 1961, it was decided that relevant information on a uniform basis should be collected from all the States. It was considered that the district would be too big a unit for this purpose; the information should be collected by *taluks*, for a period of 30 years, from 1931 to 1960, separately, for each decade. A special form was devised and the State Governments were requested to furnish the information for all such *taluks* which in their view were subject to scarcity conditions. A copy of the form is at Appendix B.

The information sought in this form was not readily available and it took the State Governments considerable time to collect the relevant information from district and *taluk* headquarters. At the end of May, 1962, the particulars requested had been received for a total of 177 *taluks* 35 in Andhra Pradesh, 10 in Madhya Pradesh, 51 in Maharashtra, 75 in Mysore and 6 in Orissa.

8-19 On an examination of the data furnished by the States it was found that :

- (a) the conditions under which an area could be declared as 'scarcity area' were not well-defined;
- (b) the rules and regulations for suspension and remission of land revenue differed a great deal from State to State and in some cases from district to district in the same State;
- (c) in a number of cases, the amount of land revenue suspended or remitted in an individual year was found to be far in excess of the corresponding total annual amount of dry assessment;*

**In spite of references to the State authorities it was not found possible to reconcile this apparent discrepancy within the time at the disposal of the Commission.*

- (d) the expenditure on relief works was not, in all cases, charged to the account head 54-Famine Relief Works but was debited sometimes to the normal development works and booked against the projects concerned; as such, expenditure could not be determined;
- (e) no statistics were available for large areas which formed part of the *jagirs*, referred to in paragraph 2-9; and
- (f) in addition to the suspensions and remissions of land revenue given under general rules relating to scarcity areas, special suspensions and remissions had also been granted to meet conditions and circumstances not covered by the general rules.

8-20 After a careful study of the information received, which, it may be restated, is neither complete nor fully verified, the Commission decided to make a list of those *taluks* in which 25 per cent or more land revenue was suspended in any year during the period 1931—60. The Commission did not consider it worthwhile to take note, at this stage, of *taluks* where the land revenue suspended in any year was less than 25 per cent of the yearly assessment for the *taluk*.

8-21 This list is shown in Table XVIII in which land revenue suspended is indicated as follows :

- A denotes suspension of land revenue equal to or exceeding 75 per cent of the yearly assessment;
- B denotes suspension of land revenue from 50 to 74 per cent of the yearly assessment; and
- C denotes suspension of land revenue from 25 to 49 per cent of the yearly assessment.

The numbers, shown in the Statement, against these letters, denote the number of years during which suspension of a given order was granted during any ten years period, *e.g.*, 2B against a *taluk* denotes that suspension from 50 to 74 per cent of the yearly land revenue was granted in that *taluk* in two years during the particular decade.

8-22 A study of Table XVIII shows that there are many *taluks* in which the suspension of land revenue is small and in-frequent. The Commission would, however, draw attention to those *taluks* in which the suspension of land revenue exceeds the magnitude and frequency indicated by 2A or 3B—suspension of 75 per cent or more of annual land revenue twice or more in a ten year period or suspension of 50 to 74 per cent of annual land revenue, thrice or more in a ten year period.

TABLE XVIII
LAND REVENUE SUSPENSIONS

| Name of district | Name of taluk | Normal rainfall (inches) | Average rate of land revenue per acre (rupees) | Suspension of land revenue | | |
|-----------------------|----------------|--------------------------|------------------------------------------------|----------------------------|---------|---------|
| | | | | 1931-40 | 1941-50 | 1951-60 |
| ANDHRA PRADESH | | | | | | |
| Mahbubnagar | 1. Gadwal | 27.9 | 0.57 | .. | .. | 1A |
| Nellore | 1. Kandukur | 31.6 | 1.07 | .. | 1C | 1A |
| Nalgonda | 1. Nalgonda | 29.3 | 0.72 | 1A+1B | .. | .. |
| Anantapur | 1. Madakaira | 25.2 | 0.33 | 1B+1C | 1C | 3A |
| | 2. Anantapur | 20.1 | 0.24 | .. | .. | 2A+1B |
| | 3. Kalyan Durg | 21.8 | 0.32 | .. | .. | 2A |
| Hyderabad | 1. Vikarabad | 45.0 | 1.21 | .. | .. | 2B |
| Visakhapatnam | 1. Narsipatham | 45.8 | 0.89 | .. | .. | 1A |
| Karimnagar | 1. Manthani | 42.3 | 0.87 | .. | .. | 1C |
| | 2. Sultanabad | 34.5 | 1.14 | 1C | .. | .. |
| Medak | 1. Gajwal | 35.0 | 0.98 | .. | .. | 1C |
| MADHYA PRADESH | | | | | | |
| Seoni | 1. Seoni | NA | 5.16 | .. | .. | 4A+1B |
| | 2. Lakhnadon | NA | 6.06 | .. | .. | 5A |
| Durg | 1. Rajnandgaon | 60.3 | 0.91 | .. | 1C | 1B |
| Mandla | 1. Mandla | 54.6 | 0.69 | .. | 1A | 2A+1C |
| MAHARASHTRA | | | | | | |
| Satara | 1. Man | 20.0 | 0.34 | 1C | 1A | 1B |
| | 2. Khatav | 20.9 | 0.68 | .. | 1A | 1C |
| | 3. Koregaon | 29.5 | 1.96 | .. | .. | 1C |
| | 4. Khandala | 20.5 | 0.83 | 1B+1C | .. | 2C |
| | 5. Phaltan | 19.8 | 0.83 | .. | 1B | 1A |

TABLE XVIII (continued)
LAND REVENUE SUSPENSIONS

| Name of district | Name of taluk | Normal rainfall (inches) | Average rate of land revenue per acre (rupees) | Suspension of land revenue | | |
|------------------|-------------------|--------------------------|------------------------------------------------|----------------------------|---------|---------|
| | | | | 1931-40 | 1941-50 | 1951-60 |
| Sangli | 1. Jath | 21.3 | 0.38 | 1C | 1A+1B | |
| | 2. Tasgaon | 25.0 | 1.82 | 1C | | |
| | 3. Khanapur | 23.8 | 1.27 | 1C | 1C | |
| Sholapur | 1. Pandharpur | 24.2 | 0.86 | 2C | 1A | |
| | 2. Barsi | 27.6 | 0.61 | | 1A+1C | |
| | 3. Karmala | 25.3 | 0.65 | | 1A+1B | |
| | 4. Madha | 23.4 | 0.83 | | 2A | |
| | 5. North Sholapur | 27.9 | 0.83 | 1C | 1B+1C | |
| | 6. Mongalwedha | 29.1 | 0.60 | | 1A+1C | |
| | 7. Sangola | 22.6 | 0.46 | | 3A+2B | |
| | 8. South Sholapur | 27.9 | 0.79 | | 1A+1C | |
| | 9. Akkal Kot | 29.8 | 0.88 | | 2A | |
| | 10. Mohol | 28.2 | 0.66 | 1B | 1B | |
| Poona | 1. Ambegaon | 42.0 | 0.87 | | 1C | |
| | 2. Baramati | 20.2 | 0.71 | 1C | 2B+3C | |
| | 3. Dhond | 19.8 | 1.23 | 1C | 2C | |
| | 4. Haveli | 27.6 | 0.48 | 1A+2B | 1B+3C | |
| | 5. Indapur | 19.8 | 0.66 | | 1C | |
| | 6. Purandhar | 24.7 | 0.38 | | 1B | |
| | 7. Sirur | 21.1 | 0.91 | 2C | 3C | |
| Ahmadnagar | 1. Ahmadnagar | 26.5 | 0.64 | | 2B | |
| | 2. Parner | 22.3 | 0.49 | | 1B+1C | |
| | 3. Karjat | 24.8 | 0.38 | | 1C | |
| | 4. Nowasa | 26.0 | 0.95 | | 1B | |
| | 5. Shrirampur | 21.4 | 1.95 | | 1B | |
| | 6. Shevgaon | 26.4 | 0.91 | | 1C | |
| | 7. Sangamner | 20.4 | 0.94 | 1C | 1C | |
| | 8. Shrigonda | 22.1 | 0.56 | 1B | 2C | |
| | 9. Jamkhed | 26.9 | 0.59 | | 1B | |
| | 10. Pathardi | 27.9 | 0.65 | 1C | 1B | |
| | 11. Kopargaon | 21.4 | 1.37 | | | |
| | 12. Rahuri | 21.7 | 0.93 | 1C | 1A+1B | |

TABLE XVIII (continued)
LAND REVENUE SUSPENSIONS

| Name of District | Name of taluk | Normal rainfall (inches) | Average rate of land revenue per acre (rupees) | Suspension of land Revenue | | |
|------------------|---------------|--------------------------|------------------------------------------------|----------------------------|----------|----------|
| | | | | 1931-40 | 1941-50 | 1951-60 |
| Osmanabad | 1. Parenda | 25.6 | 0.87 | .. | .. | IB |
| Nasik | 1. Dindori | 32.2 | 0.63 | .. | 1B | .. |
| | 2. Niphad | 22.4 | 1.37 | .. | 1B | 1A+2C |
| | 3. Sinnar | 24.9 | 0.68 | .. | .. | 1C |
| | 4. Yeola | 24.0 | 0.78 | .. | .. | 1B |
| | 5. Chander | 25.9 | 0.58 | .. | .. | 1A |
| Bhir | 1. Ashti | 25.7 | 0.64 | 2B | 1B+1C | 1C |
| | 2. Patoda | 31.6 | 0.80 | 2C | 1C | 2C |
| | 3. Bhir | 31.6 | 0.82 | 3C | 1C | .. |
| | 4. Manjlegaon | 30.0 | 0.90 | 1A | 1A | 1B |
| | 5. Georai | 30.5 | 0.88 | 1A | . | .. |
| Aurangabad | 1. Vijapur | 22.6 | 1.60 | .. | .. | 1C |
| | 2. Gangapur | 27.3 | 1.52 | .. | .. | 1C |
| MYSORE | | | | | | |
| Belgaum | 1. Sampagoan | 31.1 | 1.81 | 1C | 1B+2C | |
| | 2. Athani | 23.1 | 0.86 | 2C | 3A+4B+3C | 3B+6C |
| | 3. Parasgad | 27.5 | 0.93 | 2B | 2A+4B+2C | 2A+5B+2C |
| | 4. Ram Durg | 22.9 | 0.81 | .. | 1C | 6A+2B+2C |
| | 5. Raibag | 22.4 | 0.75 | .. | .. | 2C |
| | 6. Gokak | 21.8 | 0.64 | .. | 5A+3B+1C | 4A+2B+2C |
| Dharwar | 1. Dharwar | 35.0 | 1.61 | 3C | 3A+1B | 2A+1C |
| | 2. Haveri | 30.2 | 1.16 | .. | 1B | .. |
| | 3. Hubli | 28.9 | 2.16 | .. | 5A+1B+1C | 3A |
| | 4. Kundgol | 32.6 | 2.64 | .. | .. | .. |
| | 5. Ranebennur | 26.1 | 1.23 | .. | .. | 1C |
| | 6. Gadag | 26.4 | 1.05 | .. | 4A+1B+3C | 1A+3B |
| | 7. Mundargi | 20.4 | 0.76 | .. | 4C | 2A+2C |
| | 8. Nargund | 23.3 | 1.48 | .. | 1A | 10A |
| | 9. Navalgund | 24.9 | 1.73 | 2B+4C | 9A+1C | 10A |

TABLE XVIII (concluded)
LAND REVENUE SUSPENSIONS

| Name of District | Name of taluk | Normal rainfall (inches) | Average rate of land revenue per acre (rupees) | Suspension of land Revenue | | |
|------------------|----------------|--------------------------|------------------------------------------------|----------------------------|--------------|--------------|
| | | | | 1931-40 | 1941-50 | 1951-60 |
| | 10. Ran | 26.8 | 1.20 | 2A | 2C | 2C |
| | 11. Shirahatii | 23.2 | 2.39 | 2C | .. | .. |
| Gulbarga | 1. Shorapur | 23.1 | 1.04 | .. | .. | 1A |
| | 2. Shahapur | 35.0 | 1.25 | .. | 1C | 1B+1C |
| | 3. Jowargi | 25.2 | 0.98 | .. | 2C | .. |
| | 4. Yadgir | 27.9 | 1.00 | .. | .. | 2A |
| Bijapur | 1. Badami | 23.1 | 1.37 | 1C | 2A+1B +1C | 2B+1C |
| | 2. Bagewadi | 24.7 | 0.54 | 1A+1B | 1A+1C | 4C |
| | 3. Bacalkot | 23.2 | 1.59 | .. | 2B+1C | 1B |
| | 4. Bijapur | 21.2 | 0.56 | 3B | 3B | 1A+2B +4C |
| | 5. Bilgi | 21.6 | 1.23 | 1C | 2B+1C | 1C |
| | 6. Hangund | 23.5 | 1.25 | 1B | 2C | 2C |
| | 7. Indi | 22.5 | 0.44 | .. | 2B+1C | 1A+1B +2C |
| | 8. Muddibihal | 22.3 | 0.73 | 2B | 1B+3C | 2C |
| | 9. Mudhol | 19.5 | 1.37 | .. | 1C | 4C |
| | 10. Sindgi | 20.8 | 0.50 | 2A | 1A+1B +2C | 2B+1C |
| | 11. Jamkhandi | 20.7 | 1.43 | .. | .. | 3C |
| Raichur | 1. Raichur | 24.7 | 1.68 | .. | .. | 1C |
| | 2. Manvi | 23.8 | 1.00 | .. | 1C | 1B+1C |
| | 3. Lingsugar | 19.2 | 0.87 | .. | 1B+1C | 2B+1C |
| | 4. Kustagi | 20.7 | 0.94 | .. | .. | 2A+1C |
| | 5. Sindhnoor | 21.9 | 1.12 | .. | 1A+1B +1C | 4A+3B |
| | 6. Koppal | 24.5 | 1.00 | .. | .. | 1A+2B +2C |
| | 7. Gangavati | 20.2 | 1.00 | .. | .. | 1C |
| | 8. Yellaburga | 20.5 | 1.00 | .. | .. | 2B+1C |
| Chitradurga | 1. Chitradurga | 23.9 | 0.60 | .. | .. | 1C |
| | 2. Hiriyur | 20.4 | 0.49 | .. | .. | 1C |
| | 3. Chellakere | 18.2 | 0.34 | .. | 1B | 1A |
| | 4. Molakalmur | 21.8 | 0.41 | .. | .. | 3A |

There are three *taluks* in the Anantapur District of Andhra Pradesh, three *taluks* in Madhya Pradesh, nine *taluks* in the districts of Sholapur, Poona and Ahmednagar in Maharashtra and 19 *taluks* in various districts of Mysore which, on the basis of data furnished, qualify for such consideration. These are shown in italics in Table XVIII.

8-23 A perusal of Table XVIII would show that the land revenue suspended during the decade 1941—50 was considerably in excess of (about three times) that granted in 1931—40 and that the land Revenue suspended during 1951—60 was even greater (about five times of that suspended during 1931—40). This large and progressive increase cannot obviously be attributed to any changed pattern of rainfall conditions.

8-24 It will also be seen from a study of Table XVIII that the *taluks* in which suspensions are granted more frequently are those for which the land revenue assessment is relatively low, indicating low crop yields.

8-25 It is indeed surprising that little should have been done for these areas in the way of irrigation facilities either by the schemes in operation prior to 1951 or by the large and extensive developments since undertaken and described in Chapter XIII.

Dependence on rainfall and water resources

8-26 It has been shown in the preceding paragraphs that the enormous forest wealth in the Krishna and Godavari basins has largely remained neglected; the level of exploitation is low. The development of power has so far been poor and the present industrial development is only a modest indication of the large potential which remains to be developed. Under these conditions, the economy of the two basins and adjoining areas depends, at present, largely on agriculture which, in view of inadequate rainfall concentrated in a short period, provides a low level of subsistence, except in a small part of the area where facilities for irrigation have been provided. The latter area is also the seat of industries based on agricultural produce. No wonder therefore that there should be keen demand in all the States in the region for large scale development of water resources.

The well being and prosperity of the entire Krishna-Godavari region is closely related to the development of the water resources of the two river systems.

CHAPTER IX

RIVER FLOW

Available flow data

9-1 There has so far been no planned and systematic observation of discharges on either the Krishna or the Godavari river system. Apart from some ad-hoc and irregular observations made on a number of tributaries, for relatively short periods, the only systematic record available pertains to existing anicuts or reservoirs where river flow is generally calculated on the basis of gauge readings observed from different parts of the works.

9-2 Tables XIX and XX give a list of the sites for which discharge data have been made available to the Commission for the period indicated against each. These sites are shown in Plate VIII.

9-3 Of the 62 sites on the Krishna river system, for which some data have been supplied (see Table XIX), regular observations are being continued at only 21 sites* observations at the remaining sites have been discontinued, or are made irregularly. Of these 21 sites, data for a period of 10 years or more are available for 16 sites and for a period of 20 years or more for only 5 sites, namely Vijayawada on the Krishna, Dhupdal on the Ghataprabha, Bhatghar on the Yelwandi, Sunkesula on the Tungabhadra and Lakka valli on the Bhadra.

9-4 On the Godavari river system, regular observations are being continued only at 29 out of 44 sites shown in Table XX. Of these 29 sites, data for a period of 10 years or more are available for 18 sites and for a period of 20 years or more for only 7 sites, namely Nandur Madhmeshwar and Dowlaishwaram on the Godavari, Lake Beale on the Darna, Palkhed on the Kadwa, Waghad on the Kolwan, Ozer on the Pravara and Nizamsagar on the Manjra.

9-5 It is surprising to note that the observations being made at some of the sites shown in Tables XIX and XX were discontinued only during 1959 and 1960.

9-6 Data of river discharges, as made available to the Commission for different sites on the Krishna river system, have been presented in Annexure III, in the form of 10-daily averages, and similar data for the Godavari river system in Annexure VI. For some years, for which data are available for the rainy season and are missing for the dry part of the year, or where data for short periods in the rainy season are not available, the Commission has assumed the missing discharges on the basis of all the relevant information available to it; the figures so obtained have been shown in brackets.

*At some of these sites continuous observations are available only for one or two years.

TABLE XIX

LIST OF SITES ON THE KRISHNA RIVER SYSTEM FOR WHICH DISCHARGE DATA
HAVE BEEN MADE AVAILABLE

Note : Sites at which observations have been discontinued are shown in italics.

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Period for which data available | | Remarks |
|---------------|----------------------------|----------------------------|-------------------|---------------------------------------------------|-----------------------------------------|--------------------------------------|
| | | | | Period | Number of years for calculating average | |
| 1 | <i>Dhom</i> | Krishna] | K-1 | June 1907 to Dec. 1918; Jan. 1922 to Apr. 1927 | 17 | |
| 2 | <i>Khodshi weir</i> | " | K-1 | Nov. 1947 to May 1961 | 12 | |
| 3 | <i>Karad</i> | " | K-1 | Aug. 1950 to Mar. 1957 | 6 | |
| 4 | <i>Chitapur</i> | " | K-2 | June 1958 to May 1959 | .. | |
| 5 | <i>Deosugur</i> | " | K-7 | July 1958 to May 1959 | .. | |
| 6 | <i>Siddeswaram</i> | " | K-7 | June 1948 to July 1953 | 5 | |
| 7 | <i>Nagarjunasagar Dam.</i> | " | K-7 | Aug. 1956 to May 1961 | 3 | Irregular Observations. |
| 8 | <i>Vijayawada</i> | " | K-7 | June 1901 to May 1961 | 60 | Earlier data from 1894 not included. |
| 9 | <i>Jalkewadi</i> | Koyna | K-1 | 1949 to 1960 | 12 | June to Oct. only. |
| 10 | <i>Helwak</i> | " | K.1 | 1906 to 1925-26 | 20 | Annual yield only. |
| 11 | <i>Yeralwadi</i> | Yerla | K-1 | 1913 to 1916, 1919 to 1926 | 12 | |
| 12 | <i>Ramapur</i> | " | K-1 | Aug. 1956 to May 1961 | — | Irregular observations. |
| 13 | <i>Radhanagri</i> | Bhogawati | K-3 | Jan. 1954 to May 1961 | 7 | |
| 14 | <i>Hadalga</i> | Ghataprabha | K.3 | 1906 to 1918 June 1919 to May 1927 | 13 | Annual Yield. |
| 15 | <i>Daddi</i> | " | K-3 | June 1949 to Oct. 1955 | 4 | Irregular observations. |
| 16 | <i>Dhupdal</i> | " | K-3 | 1906 to 1925-26 Jan. 1938 to May 1961 | 20 23 | Annual yield only. |

TABLE XIX—(continued.)

LIST OF SITES OF THE KRISHNA RIVER SYSTEM FOR WHICH DISCHARGE DATE
HAVE BEEN MADE AVAILABLE

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Period for which data available | | Remarks |
|---------------|-----------------|----------------------------|-------------------|---------------------------------------|-----------------------------------------|--------------------------------------------|
| | | | | Period | Number of years for calculating average | |
| 17 | Chinchkandi | Ghataprabha | K.3 | 1953 to 1958 | 4 | June to Nov. only, irregular observations. |
| 18 | Anagwadi | „ | K.3 | 1949 to 1957 | 3 | Do. |
| 19 | Murmuttisangam | „ | K.3 | 1949 to 1957 | 5 | Do. |
| 20 | Ajra | Hiranyakeshi | K.3 | 1904 to 1926 | 22 | June to Dec. only. |
| 21 | Basapur | Markandeya | K.3 | 1949 to 1954 | 5 | June to Nov. only. |
| 22 | Asoga | Malaprabha | K.4 | 1949 to 1960 | 8 | June to Dec. only, irregular observations. |
| 23 | Kolchi | „ | K.4 | June 1951 to May 1961 | 10 | |
| 24 | Hiresangam | „ | K.4 | 1952 to 1956 | 5 | June to Nov. only. |
| 25 | Chaskaman | Bhima | K.5 | 1906 to 1925-26 | 20 | Annual yield only. |
| 26 | Dhond | „ | K.6 | 1955-56, 1958-59, 1959-60 and 1960-61 | 4 | Dec. to May only. |
| 27 | Yadgir | „ | K.6 | July 1957 to Mar. 1959 | .. | |
| 28 | Waki | Bhama | K.5 | June 1949 to July 1959 | 9 | |
| 29 | Wadivala | Kudil Nalla | K.5 | June 1949 to Oct. 1959 | 9 | |
| 30 | Shikrapur | Vel | K.5 | June 1949 to May 1961 | 11 | |
| 31 | Pimpalgaon Rahu | Mula-Mutha | K.5 | 1950 to 1959 | 5 | Jan. to May only, irregular observations. |
| 32 | Mulshi Dam | Mula | K.5 | June 1930 to May 1961 | 31 | Monthly figures only. |
| 33 | Khadakwasla | Mutha | K.5 | June 1946 to May 1961 | 15 | |

TABLE XIX—(Continued.)

LIST OF SITES ON THE KRISHNA RIVER SYSTEM FOR WHICH DISCHARGE DATA HAVE BEEN MADE AVAILABLE

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Period for which data available | | Remarks |
|---------------|-------------------|----------------------------|-------------------|--------------------------------------------------------------|-----------------------------------------|---------------------------------------------------|
| | | | | Period | Number of years for calculating average | |
| 34 | Nirgudsar . . . | Ghod | K.5 | 1906 to 1927 | 21 | June to Dec. only |
| 35 | Wadgaon . . . | Mina | K.5 | 1904 to 1912 and 1917 to 1924 Jan. 1947 to May 1961 | 17 | June to Dec. only |
| 36 | Edgaon . . . | Kukdi | K.5 | 1906 to 1925-26 | 20 | Annual yield only |
| 37 | Visapur . . . | Hanga | K.5 | Dec. 1949 to May 1961 | 10 | |
| 38 | Natambi . . . | Nira. | K.5 | 1906 to 1925-26 | 20 | Annual yield only |
| 39 | Vir . . . | " | K.5 | June 1942 to May 1961 | 19 | |
| 40 | Sarati . . . | " | K.5 | 1949 to 1960 | 3 | Jan. to May only, irregular observa- tions. |
| 41 | Narasingpur . . . | " | K.5 | 1950 to 1959 | 30 | Do. |
| 42 | Bhatghar . . . | Yelwandi | K.5 | June 1941 to May 1961 | 20 | |
| 43 | Mohri . . . | Gunjawani | K.5 | 1906 to 1925-26 | 20 | Annual yield only |
| 44 | Hatwalan . . . | Sina | K.5 | June 1902 to May 1916 and June 1948 to May 1960 | 21 | |
| 45 | Wadakbal . . . | " | K.5 | 1952, 1953, 1958, 1959 and 1960 | 5 | Jan. to May only |
| 46 | Ekrak Tank . . . | Ekrak Nalla | K.5 | May 1944 to May 1961 | 17 | |
| 47 | Hallur . . . | Tungabhadra | K.8 | Jan. 1951 to May 1955 | 4 | |
| 48 | Harihar . . . | " | K.8 | Nov. 1950 to Oct. 1955 | 4 | |
| 49 | Havanur . . . | " | K.8 | Nov. 1950 to Oct. 1955 | 4 | |
| 50 | Hasrur . . . | " | K.8 | Nov. 1950 to Oct. 1954 | 3 | |

TABLE XIX—(concluded)

LIST OF SITES ON THE KRISHNA RIVER SYSTEM FOR WHICH DISCHARGE DATA HAVE BEEN MADE AVAILABLE

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Period for which data available | | Remarks |
|---------------|--------------------------|----------------------------|-------------------|---------------------------------------------------|-----------------------------------------|-------------------------|
| | | | | Period | Number of years for calculating average | |
| 51 | Tungabhadra Dam | Tungabhadra | K.8 | June 1931 to May 1941 | 10 | Monthly figures |
| | | | | Feb. 1950 to May 1961 | 11 | |
| 52 | Rajolibanda | „ | K.8 | July 1960 to May 1961 | .. | |
| 53 | Sunkesala | „ | K.8 | June 1904 to May 1936 | 32 | |
| | | | | June 1936 to May 1953 | 17 | |
| | | | | June 1953 to May 1961 | 8 | |
| 54 | Tunga Anicut (Sacrebyle) | Tunga | K.8 | Jan. 1946 to June 1955 and July 1958 to Mar. 1961 | 10 | Irregular observations |
| 55 | Lakkavalli | Bhadra | K.8 | June 1930 to May 1961 | 31 | |
| 56 | Bhadra Anicut | „ | K.8 | May 1947 to Sep. 1954 | .. | Do. |
| 57 | Banavasi | Varada | K.8 | May 1908 to 1925-26 | 18 | Annual yield only |
| 58 | Vani Vilas Sagar | Hagari | K.9 | July 1913 to Dec. 1960 | 47 | Seasonal yield only |
| 59 | Naranapur Anicut | „ | K.9 | Feb. 1960 to May 1961 | .. | |
| 60 | Bhairavanithippa | „ | K.9 | Jan. 1957 to May 1961 | 4 | |
| 61 | Gundlapalli Dam (Dindi) | Dindi | K.7 | June 1958 to May 1961 | 3 | |
| 62 | Paleru | Paleru | K.11 | June 1958 to May 1961 | 2 | Irregular observations. |

TABLE-XX

LIST OF SITES ON THE GODAVARI RIVER SYSTEM FOR WHICH DISCHARGE DATA HAVE BEEN MADE AVAILABLE

Note : Sites at which observations have been discontinued are shown in italics.

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Period for which data available | | Remarks |
|---------------|--------------------|----------------------------|-------------------|------------------------------------------------------------|-----------------------------------------|-------------------------------------------------------------------------------------------|
| | | | | Period | Number of years for calculating average | |
| 1 | Gangapur | Godavari | G-1 | 1906 to 1925-26 Nov. 1945 to May 1961 | 20 14 | Annual yield only |
| 2 | Nandur Madhmeshwar | " | G-1 | 1906 to 1925-26 June 1941 to May 1961 | 20 20 | Do. |
| 3 | Puntamba | " | G-1 | Apr. 1951 to Dec. 1960 | 9 | |
| 4 | Toka | " | G-1 | June 1954 to Dec. 1960 | 6 | |
| 5 | Mungi | " | G-1 | June 1954 to Dec. 1960 | 6 | |
| 6 | Soan Bridge | " | G-5 | June 1946 to May 1961 | 15 | |
| 7 | Mancherial | " | G-5 | Aug. 1955 to Dec. 1959 | .. | Irregular observations. |
| 8 | Dummagudem | " | G-10 | Apr. 1953 to Jan. 1954 and June 1957 to May 1961 | .. | Do. |
| 9 | Dowlaishwaram | " | G-10 | June 1901 to May 1961 | 60 | June 1901 to Dec. 1919 Monthly figures only. Earlier data from 1895 to 1900 not included. |
| 10 | Darna (Lake Beale) | Darna | G-1 | 1906 to 1925-26 June 1941 to May 1961 | 19 20 | Annual yield only |
| 11 | Chehadi | " | G-1 | June 1949 to Dec. 1960 | 8 | |
| 12 | Padli (Mukne) | Aundh Nalla | G-1 | 1906 to 1925-26 June 1948 to May 1961 | 20 10 | Annual yield only |
| 13 | Pimpalgaon Dukra | Karwa | G-1 | 1900 to 1914, 1920, 1922 and 1923 June 1947 to May 1959 | 9 10 | June to Dec. only |

TABLE XX (Continued.)

LIST OF SITES ON THE GODAVARI RIVER SYSTEM FOR WHICH DISCHARGE DATA HAVE BEEN MADE AVAILABLE

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Period for which data available | | Remarks |
|---------------|-----------------|----------------------------|-------------------|------------------------------------------|-----------------------------------------|------------------------|
| | | | | Period | Number of years for calculating average | |
| 14 | Nasik Road | Waldevi | G-1 | Jan. 1956 to Dec. 1960 | .. | Irregular observations |
| 15 | Lakhmapur | Kadwa | G-1 | 1906 to 1925-26 June 1948 to May 1961 | 20 12 | Annual yield only |
| 16 | Palkhed (weir) | .. | G-1 | 1906 to 1925-26 June 1941 to May 1961 | 20 20 | Do. |
| 17 | Ozarkhed | Unanda | G-1 | 1906 to 1925-26 June 1948 to May 1961 | 20 12 | Do. |
| 18 | Waghad | Kolwan | G-1 | June 1941 to May 1961 | 20 | |
| 19 | Khadakozar | Odal | G-1 | June 1906 to May 1916 1917 to 1925-26 | 10 9 | Do. |
| 20 | Bhandardhara | Pravara | G-2 | Jan. 1947 to May 1961 | 14 | |
| 21 | Ozer | .. | G-2 | 1906 to 1925-26 June 1941 to May 1961 | 20 20 | Do. |
| 22 | Newasa | .. | G-2 | June 1954 to Dec. 1960 | 6 | |
| 23 | Chikalthan | Mula | G-2 | 1906 to 1925-26 Aug. 1945 to May 1961 | 20 13 | Annual yield only |
| 24 | Khadakwagulgaon | Shiv | G-1 | Nov. 1958 to May 1961 | 2 | |
| 25 | Siddheshwar | Purna | G-3 | Jan. 1958 to May 1961 | 3 | |
| 26 | Purna Bridge | .. | G-3 | Feb. 1958 to May 1961 | | |
| 27 | Ghanpur | Manjra | G-4 | June 1951 to May 1961 | 10 | |

TABLE XX (Concluded)

LIST OF SITES ON THE GODAVARI RIVER SYSTEM FOR WHICH DISCHARGE DATA HAVE BEEN MADE AVAILABLE

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Period for which data available | | Remarks |
|---------------|-------------------------------------|----------------------------|-------------------|-------------------------------------------------|-----------------------------------------|---------------------------|
| | | | | Period | Number of years for calculating average | |
| 28 | Nizamsagar | Manjra | G-4 | Sep. 1934 to May 1961 | 26 | |
| 29 | Pocharan | Alair | G-4 | June 1948 to May 1961 | 13 | |
| 39 | Manair | Maner | G-6 | June 1951 to May 1961 | 10 | |
| 31 | Sanigram | Siddepetvagu | G-6 | June 1953 to May 1961 | 8 | |
| 32 | Ramappa Lake | Moruvanchavagu | G-6 | Jan. 1956 to May 1961 | 5 | |
| 33 | Ghanpur Cheroo | " | G-6 | Jan. 1956 to May 1961 | 5 | |
| 34 | Jafferabad | Pranhita | G-9 | Oct. 1957 to Nov. 1959 | .. | |
| 35 | Majri | Wardha | G-8 | Aug. 1955 to May 1961 | 5 | |
| 36 | Ballarshah | " | G-8 | Aug. 1955 to May 1961 | 5 | |
| 37 | Lakhanwara | Wainganga | G-9 | 1959 and 1960 | 2 | June to Oct. only. |
| 38 | Dhuti | " | G-9 | June 1941 to May 1961 | .. | Irregular observations. |
| 39 | Warsa | " | G-9 | June 1957 to May 1961 | 4 | |
| 40 | Shingodi | Pench | G-9 | 1959 to 1960 | 2 | June to Oct. only. |
| 41 | Totletoh | " | G-9 | June 1960 to Jan. 1961 | .. | |
| 42 | Pathagudem | Indravati | G-11 | Oct. 1957 to Dec. 1959 | .. | |
| 43 | Pulusura (Upper Kolab H.E. Scheme). | Sabari | G-12 | June 1921 to May 1929 | 8 | Fortnightly figures only. |
| 44 | Jalaput (Machkund H.E. Scheme) | Sileru | G-12 | June 1942 to May 1955 and Oct. 1959 to May 1961 | 13 | |

The year has been taken as the water year applicable to the hydrologic and agricultural conditions on the Krishna and the Godavari rivers, from 1st June, of one year to 31st May of the following year.

9-7 It may be mentioned that the flow at a particular point, as shown in these Annexures, is the actual flow reaching that point. It excludes upstream withdrawals and extractions for storage and includes releases into the river, if any, from upstream reservoirs; it includes the withdrawals, if any, at that point.

9-8 Since the reliability of river discharge data is closely related to the method of observation or estimation of discharge, the Commission made special efforts to ascertain these methods. The information obtained has been set out fully in the respective Annexures.

9-9 Abstracts, on a monthly basis, of the data contained in Annexures III and VI have been prepared separately for the Krishna and the Godavari river systems and have been presented in Annexures II and V respectively.

9-10 It may be mentioned here that the available data of river flow in the two basins, as presented in Annexures II, III, V and VI, have been assembled for the first time; until now no State had available to it any data observed by another State. So far as the Commission has been able to find out, there has been no attempt in the past to study the overall hydrology of either of the two river systems. Madras, Mysore and the erstwhile Hyderabad State made a study about 1935 of the flow of the Tungabhadra at Mallapuram and Sunkesula and some study has been made of the recorded flow of the Krishna and the Godavari at the heads of their respective deltas. Apart from the above, the only other study known to the Commission is that of the Ghat catchments made in Bombay Technical paper No. 30.

Reliability of available data

9-11 A study of the methods of observation and estimation of river discharges, as adopted at various sites in the Krishna and the Godavari basins and given in Annexures III and VI, would show that, in most cases, rough and ready methods as followed many years ago are still in use and that no advantage appears to have been taken of later developments leading to modern standards for such observations and estimation. The records of observations *etc.* have not in all cases been properly maintained and this adds to the difficulty of assessing their reliability.

9-12 At some sites, with erodible beds, river discharges were computed on the basis of daily, or even more frequent, velocity observations by floats but the cross-section was taken only once a year, or even less frequently once in three to five years. At other places, the slope-area method was used but a uniform slope was assumed once a year or less frequently. The results of such observation cannot be considered reliable. The Commission have, therefore, not made any use of the data obtained from such discharge observations at 23 sites on the Krishna river system and 15 sites

on the Godavari river system. These sites are :

Krishna river system : serial numbers 3, 4, 5, 7, 12, 17, 18, 19, 21, 24, 27, 28, 29, 30, 31, 36, 40, 45, 47, 48, 49, 50 and 57 (see Table XIX).

Godavari river system : serial numbers 5, 6, 7, 12, 13, 14, 17, 22, 24, 25, 34, 35, 36, 39 and 42 (see Table XX).

The data for these sites have, however, been included in the Annexures to this report as these might give some general qualitative information about river flow at these sites.

9-13 At the sites named below, discharges were computed from velocity observations made by floats and gauge readings. The floats were sometimes placed in position by boat or by men wading the stream, at other places they were thrown from the river bank or from a bridge. The cross-section was observed once a year or less frequently, but the river bed is stated to be not erodible. In the light of modern standards for determining river flow, the data so obtained cannot be regarded as accurate, the error might be as high as 20 per cent, plus or minus, of the actual.

Krishna river system : serial numbers 1, 10, 11, 14, 15, 20, 22, 23 (upto 1956) 25, 26, 34, 35, 38, 41, 43, 44, 51 and 55 (see Table XIX).

Godavari river system : serial numbers 1 (upto 1955), 2 (upto 1925-26), 3, 4, 11, 15, 19, 23, 25, 37, 40 and 41 (see Table XX).

9-14 At Siddeswaram on the river Krishna (serial number 6), discharges were observed for a period of five years by the slope-area method but, unlike other places, estimation of slope, though rough, was made every day. The data for this site may be taken as correct within 20 per cent.

At Pulusura on the Sabari, a gauge discharge relationship was established and observations made from 1921 to 1929. Details of this relationship are not available. The Commission have assumed these data also to be correct within 20 per cent, plus or minus.

9-15 At the following sites, river discharges have been computed from the daily content of the lake or reservoir (based on observed water levels) and the daily flow through sluices or over the waste weir, allowing for assumed evaporation losses. The accuracy of the data so obtained would vary widely from place to place, depending on the formulae adopted for flow through sluices and over weirs in relation to prevailing flow conditions through or over these works. The Commission have, however, assumed these data to be correct within 20 per cent, plus or minus, of the actual.

Krishna river system : serial numbers 13, 32, 33, 37, 42, 46, 51, 55, 58, 60, 61 and 62 (see Table XIX).

Godavari river system : serial numbers 1 (from 1955), 10, 18, 20, 28, 29, 30, 31, 32, 33 and 44 (see Table XX).

9-16 At the following sites, river flow has been determined from the discharges let through various sluices at the weir and the quantity flowing over the weir calculated with the help of anicut formulae *etc.* These formulae have been stated for each site in the respective Annexures. The accuracy of the results would vary from place to place, depending on the position of the reference gauge,* the formulae and the co-efficients adopted and their applicability to actual hydraulic conditions at each anicut.

Krishna river system: serial numbers 2, 8, 16, 23, 39, 52, 53, 54, 56 and 59 (see Table XIX).

Godavari river system: serial numbers 2 (from 1945), 8, 9, 16, 21, 27 and 38 (see Table XX).

9-17 On most weirs or anicuts (except the Krishna anicut at Vijayawada and the Godavari anicut at Dowlaishwaram), the discharge formula in use is that applicable to modular flow over the weir; in actual practice, on some anicuts the flow is not modular and on others the flow is sometimes modular and sometimes non-modular or is modular on one side of the weir and non-modular on the other side. Also, the same discharge co-efficient is being applied to all stages of flow; under ordinary hydraulic conditions, this co-efficient should vary with the depth of flow over the anicut.

9-18 The flow data as made available for each of the sites mentioned above would, therefore, need to be modified differently for different anicuts and for different stages of flow over the same anicut. The Commission would recommend that the State Governments concerned may attempt to reconstruct the data of yearly flow at these anicuts taking into account all the relevant factors and, when necessary, after carrying out model experiments. For the purpose of this report, the Commission has assumed the recorded data to be correct within 20 per cent.

9-19 The Commission has made a detailed study of the data made available to it for river flow at Vijayawada on the Krishna and the method of observation followed. Some model experiments had been carried out at the Poondi Research Station in Madras in 1949 to verify the accuracy of the formulae in use at Vijayawada anicut. At the Commission's request, a fresh series of model experiments were carried out at the Central Water and Power Research Station, Poona, and the Indian Institute of Science, Bangalore. Simultaneously, the Government of Andhra Pradesh also carried out three-dimensional model experiments. The reports of these investigations have been presented in Annexure XVII.

9-20 It would be clear from a perusal of the method of observations at Vijayawada, as given in Annexure III, and from a study of the reports in Annexure XVII, that

(a) significant changes were introduced in 1913, 1917 and 1936 in the co-efficients of discharge and methods of calculating the head due to velocity of approach;

* During its visit to various anicuts in the Krishna and Godavari basins, the Commission found that in most cases the position of the reference gauge did not conform to modern standards.

(b) during June to October, under conditions of submerged flow over the anicut, *i.e.*, when the water level downstream of the anicut is higher than the crest of the anicut,* the formula** for submerged flow given in the Madras Detailed Standard Specifications, which was in use at Vijayawada is incorrect; most of the time, flow over the anicut is modular, *i.e.*, the discharge over the anicut is independent of the water level below the anicut and is dependent only on the water level upstream;

(c) the discharge co-efficient C in the formula used at Vijayawada, for free-fall conditions should have been varied with the depth of flow over the anicut.

9-21 A comparative study (see Annexure XVII) of the recorded total volume of flow at the Krishna anicut, for five years, during the days on which all the weir shutters were down, with the total volume of flow as calculated, for the same days, on the basis of results obtained at the Andhra Pradesh Engineering Research Laboratories, is abstracted below:

| Year (June to May) | Volume in T.M.C. for the days when all shut- ters were down | | Percentage excess of calculated over recorded discharge |
|-----------------------|-------------------------------------------------------------------|----------|------------------------------------------------------------------------|
| | Calculated | Recorded | |
| 1947-48 | 1,264.1 | 1,141.7 | 10.7 |
| 1948-49 | 974.1 | 901.2 | 8.1 |
| 1949-50 | 657.5 | 608.0 | 8.1 |
| 1950-51 | 1,485.2 | 1,220.7 | 21.7 |
| 1951-52 j | 576.3 | 525.4 | 9.7 |

The Commission does not have sufficient data to make similar comparisons for whole years but recommends that the Andhra Pradesh Government may attempt to reconstruct the data of yearly flow at Vijayawada on the basis of results† of three-dimensional model tests made at the Andhra Pradesh Engineering Research Laboratories. It is likely that this would not show any appreciable difference in the data for the dry months, November to May, when there is little escape below the anicut and

*In some of the modern text books, "submerged flow" is now defined in the sense of non-modular flow.

**This formula was abandoned and replaced by more accurate methods in different parts of India a long time ago. It was given up by the Madras Government, vide orders issued in January 1960, but, somehow this formula is still in use at the Krishna anicut (as also at the Godavari anicut at Dowlaishwaram).

†The results of experiments at other research stations, while correctly indicating the hydraulics of flow at Vijayawada anicut, are not directly applicable as the position of the reference gauge at Vijayawada could not be simulated in the experimental flumes.

that the recorded data for the remaining part of the year, when only part of the weir shutters were up, might show an over-estimation of, say about 5 per cent; the overall annual result would, perhaps, show an under-estimation of the order of, say, 10 per cent.

9-22 A study of the methods adopted for estimating river flow at Dowlaishwaram on the Godavari shows that these methods employed some other approximations in addition to those adopted at Vijayawada.

For the Godavari anicut at Dowlaishwaram, experiments were carried out, at the Commission's request, at the Central Water and Power Research Station, Poona. The report of these experiments is also presented in Annexure XVII. A perusal of this report shows that unlike the situation at the Vijayawada anicut, the flow over different sections of the Godavari anicut is modular only up to depths on crest varying for different sections from 5.75 feet to 11.0 feet; for larger depths of flow, the anicuts work non-modularly when the co-efficients of discharge would vary from day to day, depending on the sub-mergence and would be lower than that under free-fall conditions.

9-23 An attempt was made to compare the recorded discharges at Dowlaishwaram with discharges re-calculated on the basis of the model experiments referred to in the preceding paragraph. Because of the differing hydraulic characteristics of different sections of the anicut, however, the problem at Dowlaishwaram is much more complicated than at Vijayawada. Also, the reference gauges upstream and downstream at Dowlaishwaram had not been correctly simulated in the model experiments, in which these gauges had been fixed in accordance with modern hydraulic practice. It appears likely, however, that the recorded flow at Dowlaishwaram would be correct within 10 to 15 per cent, plus or minus, of the actual.

9-24 It would appear from the above that such flow data, as are available for various sites on the Krishna and the Godavari river systems, are either unreliable or, if somewhat reliable, are available only for relatively short and irregular periods.

Uneven distribution of discharge sites

9-25 A perusal of Plate VIII would show that the distribution of the discharge sites over the catchment area is very uneven. For instance, of the 41 sites on the Krishna river system for which somewhat dependable data are available as many as 16 lie in one sub-basin, K.5 Upper Bhima, and there are no data at all for four sub-basins K.2. Middle Krishna, K.6 Lower Bhima, K.10 Musi and K.12 Muneru. Likewise, of the 28 similar sites on the Godavari, as many as 10 lie in one sub-basin G.1 Upper Godavari and there are no data at all for four sub-basins, G.5 Middle Godavari G.7 Penganga, G.8 Wardha and G.11 Indravati. For some other sub-basins, the data available are for too short a period to be of much use.

Plate VIII shows a large cluster of discharge sites in the Western Ghats area and very irregular distribution elsewhere in the vast expanse of the two basins below the Western Ghats. Discharge sites are particularly scarce in the north-east part of the Godavari basin which yields the major part of the Godavari flow.

9-26 The available data would not, therefore, enable one to make an adequate quantitative assessment of the hydrologic features of either of the two basins.

General features of river flow

9-27 A study of the available river flow data, as contained in Annexures II and III for the Krishna river system would show the following general features:

- (a) In their upper reaches, the Krishna and its tributaries, are generally dry before the advent of the south-west monsoon and they begin to flow after the onset of the rains. While the Tungabhadra rises towards the end of May, the Krishna and the Bhima do not have much water before June. July and August are the months of maximum discharge; the volume of flow in these two months varies from 55 to 85 per cent of the annual flow. There is a sharp fall in river supplies in September and October and November carry only a relatively small discharge.

In general, the volume of flow during the six months, June to November, is about 95 to 97 per cent of the annual river flow. After January, the river is practically dry.

- (b) In the lower reaches, the Krishna and its tributaries begin to rise after the onset of the monsoon generally by the middle of June. The highest discharges generally occur in August, July being next and these two months together carry about 50 to 60 per cent of the annual flow. The river falls in September and October, but these two months together account for about 30 per cent of the annual flow. There is then a sharp fall and after December the rivers are practically dry.

In general, the volume of flow during the six months, June to November, is about 90 to 95 per cent of the annual river flow.

- (c) Plate XXXV shows a hydrograph of the recorded flow as at Vijayawada, the tail end of the Krishna river system. The hydrograph shows the average recorded flow by ten-day periods, during 1951--60, as well as that for the years 1954-55 and 1958-59.

9-28 A study of the available river flow data, as presented in Annexures V and VI for the Godavari river system would show the following general features :

- (a) The Godavari and its tributaries generally start rising after the onset of the south-west monsoon during the month of June. The river flow is maximum during the months of July and August and together these two months account for 40 to 75 per cent of the annual flow. In September, the flow varies from 15 to 35 per cent of the annual flow. The flow declines sharply in the month of October and varies from 5 to 15 per cent of the annual flow.

In general, the six months, from June to November, contribute in different streams about 90 to 100 per cent of the annual flow.

- (b) Plate XXXVI shows a hydrograph of the recorded flow as at Dowlaishwar, the head of the Godavari Delta. The hydrograph shows the average recorded flow by ten-day periods during 1951-60, as well as that for the years 1954-55 and 1958-59.

Lack of flow data at project sites

9-29 It is indeed unfortunate that no attempt has so far been made to undertake regular discharge observations even at the project sites. Though a big project like the Nagarjunasagar Project has been under active consideration since 1951, and under construction since 1954, little attention has been paid to the observation of accurate flow data at this site. The Commission cannot help recording that no discharge observations are being made even on the Musi Project, the Ghod Project and the Kaddam Project, which have recently come into operation. From amongst other larger projects which are under construction but for which no discharge observations are being made may be mentioned, the Sileru, the Mula, the Manar and the Bor.

Similarly, no discharge data are available, nor any discharge observations are being made, at many of the projects referred to in III Plan, e.g., Srisailem, Bhima Lift, Malaprabha, Upper Krishna, Pochampad, Deodha, Penganga, Pus, Bagh, Itiadh, Dina, Peddavagu (Adilabad), Jayakwadi, Upper Wardha and Kayadhu, not to mention many smaller schemes.

Estimating river flow for project purposes

9-30 It would have been obvious from the facts and considerations described in the preceding paragraphs that not much use could have been made of the available flow data in the planning of irrigation and power schemes in the Krishna and Godavari basins. In fact, for the projects which have been undertaken on the two rivers since 1951, little use has been made of the available flow data, except in a few cases.

9-31 In the absence of observed river flow data, different empirical formulae and methods are in use in different parts of the Krishna and Godavari basins for estimating river supplies at the site of a project. These may now be described :

(a) Binny's percentages

In Madhya Pradesh, Binny's percentages* of run-off to rainfall are adopted for estimating the yield at project sites and the yield available in 75 per cent of the years adopted for project planning.

For the last few years, inflow data of several tanks are being observed.

*In 1872, Mr. (later Sir Alexander) Binny made some observations on a single reservoir (Ambajari) near Nagpur and prepared a table showing the percentage of rainfall which appeared as run-off.

(b) Strange's Table

(i) In Andhra Pradesh, Strange's Table* is in use for ascertaining the yields of tanks and for other minor schemes on small streams. The influence zones of the rain gauge stations in the catchments are marked by drawing Thiesson's Polygons. Each zone is classified as 'good' or 'average'; generally 'average' in Telangana. The monsoon period is taken as the period from 1st June to 31st October and the run-off is taken as the yield for the same period. For the rest of the year, the yield is taken as nil.

(ii) If the catchment is intercepted by other tanks, the intercepted yield is taken as 6/7th of the run-off from the intercepted catchment in Telangana and 4/5th in the Andhra region of Andhra Pradesh. In other words 1/7th or 1/5th of the intercepted catchment is added to the free catchment and the run-off worked out for the equivalent total catchment area.

(iii) From the run-off series obtained for a number of years, the 75 per cent dependable yield is selected as the basis of design.

(iv) The distribution month-wise of the total monsoon yield, as obtained with the method described above, is determined, if necessary, on an *ad-hoc* basis as follows :

| | | | | | | | | | | |
|-----------|---|---|---|---|---|---|---|---|---|-------------|
| June | . | . | . | . | . | . | . | . | . | 5 per cent |
| July | . | . | . | . | . | . | . | . | . | 15 per cent |
| August | . | . | . | . | . | . | . | . | . | 30 per cent |
| September | . | . | . | . | . | . | . | . | . | 40 per cent |
| October | . | . | . | . | . | . | . | . | . | 10 per cent |

(v) In the Vidarbha region of Maharashtra, in applying Strange's Table, the monsoon period is taken as the period from 1st June to 30th September and the run-off is taken as the annual run-off. The catchment area is classified as under :

| | | | | | | | | | |
|-------------------------------------------------|---|---|---|---|---|---|---|---|--------|
| Upper portions of the valleys with steep slopes | . | . | . | . | . | . | . | . | 'Good' |
| Areas adjoining the rivers | . | . | . | . | . | . | . | . | 'Bad' |
| Intermediate areas | . | . | . | . | . | . | . | . | 'Good' |

*About 1903, Mr. W. L. Strange put forward a Table showing the percentage of the total monsoon rainfall which appeared as run-off and the corresponding yield per square mile from catchment areas which he divided into three classes, 'good', 'average' and 'bad'; he did not give any definition for these classes. The basis of this Table was not stated except that "it is based on general ideas". The figures for a 'good' catchment approximate to those given earlier by Binny for the Ambajari catchment. The run-off from a 'bad' catchment is half of that from a 'good' catchment and the run-off from an 'average' catchment has been fixed exactly between the first two.

Strange did not indicate any limit to the size of catchments to which his Table should be applied, but laid emphasis (which was completely ignored) on the need for regular observation of discharges and for treating each catchment as a unit by itself. It is not clear whether Strange intended his figures to be regarded as run-off during the monsoon period or for the year as a whole. Of course, in the case of small catchments, which be evidently had in mind, it really does not matter as there is little flow from rains which fall spasmodically outside the monsoon season.

No attempt is made to distribute the annual run-off month-wise.

(vi) In Orissa also, Strange's Table is in use.

(c) Modification of Strange's Table

(i) This method has been applied to the estimation of yield of a large river basin for the medium-sized Pochampad Project. In this case, the procedure described above is first followed except that a new classification has been introduced in between 'good' and 'average' and the run-off and yield taken intermediate between those given in Strange's Tables for 'good' and 'average'. The month-wise distribution of the monsoon yield, so worked out, is determined in this case by applying the relation which the monthly in-flows bear to the total monsoon flow obtained by applying Buckley's percentages. These percentages are as follows :

| Month | Buckley's percentages of run-off to total monthly rainfall | |
|---------------------|------------------------------------------------------------------|-------------------|
| | Ordinary rainfall | Heavy rainfall |
| June | 5 | 10 |
| July | 10 | 20 |
| August | 25 | 50 |
| September | 40 | 50 |
| October | 40 | 50 |

The yield obtained by the application of Strange's Tables is taken as the monsoon yield, for the non-monsoon period from November to May the additional yield is not taken as zero, but certain percentages of the monsoon yield is added as yield from percolation *etc.* during the non-monsoon period. On the basis of the flow data for Nizamsagar, the yield during the non-monsoon period is taken as 9.5* per cent of the total monsoon run-off. The month-wise distribution of the non-monsoon yield is determined on an *ad-hoc* basis as follows :

| | |
|--------------------|-------------|
| November | 32 per cent |
| December | 23 " |
| January | 16 " |
| February | 10 " |
| March | 8 " |
| April | 7 " |
| May | 4 " |

*The percentage ratio of non-monsoon flow from November to May to monsoon flow from June to October, obtained from the data for the Nizamsagar reservoir for the 33 years 1925-26 to 1957-58, varies from 46.4 to 1.4. The figure of 9.5 per cent is arrived at by omitting the data for 10 years having a percentage ratio more than 20 per cent and for one year having a percentage ratio less than 2 per cent and taking the average of the percentages for the remaining 22 years. The average of the percentages for all the 33 years from 1925-26 to 1957-58 is 16.63

(ii) A similar method is adopted in the Marathwada region of Maharashtra. The catchment is divided into 'good' or $\frac{\text{good} + \text{average}}{2}$. The present view in Ma-

harashtra, however, is that the run-off, as calculated from Strange's Tables, is not likely to be obtained in practice in Marathwada. Nothing has, however, been done so far to alter the scope of any project based on Strange's Table.

(iii) In the Marathwada region, the monsoon period is taken as from 1st June to 31st October and the run-off is taken as the run-off in that period. The post-monsoon flow is assumed as varying from 5 to 10 per cent of the monsoon run-off.

(iv) In some cases, the annual run-off is distributed over the months on the basis of Buckley's proportions, applying the percentages for ordinary rainfall.

(d) Inglis formula for ghat catchment

In the Bombay region of Maharashtra and in the Bombay-Karnatak region of Mysore the Inglis ghat catchments formula is employed to obtain the *average* (over a number of years) annual run-off. This average annual run-off = $(0.85 \times \text{annual average rainfall}) - 12$ inches. Both rainfall and run-off are in inches.

A utilization factor is then applied to determine the utilisable run-off, *i.e.*, the quantity of water to be utilised for development of irrigation and/or power. This utilization factor for a given percentage dependability is determined as follows :

From the known discharge data at any site over a long period of about 20 years as a minimum, the dependable flow is worked out by arranging the run-off series in a descending or an ascending order and the flow available in 75 per cent of the years is then marked from these series. The average annual flow for the same period is also worked out by taking the arithmetic mean of the annual run-offs for the entire period. The utilisation factor for the required dependability (in this case 75 per cent) is then obtained by dividing the known dependable flow by the average annual flow. This ratio represents the utilisation factor.

No attempt is made to determine the available flow by months or shorter periods.

(e) Inglis formula for non-ghat catchments

For non-*ghat* catchments, where the annual rainfall is more than 30 inches, the Inglis formula for non-ghat catchments is applied to obtain the average annual run-off. This formula is

$$\text{Run-off} = \frac{(\text{Average annual rainfall} - 7 \text{ inches})}{100} \times \text{average annual rainfall.}$$

Both run-off and rainfall are in inches.

A utilisation factor is then applied in the same manner as explained above.

In Maharashtra for areas with annual rainfall less than 30 inches, the dependable annual yield is taken as 5 M.Cft. per square mile of catchment.

(f) Khosla's formula

(i) Khosla's formula has been used to determine the annual average yield for the Upper Krishna Project. This formula gives an estimate of the total annual run-off from a catchment based on the mean monthly rainfall and the mean monthly temperature of the catchment. Khosla's formula may be written as:

$$R_A = \text{Sigma } R_m$$

$$R_m = P_m - L_m$$

$$\text{and } L_m = \frac{T_m - 32}{9.5}$$

in which

R_A - mean annual run-off in inches.

R_m - mean monthly run-off in inches.

P_m - mean monthly rainfall in inches.

L_m - mean monthly loss in inches.

T_m - mean monthly temperature in degrees Fahrenheit.

It should be made clear that R_m or the mean monthly run-off represents the component of R_A or annual run-off attributable to the rainfall of a particular month and does not necessarily appear as run-off within the same month.

(ii) Khosla's formula has also been used in the Nagarjunasagar and Srisailem projects to determine that proportion of the flow at Vijayawada which is contributed by the catchment between the project site and Vijayawada.

(g) Analogy of near-by catchment

On some projects in Orissa, the run-off per square mile of catchment, observed during 1921-29 at Pulusura on the Kolab, has been taken as the basis for calculating the yield available at the project site.

9-32 It would appear from the above that many projects undertaken or proposed in the Krishna and the Godavari basins are based on estimates of available river flow derived from empirical formulae.

9-33 Khosla's and Inglis' formulae give an estimate of the *average annual* yield from a catchment; Khosla's formula can also be used to give the annual run-off for a particular year. The figures so obtained may be useful for obtaining a general idea of the potential of a particular river basin as a preliminary to the undertaking of detailed investigations; it cannot be taken as the only and final basis of water supply estimates. Neither of the two formulae can furnish any idea of the monthly or daily discharges in a river. Before a project should be undertaken and considerable sums of public money spent on it, it is absolutely essential to ascertain the full pattern of river flow with hydrographs of daily flow over a number of years. Projects undertaken without ascertaining this essential element of project data involve large risk; there may be serious catastrophes or incomplete exploitation of the resources available at a particular site.

9-34 Binny's percentages and Strange's Table may have had some merit sixty years ago, with the modern knowledge of hydrology, these are, in the Commission's view, completely outmoded and unreliable.

9-35 About 30 years ago, the Government of Madras made some observations at Mopad Reservoir and Wellington Reservoir and compared the actual yield with Strange's Table. The result was as follows :

| Year | Total Monsoon Rainfall in inches | Observed yield in M. Cft. per square mile | Yield in M. Cft. per square mile as per Strange's Table | | |
|------------------------|----------------------------------|-------------------------------------------|---------------------------------------------------------|---------|------|
| | | | Good | Average | Bad |
| MOPAD RESERVOIR | | | | | |
| 1927-28 | 17.34 | 5.84 | 4.84 | 3.63 | 2.42 |
| 1928-29 | 15.25 | 1.94 | 3.43 | 2.58 | 1.72 |
| 1929-30 | 23.66 | 5.39 | 10.52 | 7.88 | 5.26 |
| 1930-31 | 28.43 | 32.93 | 16.17 | 12.13 | 8.09 |
| 1931-32 | 18.84 | 7.39 | 5.99 | 4.54 | 3.03 |

Mopad catchment generally referred as 'good'

| WELLINGTON RESERVOIR | | | | | |
|-----------------------------|--------|-------|-------|-------|-------|
| 1929-30 | 28.26* | 8.31 | 16.39 | 11.96 | 7.96 |
| 1930-31 | 35.60 | 13.28 | 26.94 | 20.20 | 13.48 |
| 1931-32 | 36.13 | 7.94 | 27.82 | 20.87 | 13.91 |

Wellington Reservoir Catchment generally assumed as 'average'.

*Total of north-east and south-west monsoon.

The above statement speaks for itself; there is no relation at all between the yields obtained from Strange's Table and the observed data.

9-36 Enquiries made from other States regarding steps, if any, taken to verify Strange's Table did not yield any further information.

9-37 It is indeed surprising that Strange's Tables and Binny's percentages should continue to have been used until now, not only for the design of un-important small tanks but also for large projects.

9-38 In the view of the Commission, the basis of design of projects in the Krishna and Godavari basins, in so far as these are based on inadequate or unsatisfactory information of water availability, is not sound. Considerable caution is, therefore, called for in undertaking any new projects in these basins and a careful review of the major projects under construction would also appear to be necessary.

Proposals for comprehensive system of Discharge observations:

9-39 The need for setting up a comprehensive system of daily discharge observations on the Krishna and the Godavari rivers, and their tributaries, would have clearly emerged from the facts and considerations described above. This need, in the view of the Commission, cannot be over-emphasised.

9-40 As stated in paragraphs 9-33 and 9-35 above, a knowledge of daily river flow, over a long period, is indispensable for a correct determination of the scope of a project and for preventing defective design of the component engineering works. Apart from this, such a knowledge is equally indispensable for a study of the effect of one project on another lower down on the same river system. It is logical to assume that the diversion of water, or abstraction for storage, from the upper reach of a river or from one of its tributaries, would diminish the flow available at a lower site on the same river; but it is not unlikely that this diminution would be compensated, to some extent, by the seepage, or regeneration, into the river of a portion of the withdrawals made upstream. Also, it is well known that the quantity of water withdrawn or abstracted upstream, if not withdrawn or abstracted, would have been partly lost in transit to a lower point on the river. This loss in total availability can be salvaged if that quantity of water is withdrawn or abstracted upstream.

Considerable theory and many precedents can be quoted in support of the facts of regeneration and salvage of losses mentioned above. However, the quantum of such regeneration or salvage varies widely from one set of conditions (such as topography, nature of soil and subgrade, pattern of withdrawals in relation to crops) on one river system to another set of conditions on another. Unless data of daily flow at a number of sites along a river are available and unless these data are analysed to determine statistically the actual quantum of regeneration or of losses to be salvaged, no practical benefit can be derived from these factors in the optimum development of the water of any river system. Also see paragraphs 11-23, 11-26, 11-27 and 14-28 to 14-31.

9-41 Another important consideration in the co-ordinated operation of a number of large irrigation and power projects on a long river system is time-lag, or the time required for water from one point of the river to reach another point lower down on the same river, under different stages of flow. The regulation of supplies, to best advantage, would be impossible without a knowledge of time-lag applicable to different river reaches. It can, however, be determined only from a study of long-term data of daily discharges at a number of sites along the river system.

9-42 In January 1921, the Government of India stated in a letter addressed to the then Governments of Punjab and Bombay in connection with the distribution of the waters of the Indus system of rivers.

“Almost all the controversies which have up-to-date taken place in India in respect of questions of water-rights have been directly attributable to the fact that adequate figures were not forthcoming and that consequent recourse had to be had to indirect deductions and presumptions; the only method of averting such controversies is to have at hand reliable information on the factors in the case.”

It is sad to note that forty years later, the position in respect of flow data on the Krishna and the Godavari rivers should turn out to be similar to that on the Indus in 1920. In magnitude of supplies, the Krishna and the Godavari rivers are not less important than the Indus, their hydrology is more complicated.

9-43 In view of what has been stated above, the Commission would strongly urge, as a matter of first urgency, the establishment of regular gaugings, on a daily basis, at a number of sites on the Krishna and the Godavari river systems. Observations should be made in a systematic and scientific manner. The results of these observations should be scrutinized, tabulated and carefully recorded, so that the data can be studied regularly.

It is, of course, important that the data to be obtained must be reliable and should command the confidence of all concerned. For this purpose, it is necessary that there should be the same high standards and scientific approach in the methods and technique adopted throughout each river basin.

9-44 After a careful study of the two river systems, and after a general discussion on the subject with the representatives of the State Governments concerned, the Commission has prepared a list of discharge sites (38 on each river system) at which regular discharge observations should be started immediately. These sites are listed in Tables XXI and XXII and have also been shown in Plate IX.

9-45 The sites proposed by the Commission are, in its view, key sites necessary for the determination of important elements relating to the hydrology of the river system. The river flow data to be obtained at these sites are essential for the preparation of individual projects, for the preparation of an intergrated basin-wide plan, for the subsequent operation of such a plan and the regulation, to best advantage, of the available river waters in any year.

9-46 In addition to observations of river flow at the discharge sites mentioned above, it would be indispensable:

- (a) to measure river flow and prepare “water-accounts” at the sites of all storage projects and diversion weirs in operation at any time;

TABLE XXI

KRISHNA RIVER SYSTEM

LIST OF SITES AT WHICH DISCHARGE OBSERVATIONS SHOULD BE MADE DAILY

| Serial Number | Name of site | Name of river or tributary | Name of sub-basin | Location |
|---------------|---------------------------------|----------------------------|-------------------|-------------------------------------------------------|
| 1. | Khodshi Weir | Krishna | K-1 | Upstream of the confluence with Koyna |
| 2. | Shirol | " | K-1 | " " " " Panchganga |
| 3. | Kolhar | " | K-2 | " " " " Ghataprabha |
| 4. | Upper Krishna Dam | " | K-2 | — |
| 5. | Gonal | " | K-2 | Upstream of the confluence with Bhima |
| 6. | Deosugur (Devarsugar) | " | K-7 | Below the confluence with Bhima |
| 7. | Pragatur | " | K-7 | Upstream of the confluence with Tungabhadra |
| 8. | Srisailam | " | K-7 | — |
| 9. | Nagarjunasagar Dam | " | K-7 | — |
| 10. | Pulichintala | " | K-7 | — |
| 11. | Amaravati | " | K-7 | Upstream of the confluence with Muneru |
| 12. | Vijayawada | " | K-7 | — |
| 13. | Koyna Dam (Falkewadi) | Koyna | K-1 | — |
| 14. | Karad | " | K-1 | Upstream of the confluence with Krishna |
| 15. | Samdoli | Varna | K-1 | " " " " " " " " |
| 16. | Kurandvad | Panchganga | K-1 | " " " " " " " " |
| 17. | Dattwad | Dudhganga | K-1 | " " " " " " " " |
| 18. | Dhupdal | Ghataprabha | K-3 | — |
| 19. | Murmuttisangam | " | K-3 | Upstream of the confluence with Krishna |
| 20. | Hiresangam | Malaprabha | K-4 | " " " " " " " " |
| 21. | Dhond | Bhima | K-5 | Below the confluence with Ghod |
| 22. | Maligaon | " | K-5 | " " " " " " Nira |
| 23. | Takali | " | K-5 | Upstream of the confluence with Sina |

TABLE XXI—concluded
KRISHNA RIVER SYSTEM

LIST OF SITES AT WHICH DISCHARGE OBSERVATIONS SHOULD BE MADE DAILY

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Location |
|---------------|-------------------------|----------------------------|-------------------|------------------------------------------------|
| 24. | <i>Sugur</i> | Bhima | K-6 | Upstream of confluence with Krishna |
| 25. | <i>Narsingpur</i> | Nira | K-5 | " " " " Bhima |
| 26. | <i>Wadakbal</i> | Sina | K-5 | " " " " " |
| 27. | <i>Havanur</i> | Tungabhadra | K-8 | — |
| 28. | <i>Tungabhadra Dam</i> | " | K-8 | — |
| 29. | <i>Rajolibanda</i> | " | K-8 | — |
| 30. | <i>Sunkesula</i> | " | K-8 | — |
| 31. | <i>Roza</i> | " | K-8 | Upstream of confluence with Krishna |
| 32. | <i>Tunga Anicut</i> | Tunga | K-8 | — |
| 33. | <i>Lakkavalli</i> | Bhadra | K-8 | — |
| 34. | <i>Belvigi</i> | Varada | K-8 | Upstream of confluence with Tunga- bhadra. |
| 35. | <i>Bhairavanithippa</i> | Vedavati | K-9 | — |
| 36. | <i>Sidaragadde</i> | " | K-9 | Upstream of confluence with Tunga- bhadra } |
| 37. | <i>Wazirabad</i> | Musi | K-10 | " " " " Krishna |
| 38. | <i>Vemulapalle</i> | Muneru | K-12 | " " " " " |

NOTE :

1. Sites, where discharge observations are being made, have been shown in italics.
2. In addition to the sites described above, daily discharge observations should be made at the sites of all major and medium projects in operation, sites of all proposed major projects and at the head of all off-taking canals.
3. The exact location of every site should be clear of submergence by any proposed reservoir and the back-water effects of confluence with another stream or of the disturbance caused by any obstruction.

TABLE XXII

GODAVARI RIVER SYSTEM

LIST OF SITES AT WHICH DISCHARGE OBSERVATIONS SHOULD BE MADE DAILY

| <i>Serial number</i> | <i>Name of site</i> | <i>Name of river or tributary</i> | <i>Name of sub-basin</i> | <i>Location</i> |
|----------------------|---------------------|-----------------------------------|--------------------------|--------------------------------------------|
| 1. | Nandur-Madhmeshwar | Godavari | G-1 | — |
| 2. | Toka | " | G-1 | Below the confluence with Pravara |
| 3. | Nathrah | " | G-1 | Upstream of the confluence with Sindphana. |
| 4. | Barbara | " | G-1 | " " " " Purna |
| 5. | Dharmabad | " | G-1 | " " " " Manjra |
| 6. | Chinnur | " | G-5 | " " " " Pranhita |
| 7. | Inchampalli | " | G-10 | Below the confluence with Indravati |
| 8. | Ippur | " | G-10 | " " " " Sabari |
| 9. | Dowlaishwaram | " | G-10 | — |
| 10. | Ozar | Pravara | G-2 | Below the weir. |
| 11. | Depegaon | Sindphana | G-1 | Upstream of the confluence with Godavari. |
| 12. | Purna | Purna | G-3 | " " " " " " |
| 13. | Nadiwari | Manjra | G-4 | " " Maharashtra Mysore border |
| 14. | Devnoor | " | G-4 | — |
| 15. | Machinur | " | G-4 | Upstream of the confluence with Godavari. |
| 16. | Damarkunta | Maner | G-6 | " " " " " " |
| 17. | Sironcha | Pranhatia | G-9 | " " " " " " |
| 18. | Wedi | Wardha | G-8 | " " " " Penganga |
| 19. | Adegaon | " | G-8 | " " " " Wainganga |
| 20. | Kareri | Penganga | G-7 | " " " " Kiadoh |
| 21. | Savangi | " | G-7 | Below the confluence with Waghari |

TABLE XXII—concluded.

GODAVARI RIVER SYSTEM

LIST OF SITES AT WHICH DISCHARGE OBSERVATIONS SHOULD BE MADE DAILY

| Serial number | Name of site | Name of river or tributary | Name of sub-basin | Location |
|---------------|------------------------------|----------------------------|-------------------|-----------------------------------------------------|
| 22. | <i>Bargaon</i> | Penganga | G-7 | Upstream of the confluence with Wardha |
| 23. | <i>Bhanegaon</i> | Kiadoh | G-7 | „ „ „ Penganga |
| 24. | <i>Ambhorah</i> | Wainganga | G-9 | Below the confluence with Kanhan |
| 25. | <i>Ashti</i> | „ | G-9 | Upstream of the confluence with Wardha. |
| 26. | <i>Nowrangapur</i> | Indravati | G-11 | — |
| 27. | <i>Jagdapur</i> | „ | G-11 | — |
| 28. | <i>Kudurgaon</i> | „ | G-11 | Below the confluence with Baordhig |
| 29. | <i>Darba</i> | „ | G-11 | Upstream of the confluence with Nibra |
| 30. | <i>Regalgudem</i> | „ | G-11 | „ „ „ Godavari |
| 31. | <i>Gurgura Tola</i> | Nibra | G-11 | „ „ „ Indravati |
| 32. | <i>Bhamragarh</i> | Kotri | G-11 | „ „ „ „ |
| 33. | <i>Cherla</i> | Talperu | G-10 | — |
| 34. | <i>Pakki</i> | Sabari | G-12 | Near proposed dam site of Upper Kola H. E. project. |
| 35. | <i>Karimati</i> | „ | G-12 | Upstream of Orissa-Madhya Pradesh border. |
| 36. | <i>Motu</i> | „ | G-12 | Upstream of confluence with Sileru |
| 37. | <i>Jalput (Machkund) Dam</i> | Sileru | G-12 | — |
| 38. | <i>Kottagudem</i> | „ | G-12 | Upstream of confluence with Sabari |

NOTE :

1. Sites, where discharge observations are being made, have been shown in italics.

2. In addition to the sites described above, daily discharge observations should be made at the sites of all major and medium projects in operation, sites of all proposed major projects and at the head of all off-taking canals.

3. The exact location of every site should be clear of submergence by any proposed reservoir and of the back-water effects of confluence with another stream or of the disturbance caused by any obstruction.

- (b) to make accurate measurements of the daily withdrawals by all major irrigation canals and power channels and an estimate, from gauge discharge curves, of the withdrawals by all other canals and power channels; such gauge discharge curves to be regularly checked and kept up-to date; and
- (c) as soon as a new project is conceived, to take immediate action to set up, as a first priority, regular discharge observations at that site.

9-47 It should be made clear that the discharge sites proposed by the Commission, in paragraph 9-44 above, are based on the present stage of development of the two river basins. These sites will certainly need to be added to and their exact location, as broadly indicated by the Commission, may need to be modified from time to time depending on the new works of development that may be undertaken. It is, therefore, important that the number and location of these gauge sites should be constantly kept under review by a competent body, in the light of all the changed circumstances.

9-48 The exact method of observation to be followed at each of the discharge sites will have to be determined in the light of a survey of the physical and hydraulic conditions at each site. The method most appropriate to each site should be adopted.

9-49 The Commission would like to emphasise that no trouble and expense is too great when compared with the advantage to be gained from reliable and continuous observations. The work being of extreme importance to all concerned, officers to be entrusted with this task should be selected from amongst those who are likely to take a keen and scientific interest in the work.

Need for a special organisation

9-50 It would be obvious that in the Krishna and the Godavari rivers, which are of concern to a number of States, close co-ordination is necessary in the setting up of the discharge sites, in the circulation of the data obtained and in the systematic analysis of the data. As already stated, the data must be reliable and should command the confidence of all concerned.

In addition, it is necessary that there should be uniformity of methods and technique throughout each basin so that the data of different sites should be comparable. It is also necessary that the entire data should be assembled, and preferably published, on a common pattern.

9-51 The Commission has given considerable thought to the appropriate organisation for observing river discharge data in the two basins and in particular to the following three alternatives:

- (a) Each State undertaking the operations in its own territory with an inter-State committee, under the chairmanship of a senior engineer of the Central Government, to be charged with the responsibility of co-ordination, reviewing the number and location of discharge sites, setting up and maintaining adequate standards, check-observations of discharges and maintenance of relevant records; the States to agree to abide by the advice of this committee.

- (b) The entire work to be entrusted to a special organisation under a River Board to be set up under the River Boards Act 1956 or otherwise by agreement between the States concerned.
- (c) A special organisation for the purpose to be set up by the Central Government.

The Commission has also discussed this matter informally with the Chief Engineers of the States concerned and other high-ranking engineers in the country.

9-52 It may be pointed out that in spite of the recommendations of the Central Board of Irrigation and Power since 1947 and of the Planning Commission since 1951, the State Governments have not shown much interest in hydrologic observations.

In paragraph 88, Chapter XXVI of the First Five Year Plan, the Planning Commission recommended that all States should carry out detailed hydrologic investigations for important river systems. It was stated:

“During the next 15 to 20 years, a large number of irrigation and power projects have to be undertaken. Before work can be taken up on any such large project, it is necessary to collect detailed data about the availability of water and the manner in which available supplies vary from year to year and during different periods in the same year. This information, which for proper designs should be available for 30 to 50 years, has to be supplemented with rainfall data of the catchment area, the distribution of rainfall, its intensity, temperature, regeneration in the river etc. Unfortunately, there has been no systematic collection of basic hydrologic data for the rivers of India. State Governments during the last 20 to 30 years have undertaken collection and study of data with reference to individual projects under operation or under consideration but no overall study of river system or its catchment has been attempted. Lack of hydrologic data can lead to defective designs.

“We, therefore, recommend that all State Governments should carry out detailed hydrologic investigations for important river systems. The expenditure on these investigations is small when compared with the benefits likely to be achieved when the river or any part of it is developed. The Central Water and Power Commission should prepare necessary technical instructions for the collection of basic hydrological data in consultation with the States and the State Governments should set up arrangements for collecting such data.”

9-53 It would appear that the above recommendation went unheeded in the Krishna and Godavari basins. During the preliminary meetings with the representatives of the State Governments, referred to in paragraph 1-3, the Commission requested that urgent steps be taken to make accurate discharge observations at a few sites in each State. This request also brought no response.

9-54 It has been the experience of the members of the Commission and of many other engineers with whom the Commission has discussed this problem that the work of observation of river discharges, as part of the functions of a large organisation, does not receive the necessary attention and is often relegated to the status of an unimportant appendage of the Department. For these reasons and the likely difficulties in the effective working of the inter-State committee referred to in (a) above, the Commission does not recommend this alternative.

Between alternatives (b) and (c), the Commission is of the view that better results would be secured if the Central Government should assume responsibility for the work of hydrologic surveys in the Krishna and Godavari basins and set up a separate organisation for this work under the Ministry of Irrigation and Power.

9-55 In the view of the Commission, the observation of discharges at the sites specified in Tables XXI and XXII in the Krishna and Godavari basins should furnish the kind of basic data like topographic and meteorological data which along with information on land-use, soils, census of population and production of goods and services should be collected by a politically organised State as a matter of course, as the continuing records of the basic mensuration of the country. Collection of river flow data must be regarded as part of the fundamental business of national stock-taking.

9-56 Other discharge data specified in paragraph 9-46 above are operational or specific data, distinct from the basic data mentioned above, the kind of data which, in the view of the Commission, should be collected by the State Government in charge of a project. A close co-ordination would have to be established between the national discharge data gathering agency proposed above and the local agencies of the State Governments in charge of various projects.

Appraisal of the present position

9-57 Under its terms of reference, the Commission has been asked to report, separately, for the Krishna and the Godavari rivers, the availability of supplies on the basis of annual flows, respectively, at Vijayawada and Dowlashwaram and at other points, taking into account upstream utilisation and allowing for regeneration—

- (i) for 86 per cent dependability as assumed in 1951;
- (ii) for 75 per cent dependability; and
- (iii) for such other criterion of dependability as may be considered appropriate.

9-58 It has been shown in paragraphs 9-20 and 9-22 above that :

- (a) the record of river flow as at Vijayawada, prior to 1936, was based on assumptions and co-efficients different from those followed after 1936 and that the data, as from 1936, when corrected for the errors in the formula used, is likely to reveal an overall under-estimate of about 10 per cent.

- (b) at Dowlaiswaram, on the Godavari, the recorded flow prior to 1936 was based on assumptions and co-efficients different from those followed after 1936 and that the data, as from 1936, are based on incorrect formulae and co-efficients; the magnitude of error is not easy to determine.

The Commission has recommended a reconstruction of the flow data at Vijayawada on the basis of results of model experiments carried out at the Andhra Pradesh Engineering Research Laboratories and at Dowlaiswaram on the basis of results of model experiments carried out at Poona or after undertaking a fresh series of experiments.

9-59 The Commission has not itself undertaken the task mentioned above because to obtain the additional data required for this purpose and to carry out the requisite study after the results of model experiments had been received by the Commission would have taken appreciable time and involved considerable delay in the submission of the Commission's report. Though the result to be obtained from this study would constitute important data, in the view of the Commission, these would not be particularly useful at this stage. The data at Vijayawada and Dowlaiswaram, when reconstructed as suggested above, would be directly applicable only to projects situated within a short distance upstream of these sites. These data would not be of much help for projects higher up the basin.

9-60 With regard to the data at other points (of storage or withdrawal by new projects and by those now under construction), observed data are either not available or if available, these are for relatively short periods and only approximate within about 20 per cent, plus or minus, of the actual.

9-61 In view of the above, it is not possible at this stage to determine the flow for 86 per cent dependability, or 75 per cent dependability, or for any other criterion of dependability. Any figures now worked out, based on various assumptions, might lead to erroneous results. It is unfortunate that the position should be so unsatisfactory. This, however, emphasises the urgency of taking immediate and effective measures for setting up the organisation proposed by the Commission in paragraph 9-54 above, for taking regular discharge observations in the two basins. Also see paragraphs 14-32 to 14-35

9-62 The Commission is unable to support the methods now in use in different States to estimate the utilisable flow, on the basis of empirical formulae and approximate methods some of which are now known to be irrational. None of these formulae or methods can furnish all the detailed information required for project planning.

9-63 It has been stated in paragraph 9-40 above that until regular gaugings are established at key sites on both the river systems and results of such gaugings are available for a number of years (in no case less than ten), the Commission is unable to indicate the effect of upstream utilisation at points lower down the river nor is

the Commission able to give any quantitative assessment of regeneration or salvage of losses or time lag. With the nature of the data now available, any attempt in this direction would be no better than guess work.

9-64 Since it is not possible to give any positive replies to the questions stated in paragraph 9-57 above, because of the lack of adequate and reliable flow data for the two river systems, it seems necessary to indicate the procedure that should be adopted with regard to projects under construction and those which the State Governments are anxious to undertake immediately.

The discharge data at Vijayawada and Dowlaiswaram would not be sufficient to determine the adequacy or otherwise of river supplies available at the sites of various projects upstream of these two points. The Commission has therefore divided each river system into 12 sub-basins (see paragraphs 3-22 and 4-27). The availability of river flow, requirements of projects and other relevant factors for each sub-basin have been examined in Chapter XV, in as much detail as possible with the data and information available. It is not the intention to deal separately in an un-coordinated manner with parts of a river basin but a study of each sub-basin is an essential step preliminary to an examination of the basin as a whole. The hydrologic unity of the entire basin has always to be kept in view.

Quality of river waters

9-65 Before concluding this chapter, it seems necessary to place on record such information as is available with regard to the quality of river waters in the Krishna and Godavari basins.

9-65 Among the criteria for defining the quality of water for irrigation purposes, the "electrical conductivity" and the "sodium percentage" are the most important. The former, generally expressed in micromhos, is the measure of the total soluble salt content of water and the latter represents the proportion* of sodium ion to total cations, all elements expressed in milli-equivalents. Another criterion, total hardness, though not important for defining the quality of water for irrigation, is significant for the use of water in boilers and for industrial purposes.

9-67 Standards for the permissible salt content in irrigation waters have not yet been determined for all parts of India. The Punjab practice has been to regard up to 60 parts of total salts per 100,000 parts of water as safe. This corresponds to a conductivity of about 750. If the salt content ranges between 60-120 parts per 100,000 (corresponding to a conductivity of 750-1500), it is obligatory, under Punjab practice, to examine the nature of soil to be irrigated with such water to see that no harmful effect would ensure.

*
$$\frac{\text{Na} \times 100}{\text{Na} + \text{K} + \text{Ca} + \text{Mg}}$$

9-68 The U.S. Salinity Laboratory has specified the following standards :

| <i>Conductivity (micromhos)</i> | <i>Suitability, or otherwise, for irrigation</i> |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| below 250 | suitable for most crops and most soils |
| from 250 to 750 | safe under practically all conditions |
| from 750 to 2,250 | safe with permeable soil and moderate leaching; not suitable for soils with restricted drainage, special management for salinity control may be required; plants with good salt tolerance may grow. |
| above 2,250 | unfit for irrigation |

As regards sodium percentage, Magistad has suggested the following classification:

| <i>Class</i> | <i>Sodium percentage</i> | <i>Suitability, or otherwise, for irrigation</i> |
|--------------|--------------------------|--------------------------------------------------------------------------------------------------------------|
| I | below 60 | excellent to good, suitable for most plants and most conditions |
| II | from 60 to 75 | good to injurious, probably harmful to the more sensitive crops |
| III | above 75 | injurious to unsatisfactory, probably harmful to most crops and unsatisfactory for all but the most tolerant |

9-69. It is now being increasingly realised that for defining the quality of water for irrigation, consideration has to be given not only to conductivity and sodium percentage but also to the type of soil intended to be irrigated and the crops to be grown. There is, in fact, a distinct water-soil-crop relationship and attempts are now being made in several countries to define the quality of irrigation water in terms of this relationship. Till such time, however, that such relationships are worked out for particular soil types and crops, the criteria mentioned in paragraph 9-68 above should afford some indication in regard to the suitability or otherwise of any river water for irrigation.

9-70 Data with respect to the chemical analysis of water samples taken from the Krishna, at Nagarjunasagar and at Karikal, (4 miles below the confluence of the Bhima with the Krishna) and from the Godavari, at Nanded, during the period from October 1958 to September 1960 are available in the Annual Reports of the Central, Water and Power Research Station, Poona, for years 1959 and 1960. Important particulars have been reproduced in Table XXIII.

TABLE XXIII
CHEMICAL ANALYSIS OF WATERS

| <i>Date</i> | <i>Conductivity</i> | <i>pH</i> | <i>Hardness number</i> | <i>Sodium per cent</i> |
|----------------------------------|---------------------|-----------|----------------------------|----------------------------|
| Krishna at Nagarjunasagar | | | | |
| 1958 | | | | |
| October 24 | 350 | 8.5 | 73 | 57.9 |
| November 14 | 500 | 8.7 | 103 | 57.9 |
| December 13 | 650 | 8.6 | 140 | 57.1 |
| 1959 | | | | |
| January 20 | 775 | 8.2 | 148 | 54.5 |
| February 16 | 580 | 8.6 | 120 | 48.0 |
| March 16 | 615 | 8.5 | 114 | 51.6 |
| April 27 | 545 | 8.4 | 111 | 48.2 |
| May 19 | 500 | 8.7 | 809 | 60.8 |
| July 9 | 225 | 8.3 | 77 | 30.0 |
| September 2 | 210 | 7.9 | 69 | 31.4 |
| December 10 | 490 | 8.9 | 117 | 53.5 |
| 1960 | | | | |
| February 22 | 620 | 8.4 | 108 | 49.9 |
| March 22 | 450 | 8.3 | 93 | 53.4 |
| April 16 | 515 | 8.6 | 88 | 58.8 |
| May 14 | 550 | 8.4 | 91 | 62.6 |
| June 11 | 560 | 8.1 | 89 | 62.8 |
| July 9 | 240 | 8.0 | 101 | 16.6 |
| August 18 | 260 | 8.3 | 65 | 18.5 |
| September 19 | 290 | 8.6 | 88 | 43.8 |
| Krishna at Karikal | | | | |
| 1958 | | | | |
| October | 300 | 8.0 | 92 | 37.2 |
| November 2 | 405 | 8.5 | 108 | 46.7 |
| December 1 | 710 | 8.5 | 166 | 52.5 |

TABLE XXIII (continued)
CHEMICAL ANALYSIS OF WATER

| <i>Date</i> | <i>Conductivity</i> | <i>pH</i> | <i>Hardness number</i> | <i>Sodium per cent</i> |
|---------------------------------------|---------------------|-----------|----------------------------|----------------------------|
| Krishna at Karikal (continued) | | | | |
| 1959 | | | | |
| January | 920 | 8.0 | 187 | 50.6 |
| February 4 | 1,070 | 8.3 | 185 | 52.4 |
| March 1 | 1,260 | 8.6 | 161 | 63.3 |
| April 7 | 1,410 | 8.4 | 217 | 60.8 |
| May 7 | 2,000 | 8.6 | 311 | 57.2 |
| June 6 | 480 | 8.1 | 75 | 63.2 |
| July 5 | 390 | 8.5 | 122 | 35.6 |
| September 1 | 135 | 8.0 | 53 | 21.3 |
| November 12 | 425 | 8.6 | 131 | 40.0 |
| December 15 | 325 | 8.8 | 86 | 49.1 |
| 1960 | | | | |
| January 7 | 840 | 8.4 | 172 | 49.3 |
| March 22 | 1,125 | 8.7 | 192 | 65.0 |
| April 22 | 1,090 | 8.6 | 171 | 60.6 |
| May 7 | 1,390 | 8.6 | 229 | 62.1 |
| June 5 | 610 | 8.3 | 116 | 57.3 |
| July 5 | 285 | 8.1 | 129 | 10.2 |
| August | 135 | 7.8 | 56 | 14.9 |
| September 7 | 150 | 8.3 | 66 | 19.2 |
| Godavari at Nanded | | | | |
| 1958 | | | | |
| October 25 | 450 | 8.5 | 112 | 51.2 |
| November 7 | 610 | 8.7 | 155 | 50.5 |
| December 15 | 585 | 8.6 | 151 | 50.2 |
| 1959 | | | | |
| January 15 | 910 | 7.8 | 181 | 53.6 |
| February 10 | 1,090 | 8.6 | 164 | 59.8 |
| March 31 | 1,350 | 8.7 | 215 | 59.2 |
| April 24 | 1,560 | 8.6 | 236 | 61.0 |
| May 14 | 1,755 | 8.8 | 221 | 66.1 |
| June 20 | 470 | 8.7 | 103 | 50.3 |
| July 24 | 315 | 8.2 | 93 | 37.5 |

TABLE XXIII (concluded)
CHEMICAL ANALYSIS OF WATER

| Date | Conductivity | pH | Hardness number | Sodium per cent |
|---------------------------------------|--------------|-----|-----------------|-----------------|
| Godavari at Nanded (continued) | | | | |
| August 31 | 260 | 8.3 | 88 | 32.7 |
| September 28 | 350 | 8.4 | 122 | 31.5 |
| October 27 | 465 | 8.4 | 148 | 37.5 |
| November 9 | 505 | 8.8 | 150 | 43.6 |
| December 9 | 600 | 8.9 | 169 | 47.9 |
| 1960 | | | | |
| January 30 | 985 | 8.7 | 168 | 56.6 |
| February 24 | 1,150 | 8.7 | 194 | 58.0 |
| March 11 | 980 | 8.9 | 192 | 58.9 |
| April 28 | 1,400 | 8.8 | 233 | 62.5 |
| June 25 | 320 | 8.6 | 92 | 42.7 |
| July 21 | 290 | 8.4 | 88 | 37.3 |
| September | 280 | 8.6 | 88 | 42.5 |
| October | 580 | 8.0 | 136 | 54.6 |

9-71 It would appear from a perusal of Table XXIII that the conductivity of the waters of the Krishna at the Nagarjunasagar Dam exceeds 750 only occasionally in January but of those at Karikal exceeds 750 from January to May and may go up to 2,000 in May. Similarly, the conductivity of the waters of the Godavari also exceeds 750 during the lean flow period.

The sodium percentage of the waters of the Krishna, at both the sites, and of the waters of the Godavari exceeds 60, during the lean flow period from March to June, when these waters would be "good to injurious."

It stands to reason that some precautions with respect to the nature of soil and crops to be grown are called for if the high conductivity waters of these rivers with injurious sodium percentage, during the lean flow periods, are intended to be used directly for irrigation. When combined with releases from storages, the waters of both the rivers are likely to be safe for irrigation.

9-72 The hardness numbers are also high on both rivers, more so on the Godavari where they lie between 200—300 from March to May. In comparison, the hardness numbers for the waters of the Ganga and the Brahmaputra are below 150.

9-73 Except as stated in paragraph 9-74 *infra*, no data are available of the quality of water in the tributaries. But from what has been stated above, it would appear that the direct use for irrigation of the waters of at least some of the tributaries, if available during the lean flow period, would call for caution.

9-74 Results are available * of systematic periodical analysis of the waters of the Tungabhadra, China-Hagari and Pedda-Hagari. The range of concentration (expressed in parts per 100,000) of some of the main chemical constituents in the waters of these three rivers and their pH value are as follows :

| | <i>Tungabhadra</i> | <i>Pedda-Hagari</i> | <i>Chinna-Hagari</i> |
|-----------------------------|--------------------|---------------------|----------------------|
| Calcium bicarbonate . . . | 1.2 to 9.1 | 0.1 to 14.0 | 3.3 to 14.3 |
| Magnesium bicarbonate . . . | 0.8 to 3.6 | 0.8 to 25.4 | 1.1 to 21.5 |
| Sodium bicarbonate . . . | 1.5 to 7.6 | 8.8 to 64.5 | 26.8 to 64.4 |
| Sodium sulphate . . . | 0.2 to 1.1 | 0.4 to 10.5 | 4.8 to 20.1 |
| Sodium chloride . . . | 2.6 to 3.5 | 3.3 to 35.1 | 22.4 to 65.5 |
| Total solids . . . | 10.0 to 16.4 | 19.5 to 93.6 | 68.8 to 149.2 |
| pH . . . | 7.3 to 7.9 | 7.4 to 9.1 | 7.9 to 9.1 |

The waters of Pedda-Hagari and Chinna-Hagari show seasonal variations in the soluble salt content which goes on increasing in concentration from October onwards attaining a maximum in January; this variation is more marked in the Chinna-Hagari. The salts in the Chinna-Hagari are mostly sodium chloride. As such, when used for irrigation, not only base exchange reactions are set up leading to the formation of sodium clay but there is also an accumulation of sodium in the soil. Under such conditions, if drainage was possible, the accumulation of sodium in the soil would not have taken place. Under the Pedda-Hagari, carbonate is present which reacts on the clay complex leading to the formation of sticky, highly permeable sodium clay on the surface, creating conditions favourable for its accumulation. Further, the low content of exchangeable lime in the soil assists in the formation of sodium clay.

9-75 Under irrigation with Tungabhadra water, the soils are likely to benefit by having their carbonates leached out or driven down to below the zone of root penetration.

9-76 Water samples from the Wainganga river at Bhimgarh were analysed once a month by the Central Water and Power Commission. The range of total soluble salt content and pH of waters are as below :

| | |
|--------------------------------------|-----------------------------------------------|
| Total soluble salt content | 12.4 to 26.4 parts per 100,000 parts of water |
| pH | 8.3 to 8.65 |

As will be noticed, the range of total soluble salt content is narrow and even the maximum value of soluble salts cannot do any harm to the soil.

*Venkata Ramiah, Report on the soil survey of Tungabhadra project 1937 Department of Agriculture, Madras.

CHAPTER X GROUND WATER RESOURCES

Nature of sub-soil strata

10-1 No systematic ground water surveys of the Krishna and Godavari basins, or of any part of them, appear to have been carried out so far. No data and statistics in this respect are, therefore, available.

10-2 Plate VII, based on a map obtained from the Geological Survey of India, shows the distribution of hard and soft rocks in the Krishna and Godavari basins and adjoining areas. It will be seen therefrom that a narrow belt of alluvium, about 20 miles wide, along the eastern coast and the Gondwana sediments, about 40 miles wide, along the Godavari, the Pranhita and lower Penganga valleys, in sub-basin G. 10 and parts of G. 9 and G. 8, are the only two areas with sub-strata having "good" and "good to fair" water bearing characteristics. A large part of the Krishna basin and the north-eastern part of the Godavari basin lie over ancient crystallines and metamorphics which have "very poor" water bearing capacity. The Deccan trap, which extends in the rest of the Godavari and Krishna basins, has been stated as having "poor" water-bearing characteristics.

Tube-wells

10-3 The number of tube-wells in the Krishna and Godavari basins appears to be small. No statistics of tube-well operations are available.

The Exploratory Tube-well Organisation of the Ministry of Food and Agriculture recently carried out some exploratory work in these two basins in Andhra Pradesh and Maharashtra. A brief review of the results obtained are given below :

In *Andhra Pradesh*, fifteen trial bores were drilled, four in West Godavari District, eight in East Godavari District and three in Krishna District. Out of these, twelve were converted into production wells.* The total depths varied from 186 feet to 727 feet and the discharge from 1 to 2 cusecs. Chemically, water was found to be suitable for irrigation.

In *Maharashtra*, fourteen trial bores were made in an area of about 600 square miles in the districts of Akola, Amravati and some parts of Buldana in the Purna valley. The yields obtained were poor and not up to the standard of a production well. All bores were abandoned. The explorations indicated that the area was covered by alluvium flanked on all sides by basaltic trap.

No exploratory bores were made in any part of the Krishna and Godavari basins in *Madhya Pradesh, Mysore and Orissa*.

Surface-wells

10-4 Indirect information regarding the availability of sub soil waters can be had from a study of the large number of surface wells in use in the Krishna and Godavari basins for irrigation.

*The Tubewell Organisation had fixed a minimum yield of 20,000 gallons per hour with a maximum draw-down of 20 feet as the standard for a production well.

TABLE XXIV
DISTRICTWISE STATISTICS OF WELLS IN THE KRISHNA BASIN

Based on the 'Season and Crop Report' for the year 1957-58.

| Serial Number | State/ District | Percentage of district in the basin | Number of wells used for Irrigation | | | Wells used for domestic purposes | Wells not in use | Grand Total |
|-----------------------|------------------------|-------------------------------------------------|----------------------------------------|-----------------|---------------|-------------------------------------------|------------------------|----------------|
| | | | Masonry | Non- masonry | Total | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| ANDHRA PRADESH | | | | | | | | |
| 1 | Anantapur | 23.6 | 7,304 | 6,498 | 13,802 | 2,791 | 589 | 17,182 |
| 2 | Guntur | 36.4 | 1,121 | — | 1,121 | 25,225 | — | 26,346 |
| 3 | Hyderabad | 98.5 | 1,195 | 3,611 | 4,806 | 7,162 | 444 | 12,412 |
| 4 | Karimnagar | 0.3 | 15 | 78 | 93 | 245 | 10 | 348 |
| 5 | Khammam | 43.5 | 1,415 | 231 | 1,646 | 832 | 2,750 | 5,228 |
| 6 | Krishna | 42.5 | 411 | 87 | 498 | 1,518 | 8 | 2,024 |
| 7 | Kurnool | 42.4 | 5,336 | 152 | 5,488 | 752 | 1,098 | 7,338 |
| 8 | Mahbubnagar | 100.0 | 9,267 | 12,343 | 21,610 | 8,882 | 2,678 | 33,170 |
| 9 | Medak | 15.2 | 935 | 1,091 | 2,026 | 5,483 | 59 | 7,568 |
| 10 | Nalgonda | 100.0 | 7,289 | 12,953 | 20,242 | 9,092 | 1,715 | 31,049 |
| 11 | Warangal | 47.5 | 7,336 | 213 | 7,549 | 1,344 | 790 | 9,683 |
| | TOTAL | | 41,624 | 37,257 | 78,881 | 63,326 | 10,141 | 152,343 |

MAHARASHTRA :

| | | | | | | | | |
|---|---------------------------------|-------|---------------|---------------|----------------|---------------|---------------|----------------|
| 1 | Ahmednagar | 36.2 | 16,653 | 2,773 | 19,426 | 2,448 | 2,427 | 24,301 |
| 2 | Bhir | 14.2 | 3,810 | — | 3,810 | 1,326 | 302 | 5,438 |
| 3 | Kolhapur | 91.4 | 2,427 | 6,368 | 8,795 | 2,747 | 1,238 | 12,781 |
| 4 | Osmanabad | 31.8 | 2,417 | 2,585 | 5,057 | 1,185 | 790 | 7,032 |
| 5 | Poona | 99.1 | 25,118 | 11,530 | 36,647 | 4,618 | 5,361 | 46,627 |
| 6 | Ratnagiri | 0.9 | 45 | 62 | 107 | 297 | 15 | 419 |
| 7 | Sangli (South Satara) | 100.0 | 5,382 | 24,406 | 29,788 | 2,226 | 4,526 | 36,540 |
| 8 | Satara | 100.0 | 15,227 | 12,910 | 28,137 | 5,682 | 4,706 | 38,525 |
| 9 | Sholapur | 99.2 | 11,680 | 33,688 | 45,568 | 3,890 | 3,016 | 52,472 |
| | TOTAL | | 82,813 | 94,522 | 177,335 | 24,419 | 22,381 | 224,135 |

MYSORE :

| | | | | | | | | |
|----|------------------------|----------|---------------|---------------|---------------|---------------|---------------|----------------|
| 1 | Belgaum | 90.8 | 12,719 | 23,998 | 36,717 | 5,506 | 4,486 | 46,709 |
| 2 | Bellary | 100.0 | 1,329 | 655 | 1,984 | 2,174 | 271 | 4,429 |
| 3 | Bidar | 17.9 | 1,108 | 172 | 1,280 | 887 | 174 | 2,340 |
| 4 | Bijapur | 100.0 | 10,345 | 8,183 | 18,528 | 5,513 | 1,208 | 25,249 |
| 5 | Chikmagalur | 86.0 | 16 | 17 | 33 | 2,491 | 219 | 2,743 |
| 6 | Chitradurga | 100.0 | 4,344 | 2,436 | 6,780 | 3,035 | 404 | 10,219 |
| 7 | Dharwar | 86.5 | 1,576 | 2,357 | 3,933 | 3,723 | 2,742 | 10,398 |
| 8 | Gulbarga | 100.0 | 88 | 165 | 253 | 248 | 47 | 548 |
| 9 | Hassan | 19.3 | 11 | 4 | 15 | 246 | 10 | 271 |
| 10 | Kanara | 6.2 | 360 | 669 | 1,029 | 2,047 | 273 | 3,350 |
| 11 | Raichur | 100.0 | 3,345 | 858 | 4,203 | 1,444 | 722 | 6,369 |
| 12 | Shimoga | 74.4 | 110 | 39 | 149 | 4,184 | 125 | 4,457 |
| 13 | Tumkur | 37.1 | 2,806 | 1,762 | 4,568 | 1,620 | 242 | 6,431 |
| | Total | — | 38,157 | 41,315 | 79,472 | 33,118 | 10,923 | 123,513 |

Grand Total for the Basin — 162,594 173,094 335,688 120,863 43,445 499,996

TABLE XXV
DISTRICTWISE STATISTICS OF WELLS IN THE GODAVARI BASIN
Based on the 'Season and Crop Report' for the year 1957-58

| Serial Number | State | | Percentage of district in the basin | Number of wells used for irrigation | | | Wells used for domestic purposes | Wells not in use | Grand Total |
|-----------------------|---------------|---|-------------------------------------|-------------------------------------|---------------|---------------|----------------------------------|------------------|----------------|
| | District | | | Masonry | Non-masonry | Total | | | |
| 1 | 2 | | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| ANDHRA PRADESH | | | | | | | | | |
| 1 | Adilabad | : | 100.0 | 121 | 145 | 266 | 3,266 | 656 | 4,188 |
| 2 | East Godavari | : | 66.8 | 244 | — | 244 | 1,144 | 43 | 1,431 |
| 3 | Hyderabad | : | 1.5 | 18 | 55 | 73 | 109 | 7 | 189 |
| 4 | Karimnagar | : | 99.7 | 4,783 | 26,167 | 30,950 | 81,545 | 3,207 | 115,702 |
| 5 | Khammam | : | 51.8 | 1,685 | 275 | 1,960 | 990 | 3,275 | 6,225 |
| 6 | Medak | : | 84.8 | 5,217 | 6,081 | 11,299 | 30,592 | 332 | 42,223 |
| 7 | Nizamabad | : | 100.0 | 915 | 2,370 | 3,285 | 10,892 | 1,349 | 15,526 |
| 8 | Visakhapatnam | : | 27.5 | 3,820 | 1,557 | 5,376 | 1,815 | 27 | 7,218 |
| 9 | Warangal | : | 52.5 | 8,109 | 235 | 8,344 | 1,486 | 874 | 10,704 |
| 10 | West Godavari | : | 20.0 | 1,223 | 26 | 1,249 | 593 | 4 | 1,846 |
| | Total | | .. | 26,135 | 36,911 | 63,046 | 132,432 | 9,774 | 205,252 |
| MADHYA PRADESH | | | | | | | | | |
| 1 | Balaghat | . | 75.8 | 9,512 | 3,060 | 12,572 | 10,584 | 834 | 23,990 |
| 2 | Bastar | . | 94.4 | 2,051 | 3,233 | 5,284 | 2,642 | 793 | 8,719 |
| 3 | Betul | . | 22.3 | 1,232 | 2,092 | 3,324 | 494 | 1,205 | 5,023 |
| 4 | Chhindwara | . | 75.8 | 10,045 | 4,398 | 14,443 | 1,947 | 7,600 | 23,990 |
| 5 | Durg | . | 13.2 | 835 | 1,508 | 2,343 | 1,172 | 1,075 | 4,590 |
| 6 | Mandia | . | 6.2 | 27 | 54 | 81 | 192 | 25 | 298 |
| 7 | Raipur | . | 0.5 | 78 | 114 | 192 | 59 | 26 | 277 |
| 8 | Seoni | . | 74.8 | 3,509 | 1,989 | 5,498 | 4,971 | 1,642 | 12,111 |
| | Total | | .. | 27,289 | 16,448 | 43,737 | 22,061 | 13,200 | 78,998 |

MAHARASHTRA

| | | | | | | | | |
|----|------------------------|-------|----------------|---------------|----------------|----------------|---------------|----------------|
| 1 | Ahmednagar | 63.8 | 29,350 | 4,887 | 34,237 | 4,315 | 4,277 | 42,829 |
| 2 | Akola | 35.3 | 967 | 85 | 1,052 | 8,764 | 1,865 | 11,681 |
| 3 | Amravati | 34.3 | 2,908 | 1,291 | 4,199 | 13,851 | 1,473 | 19,523 |
| 4 | Aurangabad | 93.0 | 17,421 | 8,617 | 26,038 | 5,213 | 3,135 | 34,386 |
| 5 | Bhandara | 100.0 | 5,777 | 2,918 | 8,695 | 10,304 | 2,902 | 21,901 |
| 6 | Bhir | 85.8 | 23,023 | — | 23,023 | 8,011 | 1,827 | 32,961 |
| 7 | Buldana | 39.6 | 3,557 | 1,832 | 5,390 | 5,801 | 2,708 | 13,899 |
| 8 | Chanda | 99.0 | 2,512 | 3,996 | 6,508 | 7,227 | 2,768 | 16,503 |
| 9 | Jalgaon | 0.5 | 161 | 14 | 175 | 161 | 57 | 393 |
| 10 | Nagpur | 100.0 | 6,922 | 12,522 | 19,444 | 8,648 | 15,699 | 43,791 |
| 11 | Nanded | 100.0 | 5,688 | — | 5,688 | 3,056 | 1,238 | 9,982 |
| 12 | Nasik | 47.2 | 17,399 | 4,965 | 22,364 | 5,086 | 1,735 | 29,185 |
| 13 | Osmanabad | 68.2 | 5,301 | 5,544 | 10,844 | 2,542 | 1,694 | 15,080 |
| 14 | Parphani | 100.0 | 9,969 | 1,697 | 11,666 | 676 | 1,072 | 13,414 |
| 15 | Poona | 0.9 | 228 | 104 | 332 | 42 | 49 | 423 |
| 16 | Sholapur | 0.8 | 94 | 273 | 367 | 31 | 24 | 422 |
| 17 | Wardha | 100.0 | 3,967 | 1,831 | 5,798 | 7,969 | 10,670 | 24,437 |
| 18 | Yeotmal | 100.0 | 3,069 | 1,249 | 4,318 | 18,753 | 2,848 | 25,919 |
| | Total | | 138,313 | 51,825 | 190,138 | 110,450 | 56,041 | 356,629 |

MYSORE

| | | | | | | | | |
|---|-----------------|------|-------|-----|-------|-------|-----|--------|
| 1 | Bidar | 82.1 | 5,079 | 788 | 5,867 | 4,069 | 798 | 10,734 |
|---|-----------------|------|-------|-----|-------|-------|-----|--------|

ORISSA

| | | | | | | | | |
|---|------------------------|------|------------|------------|------------|------------|-----------|--------------|
| 1 | Kalahandi | 11.0 | 101 | 250 | 351 | — | — | 351 |
| 2 | Koraput | 63.8 | 3 | 77 | 80 | 798 | 38 | 916 |
| | Total | | 104 | 327 | 431 | 798 | 38 | 1,267 |

| | | | | | | | | |
|--|--------------------------------------------|--|----------------|----------------|----------------|----------------|---------------|----------------|
| | Grand total for the Basin | | 196,920 | 106,299 | 303,219 | 269,810 | 79,851 | 652,880 |
|--|--------------------------------------------|--|----------------|----------------|----------------|----------------|---------------|----------------|

Based on the Season and Crop Report, 1957-58, and applying the percentages, given in Table I, of the area of each district in the Krishna or Godavari basin to the total area of the district, it is found that the total number of irrigation wells in use, in the Krishna basin, is 336,000 and in the Godavari basin 303,000. District-wise figures are shown in Tables XXIV and XXV. These wells irrigate annually about 1.13 million acres in the Krishna basin and about 0.75 million acres in the Godavari basin.

10-5 No statistics are available with regard to the yield from these wells. Some idea of the performance of these wells can be had, however, from the following figures showing the number of wells in each State, as given in Tables XXIV and XXV, and the area irrigated by "wells and other sources", as given in paragraph 7-6, assuming, what should be largely correct, that all this irrigation is from wells.

| <i>Name of State</i> | <i>Number of irrigation wells in operation</i> | <i>Area irrigated by wells and other sources</i> | <i>Area irrigated per well</i> |
|--------------------------|------------------------------------------------|--------------------------------------------------|--------------------------------|
| | | <i>Acres</i> | <i>Acres</i> |
| Krishna basin | | | |
| Andhra Pradesh | 79,000 | 260,000 | 3.3 |
| Maharashtra | 177,000 | 520,000 | 2.9 |
| Mysore | 80,000 | 350,000 | 4.4 |
| Godavari basin | | | |
| Andhra Pradesh | 63,000 | 170,000 | 2.7 |
| Madhya Pradesh | 44,000 | 60,000 | 1.4 |
| Maharashtra | 190,000 | 480,000 | 2.5 |
| Mysore | 6,000 | 20,000 | 3.3 |

10-6 The following extract from the Report of the Fact-Finding Committee for survey of scarcity areas in Bombay State (1960) gives some particulars about wells in Maharashtra :

“Unlike the alluvial plains in the country, such as those in the Punjab and Uttar Pradesh, the Deccan conditions present altogether a different and complicated problem in so far as ground water and its flow is concerned. In the Indo-Gangetic plains striking water wells is not at all an uncertain factor as it is related to a water table which spreads all over the area.....In the Deccan, however, there is no such thing as a water table. The wells derive their supply from water seams the exact location of which cannot be predicted. Any well sunk in the Deccan has to be excavated in rock to some extent except in certain regions where the rock level happens to be very low and excavation is limited to the upper layers consisting of “MAN” or “CHOPAN”. The cost of sinking wells in the Deccan varies from about Rs. 3,000 to Rs. 5,000. A normal well in the Deccan plateau is about 40 to 50 feet deep and water is struck at a depth of about 25 to 40 feet. The capacity for irrigation of a normal well in the Deccan (not within the commands of irrigation canals) is noticed to be between three to five acres. The supplies of these wells are adequate for irrigation upto about the middle of March and then dwindle rapidly, giving barely sufficient water for drinking purposes at the end of the hot weather. As a matter of fact, a number of wells are known to get dry by the end of April..... Well irrigation, should therefore be resorted to where the other more economic modes of providing irrigation are not available or where an adequate and copious supply of underground water with a low lift can be guaranteed as, for example, in the areas under command of major irrigation works.”

It would seem that the conditions in respect of wells, in other parts of the Krishna and Godavari basins would not be very different from those described above, excepting areas with “good” or “good to fair” water bearing characteristics, described in paragraph 10-2 above.

10-7 It would appear from the above that even though there is no water table in the Krishna and Godavari basins of the type one finds in the Indo-Gangetic plains, wells have played a very important role in the irrigation development of these basins. About 30 per cent of the irrigated area in the Krishna basin and 20 per cent in the Godavari basin get their water supplies from surface wells.

10-8 As in other parts of India, there has been considerable activity in the Krishna and the Godavari basins during the last few years under the programme of minor irrigation. Large sums have been spent, and are being spent, under this programme on improvements to wells, digging new wells *etc.* The Commission has not been able to obtain particulars of the physical achievement either from the Ministry of Agriculture or from the State Governments. Most of this work is done

through civil officers. An attempt made to obtain the statistics of irrigation wells from the Season and Crop Report for the year 1950-51 was not helpful as no data are available for a large part of the Krishna and the Godavari basins, which were in the former Hyderabad State, former Mysore State, other princely States and *jagirs*.

10-9 The following comparison with regard to the districts for which data are available and in which a large number of wells have been dug would, however, give some idea of the developments in irrigation from wells between the period 1950-51 and 1957-58 :

| <i>Name of district</i> | 1950-51 | | 1957-58 | |
|-------------------------|-----------------------------------------|-------------------------------|-----------------------------------------|-------------------------------|
| | <i>Total number of irrigation wells</i> | <i>Area irrigated (acres)</i> | <i>Total number of irrigation wells</i> | <i>Area irrigated (acres)</i> |
| West Godavari | 3,040 | 24,300 | 6,246 | 30,400 |
| Nasik | 42,766 | 26,900 | 47,382 | 53,600 |
| Poona | 29,262 | 71,300 | 36,980 | 75,800 |
| Sholapur | 36,046 | 165,500 | 45,934 | 172,800 |
| Bijapur | 15,206 | 41,300 | 18,528 | 61,000 |

The figures given above are for whole districts including, in case of some, their portions outside the Krishna and Godavari basins.

Possibility of further development

10-10 There is considerable room for further development from ground waters in the coastal area, along the Godavari valley in sub-basin G. 10 and parts of G.9 and G. 8 and in the areas under command of major irrigation works, existing and proposed. Increased withdrawals from the sub-soil in these areas are even otherwise necessary for preventing water-logging.

10-11 The hydrologic aspects of ground waters will be discussed in Chapter XI.

10-12 For planning future developments on a sound basis and to maintain a close watch on the behaviour of ground waters, particularly in view of the large-scale new developments in the Krishna and Godavari basins, it is important that regular observations should be made of the position of the ground waters below the surface and their fluctuations during the year. The methods to be adopted would vary in different parts of the two basins according to local conditions.

CHAPTER XI

HYDROLOGIC CHARACTERISTICS

General

11-1 In this chapter it is proposed to make a brief study of the hydrologic characteristics of the Krishna and the Godavari basins, and adjoining areas where the waters of the Krishna are being used, or are proposed to be used, for irrigation. The inadequacy and un-reliability of the data of stream flow and lack of data regarding sub-soil water conditions makes this study all the more important.

11-2 The source of all water in the Krishna and the Godavari basins, whether in stream flow or under the surface, is the rain which falls within each basin. There is no evidence of any sub-soil flow from outside getting into either of the two basins nor has it been possible to find evidence of any sub-soil water escaping from either of these two basins.

Rainfall zones

11-3 Based on the information given in chapter V and the maps referred to therein, from the point of view of rainfall, the Krishna and the Godavari basins may be divided into the following zones :

Zone A comprising the eastern slopes of the Western *Ghats* with a varying width of country, up to about 30 miles, to their east, which get a high rainfall during the south-west monsoon, from June to September ;

Zone B comprising the north-east part of the Godavari basin, lying in sub-basins G. 9, G. 11, G. 12 and part of G. 10, which gets good rainfall during the south-west monsoon, the eastern part of this Zone receives some rainfall also during the north-east monsoon, from October to December, and some showers in April and May.

Zone C comprising sub basins G. 5, G. 7, G. 8. and portions of G. 4, G. 6, G. 10 and K. 7 which get adequate rainfall (more than 24 inches) during the south west monsoon

Zone D comprising the south-eastern part of the Krishna basin, K. 9 and parts of K. 7 and K. 8, and the adjoining areas of Guntur, Nellore, Cuddapah, Anantapur, Kurnool, Chingleput and South Arcot ; rainfall during the south-west monsoon is low in this zone ; the eastern part of this zone receives adequate, but not assured, rainfall in the north-east monsoon but the western part gets adequate rainfall neither during the south-west monsoon nor during the north-east monsoon, and

Zone E comprising the rest of the Krishna and Godavari basins, which gets inadequate rainfall during the south-west monsoon. This zone also gets some rainfall from the retreating monsoon, but this is neither assured nor adequate.

Disposal of rain waters

11-4 Broadly speaking, as rain falls, it is held by trees, plants, crops *etc.*, it moistens the ground, is held in local depressions, in furrows and fields and what is surplus to all these appears as surface run-off.

Of the water which is held by crops and trees on the surface of leaves, or which is held on the ground, part is evaporated, part is retained in the root zone for sustaining plant life and part soaks into the sub-soil (to add to ground waters). Of the water which appears as surface run-off, a small part is evaporated, part soaks into the sub-soil (to add to ground waters) and large part finds its way into natural drainages, streams and rivers.

11-5 The entire rainfall over a basin or sub-basin is thus disposed of ultimately in four ways ;

- (a) lost by evaporation ;
- (b) held as surface detention and used directly for sustaining crops and plant life ;
- (c) contribution to ground waters ; and
- (d) contribution to stream flow.

The amount of rainfall, its distribution in time and space, the intensity of each shower, topography, soil cover, the type of top soil and the nature of the sub-grade are all important factors which determine the proportion of the rain in any area which is disposed of by each of the four ways described above. Some of these factors also govern the nature of stream flow, its variations, *etc.*, and the accumulation or final disposal of ground waters.

Loss by direct evaporation

11-6 As stated above, evaporation losses occur from that part of rainfall which is initially held on the surface of the ground or on the surface of leaves, plants, *etc.* Evaporation also takes place from the surface run-off before it finds its way into river streams but, in view of the relatively steep slopes in the Krishna and the Godavari basins, losses on this account would be relatively small. With the high rates of potential evaporation in these two basins, as described in paragraphs 5-25 to 5-33, evaporation losses would be high from moist soil wherever water is held in natural depressions on cultivated fields or in forest areas on the surface of leaves, *etc.*

Direct use for sustaining plant life

11-7 The part of rainfall which is directly utilised for sustaining crops and plant life (or transpiration) would obviously vary with the nature of vegetal cover in different parts of the two basins. Dense forests and native vegetation along river streams and in water-logged areas consume large quantities of water. The quantity consumed by crops depends on the retentive capacity of the soil and the stage of growth of the crops. Except for rainfalls of high intensity, the rest of the rainfall in the low rainfall Zones may be directly consumed by standing crops and, where there is no irrigation, the amount of water consumed by the crops would be directly proportional to such rain-fall.

11-8 While no observations have been made in the Krishna and Godavari basins with regard to the water consumed by various crops, forests and native vegetation, it has been found in other parts of the world that sparse native vegetation consisting of scattered grass and brush consumes about one foot depth of water, and the heavier growths of vegetation in wet areas as much as 4 to 6 feet. Dense forests consume 4 to 6 feet depth of water per year. Rain-fed crops consume up to about two feet depth of water, if the rainfall is properly distributed over the growing season of the crop.

11-9 It would thus appear that forests, native vegetation and cultivated crops deplete the water supply of a basin. This depletion, varying in different parts of the Krishna and the Godavari basins, would represent a substantial part of the annual rainfall.

Contribution to ground waters

11-10 It has been stated in Chapter II that the Krishna and the Godavari basins largely comprise a series of valleys and ridges. By and large, the soil cover at the ridges is small, from a few inches to two or three feet, and below it is hard rock or a few feet of *moorum* and then hard rock. Accordingly, the water-holding capacity of these shallow soils is low and as rain water soaks into these, it cannot be retained there but must pass on laterally into lower ground. Ultimately, this water gets to the bed of the valley where the soils are generally deep, and, therefore, have some water retaining capacity. The ground waters in the Krishna and Godavari valleys are thus to be found generally in the valley bottoms. Unless withdrawn through wells or by pumps, these waters must in due course, seep into river channels; an increase in such withdrawals would reduce this seepage.

Alternatively, and particularly on broad plateaus, the ground water sometimes finds its way through faults in the rock to form local pockets which are not easy to locate.

11-11 In view of the relatively steep slopes in the area, rain water flows away fast and it does not get enough time to soak into the ground except from depressions and cultivated fields. Any change in the surface configuration of the land would alter the balance between stream flow and ground waters. For example,

where contour bunding has been done it has been noticed, that it has been followed by an improvement in the water supply of wells in that particular area. This would imply a corresponding reduction in surface run-off.

Contribution to stream flow

11-12 As indicated in paragraph 11-5 above, contribution to stream flow represents that part of rainfall which is left over after meeting evaporation losses, the use by crops and plant life and the contribution to ground waters, as described in the preceding paragraphs. The depletion by those processes from the total water supply of any area would vary in different parts according to local conditions. Consequently, the proportion of rainfall which would appear as stream flow would be different for different parts of the two basins.

11-13 Zone A, an area of high rainfall, comprises hills and steep sloping country covered with dense forests or thick vegetal cover. Most of the rainfall in this zone therefore quickly appears as run-off. Such rainfall as is initially retained by the vegetal cover or which soaks into the hill sides also appears as run-off soon after, except the part utilised in sustaining plant life.

All the major rivers of the Krishna basin, the Godavari main and the Pravara rise in this zone. The rivers begin to flow after the first good rain, some time in June, and in general flow continuously thereafter but with largely varying discharges, depending on the succession of rain showers. The flow practically ceases in October-November.

11-14 Zone B comprises hills, large wide plateaus and table-lands. It is covered by thick forests, scrub jungle or cultivation, mainly paddy fields. Rainfall in this Zone extends over a longer period, from April to November. A large part of the rainfall appears as run-off and because of the nature of the terrain and the dense forests, a small perennial outflow is maintained.

11-15 The country in Zone C is not as steep as in Zones A and B. A large part is under crops or is uncultivated fallows. A shower of relatively low intensity would generally be held by the fields and the crops and may not contribute materially to run-off. It is only showers of high intensity, occurring irregularly during the rainy season, which produce run-off. The contribution to river flow would, therefore, be in the nature of spasmodic freshets of varying intensity.

11-16 The characteristics of Zones D and E are similar to those of Zone C but in view of the relatively small total rainfall, the run-off would be even more irregular than that from Zone C.

11-17 It would thus appear that an important feature of flow in the Krishna and Godavari river systems is the fact that different parts of the catchment would be contributing to river flow at different times during the rainy season. While the contribution from Zone A and Zone B is more or less continuous during the rainy season and would vary only in intensity depending on successive showers, that from the remaining part of the catchment would occur spasmodically and at different times in different river reaches. This feature introduces considerable complication in the optimum utilisation of the waters of these river systems.

Effect of small tanks on stream flow

11-18 In most parts of the Krishna and the Godavari basins, there are large number of tanks (about 60,000 in the two basins) varying in area from a few acres to a few thousand acres. These tanks have been built on small streams and are sometimes in the nature of a chain, one below the other. Accordingly, any surface run-off which finds its way into these streams or *nallahs* is first held up in these tanks, from where it is almost continuously drawn upon for irrigation. Each successive freshet, therefore, must first fill these tanks before it can find its way into any major tributary or river. This is an important feature of the hydrology of the Krishna and Godavari river systems.

11-19 Unfortunately, no data are available of the performance of these tanks in the Krishna and the Godavari basins. In general, it may be stated that the quantity of water held by a tank or a reservoir, during a season, would depend on (i) its live capacity, (ii) distribution of rainfall in the season and (iii) magnitude and distribution in time of withdrawals or releases from the tank or reservoir. In the Telangana area and parts of Mysore, the tanks are expected to fill at least twice in a year.

11-20 Unless systematic data are collected, the net effect of these tanks and reservoirs on river flow downstream cannot be ascertained. It would be obvious that with the large number of existing tanks and reservoirs and new storage works under construction, this information would be indispensable for the design and operation of an integrated basin-wide plan of development.

Transit losses

11-21 Apart from the direct evaporation mentioned in paragraph 11-6 above, evaporation also takes place from the waters flowing in the rivers. It would take about 6 to 10 days for water from the Western Ghats to flow through any of the river systems to the Bay of Bengal. During all these days there will be a continuous loss of water from the rivers on account of evaporation, which is pretty high in the Krishna and the Godavari basins. Under certain conditions, in the lower valley, where a river has built up its bed above the ground surface, there may also be some contribution from the river to ground waters.

11-22 These transit losses would be more in wider and slow-moving rivers than in narrow fast streams. In the entire length, the transit losses can be fairly large, up to 20 percent or more of the flow in the head reach of a river.

River gains

11-23 It has been stated in paragraph 11-10 that ground waters, unless withdrawn through wells or pumps, must seep into river channels. This seepage represents river gains. As already indicated, these river gains, in most parts of the Krishna and Godavari basins, appear soon after the rain ceases but, from deep soils, the gains may appear even a few months after the rainy season.

Valley storage

11-24 As the river rises in June, a fairly large quantity of water is taken up in filling the river beds up to the requisite depth to maintain flow. As the river falls, these waters gradually drain away, thus presenting an alternate process of apparent losses and apparent gains. In any co-ordinated regulation of withdrawals from a river system, this valley storage and the consequent apparent gains and apparent losses have to be duly accounted for each freshet and for the flow season as a whole.

Water balance

11-25 From what has been stated in the preceding paragraphs, it would have been clear that there is a water balance between the rainfall on the one hand and stream flow, ground waters, evaporation and transpiration on the other. Again, the accretions to ground water are generally balanced by withdrawals from the ground by wells and pumps and the seepage into the rivers. It is important to note these phenomena as their study helps in forecasting the consequences of a change imposed on the natural water balance in any sub-basin or basin.

11-26 When water is withdrawn from a river stream and spread on the land for the purpose of agriculture an important new contribution to ground waters is the seepage from irrigation channels, most of which are unlined, and from the irrigation waters let into the fields over and above the quantity actually utilised for sustaining plant growth. The quantity of water which seeps into the ground depends on the nature of the irrigation channels and on the amount of water supplied to the fields for growing different crops. Although little statistical data are available, it can be stated from general consideration that this contribution to ground waters from irrigation channels and irrigated fields may be as large as, sometimes even much more than, the quantity actually utilised by the crops.

11-27 Unless ground waters are withdrawn from the soil, these waters under good sub-surface drainage conditions, will seep into the rivers ; under other conditions these waters will fill pockets, form perched water tables and may cause local water logging.

In the Krishna and Godavari deltas, the surplus waters poured on the ground are disposed of by a large number of drains (see paragraph 12-29 *infra*) which outfall in to the sea.

11-28 Ground waters can be a valuable source of water for irrigation in the dry weather and can be utilised in the same manner as storage above ground, except where ground waters may tend to be saline. Underground storage is superior to surface storage in as much as there are no losses from evaporation. In the Krishna and Godavari basins, with very high evaporation rates, this is an advantage of great significance.

CHAPTER XII

WATER RESOURCES DEVELOPMENT UP TO 1951

Wells

12-1 As stated in paragraph 7-6, there are a large number of wells in the two basins irrigating in 1956-57* an area of about 1·13 million acres in the Krishna basin and about 0·75 million acres in the Godavari basin. These wells are ancient in concept and largely the result of the cultivator's own efforts. In recent years, there has been some assistance from Government for the resurrection of dilapidated wells and some encouragement towards the construction of new wells.

Tanks

12-2 Flying over the Krishna and the Godavari basins, one cannot help noticing the large number of tanks which stud the landscape. Some of these tanks are pre-historic; others were built from time to time by progressive rulers or by the efforts of the people themselves. Each tank is the source of water supply for the village, or the villages in its vicinity, and provides irrigation water to a small patch of land, a few acres to a few hundred acres, infrequently a few thousand acres. Most tanks, however, irrigate an area of less than 500 acres.

12-3 The general pattern of these tanks is that an earthen embankment of varying height has been put across a valley, a natural *nullah* or a small stream and the valley immediately below the embankment bears a paddy crop, mainly in *kharif*. The tanks are practically dry just before the monsoon; the first good shower fills them up, in part, and withdrawals for sowing paddy follow immediately thereafter. The next shower again fills the storage in part and the process continues throughout the rainy season. It is only when the tank is full that there is any escape into the *nullah* or stream. On the conclusion of the south-west monsoon, the tank would, generally be full and the waters available are utilised for maturing the paddy crop and for domestic use until the next monsoon.

In some tanks, under influence of the retreating monsoon, there is sufficient storage left at the end of the *kharif* season for growing a second crop of paddy in part of the area dependent on it.

It should be noted that irrigation from these tanks is largely in the beds of *nullahs* and streams or other low lying areas and in isolated small patches.

12-4 On some streams, tanks have been built one below the other in a sort of chain and each tank receives the escape of the tank immediately upstream as well as the in-flow from the intermediate catchment.

*Figures for 1951 are not available.

Diversions

12-5 On some streams, where topographical conditions are favourable, weirs have been built across them and small canals are taken a short distance from the stream to irrigate areas of paddy, in some cases, of sugarcane or gardens. These diversions, also generally irrigate areas less than 500 acres each.

Minor schemes

12-6 For convenience in presentation, tanks and diversion described above have been divided, as stated in paragraph 1-9, into two groups as follows :

- (a) minor schemes, each having C. C. A. or Ayacut of less than 5,000 acres but not less than 500 acres ; and
- (b) small tanks and diversions, each having C. C. A. or Ayacut of less than 500 acres.

The only difference between the two is that of size of the area irrigated from an individual scheme.

Operational statistics of small tanks and diversions and minor schemes

12-7 There are about 27,000 small tanks and diversions on the Krishna river system, mostly in Andhra Pradesh and Mysore. Similarly, there are about 32,000 small tanks and diversions on the Godavari river system. There are 211 minor schemes in the Krishna basin and 186 in the Godavari basin. Most of these works are under the control of civil authorities and the Public Works Department only carry out some repair works when called upon to do so.

No observations have ever been made and no records are maintained of the quantity of water diverted by these works. Some information is available with regard to the areas irrigated but the practice in this respect has been different in different political units and, because of the political changes described in paragraphs 2-6 to 2-10, some of the records cannot now be traced.

12-8 The Commission tried to obtain all such information as was available for individual minor schemes and district-wise statistics for the small tanks and diversions. This information for the Krishna river system is furnished in Tables II to VI of Annexure VIII and that the Godavari river system in Tables II to VI of Annexure XII.

The Commission have tried to fill in the gaps in the available data on the basis of all the relevant information available to it. The figures, so assumed, have been shown in brackets in the Tables mentioned above and full particulars of the methods adopted are given in the form of notes.

12-9 On the basis of rough duties in acres per m. cft, as furnished by the State for the minor works, small tanks and diversions in each district (see Table VI of Annexures VIII and XII), the Commission have made a rough estimate of the quantity of water diverted for irrigation from these works. In doing so, the Commission do not express any view on the correctness of these duties—little information is available to do so. It would, however, like to emphasise that the figures of area irrigated and water diverted by these works, as given in the Annexures and in Tables XXVI and XXVII below, are very rough.

12-10 It is difficult to show these minor schemes, small tanks and diversions on any convenient map of the two basins but the total area irrigated by these works, annually, in each district, is shown diagrammatically on Map VI. It will be seen that, by and large, these minor schemes, small tanks and diversions are concentrated in Telangana, Balaghat district of Madhya Pradesh, Bhandara district of Maharashtra and Dharwar, Shimoga, Chitradurga and Chikmagalur districts of Mysore.

Delta Canals

12-11 The most prominent feature of irrigation in the two basins are the Krishna Delta Canals and the Godavari Delta Canals.

The Krishna Delta Canals were constructed in 1855 and during the 10 years ending March 1951, they withdrew, on an average, 187 T.M.C. of water, annually, for paddy cultivation over an area of 1.12 million acres*, mainly *abi*.

The Godavari Delta Canals were constructed in 1852 and during the 10 years ending March 1951, withdrew 253 T.M.C. of water, annually, for paddy cultivation over an area of 1.22 million acres, mainly *abi*, but since some perennial supply is available in the Godavari river, *tabi* paddy is grown over part of the area.

Between them, the two Delta Canal systems catered, in 1951, for about 40 per cent of the total irrigated area from the two rivers.

Other irrigation works

12-12 Apart from the Krishna Delta Canals, the other major irrigation works on the Krishna river system, which were in operation in 1951, are :

- (a) Nira Canals in Maharashtra, constructed in 1885, irrigating about 150,000 acres.
- (b) Kurnool-Cuddapah Canal in Andhra Pradesh, built in 1886, which, until 1951 was largely a failure. It irrigated only about 100,000 acres.

In addition, there were 17 medium schemes irrigating, annually, about 150,000 acres.

*The figures of area irrigated and of river supplies diverted, as given in this chapter, are averages for the ten years period ending May 1951. The yearly figures vary above and below the average ; these can be referred to in the relevant Annexures.

12-13 Apart from the Godavari Delta Canals, the other major irrigation works on the Godavari river system, which were in operation in 1951, are :

- (a) Godavari Canals in Maharashtra, constructed in 1915, irrigating about 50,000 acres ;
- (b) Wainganga Canal in Madhya Pradesh, constructed in 1923, irrigating about 50,000 acres ;
- (c) Pravara Canals in Maharashtra, constructed in 1926, irrigating about 60,000 acres ; and
- (d) Nizamsagar Canal in Andhra Pradesh, constructed in 1941, irrigating an area of about 130,000 acres.

In addition, there were 20 medium schemes, irrigating annually about 140,000 acres.

12-14 Brief particulars of all major and medium schemes are given in Table I of Annexure VIII for the Krishna basin and Table I of Annexure XII for the Godavari basin. Fuller particulars, separately, for each major and medium scheme, are given in Section 3 of Annexures VIII and XII. Also see Map VI. Statements of 10-daily mean withdrawals by all canals are given in Annexures IV and VII.

12-15 The overall State-wise picture of irrigation developments from the Krishna and Godavari river systems, as of 1951, is given in Tables XXVI and XXVII. It will be seen that 411.4 T.M.C. of water was being diverted from the Krishna river system, annually, for the irrigation of 2,302,377 acres. From the Godavari river system, 470.6 T.M.C. of water was being diverted, annually, for the irrigation of 2,734,864 acres.

12-16 It has been stated earlier that the benefits from the waters of the Krishna and the Godavari extend outside the drainage basins of the two rivers. Ninety five per cent of the area irrigated by the Krishna Delta Canals and about 90 per cent of the area irrigated by the Kurnool-Cuddapah Canal or a total irrigated area of about 1.11 million acres lies outside the drainage basin of the Krishna. Similarly, 65 per cent of the irrigated area from the Godavari Delta Canals, about 0.79 million acres, lies outside the drainage basin of the Godavari.

TABLE XXVI

Irrigation development from the Krishna river system as of 1951

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|------------------------------------------|
| ANDHRA PRADESH | | |
| Krishna Delta system | 1,119,900 | 186.8 |
| Kurnool Cuddapah Canal | 97,800 | 33.0 |
| 5 medium schemes | 45,300 | 11.3 |
| 106 minor schemes | 347,345 | 59.0 |
| 12,617 small tanks and diversions | | |
| Total | 1,610,345 | 290.1 |
| MAHARASHTRA | | |
| Nira Canals | 155,100 | 32.0 |
| 7 medium schemes | 48,200 | 9.9 |
| 19 minor schemes | 14,961 | 1.1 |
| 16 small tanks and diversions | 3,895 | |
| Total | 222,156 | 43.0 |
| MYSORE | | |
| 5 medium schemes | 56,300 | 11.3 |
| 86 minor schemes | 70,000 | 67.0 |
| 14,019 small tanks and diversions | 343,576 | |
| Total | 469,876 | 78.3 |
| Grand Total | 2,302,377 | 411.4 |

TABLE XXVII

Irrigation development from the Godavari river system as of 1951

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|------------------------------------------|
| ANDHRA PRADESH | | |
| Godavari Delta System | 1,220,500 | 253·0 |
| Nizamsagar Project | 128,000 | 40·0 |
| 6 medium schemes | 40,700 | 13·3 |
| 116 minor schemes | 62,866 | 86·5 |
| 15,547 small tanks and diversions | 455,675 | |
| Total | 1,908,741 | 392·8 |
| MADHYA PRADESH | | |
| Wainganga Canal | 52,100 | 5·9 |
| 6 medium schemes | 27,200 | 2·0 |
| 11 minor schemes | 8,800 | 12·3 |
| 9,080 small tanks and diversions | 114,360 | |
| Total | 202,460 | 20·2 |
| MAHARASHTRA | | |
| Godavari Canals | 46,600 | 10·3 |
| Pravara Canals | 58,000 | 15·3 |
| 8 medium schemes | 84,600 | 7·1 |
| 44 minor schemes | 31,144 | 23·3 |
| 7,561 small tanks and diversions | 385,250 | |
| Total | 605,594 | 56·0 |
| MYSORE | | |
| 22 small tanks and diversions | 1,069 | 0·2 |
| ORISSA | | |
| 15 minor schemes | 6,000 | 1·4 |
| 128 small tanks and diversions | 11,000 | |
| Total | 17,000 | 1·4 |
| Grand Total | 2,734,854 | 470·6 |

Power development

12-17 Up to 1951, no hydro-electric power had been developed anywhere on the Godavari river system.

On the Krishna river system, three hydro-electric projects had been developed by the Tatas between 1918 and 1929 with a total generating capacity of 274,000 kW, in Maharashtra. The power generated was being used mostly for railway traction on the Central and Western Railways, for local industries and for domestic use in Bombay-Poona area. There was, in addition, a small private hydro-electric plant at the Gokak falls, now in Mysore; its capacity and other particulars are not available.

12-18 The three hydro-electric schemes in Maharashtra, in 1951, used 38.0 T.M.C. of water, which was diverted, outside the basin, into the Arabian sea.

Navigation

12-19 Navigation has been an important aspect of river development in the Krishna and the Godavari basins.

The Krishna river is navigable from sea to 22 miles upstream of Vijayawada anicut, throughout the year and up to about 60 miles upstream of the anicut during the monsoon months.

The Godavari river is navigable for about 116 miles up to Dummagudem by craft drawing 3 to 4 feet of water and for another 72 miles upstream to Chandrupatla by lighter crafts from July to February. In the dry season, between March and June, the river is navigable only upto Kannavaram, 90 miles upstream of Dowlaishwaram anicut.

12-20 The net-work of canal systems taking off the Krishna and the Godavari anicuts connect these two rivers to the sea-ports of Kakinada and Masulipatnam. These canals are open to navigation for about nine months in the year. The traffic is confined to slow-moving country boats. No waters are released specifically for navigation in the Godavari Delta Canals. For the Krishna Delta Canals, information in this respect is not available.

12-21 The Kommamur Canal, taking off the Vijayawada anicut on the Krishna, joins the Buckingham canal and connects the two rivers with Madras. The Buckingham canal has a total length of 262 miles with an inter-connected system of waterways providing a valuable navigation route for over 400 miles between the port of Kakinada and the southern limit of the canal up to Markanam, 66 miles south of Madras.

12-22 Of the other canals in the Krishna and Godavari basins, only the Kurnool-Cuddapah canal is navigable.

12-23 In spite of the important rôle, which these navigation canals should play, it is seen from the Administration Reports of the Public Works Department of the former Madras Presidency* that during the five years ending 1952-53, the maintenance charges on account of navigation were far in excess of the navigation receipts, both on the Krishna Delta Canals and the Godavari Delta Canals. In the former, the annual loss during these five years varied from Rs. 408,000 to Rs. 92,000 and on the latter the annual loss varied from Rs. 325,000 to Rs. 29,000.

Reservoir losses

12-24 It has been stated in paragraph 12-15 that, in 1951, 411.4 T.M.C. of water was being diverted for irrigation from the Krishna river system and 470.6 T.M.C. from the Godavari river system. In this connection it is important to take note also of the evaporation and other losses from reservoirs and tanks.

In the irrigation developments as up to 1951, the Krishna Delta Canals and the Kurnool Cuddapah Canal from the Krishna and the Godavari Delta Canal and the Wainganga Canal from the Godavari were run-of-river projects; so there were no reservoir losses on account of these canals.

As regards other major and medium schemes, a reference to their particulars as given in Annexures VIII and XII, would show that, on the Krishna, the total live storage capacity were 112.3 T.M.C. and the total estimated (see paragraphs 5-34 and 5-35) reservoir losses were 13.3 T.M.C. On the Godavari the corresponding figures were 64.9 T.M.C. and 12.8 T.M.C.

12-25 For minor schemes and small tanks as already stated, no operational statistics are available. It is, therefore difficult to estimate the losses from the large number of tanks in the two basins and to get some idea of these losses, some rough and ready method must be found.

From a study** of 4,185 tanks in Andhra Pradesh, it was found that these tanks had a water-spread of 306,000 acres against a registered Aya cut of 394,000 acres. This gives a ratio of 1.0 to 1.3 as between the water-spread and the registered Ayacut. In other words, the water-spread was, on an average, equal to 77 per cent of the registered Ayacut.

It was also found† that the area irrigated from tanks was, on an average, about 88 per cent of the registered Ayacut. On this basis, the water-spread of tanks would be 87.5 per cent of the irrigated area.

*No administration reports financial or water supply statistics have been published by Andhra Pradesh since its formation.

**Report on Minor Irrigation Works (Andhra Pradesh); Committee on Plan Projects (Irrigation and Power Team); May 1960 : page 8, paragraph 14.

†Report on Minor Irrigation Works (Andhra Pradesh); Committee on Plan Projects (Irrigation and Power Team); May 1960, page 35, Appendix IIIB.

Assuming a total loss of, say, 3.5 feet over the surface area for the period the tanks are full (from June to December, approximately), the total losses from the tanks in the Krishna and Godavari basins would be:

Krishna basin:

$$0.875 \times 780,000 \times 3.5 \times 43,560 = 104.7 \text{ T.M.C. say } 105.0 \text{ T.M.C.}$$

Godavari basin:

$$0.875 \times 1,070,000 \times 3.5 \times 43,560 = 144.7 \text{ T.M.C. say } 145.0 \text{ T.M.C.}$$

12-26 The average annual diversion by minor schemes and small tanks on the Krishna is about 127 T.M.C. Against this, the annual evaporation loss is 105 T.M.C. On the Godavari, against an annual diversion of about 124 T.M.C., the losses are 145 T.M.C.

The losses by evaporation from minor schemes, small tanks and diversions are thus, as large as the supplies diverted for irrigation from these works.

Drainage

12-27 Drainage is an essential supplement to irrigation and no survey of irrigation developments would be complete without a study of the drainage problems that have arisen in the past and a description of the measures taken to deal with them.

12-28 The main drainage problem in Andhra Pradesh "is the disposal of surface water from flat deltaic tracts where rice is the staple crop———"

"The Kistna and the Godavari system are———comparatively modern systems. The canals take off at anicuts on the river, and river floods are kept out of the canals at the head. The high flood levels in the rivers are above the general ground level of the delta, and the rivers are banked right up to the sea to prevent spill of river floods.

"The canals (which are also used for navigation), are suitably aligned on ridges, and natural drains running in valleys between the canals have been improved to form a system of drains leading the surface and storm water to the sea, or into the Collair Lake, which is a natural depression draining into the sea.

"The problem in these two deltas is to provide adequate drain capacity to meet the varying flow which the drains have to carry, and to provide suitable outfalls into the sea. Some portions of the deltas are traversed by 'upland drains' and large quantities of storm water from these areas enter into and aggravate the drainage problem of low lying parts of the delta. The 'upland drains' have to be carried through the deltaic tracts, and have to be often 'banked', suitable infalls being provided for the drains of the area traversed. The feasibility of mitigating these upland floods by 'storage works' in the uplands has been examined in many cases but such schemes have not materialised so far as it is financially impracticable to design schemes to prevent occasional submersion in years of heavy rainfall."*

*Central Board of Irrigation & Power ; Questionnaire on Drainage Systems in Irrigated Areas, 1940, pages 4-5,

Apart from the two deltas, it is stated that the country is generally undulating and easily drained; no drainage problems have so far arisen.

12-29 In the Krishna and Godavari deltas, the drains are divided into three classes as follows:

- (a) Major drains, with catchment area of each drain exceeding 20 square miles;
- (b) medium drains, with catchment area of each drain from 5 to 20 square miles; and
- (c) minor drains, with catchment area of each drain less than 5 square miles.

In all, there are 966 miles of drains in the Krishna Delta area and 1,296 miles of drains in the Godavari Delta area. Their classification is as follows:

| | <i>Major drains</i> | | <i>Medium drains</i> | | <i>Minor drains</i> | | <i>Total</i> | |
|--------------------------------|---------------------|-----------------------|----------------------|-----------------------|---------------------|-----------------------|---------------|-----------------------|
| | <i>Number</i> | <i>Length (miles)</i> | <i>Number</i> | <i>Length (miles)</i> | <i>Number</i> | <i>Length (miles)</i> | <i>Number</i> | <i>Length (miles)</i> |
| Krishna delta system | | | | | | | | |
| Eastern Section . . . | 12 | 288 | 8 | 43 | .. | .. | 20 | 331 |
| Central Section . . . | 3 | 43 | 14 | 65 | 58 | 97 | 75 | 205 |
| Western Section . . . | 20 | 139 | 11 | 46 | 62 | 245 | 93 | 430 |
| Total . . . | 35 | 470 | 33 | 154 | 120 | 342 | 183 | 966 |
| Godavari delta system | | | | | | | | |
| Eastern Section . . . | 6 | 97 | 33 | 152 | 43 | 75 | 82 | 324 |
| Central Section . . . | 9 | 94 | 21 | 123 | 90 | 205 | } 160 | 464 |
| Polavaram Island Project . . . | .. | .. | .. | .. | 40 | 37 | | |
| Western Section . . . | 5 | 63 | } 67 | 68 | 88 | 251 | } 105 | 503 |
| | 6 | 126 | | | | | | |
| Total . . . | 26 | 380 | 61 | 343 | 251 | 563 | 343 | 1,296 |

12-30 The drains in the Godavari delta are designed for a run-off equivalent to a depth of 2 inches in 24 hours. For 'upland drains' the discharge Q is determined by the formula

$$Q = CM^{2/3}$$

in which M is the catchment area in square miles and C is co-efficient varying from 400 to 600, depending on the nature of the catchment and the intensity of rainfall.

The same formula is adopted for the upland drains in the Krishna delta but the co-efficient C varies from 450 to 550. For the delta drains the discharge is worked out as follows:

for minor drains: $Q = 44M$

for medium drains: $Q = 27M$

The drains are designed so as to keep the ordinary flood level generally one foot lower than the lowest adjoining field. For maximum flood levels, the lowest adjoining fields are allowed to be submerged by one foot.

12-31 No data are available of discharges in the drains.

12-32 There have been no drainage problems so far in Madhya Pradesh, Mysore and Orissa; no drains have been constructed.

12-33 As regards Maharashtra, "when a large canal is opened, wide-spread waterlogging is likely to ensue. Some of this water-logging dries out later, but the damage often extends rapidly into the valleys, and unless steps are taken to set matters right, the damage consisting mainly of salt-efflorescence, becomes permanent. The seriousness of the menace was realised as early as 1888 and the controversy regarding the relative effect of losses and wasteful irrigation, and the best methods to adopt to safeguard the land, became yearly more acute. Various experiments were carried out at the instance of the Agricultural Department, but by 1913 it was clear that all the methods tried so far had failed. It was eventually decided to open a Special Irrigation Division"* to undertake investigations with regard to safeguarding the soil.

Nearly 230 miles of drains have since been constructed in Maharashtra at a cost of nearly Rs. 40,00,000 in the areas irrigated by Nira canals, Mutha canals, Pravara canals and the Godavari canals. More drains at an approximate cost of Rs. 27,00,000 are under construction. In factory areas drainage channels are provided by the factory owners at their own cost.

*Central Board of Irrigation; Questionnaire on Drainage System in Irrigated Areas, 1940; page 1.

12-34. The drains in Maharashtra are mainly seepage drains and the designed discharge is calculated as a fraction of the water required for the irrigation of crops in that area on the following basis:

- (a) for drainage of areas allowed to sugarcane factories—1 cusec for every 133 acres of sugarcane;
- (b) for other areas in which perennial irrigation is allowed—1 cusec for every 250 acres.

12-35 No data are available of the discharges from these drains.

CHAPTER XIII

DEVELOPMENTS SINCE 1951

General

13-1 As in other parts of the country, considerable development works have been undertaken since Independence in the field of irrigation in the Krishna and Godavari basins.

A number of schemes, large and small, had been under consideration as part of the Post-War Reconstruction Programme when the acute food shortage in the country, soon after Independence, added urgency to their early execution. Some projects had been sanctioned prior to 1951. On others, work was taken in hand as soon as the investigations considered necessary had been carried out and the schemes had found their place in the First, Second or Third Five Year Plan.

13-2 There have been some developments, since 1951, also in hydro-electric power generation ; these are also described in this chapter.

13-3 For the purpose of this Report, all the schemes mentioned above have been divided into two categories :

- (a) those which had come into operation, even partially, prior to March 1961 (designated as category B in paragraph 1—8) ; and
- (b) others which had not come into operation until March 1961 and are still under construction (designated as category C. 1 in paragraph 1—8).

It may be stated here that works of category B have not, in most cases, reached anywhere near full development; on some of these considerable work has still to be done. Many of the works in category C. 1 have not yet made much progress in construction and are only in a preliminary stage of execution.

13-4 Apart from the new works mentioned above, it was but natural that there should have been some further developments on the works which were already in operation in 1951 and which have been described in the previous chapter. Some of these works were relatively new and had not reached full development by 1951. In any case, there is always some continuing improvement on most old irrigation projects.

Works in operation in 1951

13-5 The average annual irrigation during the ten years ending March 1961 and the average annual diversion by works of category A are shown in Table I of Annexure VIII and Table I of Annexure XII for the Krishna and the Godavari river systems respectively. These Tables also show the average annual irrigation and the average annual diversion in the earlier decade.

13-6. It will be seen from the Tables referred to above, that the withdrawals by the Krishna Delta Canals and the Kurnool Cuddapah Canal were substantially more during the ten years after 1951 than in the ten years preceding 1951*. Similarly, the Tata hydel schemes diverted into the Arabian Sea 42.60 T.M.C. instead of 38.0 T.M.C. in the earlier decade. Some medium schemes in Andhra Pradesh also show an improvement, both in the average annual irrigation and average annual diversion. On other canals, there is no significant change.

13-7 Taken as a whole, the average annual irrigation in the Krishna basin from these works during the ten years ending 1960-61 was 1.66 million acres as against 1.52 million acres in the earlier decade, or an increase in the area irrigated of 140,000 acres. The average annual diversion increased by 34.2 T.M.C.

13-8 On the Godavari river system, the Godavari Delta Canals show an increase in the average annual irrigation of about 50,000 acres with a reduction in the average annual diversion of 21.4 T.M.C. This may be due to an improvement in irrigation delta or to more favourable rainfall conditions.

The Nizamasagar Project, in Andhra Pradesh, shows a substantial increase in the area irrigated and in the average annual diversion; so does the Maner Project. Out of the storage provided by the Gangapur Project (see paragraph 13-15 *infra*), 1.2 T.M.C. is for expansion of irrigation under Godavari Canals. It is anticipated that this supply would result in an additional irrigation of 20,000 acres.

There is no significant improvement on any other canal.

13-9 For the Godavari basin as a whole, there was an increase in the average annual irrigation from these works of about 140,000 acres, with a reduction in the average annual diversion of 14.9 T.M.C.

Works which have come into operation since 1951

13-10 Particulars of all works which have come into operation after March 1951 are given in Annexure IX for the Krishna river system and in Annexure XIII for the Godavari river system. As before, each of the major and medium schemes has been described in detail, individual minor schemes are listed in Table II of the Annexures and district-wise statistics of small tanks and diversions are given in Table III. Tables IV, V and VI give other particulars about minor schemes, small tanks and diversions. Also see Map VI.

Krishna river system

13-11 It will be seen from a study of Annexure IX that the following new major projects came into operation on the Krishna river system :

- (a) *Tungabhadra Project* was taken in hand, in 1945 jointly by the erstwhile Hyderabad State and Madras at a cost of Rs. 68.7 crores. After the

*On the Krishna Delta Canals, partly as a result of the regulated flow provided by the Tungabhadra Dam during the post-monsoon season.

reorganisation of States, this scheme is now a joint scheme between Mysore and Andhra Pradesh and is intended to provide irrigation, annually to an area of 0·67 million acres in Mysore and 0·16 million acres in Andhra Pradesh. The scheme also has an installed capacity of 63,000 kW.

The irrigation part of the scheme came into partial operation in 1953; only 34 per cent of the anticipated annual irrigation had been developed up to 1961. Some irrigation channels are still under construction on the Left Bank Canal.

On the power side, out of a total of seven units, two came into operation in 1957, and two in 1958.

- (b) *Rajolibanda Diversion Scheme*—This is also a joint scheme of Mysore and Andhra Pradesh. It was taken in hand in 1944 at an estimated cost of Rs. 1·63 crores. The revised estimated cost is about Rs. 4·5 crores. The scheme came into operation in 1958 and, although intended to irrigate 93,000 acres, annually, the maximum annual irrigation so far has been 20,000 acres.
- (c) *Musi Project* was taken up in 1953 by the erstwhile Hyderabad State and it came into partial operation in 1957. It is estimated to cost Rs. 2·5 crores (revised estimate) and will irrigate annually 52,600 acres. Until 1961 the area irrigated was only 6,000 acres.
- (d) *Radhanagari Project* was taken up in 1940 by the erstwhile Kolhapur State, which merged in Bombay, now Maharashtra. Estimated to cost Rs. 1·7 crores, irrigation benefits started accruing from 1951-52 and the power, 4 units of 1,200 kW. each were commissioned in 1953-54. The maximum irrigation so far developed is 19,700 acres.
- (e) *Ghod Dam Project* was taken up in 1954 by the former Bombay State at a cost of Rs. 5·0 crores. It came into partial operation in 1958. Against an anticipated annual irrigation of 62,000 acres, the maximum area so far irrigated is 15,000 acres.
- (f) *Ghataprabha Project (Stages I and II)*, now in Mysore, was taken up in 1949 and came into partial operation in 1951. Intended to extend irrigation to an area of 298,000 acres, the maximum irrigation so far developed is only 56,400 acres including 14,400 by the former Gokak Canals. The cost of the project, according to 1960 estimates, is Rs. 18·6 crores. Considerable work on this project has still to be carried out.
- (g) Construction work on the *Bhadra Project*, in Mysore, was taken in hand in 1947 and it came into partial operation in 1957. Designed to irrigate annually 242,000 acres, the area actually irrigated in 1960-61 was 18,000 acres. Bhadra Project will have an installed power capacity of 33,200 kW. Work on the power aspects was started only in 1959. The total cost of the project is Rs. 35·7 crores.

TABLE XXVIII
PARTICULARS OF PROJECTS WHICH HAVE COME INTO OPERATION SINCE 1951
KRISHNA RIVER SYSTEM

| Index number | Name or particulars of schemes | Installed power | Annual irrigation | | Annual diversion | | Estimated cost |
|-----------------------|--------------------------------|-----------------|-------------------|-------------------|------------------|-------------------|-----------------|
| | | | Maximum to-date | Ultimate proposed | Maximum to-date | Ultimate proposed | |
| | | kW. |Acres.... | |T.M.C..... | | (rupees crores) |
| ANDHRA PRADESH | | | | | | | |
| 2B-K.8-A.2/My.3 | Tungabhadra Project . . | 63,000 | 105,400 | 156,900 | 82.6 | 135.2 | 68.7 |
| 3B-K.8-A.3/My.4 | Rajolibanda Diversion Scheme | | 16,400 | 87,000 | 10.4 | 17.1 | 4.5 |
| 5B-K.10-A.5 | Musi Project | | 6,000 | 52,600 | 2.3 | 8.4 | 2.5 |
| | 2 medium schemes . . | | 18,500 | 31,500 | 7.0 | 7.5 | 2.3 |
| | 21 minor schemes . . | | 11,625 | 20,000 | 7.7 | 11.7 | |
| | Small tanks and diversions . | | 34,219 | 50,000 | | | |
| | Total | 63,000 | 192,144 | 398,000 | 110.0 | 179.9 | |
| MAHARASHTRA | | | | | | | |
| 6B-K.1-M.1 | Radhanagari Project . . | 4,800 | 19,700 | 20,000 | 6.5 | 6.5 | 1.7 |
| 7B-K.5-M.2 | Ghod Dam Project . . . | | 15,100 | 62,400 | 0.7 | 8.4 | 5.0 |
| | 3 medium schemes . . . | | 18,300 | 30,600 | 1.8 | 2.7 | 1.7 |
| | 30 minor schemes . . . | | 22,031 | 45,000 | 1.8 | 3.5 | |
| | small tanks and diversions . | | 7,241 | 12,000 | | | |
| | Total | 4,800 | 82,372 | 170,000 | 10.8 | 21.1 | |

MYSORE

| | | | | | | | |
|------------------|------------------------------|------------------------------------|---------|-----------|----------------------|-------|------|
| 11B-K.3-My. 1 | Ghataprabha Project | . . . | 56,400 | 298,000 | 10.0 | 34.8 | 18.6 |
| 2B-K.8-A.2/My.3 | Tungabhadra Project | . . See under Andhra Pradesh | 177,200 | 672,300 | See 2 B-K.8-A.2/My.3 | | |
| 3B-K.8-A.3/My. 4 | Rajolibanda Diversion Scheme | | 3,700 | ₹5,900 | See 3B-K.8-A.3/My. 4 | | |
| 13B-K.8-My.5 | Bhadra Reservoir Project | . 33,200 | 17,900 | 241,600 | 6.7 | 56.8 | 35.7 |
| | 1 medium scheme | . . . | 17,000 | 27,200 | 5.8 | 8.8 | 2.3 |
| | 33 minor schemes | . . . | 25,569 | 50,000 | } 4.3 | 9.3 | |
| | Small tanks and diversions | | 2,657 | 4,000 | | | |
| | Total | . 33,200 | 300,426 | 1,299,000 | 26.8 | 109.7 | |
| | Grand Total | . 101,000 | 574,942 | 1,867,000 | 147.6 | 310.7 | |

13-12 In addition to the major projects described above, there are a number of medium schemes which have been listed in Table I of Annexure IX. These schemes were undertaken between 1947 and 1955 at a total estimated cost of Rs. 6.36 crores. Anticipated to irrigate 89,300 acres annually, the area actually irrigated by these medium schemes in 1961 was 53,800 acres.

13-13 There was also considerable activity on minor schemes and small tanks and diversions. These works generally cost less than Rs. 10 lakhs each and are expected to yield quick results. Anticipated to irrigate annually 181,000 acres the area actually irrigated by these works in 1961 was 103,000 acres.

13-14 The overall position with regard to works which came into operation between April 1951 and March 1961 is given in Table XXVIII.

Schemes with a potential of 1.87 million acres annual irrigation (1.60 million acres by major projects, 0.09 million acres by medium projects and the rest by smaller schemes) have come into operation, some only partially, and the development so far has been only about 30 per cent. Considerable work on most of these schemes still remains to be done.

The power potential created by these works is only 101,000 kW.

These works require a total diversion of 310.7 T.M.C.

The estimated cost of major and medium schemes is Rupees 143.0 crores.

Godavari river system

13-15 It will be seen from a study of Annexure XIII, that the following four major projects have come into operation on the Godavari River system :

- (a) *Machkund Hydro-electric Scheme* is a joint venture of Andhra Pradesh and Orissa. It was taken in hand by the former Madras State and Orissa in the year 1947 at an estimated cost of Rs. 15.67 crores. It has an installed capacity of 114,750 kW. The first unit was switched on in 1955. Andhra Pradesh and Orissa will share the costs and the benefits in 70:30 ratio for 99 years and at 50:50 ratio thereafter.

TABLE XXIX

TABLE XXIX

PARTICULARS OF PROJECTS WHICH HAVE COME INTO OPERATION SINCE 1951

GODAVARI RIVER SYSTEM

| Index number | Name or particulars of schemes | Installed power | Annual irrigation | | Annual diversion | | Estimated cost |
|-----------------------|------------------------------------------|-----------------|-------------------|-------------------|------------------|-------------------|-----------------|
| | | | Maximum to-date | Ultimate proposed | Maximum to-date | Ultimate proposed | |
| | | kW. |acres.... | |T.M.C.... | | (rupees crores) |
| ANDHRA PRADESH | | | | | | | |
| 1B-G.4-A.1) | Nizamsagar Hydro-electric Scheme | 15,000 | | | 35.0 | 55.8 | 2.41 |
| 2B-G.5-A.2 | Kaddam Project . . . | | 5,000 | 85,000 | 1.0 | 16.2 | 6.0 |
| 3B-G.12-A.3/0.1 | Machkund Hydro-electric Scheme | 114,750 | | | 33.2 | 44.2 | 15.7 |
| | 3 minor schemes . . . | | 2,052 | 5,000 | 11.7 | 14.2 | |
| | 1,815 small tanks and diversions | | 67,948 | 80,000 | | | |
| | Total | 129,750 | 75,000 | 170,000 | 12.7 | 30.4 | |
| MADHYA PRADESH | | | | | | | |
| | 3 medium schemes . . . | | 13,400 | 23,800 | 1.5 | 1.8 | 1.0 |
| | 7 minor schemes . . . | | 4,007 | 6,000 | 1.0 | 1.2 | |
| | 36 small tanks and diversions | | 6,680 | 8,000 | | | |
| | Total | .. | 24,087 | 37,800 | 2.5 | 3.0 | |

MAHARASHTRA

| | | | | | | | |
|-------------------|--------------------------------|-----------|---------------|---------------|------------|------------|-----|
| 7D-G.1-M.1 | Gangapur Project . . | | 5,200 | 44,000 | 1.4 | 7.4 | 4.9 |
| | 1 medium scheme . . | | 6,100 | 7,500 | 0.4 | 0.5 | 0.5 |
| | 7 minor schemes . . | | 858 | 5,000 | } 0.3 | 0.6 | |
| | 105 small tanks and diversions | | 4,711 | 6,000 | | | |
| | Total | .. | 16,859 | 62,500 | 2.1 | 8.5 | |

MYSORE

Nil

ORISSA

| | | | | | | | |
|------------------------|------------------------------------|----------------|----------------|----------------|--------------------|-------------|--|
| 3D-G.12-A.3/0.1 | Machkund Hydro-electric Scheme . . | | | | See 3B-G.1-A.3/0.1 | | |
| | 5 minor schemes . . | | 4,261 | 4,261 | } 1.5 | 1.5 | |
| | 116 small tanks and diversions | .. | 13,679 | 13,679 | | | |
| | Total | .. | 17,940 | 17,940 | 1.5 | 1.5 | |
| | Grand Total | 129,750 | 133,896 | 288,240 | 18.8 | 43.4 | |

- (b) *Gangapur Project* was taken up by the former Bombay State in 1948-49. The storage provided by the Gangapur Dam is utilised partly on the Godavari Canals at Nandur Madhmeshwar and partly by new canals taking off above the dam. The project came into operation in 1957. Estimated to cost Rs. 4.91 crores, the new canals will irrigate 44,000 acres annually and an additional area of 20,000 acres will be developed on the Godavari canals. In 1961, the area irrigated by the new canals was only 5,200 acres.
- (c) *Kaddam Project* was taken up by the erstwhile Hyderabad State in 1949. The estimated cost is Rs. 6.01 crores (revised). It came into partial operation in July 1955, but the dam breached in 1958. It has since been rebuilt and the project is now anticipated to irrigate 85,000 acres annually. So far, only 5,000 acres have been developed.
- (d) *Nizamsagar Hydro-electric Project* was taken up by the erstwhile Hyderabad State in 1956 to utilise the power potential at the head of the Nizamsagar canal. The installed capacity is 15,000 kW. The scheme came into operation in 1955. It is estimated to cost Rs. 2.40 crores.

13-16 In addition to the major projects described above, there are four medium schemes which have been listed in Table I of Annexure XIII. These schemes were undertaken between 1947 and 1956 at a total estimated cost of Rs. 1.60 crores. Anticipated to irrigate 31,300 acres annually the area actually irrigated by these medium schemes in 1961 was 19,500 acres.

13-17 There was also considerable activity on minor schemes, small tanks and diversions. These works generally cost less than Rs. 10 lakhs each. Anticipated to irrigate annually 127,940 acres, the area actually irrigated by these works in 1961 was 104,196 acres.

13-18 The overall position with regard to works which came into operation between 1951 and March 1961 is given in Table XXIX.

Schemes with a potential of 288,000 acres annual irrigation (129,000 acres by major projects, 31,300 acres by medium projects and the rest by smaller schemes) have come into operation, some only partially, and the development so far has been about 47 per cent. Work on these schemes has been nearly completed.

The power potential created by these schemes is 129,750 kW.

These works require a total diversion of 43.4 T.M.C.

The estimated cost of the major and medium schemes is Rs. 30.6 crores.

Works under construction

13-19 Particulars of all irrigation and hydro-electric schemes under construction which did not come into operation up to March 1961 are given in Annexure X for the Krishna river system and Annexure XIV for the Godavari river

system. As elsewhere, full particulars, to the extent available, have been given for individual major and medium schemes. Minor schemes have been listed in Table II of Annexure X and XIV and district-wise statistics are given for small tanks and diversions in Table III of these Annexures. Also see Map VI.

Krishna river system

13-20 A perusal of Annexure X would show that the following major schemes are at present under construction in the Krishna basin :

- (a) *Nagarjunasagar Project*, in Andhra Pradesh, was taken up in 1956 to provide irrigation to an area of two million acres, annually. Originally estimated to cost Rs. 91.12 crores, the revised estimate now stands at Rs. 139.5 crores. The scheme is expected to come into partial operation in 1965. About 40 per cent of the irrigated area will be outside the Krishna basin.
- (b) *Tungabhadra Project High-level Canal (Stage I)*, was taken up during 1957-58, as a joint project of Andhra Pradesh and Mysore, to provide irrigation, annually, to an area of about 190,000 acres in both States. The scheme does not include any new dam; it depends on the storage at Tungabhadra dam and is expected to come into partial operation in 1963-64. Estimated cost is Rs. 13 crores. About 45 per cent of the irrigated area will be outside the Krishna basin.
- (c) *Tungabhadra Hydro-electric Project (Stage II)*, joint project of Andhra Pradesh and Mysore, provides for an additional installation of 27,000 kW. The project is estimated to cost Rs. 7.7 crores including cost of 30,000 kW. thermal plant at Nellore.
- (d) *The Koyna Hydro-electric Project (Stage I)*, in Maharashtra, was taken up for construction in 1954. Stage II was sanctioned in 1961 and the combined project (Stages I and II) provides for a total installed capacity of 580,000 kW. and is estimated to cost Rs. 52.5 crores. The water supply required is 107.1 T.M.C. of which 67.5 T.M.C. will be diverted outside the Krishna basin into the Arabian Sea and 39.6 T.M.C. will be let into the river Koyna below the Koyna dam. The scheme has come into partial operation in 1962.
- (e) *Khadakwasla Project (Stage I)*, in Maharashtra, was taken up in 1956 at an estimated cost of Rs. 28 crores, to provide irrigation water to a new area of 77,000 acres, annually, and water supply to Poona city. It was expected to come into partial operation in 1962, but because of the failure of the Panset dam, the operation of this project will not begin till 1965 or 1966.
- (f) *Vir Dam Project* in Maharashtra, was taken up in 1956 at an estimated cost of 5.6 crores, to irrigate, annually, an area of 101,000 acres.

TABLE XXX
PARTICULARS OF PROJECTS UNDER CONSTRUCTION
KRISHNA RIVER SYSTEM

| <i>Index number</i> | <i>Name or particulars of scheme</i> | <i>Proposed installed power</i> | <i>Proposed annual irrigation</i> | <i>Proposed annual diversion</i> | <i>Live storage</i> | <i>Annual reservoir losses</i> | <i>Estimated cost</i> |
|-----------------------|--------------------------------------------------|---------------------------------|-----------------------------------|----------------------------------|---------------------|--------------------------------|---------------------------|
| | | <i>kW.</i> | <i>acres</i> | | <i>T.M.C.</i> | | <i>(crores of rupees)</i> |
| ANDHRA PRADESH | | | | | | | |
| 1C.1-K.7-A.1 | Nagarjunasagar Project . | .. | 2,000,000 | 263.6 | 88.0 | 14.0 | 139.5 |
| 2C.1-K.8-A.2/My.3 | Tungabhadra Project High-level Canal—Stage I . | .. | 189,400 | 28.8 | .. | .. | 13.0 |
| 3C.1-K.8-A.3/My.4 | Tungabhadra Hydro-electric Project—Stage II . | 27,000 | .. | .. | .. | .. | 7.7 |
| | 3 minor schemes . . | .. | 6,105 | } 1.2 | | | |
| | 4 small tanks and diversions . . | .. | 1,217 | | | | |
| | Total . . | 27,000 | 2,196,722 | 293.6 | | | |
| MAHARASHTRA | | | | | | | |
| 4C.1-K.1-M.1 | Koyna Hydro-electric Project—Stages I and II . . | 580,000 | .. | 67.5 | 69.0 | 4.5 | 52.5 |
| 5C.1-K. 5-M.2 | Khadakwasla Project—Stage I . . | .. | 77,000 | 17.5 | 14.7 | 0.6 | 23.0 |
| 6C.1-K. 5-M. 3 | Vir Dam Project . . | .. | 101,000 | 14.4 | 9.4 | 0.3 | 5.6 |
| | 4 medium schemes . . | .. | 33,500 | 2.2 | 1.7 | 0.5 | 4.5 |
| | 23 minor schemes . . | .. | 34,142 | } 2.6 | | | |
| | 32 small tanks and diversions . . | .. | 6,081 | | | | |
| | Total . . | 580,000 | 251,723 | 104.2 | | | |

MYSORE

| | | | | | | | |
|--------------------------|--------------------------------------------------------|----|------------------------|------------------|--------------|-----|-----|
| 2C.1-K.8-A.2/My.3 | Tungabhadra High Level Canal Project—Stage I | .. | See 2C.1-K.8-A.2/My. 3 | | | | |
| 3C.1-K.8-A.3/My.4 | Tungabhadra Hydro-electric Project—Stage II | .. | See 3C.1-K.8-A.3/My.4 | | | | |
| | 7 medium schemes | .. | 49,300 | 5.3 | 4.4 | 1.1 | 5.1 |
| | 31 minor schemes | .. | 28,493 | } 5.8 | | | |
| | 120 small tanks and diversions | .. | 22,446 | | | | |
| | Total | .. | 100,239 | 11.1 | | | |
| | Grand Total | | 607,000 | 2,548,684 | 408.9 | | |

13-21 In addition to the major projects described above, 11 medium schemes are under construction. These are estimated to cost Rs. 9·6 crores and provide irrigation to an area of about 83,000 acres, annually.

13-22 Fifty-seven minor schemes (see Table II of Annexure X) are under construction in the Krishna basin and these are expected to provide irrigation to 69,000 acres annually. There are also under construction 156 small tanks and diversions, which will provide irrigation to about 30,000 acres, annually.

13-23 The overall position with regard to projects under construction in the Krishna basin is shown in Table XXX.

It will be seen that these projects are expected to create a potential for annual irrigation of 2·55 million acres, 3·37 million acres by major projects, 83,000 acres by medium projects and the rest by smaller schemes.

The power potential of these projects is 607,000 kW. installed.

The total estimated cost of all the major and medium projects is Rs. 255·9 crores.

The annual diversion by these projects will be 408·9 T.M.C.

Godavari river system

13-24 A perusal of Annexure XIV would show that the following major projects are under construction in the Godavari basins :

- (a) *Upper Sileru Hydro-electric Project—Stage I*, in Andhra Pradesh, undertaken in 1959 for an installed power capacity of 120,000 kW. It will utilise 56·8 T.M.C. of water, which will be let into the river below the power house. The estimated cost is Rs. 6·3 crores.
- (b) *Mula Project*, in Maharashtra, estimated to cost Rs. 15·2 crores (revised), was taken up in 1956. It will provide irrigation, annually, to an area of 231,000 acres. The scheme is expected to come into partial operation in 1967.
- (c) *Purna Project*, in Maharashtra, estimated to cost Rs. 14·5 crores, was taken up in 1957, to provide irrigation to an area of 152,000 acres, annually. It will also have an installed power capacity of 15,000 kW.

13-25 In addition to the major projects described above, there are 19 medium projects under construction in the Godavari river basin. These projects estimated to cost Rs. 13·0 crores, will provide irrigation, annually to an area of 226,000 acres.

13-26 A number of minor schemes, 64 in all, are under construction (see Table II of Annexure XIV). These will irrigate, annually, 98,000 acres.

13-27 The small tanks and diversions under construction, numbering 123, will provide irrigation to 20,000 acres, annually.

13-28 The overall position of projects of various categories under construction in the Godavari basin is shown in Table XXXI.

It will be seen that these projects are expected to create a potential for the annual irrigation of about 728,000 acres, 383,000 acres by major projects, 226,000 acres by medium projects and the rest by smaller schemes.

The power potential of these projects is 135,000 kW.

The total estimated cost of all the major and medium projects is Rupees 49.0 crores.

The annual diversion by these projects will be 93.2 T.M.C.

Overall magnitude of new developments

13-29 It would have been clear from the preceding paragraphs that compared to the total irrigation development up to 1951 from the Krishna and Godavari rivers, the works undertaken since 1951 will create an irrigation potential much more than had been built up to 1951, during the previous 100 years or more. On the other hand, the hydro-electric power potential which will be developed by these works, even though a good deal more than that developed up to 1951, is relatively small.

13-30 The ultimate developments on the river Krishna from the works described in this chapter may briefly be reviewed as follows :

| <i>Category of projects</i> | <i>Power installed</i> | <i>Area to be irrigated annually</i> | <i>Proposed annual diversion</i> | <i>Average delta</i> |
|-----------------------------|------------------------|--------------------------------------|----------------------------------|----------------------|
| | <i>(kW.)</i> | <i>(million acres)</i> | <i>(T.M.C.)</i> | <i>(feet)</i> |
| Andhra Pradesh | | | | |
| B (Table XXVIII) | 63,000 | 0.398 | 179.9 | 3.8 |
| C. 1 (Table XXX) | 27,000 | 2.97 | 293.6 | 3.1 |
| Total | 90,000 | 2.595 | 473.5 | |
| Maharashtra | | | | |
| B (Table XXVIII) | 4,800 | 0.170 | 21.1 | 2.9 |
| C. 1 (Table XXX) | 580,000 | 0.252 | 104.2 | 3.4 |
| Total | 584,800 | 0.422 | 125.3 | |
| Mysore | | | | |
| B (Table XXVIII) | 33,200 | 1.299 | 109.7 | 4.0 |
| C. 1 (Table XXX) | .. | 0.100 | 11.1 | 2.6 |
| Total | 33,200 | 1.399 | 120.8 | |
| Grand Total | 708,000 | 4.416 | 719.6 | |

TABLE XXXI
PARTICULARS OF PROJECTS UNDER CONSTRUCTION
GODAVARI RIVER SYSTEM

| <i>Index number</i> | <i>Name or particulars of scheme</i> | <i>Proposed installed power</i> | <i>Proposed annual irrigation</i> | <i>Proposed annual diversion</i> | <i>Live storage</i> | <i>Annual reservoir losses</i> | <i>Estimated cost</i> |
|-----------------------|---------------------------------------------------|---------------------------------|-----------------------------------|----------------------------------|---------------------|--------------------------------|---------------------------|
| | | <i>kW.</i> | <i>acres</i> | <i>.....T.M.C.</i> | | | <i>(crores of rupees)</i> |
| ANDHRA PRADESH | | | | | | | |
| 3C.1-G.12-A.3 | Upper Sileru Hydro-electric Project—Stage I . . . | 120,000 | .. | 56.8 | .. | .. | 6.3 |
| | 2 medium schemes . . . | .. | 24,500 | 4.1 | 1.3 | 0.5 | 0.8 |
| | 6 minor schemes . . . | .. | 18,050 | } 3.1 | | | |
| | 11 small tanks and diversions . . . | .. | 347 | | | | |
| | Total . . . | 120,000 | 42,897 | 7.2 | | | |
| MADHYA PRADESH | | | | | | | |
| | 2 medium schemes . . . | .. | 20,800 | 1.6 | 1.0 | 0.2 | 1.5 |
| | 4 minor schemes . . . | .. | 1,633 | } 0.7 | | | |
| | 31 small tanks and diversions . . . | .. | 4,937 | | | | |
| | Total . . . | .. | 27,370 | 2.3 | | | |
| MAHARASHTRA | | | | | | | |
| 6C.1-G.2-M.1 | Mula Project . . . | .. | 231,400 | 31.8 | 32.6 | 2.7 | 15.2 |
| 11C.1-G.3-M. 6 | Purna Project . . . | 15,000 | 152,000 | 28.1 | 32.5 | 6.2 | 14.5 |
| | 14 medium schemes . . . | .. | 162,200 | 14.9 | 12.9 | 3.5 | 9.7 |

| | | | | | |
|-------------------------------|---|--------|----------------|---|-------------|
| 30 minor schemes | . | .. | 49,075 | } | 2.6 |
| 50 small tanks and diversions | . | .. | 6,074 | | |
| Total | . | 15,000 | 600,749 | | 77.4 |

MYSORE

Nil

ORISSA

| | | | | | | | |
|-------------------------------|---|---------|----------------|-----|-------------|-----|-----|
| 1 medium scheme | . | .. | 18,600 | 1.3 | 1.0 | 0.2 | 1.0 |
| 24 minor schemes | . | .. | 29,580 | } | 5.0 | | |
| 31 small tanks and diversions | . | .. | 8,364 | | | | |
| Total | . | .. | 56,544 | | 6.3 | | |
| Grand Total | . | 135,000 | 727,560 | | 93.2 | | |

13-31 Compared with Table XXVI it will be seen that the new works are expected to increase the annual irrigation from the Krishna river from 2.30 million acres to 6.72 million acres. Hydro-electric power installed will be increased from 274,000 kW. in 1951 to 982,000 kW. and the annual diversion of river waters from 449.4 T.M.C. to 1,131.0 T.M.C.

13-32 On the Godavari, the ultimate developments from the works described in this Chapter will be as follows :

| <i>Category of projects</i> | <i>Power installed</i> | <i>Area to be irrigated annually</i> | <i>Proposed annual diversion</i> | <i>Average delta</i> |
|-----------------------------|------------------------|--------------------------------------|----------------------------------|----------------------|
| | <i>(kW.)</i> | <i>(million acres)</i> | <i>(T.M.C.)</i> | <i>(feet)</i> |
| Andhra Pradesh | | | | |
| B (Table XXIX) | 129,750 | 0.170 | 30.4 | 4.1 |
| C. 1 (Table XXXI) | 120,000 | 0.043 | 7.2 | 3.8 |
| Total | 249,750 | 0.213 | 37.6 | |
| Madhya Pradesh | | | | |
| B (Table XXIX) | .. | 0.038 | 3.0 | 1.8 |
| C. 1 (Table XXXI) | .. | 0.027 | 2.3 | 2.0 |
| Total | .. | 0.065 | 5.3 | |
| Maharashtra | | | | |
| B (Table XXIX) | .. | 0.062 | 8.5 | 3.2 |
| C. 1 (Table XXX I) | 15,000 | 0.601 | 77.4 | 3.0 |
| Total | 15,000 | 0.663 | 85.9 | |
| Mysore | | | | |
| Nil | | | | |
| Orissa | | | | |
| B (Table XXIX) | .. | 0.018 | 1.5 | 1.9 |
| C. 1 (Table XXXI) | .. | 0.057 | 6.3 | 2.5 |
| Total | .. | 0.075 | 7.8 | |
| Grand Total | 264,750 | 1.016 | 136.6 | |

13-33 Compared with Table XXVII, it will be seen that the new works, are expected to increase the annual irrigation from the Godavari river from 2.74 million acres to 3.76 million acres. Hydro-electric power installed will be increased from nil to about 265,000 kW. and the annual diversion of river waters from 470.6 T.M.C. to 607.2 T.M.C.

13-34 The live storage capacity of major and medium projects described in this Chapter will be 402.9 T.M.C. on the Krishna and 126.2 T.M.C. on the Godavari. Inclusive of works described in Chapter XII, the total live storage capacity of major and medium projects will be 515.2 T.M.C. on the Krishna and 191.1 T.M.C. on the Godavari.

The estimated cost of all major and medium projects included in this Chapter is Rs. 399 crores on the Krishna and Rs. 80 crores on the Godavari.

Reservoir losses

13-35 In addition to the diversions mentioned in paragraphs 13-31 and 13-33, it may be mentioned that the estimated reservoir losses from new major and medium projects will be about 51.4 T.M.C. on the Krishna and 19.1 T.M.C. on the Godavari.

13-36 The losses from minor schemes and small tanks included in this Chapter have been estimated as 37.3 T.M.C. on the Krishna and 32.8 T.M.C. on the Godavari.

Drainage

13-37 No provision for drainage has been made in any of the projects in Andhra Pradesh described in this Chapter. It has been stated that the country is divided into ridges and valleys and no drainage problems exist. In case any difficulties arise after the introduction of irrigation, the problems will be dealt with as they occur.

As regards projects in Madhya Pradesh, it is stated that no water-logging trouble is apprehended and no provision for drainage operations is considered necessary.

With the experience gained earlier (see paragraph 12-33), the Maharashtra Government have issued orders that no water supplies be given for irrigation of crops like sugarcane, plantains, *etc.* which require heavy doses of irrigation, unless detailed scientific soil surveys have been carried out and adequate drainage facilities are found to exist.

With these precautions the State Government hope that no drainage problem would arise ; no provision has, therefore, been made for any drainage work in the Maharashtra projects described in this chapter.

In Mysore, no drainage schemes are proposed in connection with the projects described in this chapter. However, a provision of Rs. 14.3 lakhs exists in the Tungabhadra project for tackling drainage problems, if found necessary.

In Orissa, no drainage problems are anticipated.

Other uses

13-38 The works included in this Chapter make provision for water supply to Poona city, to Sholapur, to Nasik city and to Hyderabad city ; the last named representing a diversion of 2.5 T.M.C. of Godavari waters to Krishna basin. There are no specific provisions for any industrial uses except that it is anticipated that the waters escaping into the Arabian Sea from below the Koyna power-house will be utilised for industries to be set up in that area.

Fisheries are expected to be developed in connection with the Tungabhadra Project and possibly at other new reservoirs.

Change in scope of projects during construction

13-39 On the following three projects, significant changes have been made during construction :—

- (a) On the *Kaddam Project*, in Andhra Pradesh, the area to be irrigated annually has been increased from 75,000 acres to 85,000 acres ; the annual diversion now proposed is 16·2 T.M.C. against 12·0 T.M.C. in the original project.
- (b) On the *Nagarjunasagar Project* (i) the full reservoir level has been raised from R.L. 525 to R.L. 546 and the minimum pond level from R.L. 490 to R.L. 503; (ii) a new canal, the New Krishna West Canal, is proposed to irrigate an area of 150,000 acres adjoining the area irrigated by the Krishna Delta Canals; the canal will take off about 8 miles upstream of the Krishna barrage ; and (iii) all the masonry works on the Left Bank Canal are proposed to be built for 15,000 cusecs instead of 11,000 cusecs; originally the head regulator of the canal and the tunnel only were to be built for 15,000 cusecs.
- (c) On the *Mula Project*, in Maharashtra, the site and type of the dam have been changed, the reservoir capacity has been increased from 20·9 T.M.C. to 32·6 T.M.C. and the area to be irrigated annually from 131,000 acres to 231,400 acres. The increase in annual diversion would be from 26·0 T.M.C. to 31·7 T.M.C.

Exclusive developments

13-40 A study of the particulars of the major and medium projects described in this chapter, as given in Annexures IX and X for the Krishna and Annexures XIII and XIV for the Godavari, would show that, so far as river supplies are concerned, most projects have been planned, and are being executed, as independent units without regard to other projects, existing or proposed, in the basin. Accordingly, each such project assumes for itself the highest priority on all waters reaching the project site and there has been no examination of the hydrologic consequences of its operation on the river system below it.

13-41 The dam at Bhairavanitippa on the Hagari, that at Chincheni on the Ghod, the Vir dam, the Mula dam and the Manar dam do not provide any river sluices. All waters reaching these sites must therefore first fill the reservoirs behind them before any water can escape into the river below. At the Tungabhadra dam, the escape into the river below cannot exceed about 8,000 cusecs until the reservoir first fills up to the crest of the dam. Whether this will or will not adversely affect, at any time, the supplies now available to the canals, existing or proposed, lower down the river has, in most cases, not been examined or studied.

13-42 Exclusive developments can also lead to ineffective use of the potential developed. For example, the Machkund hydro-electric scheme has been letting down a regulated supply of about 1,000 cusecs for the last three years, but there has been no attempt so far to use this perennial supply for development of

irrigation facilities to any new area. There is no project even in III Plan for this purpose. Some advantage may have been taken of this regulated supply for increasing *tabi* paddy on the Godavari Delta Canals, but this is hardly an effective use for a regulated supply from Storage.

Again, a regulated flow of 39·6 T.M.C., which can now be delivered below the Koyna dam, will not be developed for irrigation, for many years.

13-43 In most cases, the small tanks existing in the areas proposed to be covered by new projects will, it is understood, continue to operate and to lose large quantities of water by evaporation.

Main aim of irrigation projects

13-44 All the irrigation projects described in this chapter aim at the conversion of rain-fed cultivation to irrigated agriculture. There are hardly any uncultivated areas which come under the scope of these projects. Thus the benefits from these projects would be the difference between the value of irrigated crops and the value of crops like jowar, millets, cotton, groundnuts, etc., which were or are grown in the project areas prior to introduction of irrigation.

The project reports do not contain the results of any survey of land-use, as existing prior to the introduction of irrigation. The information in this respect given in the Annexures has been furnished by the State Governments on the basis of district-wise or taluk-wise statistics.

13-45 The crop pattern proposed under irrigation varies between different projects. In general, on medium projects in Andhra Pradesh, Madhya Pradesh and Orissa the emphasis is on paddy; in Maharashtra, on sugarcane and other perennial crops; and in Mysore on sugarcane and paddy. For the first time, in these two basins, some of the bigger projects have been designed to cater for a somewhat diversified crop pattern. Full details of the proposals in this respect are given in the Annexures referred to above. As an illustration, the crop pattern proposed for some of the large projects is given below :

| Name of project | Perennial | Kharif | | Rabi | | Hot weather |
|--------------------------------|-----------|--------|-----------|-------|-----------|-------------|
| | | Paddy | Dry crops | Paddy | Dry crops | |
|per cent..... | | | | | | |
| (1) Tungabhadra Project : | | | | | | |
| (a) Left Bank Canal | 8 | 9 | 34 | .. | 49 | .. |
| (b) Right Bank Canal : | | | | | | |
| (i) Mysore | 17 | 10 | 32 | 10 | 31 | .. |
| (ii) Andhra Pradesh | .. | 24 | .. | .. | 76 | .. |
| (2) Vir Dam Project | 11 | .. | 47 | .. | 40 | 2 |
| (3) Ghataprabha Project | 3 | 5 | 45 | .. | 42 | 5 |
| (4) Nagarjunasagar Project : | | | | | | |
| Right Canal | .. | 33 | 67 | .. | .. | .. |
| Left Canal | .. | 65 | 35 | .. | .. | .. |
| New Krishna West Canal | .. | 100 | .. | .. | .. | .. |
| Project as a whole | .. | 52 | 48 | .. | .. | .. |
| (5) Bhadra Reservoir Project : | | | | | | |
| Right Bank Canal | 42 | 33 | 10 | .. | 15 | .. |

13-46. The large percentage of perennial crops and paddy on the Bhadra Reservoir Project may be noted.

There is no valid technical reason why the crop pattern should vary between the three canals on the Nagarjunasagar Project. The stored supply at Nagarjunasagar will be utilised mostly in meeting the requirements of *tabi* paddy during November and December and for releasing 34 T.M.C. of stored water during four months, January to April for *tabi* paddy over 150,000 acres on the Krishna Delta Canals. Originally some *rabi* irrigation had been proposed on the Left Bank Canal but that has since been dropped.

On the Tungabhadra Right Bank Canal which irrigates both in Mysore and Andhra Pradesh, the two States have adopted very different crop patterns.

13-47 The effect of the varying crop pattern is best gauged by a study of the overall delta for each project, or the amount of water in feet of depth that is proposed to be put on the land to be irrigated, measured as at the head of the canal. Average deltas for the projects in each category are shown State-wise in paragraphs 13-30 and 13-32 above. It will be seen that these vary from 2.6 feet to 4.0 feet on the Krishna and 1.8 feet to 4.1 feet on the Godavari.

High costs of projects

13-48 It will be seen from the detailed particulars of the projects that the cost of irrigation development in the Krishna and the Godavari basins is relatively high, varying from about Rs. 500 to Rs. 1,300 per irrigated acre. This high cost is due partly to the hydrologic features of the two river systems, in which 90 to 100 per cent of the river supply runs in six months of the year and the other six months are practically dry, and partly to the physical configuration of the area to be irrigated. Apart from this, the high cost is also attributable to the fact that the waters made available by storage are proposed to be utilised over a relatively small area with high doses of water, or in one season only or the full capacity of the canal is utilised for a few months only.

13-49 The direct financial returns from many projects are accordingly low and the State Governments will have to find large sums of money, from their general revenues, to meet the yearly interest charges on these projects. Of course, these general revenues will have additional receipts because of the indirect benefits from these projects.

Full development many years hence

13-50 It will have been noticed from the brief description in this chapter of some of the major projects (as well as from a study of the particulars of medium projects, given in Annexures IX, X, XIII and XIV) that a number of projects started

many years ago, have not yet been completed and that some of these projects are scheduled to be completed many years hence. Once construction work has been completed, it will take considerable further time to develop irrigation to the extent proposed.

13-51 Considering that, out of a total annual irrigation of 5.43 million acres to be developed by the projects described in this chapter, the area actually irrigated in 1961 was 0.71 million acres or only about 13 per cent of the full potential, it will, obviously, take many years before the potential being created by these works will be fully developed.

CHAPTER XIV

FURTHER DEVELOPMENTS—PROPOSED AND CONTEMPLATED

General

14-1 Under its terms of reference, the Commission was asked to report, *inter alia*, on the requirements of water for projects on the Krishna and the Godavari which were included in the Plans but not yet approved by the Government of India and those which might further be proposed by the States. Accordingly, the Commission requested the State Governments to furnish relevant particulars of all such projects. As stated in paragraph 1-11, such project reports as were available did not contain all the information required by the Commission and for many schemes, no project reports had yet been drawn up.

14-2 The position with regard to future developments varies widely from State to State. In some States, a number of projects have been investigated, others are under investigation; a few of these have already been included in III Plan and a few more are referred to in the Plan but have not yet been finally approved for inclusion in it. In other States, particularly for the areas which previously formed part of *jagirs* or were, prior to 1947, under princely States, studies of the available potential and of the possibility of developing this potential have only recently been taken up from topo-sheets. Not much work has been done in the field. Unfortunately, for some areas in the Godavari basin, even the topo-sheets are not available.

Different States are in different stages of development of their water resources.

14-3 In all, the Commission has received from the State Governments particulars of 81 proposed major and medium projects on the Krishna river system and of 156 such projects on the Godavari. In addition, the State Governments contemplate 92 minor schemes on the Krishna and 632 minor schemes on the Godavari. There will also be a number of small tanks and diversions for which only district-wise particulars have been furnished; some of these may, on investigation, turn out to be large enough to be counted as minor schemes.

14-4 The projects and schemes referred to above have been divided into two categories :

- (a) those which have been referred to in III Plan but have not yet been approved for execution (Category C.2 of paragraph 1-8) ; and
- (b) those not referred to in III Plan and later stages of schemes already sanctioned but for which financial sanction has not yet been accorded (Category C. 3 of paragraph 1-8).

14-5 Apart from new projects, some further developments are also proposed on the projects which were already in operation in 1951 and which have been described in Chapter XII. Some improvements on these projects which had taken place prior to 1961 have already been described in paragraphs 13-5 to 13-9.

New projects on the Krishna

14-6 A list of the major and medium projects referred to in III Plan and which have not yet been approved for execution is given in Table I of Annexure XI and of all other major and medium projects which are contemplated by the State Governments in Table II of the same Annexure. These Tables give the potential to be developed and the proposed annual diversions. Full particulars of each of these schemes; to the extent available, are given in Section 3 of Annexure XI.

14-7 Brief particulars of the minor schemes referred to in III Plan and other minor schemes contemplated are given in Tables III and IV respectively of Annexure XI and the district-wise particulars of small tanks and diversions in Tables V and VI of the same Annexure.

14-8 Some of the important particulars of the projects and schemes referred to above are given in Table XXXII. For multi-purpose projects, where the tail race waters from the power-house will be let into the same river, the quantity so delivered is shown in the Table in *italics*. Where the power-house will be situated in the supply line for an irrigation canal, no separate diversion for power has been shown. If, however, any part of the tail race waters from the irrigation canal is proposed to be let into the river, that quantity is shown in Table XXXII in *italics*.

The overall position, State-wise, is as follows* :—

| <i>Name of State</i> | <i>Proposed power installed</i> | <i>Proposed annual irrigation</i> | <i>Proposed annual diversion</i> | <i>Average delta</i> |
|------------------------|---------------------------------|-----------------------------------|----------------------------------|----------------------|
| | <i>Million (k W)</i> | <i>(Million acres)</i> | <i>(T.M.C.)</i> | <i>(feet)</i> |
| Andhra Pradesh | 1.34 | 6.06 | 1,258.5 | 4.8 |
| Madras | .. | 1.78 | 206.3 | 2.7 |
| Maharashtra | 1.83 | 3.15 | 550.1§ | 2.4 |
| Mysore | .. | 5.11 | 762.5§ | 3.4 |
| Total | 3.17 | 16.10 | 2,777.4§ | |

§ includes supplies proposed to be diverted westward for power generation

14-9 A reference to paragraph 13-31 would show that the developments up to 1951 and those already undertaken since 1951 would create an irrigation potential of 6.72 million acres, annually, and a hydro-electric power installed capacity of 0.982 milion kW. As against these figures, the projects and schemes described in this chapter, if carried out,** would provide an additional annual irrigation potential of 16.10 million acres and additional hydro-electric power installed capacity of 3.17 million kW. To these must be added the small improvements already made and proposed to be made to pre-1951 works.

*See paragraph 14-50.

**See paragraphs 14-50, 15-28 and 15-36 (a)(vi)

TABLE XXXII
PARTICULARS OF PROPOSED PROJECTS
KRISHNA RIVER SYSTEM

| <i>Index Number</i> | <i>Name of Scheme</i> | <i>Proposed power installed</i> | <i>Area proposed to be irrigated</i> | <i>Proposed annual diversion</i> | <i>Proposed live storage</i> | <i>Estimated annual reservoir losses</i> |
|-------------------------------------|---------------------------------------|---------------------------------|--------------------------------------|----------------------------------|------------------------------|------------------------------------------|
| | | kW | acres |T.M.C. | | |
| SCHEMES INCLUDED IN III PLAN | | | | | | |
| ANDHRA PRADESH | | | | | | |
| 1C.2-K.7-A.1 | Srisaïlam Hydro-electric Project. | 330,000 | 220,00 | 243.3 41.3 | 150.0 | 23.0 |
| 2C.2-K..7-A.2 | Nagarjunasagar Hydro-electric Project | 100,000 | | 149.1 | .. | .. |
| | 3 medium schemes | .. | 19,200 | 3.4 | 1.6 | 0.6 |
| | 2 minor schemes | .. | 1,724 | } 2.1 | | |
| | 96 small tanks and diversions | .. | 10,472 | | | |
| | Total | 430,000 | 251,396 | 46.8 | | |
| MAHARASHTRA | | | | | | |
| 6C.2-K.1-M.1 | Koyna Irrigation Schemes—Stage I | .. | 104,200 | 29.4 | .. | .. |
| 8C.2-K.5-M.3 | Bhima Lift Irrigation Project Stage I | .. | 100,000 | 15.4 | 11.4 | 2.2 |
| | 2 medium schemes | .. | 35,000 | 6.2 | 4.5 | 0.9 |
| | 6 minor schemes | .. | 6,244 | } 0.4 | | |
| | 6 small tanks and diversions | .. | 1,445 | | | |
| | Total | | 246,889 | 51.4 | | |

MYSORE

| | | | | | | |
|----------------|------------------------------|-----------|----------------|-------------|------|-----|
| 10C.2-K 4-My.1 | Malaprabha Irrigation Scheme | | 300,000 | 30.9 | 18.9 | 6.1 |
| | Minor schemes | | 10,000 | } 2.9 | | |
| | Small tanks and diversions | | 10,000 | | | |
| | Total | | 320,000 | 33.8 | | |

SCHEMES UNDER CONSIDERATION FOR INCLUSION IN III PLAN

MYSORE

| | | | | | | |
|----------------|-------------------------------|-----------|---------|------|------|------|
| 11C.2-K 2-My.2 | Upper Krishna Project—Stage I | | 533,000 | 92.5 | 65.1 | 17.2 |
|----------------|-------------------------------|-----------|---------|------|------|------|

SCHEMES ON WHICH A VIEW HAS YET TO BE TAKEN REGARDING THEIR INCLUSION IN- III PLAN

ANDHRA PRADESH

| | | | | | | |
|--|------------------|-----------|--------|-----|-----|-----|
| | 3 medium schemes | | 35,000 | 5.7 | 2.1 | 0.3 |
|--|------------------|-----------|--------|-----|-----|-----|

MAHARASHTRA

| | | | | | | |
|---------------|-----------------------|-----------|---------|------|-----|-----|
| 16C.2-K.5-M.6 | Kukdi Project—Stage I | | 122,800 | 17.4 | 4.7 | 0.7 |
| | 1 medium scheme | | 9,700 | 2.9 | 3.4 | 0.5 |

| | | | | | | |
|--|--------------|-----------|----------------|-------------|--|--|
| | Total | | 132,500 | 20.3 | | |
|--|--------------|-----------|----------------|-------------|--|--|

TABLE XXXII (Contd.)
PARTICULARS OF PROPOSED PROJECTS
KRISHNA RIVER SYSTEM

| <i>Index number</i> | <i>Name of scheme</i> | <i>Proposed power installed</i> | <i>Area proposed to be irrigated</i> | <i>Proposed annual diversion</i> | <i>Proposed live storage</i> | <i>Estimated annual reservoir losses</i> |
|--------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------|--------------------------------------|----------------------------------|------------------------------|------------------------------------------|
| | | kW | acres | | T.M.C. | |
| SCHEMES NOT REFERRED TO IN III PLAN | | | | | | |
| ANDHRA PRADESH | | | | | | |
| 1C 3-k 2-A 1 | Upper Krishna Project | .. | 180,000 | 54.4 | .. | .. |
| | (Extension to Andhra Pradesh) | | | | | |
| 2C. 3-K. 7-A. 2 | Sangameshwaram Canal Scheme | .. | 358,500 | 40.9 | .. | .. |
| 3C. 3-K. 7-A. 3 | Sangameshshwarm Canal Schemes—Stage II | .. | 720,000 | 120.0 | 118.4 | 11.9 |
| 4C. 3-K. 7-A. 4 | Nagarjunasagar Project—Stage II | 740,000 | 1,226,000 | 144.9 | 64.0 | 2.0 |
| | | | | 194.4 | | |
| 5C. 3-K. 7-A. 5 | Pulichintala Project | 120,000 | 391,000 | 73.0 | 116.6 | 16.0 |
| | | | | 205.4 | | |
| 6C. 3-K. 7-A 6 | Nagarjunasagar Project—Stage III | .. | 2,013,000 | 595.2 | 151.0 | N.A. |
| 7C. 3-K. 6-A. 7 | Bhima Project | .. | 400,000 | 100.7 | 24.6 | 6.6 |
| 9C. 3-K. 8-A. 9 | Tungabhadra Project Left Bank Low Level Canal Extension (into Andhra Pradesh) | .. | 120,000 | 19.2 | .. | .. |
| 10C. 3-K. 8-A. 10/ My. 20 | Tungabhadra Project High Level Canal—Stage II (jointly with Mysore, | .. | 198,600 | 21.2 | .. | .. |
| 11C. 3-K. 8-A. 11 | Tungabhadra High Level Canal Power Scheme | 50,000 | .. | 20.9 | .. | .. |
| | 4 medium schemes | .. | 71,200 | 19.8 | 2.4 | 0.6 |
| | 68 minor schemes | .. | 79,014 | 16.8 | | |
| | 265 small tanks and diversions | .. | 21,033 | | | |
| | Total | 910,000 | 5,778,347 | 1,206.1 | | |

| MADRAS | | II | | | | | |
|-------------------|--------------------------------------------|------------------|------------------|--------------|------|------|--|
| 15C. 3-K. 7-Md. 1 | Madras Canal Project | .. | 1,783,000 | 206.3 | N.A. | N.A. | |
| MAHARASHTRA | | | | | | | |
| 16C. 3-K. 1-M. 1 | Dhom Project | .. | 84,500 | 9.9 | 11.0 | 1.0 | |
| 17C. 3-K. 1-M. 2 | Pathkal Project | .. | 153,000 | 20.0 | 9.6 | 1.4 | |
| 18C. 3-K. 1-M. 3 | Venna Project | 7,500 | 25,000 | 3.2 | 5.8 | 0.9 | |
| 20C. 3-K. 1-M. 5 | Koyna Hydro-electric Project—Stage III | 60,000 | .. | .. | .. | .. | |
| 21C. 3-K. 1-M. 6 | Koyna Hydro-electric Project—Stage IV | 400,800 | .. | 50.4 | 32.8 | 4.4 | |
| 22C. 3-K. 1-M. 7 | Koyna Irrigation—Stage | .. | 144,600 | 8.8 | .. | .. | |
| 23C. 3-K. 1-M. 8 | Wang Project | .. | 69,500 | 8.7 | 6.0 | 0.7 | |
| 25C. 3-K. 1-M. 10 | Patharpunj Project | 30,000 | 6,000 | 3.6 | 3.3 | 0.4 | |
| 26C. 3-K. 1-M. 11 | Khujgaon Project | .. | 246,800 | 28.0 | 25.8 | 5.3 | |
| 27C. 3-K. 1-M. 12 | Gothana Project | 25,000 | 2,000 | 2.7 | 2.5 | 0.2 | |
| 28C. 3-K. 1-M. 13 | Kadvi Project | 132,000 | 10,000 | 24.0 | 24.0 | 4.0 | |
| 29C. 3-K. 1-M. 14 | Kasari Project | 367,000 | 4,000 | 48.9 | 43.4 | 5.3 | |
| 30C. 3-K. 1-M. 15 | Phonda Project | 70,000 | 64,000 | 12.6 | 5.8 | 0.4 | |
| 31C. 3-K. 1-M. 16 | Khumbni Project | 290,300 | 5,000 | 33.9 | 29.7 | 3.1 | |
| 32C. 3-K. 1-M. 17 | Dudhganga Project | 13,000 | 190,000 | 22.1 | 20.8 | 2.3 | |
| 33C. 3-K. 1-M. 18 | Vedganga Project | 100,000 | 17,000 | 15.2 | 14.8 | 2.9 | |
| 34C. 3-K. 3-M. 19 | Ajra Project | 262,500 | 8,000 | 30.5 | 26.2 | 2.7 | |
| 35C. 3-K. 5-M. 20 | Chaskaman Project | .. | 115,000 | 12.4 | 10.3 | 1.0 | |
| 36C. 3-K. 5-M. 21 | Bhima Lift Irrigation Project—Stage II | .. | 252,000 | 26.9 | 14.4 | 2.4 | |
| 37C. 3-K. 5-M. 22 | Velholi Hydel Scheme | 30,000 | .. | 4.7 | 5.0 | 0.5 | |
| 38C. 3-K. 5-M. 23 | Khadakwasla Project—Stage II | .. | 85,600 | 14.0 | 9.3 | 0.6 | |
| 39C. 3-K. 5-M. 24 | Poona City Water Supply and Power Projects | 13,500 | .. | 21.1 | 6.5 | 0.4 | |
| 40C. 3-K. 5-M. 25 | Kukdi Project—Stage II | .. | 184,600 | 22.1 | 29.1 | 2.6 | |
| 41C. 3-K. 5-M. 26 | Nira Valley Project | 15,000 | 249,700 | 17.0 | 12.5 | 1.3 | |
| | 4 medium schemes | .. | 100,700 | 10.2 | 12.8 | 1.3 | |
| | 1 minor scheme | .. | 1,165 | | 8.3 | | |
| | 2,199 small tanks and diversions | .. | 755,500 | 48.6 | | | |
| | Total | 1,831,100 | 2,773,665 | 478.4 | | | |

See paragraph 14-50

* comprises 13,57,000 acres of new irrigation and 4,26,000 acres of existing irrigation under medium and minor schemes, based on the north-east monsoon to which supplemental supplies are proposed to be given (see annexure XI)

TABLE XXXII (Concl'd.)
PARTICULARS OF PROPOSED PROJECTS
KRISHNA RIVER SYSTEM

| <i>Index number</i> | <i>Name of scheme</i> | <i>Proposed power installed</i> | <i>Area proposed to be irrigated</i> | <i>Proposed annual diversion</i> | <i>Proposed live storage</i> | <i>Estimated annual reservoir losses</i> |
|--------------------------|------------------------------------------------------------------------|---------------------------------|--------------------------------------|----------------------------------|------------------------------|------------------------------------------|
| | MYSORE | kW | acres |T.M.C..... | | |
| 44C. 3-K. 2-My. 1 | Bijapur Lift Irrigation Scheme | .. | 850,000 | 120.2 | N.A. | N.A. |
| 45C. 3-K. 2-My. 2 | Upper Krishna Project—Stage II | .. | 667,000 | 115.0 | — | .. |
| 47C. 3-K. 3-My. 4 | Ghataprabha Project—Stage III | . | 298,000 | 34.8 | 27.9 | 1.0 |
| 47C. 3-K. 3-My. 4 | Ghataprabha Project—Stage IV | . | 166,000 | 37.1 | N.A. | N.A. |
| 52C. 3-K. 6-My. 9 | Bhima Lift Irrigation Scheme | . | 100,000 | 14.3 | N.A. | N.A. |
| 53C. 3-K. 6-My. 10 | Bhima Irrigation Scheme | .. | 100,000 | 14.3 | N.A. | N.A. |
| 59C. 3-K. 6-My. 16 | Benithora Project | .. | 60,000 | 8.7 | N.A. | N.A. |
| 60C. 3-K. 8-My. 17 | Upper Tungabhadra Project | .. | 210,000 | 31.5 | N.A. | N.A. |
| 61C. 3-K. 8-My. 18 | Tunga Reservoir Project | .. | 250,000 | 37.4 | N.A. | N.A. |
| 10C.3-K. 8-A10/ My 20 | Tungabhadra High Level Canal—Stage II (jointly with Andhra Pradesh) | . | .. | .. | .. | .. |
| | 13 medium schemes | .. | 251,200 | 37.2 | N.A. | N.A. |
| | 15 minor schemes | .. | 27,645 | } 185.75 | | |
| | Small tanks and diversions | .. | 1,272,355 | | | |
| | Total | .. | 4,252,200 | 636.2 | | |

New projects on the Godavari

14-10 A list of the major and medium projects referred to in III Plan and which have not yet been approved for execution is given in Table I of Annexure XV and of all other major and medium projects which are contemplated by the State Governments in Table II of the same Annexure. These Tables give the potential to be developed and the proposed annual diversion. Full particulars of each of these schemes, to the extent available, are given in Section 3 of Annexure XV.

14-11 Brief particulars of the minor schemes referred to in III Plan and other minor schemes contemplated are given in Tables III and IV respectively of Annexure XV and the district-wise particulars of small tanks and diversions in Tables V and VI of the same Annexure.

14-12 Some of the important particulars of the projects and schemes referred to above are given in Table XXXIII. For multi-purpose projects, where the tail race waters from the power-house will be let into the same river, the quantity so delivered is shown in the Table in *italics*. Where the power-house will be situated in the supply line for an irrigation canal, no separate diversion for power has been shown. If, however, any part of the tail race waters from the irrigation canal is proposed to be let into the river, that quantity is shown in Table XXXIII in *italics*.

The overall position, State-wise is as follows :*

| Name of State | Proposed power installed* | Proposed annual irrigation* | Proposed annual diversion* | Average delta |
|----------------|---------------------------|-----------------------------|----------------------------|---------------|
| | million kW. | million acres | T.M.C | feet |
| Andhra Pradesh | 2.12 | 5.26 | 1,137.0 | 5.0 |
| Madhya Pradesh | 1.27 | 4.22 | 402.3 | 2.2 |
| Maharashtra | 0.44 | 5.24 | 471.0 | 2.1 |
| Mysore | .. | 0.16 | 27.9 | 4.0 |
| Orissa | 0.43 | 1.31 | 193.9 | 3.4] |
| Total | 4.26 | 16.19 | 2,232.1 | |

14-13 A reference to paragraph 13-33 would show that the developments up to 1951 and those undertaken since 1951 would create an irrigation potential of 3.76 million acres annually and a hydro-electric power installed capacity of 0.265 million kW. As against these figures, the projects and schemes described in this chapter if carried out,* would provide an additional annual irrigation of 16.19 million acres and additional hydro-electric power installed capacity of 4.26 million kW. To these must be added the small improvements already made and proposed to be made to pre-1951 works.

*See paragraph 14-50 and 15-28.

TABLE XXXIII
PARTICULARS OF PROPOSED PROJECTS
GODAVARI RIVER SYSTEM

| <i>Index number</i> | <i>Name of scheme</i> | <i>Proposed power installed</i> | <i>Proposed annual irrigation</i> | <i>Proposed annual diversion</i> | <i>Proposed live storage</i> | <i>Estimated annual reservoir losses</i> |
|-------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------|------------------------------------------|--------------------------------------|------------------------------------------------------|
| | | kW. | acres | |T.M.C..... | |
| SCHEMES INCLUDED IN III PLAN | | | | | | |
| ANDHRA PRADESH | | | | | | |
| 1C.2-G.5-A.1 | Godavari Canals Project (Pochampad) Stage I | .. | 340,000 | 65.8 | .. | .. |
| 4C.2-G.12-A.4/O-1 | Guntewada/Dalimela Hydro-electric Scheme (dam to be built jointly with Orissa) | 180,000 | .. | 65.5 | 100.0 | 8.6 |
| | 2 medium schemes | .. | 24,200 | 3.6 | 2.8 | 1.1 |
| | Total | 180,000 | 364,200 | 129.4 | | |
| MADHYA PRADESH | | | | | | |
| | 2 medium schemes | .. | 40,500 | 3.0 | 2.7 | 0.1 |
| | 22 minor schemes | .. | 13,901 | } 2.7 | | |
| | 81 small tanks and diversions | .. | 16,700 | | | |
| | Total | .. | 71,101 | 5.7 | | |

MAHARASHTRA

| | | | | | |
|---------------|--------------------------------|---------------|----------------|-------------|-----|
| 8C.2-G.7-M.2 | Penganga Project | 37,500 | 25.2 | 6.0 | 3.6 |
| 10C.2-G.9-M.4 | Bagh River Project | 110,000 | 8.3 | 6.6 | 1.7 |
| 11C.2-G.9-M.5 | Itiadh Project | 134,000 | 12.3 | 16.3 | 3.0 |
| | 3 Medium schemes | 84,900 | 6.6 | 6.3 | 0.9 |
| | 56 Minor schemes | 69,684 | 6.4 | | |
| | 251 Small tanks and diversions | 78,793 | | | |
| | Total | 37,500 | 477,377 | 33.6 | |

MYSORE

| | | | | | |
|--|----------------------------|--------------|------------|--|--|
| | Minor schemes | 1,000 | 0.4 | | |
| | Small tanks and diversions | 1,000 | | | |
| | Total | 2,000 | 0.4 | | |

ORISSA

| | | | | | |
|-------------------|-------------------------------------------------------------------------------------------------|----------------|---------------|------------|--|
| 4C.2-G.12-A.4/O.1 | Balimela/Guntewada Project (Stage I— Power) (dam to be built jointly with Andhra Pradesh) | 240,000 | 65.5 | | |
| | 6 Minor schemes | 4,200 | 0.9 | | |
| | 38 Small tanks and diversions | 6,650 | | | |
| | Total | 240,000 | 10,850 | 0.9 | |

See paragraph 14-50

TABLE XXXIII (Continued)
PARTICULARS OF PROPOSED PROJECTS
GODAVARI RIVER SYSTEM

| <i>Index number</i> | <i>Name of scheme</i> | <i>Proposed power installed</i> | <i>Proposed annual irrigation</i> | <i>Proposed annual diversion</i> | <i>Proposed live storage</i> | <i>Estimated annual reservoir losses</i> |
|------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------|-----------------------------------|----------------------------------|------------------------------|------------------------------------------|
| | | kW. | acres |T.M.C..... | | |
| SCHEMES ON WHICH A VIEW HAS YET TO BE TAKEN REGARDING THEIR INCLUSION IN III PLAN | | | | | | |
| ANDHRA PRADESH | | | | | | |
| | 4 Medium schemes | .. | 63,500 | 16.0 | 16.1 | 3.6 |
| | 2 Minor schemes | .. | [4,750 | 0.8 | | |
| | Total | .. | 68,250 | 16.8 | | |
| MAHARASHTRA | | | | | | |
| 17C.2-G.1-M.7] | Karanjwan Project—Stage I | .. | 110,900 | 14.4 | 5.5 | 0.7 |
| 20C.2-G.8-M. 10 | Upper Wardha Project—Stage I | .. | 68,000 | 14.1 | 13.2 | 3.2 |
| 21C.2-G.7-M.11 | Kayadhu Project | .. | 79,800 | 7.2 | 5.6 | 1.5 |
| | 3 Medium schemes | .. | 72,000 | 12.1 | 8.0 | 2.4 |
| | TOTAL | .. | 330,700 | 47.8 | .. | .. |
| SCHEMES NOT REFERRED TO IN III PLAN | | | | | | |
| ANDHRA PRADESH | | | | | | |
| 1C.3-G.5-A.1 | Godavari Canals Project (Pochampad) | .. | | | | |
| | Stage II | .. | 1,593,000 | 229.2 | 100.2 | 18.1 |
| | | 128,500 | | 311.2 | | |
| 2C.3-G.5-A.2 | Godavari Canals Project (Pochampad) | .. | 300,000 | 170.2 | .. | .. |
| | Stage III | .. | | | | |

| | | | | | | |
|-----------------|-----------------------------------------------|------------------|------------------|----------------|-------|------|
| C.3-G.10-A.3 | Inchampalli Project | .. | 450,000 | 110.0 | 390.0 | 66.7 |
| | | 600,000 | .. | 669.4 | | |
| 4C.3-G.10-A.4 | Singareddy Hydro-electric Scheme | 210,000 | .. | 820.7 | N.A. | N.A. |
| 5C.3-G.10-A.5 | Ippur Reservoir Scheme | 420,000 | 1,676,000 | 371.2 | 205.0 | 55.8 |
| | | | | 820.7 | | |
| 7C.3-G.10-A.7 | Providing 6 feet Drumgates to Godavari Anicut | .. | 249,600 | 57.4 | .. | .. |
| 8C.3-G.4-A.8 | Devnoor Hydel Project | 33,000 | .. | 45.0 | 33.7 | 11.9 |
| 11C.3-G.5A.11 | Kuntala Hydro-electric Scheme | 9,000 | .. | 3.9 | 3.3 | 0.70 |
| 12C.3G.6-A.12 | Lower Maner Project | 2,000 | 71,000 | 12.2 | 7.1 | 2.3 |
| 13C.3-G.9-A.13 | Pranhita Project | 300,000 | 250,000 | 57.7 | 110.0 | 27.0 |
| | | | | 455.3 | | |
| 15C.3-G.12-A.15 | Lower Machkund Hydel Project | 30,000 | .. | 46.7 | 3.3 | 0.2 |
| 16C.3-G.12-A.16 | Lower Sileru Hydro-electric Project | 210,000 | .. | 84.4 | 12.9 | 1.2 |
| | 4 Medium schemes | .. | 75,600 | 16.1 | 6.2 | 3.0 |
| | 2 Minor schemes | .. | 156,344 | | | |
| | 75 Small tanks and diversions | .. | 4,168 | | 26.8 | |
| | Total | 1,942,500 | 4,825,722 | 1,050.8 | | |

MADHYA PRADESH

| | | | | | | |
|-----------------|-------------------------|-------|---------|------|------|-----|
| 17C.3-G.8-Ma.1 | Wardha Scheme | 2,000 | 6,300 | 0.5 | 1.8 | 0.4 |
| | | | | 0.5 | | |
| 18C.3-G.9-Ma.2 | Upper Wainganga Project | 7,500 | 178,700 | 19.7 | 18.3 | 2.0 |
| 20C.3-G.9-Ma.4 | Bijna Project | .. | 61,500 | 6.5 | 4.4 | 0.5 |
| 27C.3-G.9-Ma.11 | Uskal Scheme | .. | 6,000 | 0.5 | 1.0 | 0.2 |
| | | 2,000 | | 0.1 | | |

TABLE XXXIII (Continued)
PARTICULARS OF PROPOSED PROJECTS
GODAVARI RIVER SYSTEM

| <i>Index number</i> | <i>Name of scheme</i> | <i>Proposed Power installed</i> | <i>Proposed annual irrigation</i> | <i>Proposed annual diversion</i> | <i>Proposed live storage</i> | <i>Estimated annual reservoir losses</i> |
|---------------------------|---------------------------------------------------|---------------------------------|-----------------------------------|----------------------------------|------------------------------|------------------------------------------|
| | | k.W. | acres |T.M.C..... | | |
| 28C.3-G.9-Ma. 12 | Nahara Hydrel Scheme | 7,700 | 25,000 | 2.9 | 4.8 | 0.7 |
| 31C.3-G.9-Ma. 15 | Deo-Ama Son Scheme | 20,200 | 10,000 | 3.7 | 13.5 | 1.8 |
| 32C.3-G.9-Ma.16/ M. 34 | Bawanthari Project (jointly with Maharashtra) | .. | 134,000 | 12.0 | 12.0 | 2.2 |
| 37C.3-G.9-Ma. 21 | Pench Diversion Scheme | .. | 307,700 | 29.7 | 23.0 | 4.0 |
| 38C.3-G.9-Ma. 22 | Kulbehra Scheme | 27,500 | 9,000 | 0.9 9.8 | 12.0 | 1.7 |
| 40C.3-G.11-Ma.24 | Indravati Hydrel Projects | 541,000 | .. | 189.2 | 411.0 | 37.1 |
| 41C.3-G.11-Ma.25/ M.45 | Bhoopalapatnam Project (jointly with Maharashtra) | 170,000 | 128,000 | 10.0 252.3 | 100.0 | 42.0 |
| 47C.3-G.11-Ma.31 | Boroda-Waler and Upper Nibra Scheme | 53,000 | 22,000 | 2.7 16.3 | 37.4 | 5.4 |
| 48C.3-G.11-Ma.32 | Gudra Hydrel Project | 10,000 | .. | 12.6 | 28.0 | 1.6 |
| 53C.3-G.11-Ma.37 | Berudi Scheme | 15,000 | 10,000 | 1.4 14.2 | 28.0 | 4.4 |

| | | | | | | |
|----------------------------|--------------------------------------------------------|------------------|------------------|--------------|-------|-----|
| 55C.3-G.11-Ma.39/ M. 46 | Kotri-Nibra Hydel Scheme (jointly with Maharashtra) | 93,000 | .. | 63.0 | 80.0 | 8.0 |
| 60C.3-G.11-Ma.44 | Kokral Scheme | 3,000 | 5,000 | 0.5 0.7 | 1.6 | 0.2 |
| 61C.3-G.11-Ma.45 | Jallavagu Scheme | 2,700 | 12,500 | 1.4 0.4 | 2.8 | 0.4 |
| 63C.3-G.10-Ma.47 | Mukpara Scheme | 7,000 | 15,000 | 1.8 1.4 | 7.0 | 1.4 |
| 64C.3-G.10-Ma. 48 | Kormanar Scheme | 1,000 | 4,800 | 0.3 0.4 | 1.1 | 0.2 |
| 67C.3-G.12-Ma. 51 /O12 | Sabari Multipurpose Project (jointly with Orissa) | 250,000 | 1,060,000 | 113.2 | 100.0 | 8.0 |
| 68C. 3-G.12 Ma 52 /O.13 | Konta Project (jointly with Orissa) | 50,000 | 30,000 | 4.0 78.8 | 38.0 | 5.0 |
| 70C.13-G. 12 Ma.54 | Kaklur Mupari Scheme | 7,300 | 20,000 | 2.5 1.5 | 4.6 | 0.4 |
| | 37 medium schemes | .. | 461,000 | 41.2 | 27.7 | 5.4 |
| | 400 minor schemes | .. | 580,660 | } 141.4 | | |
| | 23,050 small tanks and diversions | .. | 1,061,000 | | | |
| | Total | 1,269,900 | 4,148,160 | 396.6 | | |
| MAHARASHTRA | | | | | | |
| 76C.3-G.1-M.1 | Upper Godavari Project | 5,000 | 222,600 | 26.6 | 18.4 | 2.9 |
| 77C.3-G.1-M.2 | Jayakwadi Project—Stage II | .. | 620,300 | 55.8 | 23.3 | 6.6 |
| 80C.3-G.2-M.5 | Pravara River Project | 27,000 | 143,200 | 9.5 9.0 | 6.5 | 1.0 |
| 84C.3-G.3-M.9 | Lower Dudna Project | .. | 123,000 | 12.5 | 2.5 | 0.9 |

TABLE XXXIII (Concluded)
PARTICULARS OF PROPOSED PROJECTS
GODAVARI RIVER SYSTEM

| <i>Index number</i> | <i>Name of scheme</i> | <i>Proposed power installed</i> | <i>Proposed annual irrigation</i> | <i>Proposed annual diversion</i> | <i>Proposed live storage</i> | <i>Estimated annual reservoir losses</i> |
|--------------------------|---------------------------------------------------------------|---------------------------------|-----------------------------------|----------------------------------|------------------------------|------------------------------------------|
| | | kW | acres | | T.M.C..... | |
| 85C.3-G.4-M.10 | Dhanegaon Project | .. | 51,000 | 6.0 | 1.0 | 0.4 |
| 86C.3-G.4-M.11 | Devnoor Project | 33,000 | 53,000 | 9.2 | .. | .. |
| 88C. 3-G.4-M.13 | Lower Tirna Project | .. | 72,900 | 7.3 | 3.9 | 0.9 |
| 89C.3-G.4-M.14 | Lendi Project | .. | 89,000 | 7.5 | 2.1 | 0.4 |
| 92C.3-G.8-M.17 | Bembla Project | .. | 76,000 | 5.1 | 5.3 | 1.3 |
| 94C.3-G.8-M.19 | Lower Wunna Project | .. | 120,000 | 13.6 | 12.1 | 3.3 |
| 98C.3-G.7-M.23 | Dongargaon Project | .. | 98,000 | 8.2 | 17.3 | 2.5 |
| 99C.3-G.7-M.24 | Penganga Irrigation Project | .. | 375,000 | 45.6 | 19.0 | 3.9 |
| 103C.3-G.9-M.28 | Lower Wainganga Project | .. | 240,000 | 19.0 | 14.4 | 1.1 |
| 104C.3-G.9-M.29 | Pranhita Project | 217,000 | .. | 189.9 | 164.9 | 84.8 |
| 107C.3-G.9-M.32 | Kanhan River Project | 36,000 | [331,300 | 38.1 | 32.4 | 2.3 |
| 108C.3-G.9-M.33 | Pench River Project | .. | 232,500 | 21.2 | 38.4 | 5.6 |
| 32C.3-G.9-M.34/ Ma.16 | Bawanthari Project (jointly with Madhya Pradesh) | [66,700 | .. | 23.4 | .. | .. |
| 113C.3-G.9-M.39 | Tultuli Project | .. | 76,000 | 6.3 | 5.7 | 0.8 |
| 115C.3-G.9-M.41 | Kathani Project | .. | 94,000 | 7.8 | 7.7 | 1.0 |
| 118C.3-G.9-M.44 | Andhari Project | .. | 72,000 | 5.6 | 5.3 | 0.8 |

| | | | | | | | | |
|------------------------|-----------------------------------------------------------|----------------|------------------|--------------|------|------|--|--|
| 41C.3-G.11-M.45 /Ma.25 | Bhoopalapatnam Project (jointly with Madhya Pradesh) | | | | | | | |
| 55C.3-G.11-M. 46/Ma.39 | Kotri-Nibra Hydel Scheme (jointly with Madhya Pradesh) | | | | | | | |
| 119C.3-G.11-M.47 | Bandia Hydro-electric Project | 16,000 | . | 24.9 | 21.0 | 3.4 | | |
| | 24 medium schemes | .. | 560,200 | 46.1 | 50.4 | 11.1 | | |
| | 12 minor schemes | .. | 7,260 | } 38.6 | | | | |
| | 1,620 small tanks and diversions | .. | 771,240 | | | | | |
| | Total | 400,700 | 4,429,500 | 389.6 | .. | .. | | |
| MYSORE | | | | | | | | |
| | 3 medium schemes | .. | 63,200 | 8.1 | .. | .. | | |
| | Minor schemes | .. | | | | | | |
| | Small tanks and diversions | .. | 97,000 | 19.4 | .. | .. | | |
| | TOTAL | .. | 160,200 | 27.5 | | | | |
| ORISSA | | | | | | | | |
| 123C.3-G.11-O.1 | Upper Indravati Project | 89,500 | 187,200 | 25.1 | 12.0 | N.A. | | |
| 124.C.3-G.11-O.2 | Indravati-Kolab Project | .. | 408,900 | 63.3 | 12.7 | N.A. | | |
| 126C.3-G.11-O.4 | Bhaskel Project | .. | 61,800 | 8.7 | .. | N.A. | | |
| 132C.3-G.12-O.10 | Upper Kolab Hydel Project | 101,000 | .. | 34.7 | 28.0 | N.A. | | |
| 67C.3-G.12-Ma. 51/o.1 | Sabari Multipurpose Project (jointly with Madhya Pradesh) | .. | .. | .. | .. | .. | | |
| 68C.3-G.12-Ma. 52/o.13 | Konta Project (jointly with Madhya Pradesh) | .. | .. | .. | .. | .. | | |
| 134C.3-G.12-O.14 | Balimela Irrigation Project | .. | 319,200 | 62.8 | .. | .. | | |
| | 7 medium schemes | .. | 130,600 | 17.1 | N.A. | N.A. | | |
| | 3 minor schemes | .. | | | | | | |
| | Small tanks and diversions | .. | 192,000 | | N.A. | N.A. | | |
| | Total | 190,500 | 1,299,700 | 193.0 | | | | |

Reservoir losses

14-14 In addition to the total diversions, shown in paragraphs 14-8 and 14-12 above, the estimated reservoir losses from new major and medium projects, will exceed 136 T.M.C. on the Krishna and 485 T.M.C. on the Godavari. The total live storage capacity of new major and medium works on the Krishna and the Godavari will exceed 1,136 T.M.C. and 2,513 T.M.C. respectively.

14-15 The losses from minor schemes and small tanks included in this chapter have been estimated on the lines explained in paragraph 12-25 and these amount to 293 T.M.C. on the Krishna and 409 T.M.C. on the Godavari against proposed annual diversions of 256.4 T.M.C. on the Krishna and 253.2 T.M.C. on the Godavari. See also paragraph 15-26.

Proposed annual diversions

14-16 It seems necessary to point out here that the annual diversions for different projects described in this chapter (as well as for those described in the preceding two chapters) are as furnished in each case by the State Government in whose territory the project is located.*

14-17 The quantity of water proposed to be diverted for an irrigation canal depends not only on the area proposed to be irrigated but also on the crop pattern adopted. Full particulars, to the extent available, have been given in Section 3 of Annexures XI and XV of the area to be irrigated from each project, the crops proposed to be grown, the duties (acres per mean cusec of water) assumed for each crop and the anticipated diversions month by month or by crop seasons. It will be seen therefrom that the amount of water, in feet depth of water, proposed to be diverted for each acre to be irrigated (delta) varies widely from project to project. The overall result can be seen from the figures of average delta given in paragraphs 14-8 and 14-12 above. It will be seen that Andhra Pradesh proposes to divert the largest amount of water per acre irrigated, next comes Mysore and then Orissa.

14-18 Obviously, by adopting a different crop pattern on any project, the diversions required can be increased or reduced considerably. For example, much more water is needed by sugarcane than, say, *kharif* paddy and about twice as much water is needed by *kharif* paddy in Andhra Pradesh and Mysore than by say *jowar* and other dry crops in *kharif* in those States. Paddy, in *rabi* (which is an inferior crop than paddy in *kharif* and has a lower yield) needs about twice as much water as paddy in *kharif*. Again, *kharif* paddy in Andhra Pradesh, Maharashtra or Mysore generally needs twice as much water as *kharif* paddy in Madhya Pradesh.

14-19 Little field or experimental data are available of the duties or water requirements, of different crops. The figures adopted for various projects are stated to be based on local experience. While it appears to the Commission that considerable improvement can be effected in these duties, it is difficult to formulate any firm conclusions because these duties vary from place to place, depending on the nature of the soil, the prevailing temperatures, the rainfall during the growing season and, what is equally important, irrigation methods adopted, the habits of the

*During inter-State discussions it was held that the other States were in no way committed to an acceptance of these figures.

cultivators and the use of manure. It is well known that in some places the cultivators over-irrigate even to the extent of reducing the out-turn of crops thereby. This is a subject on which considerable experimental and demonstration work must be done in each region and in each district or part of a district.

14-20 The diversions for irrigation also include an element of losses in irrigation canals and distributaries. These losses are considerable and ordinarily amount, in the case of unlined channels, to about 25 per cent of the total diversion at head of a canal. These losses would, however, be proportionately much more where the canals are proposed to be run with a low-capacity factor for many months. This situation emerges because of the crop pattern adopted on many projects requiring the canals to be run only with a fraction of their capacities for a number of months.

14-21 For power projects the particulars given in Section 3 of Annexures XI and XV show the quantity of water proposed to be used for generation of power by months or by seasons. Except in projects described in paragraphs 14-22 and 14-23 below, this use does not represent a diversion. As stated in paragraphs 14-8 and 14-12 above, the quantity of the water to be let down into the river below the power house has been shown in *italics* in Tables XXXII and XXXIII. This water may be picked up by another project lower down either for further generation of power or for irrigation.

14-22 There are a number of hydro-electric projects on the Krishna river system which involve the diversion of Krishna waters outside the basin. These diversions are shown in Tables XXXII and XXXIII in the same manner as for irrigation and as are follows:

| <i>Index number</i> | <i>Name of scheme</i> | <i>Installed power</i> | <i>Annual diversion</i> |
|---------------------|----------------------------------------|------------------------|-------------------------|
| | | kW. | T.M.C. |
| 21 C.3-K. 1-M.6 | Koyna Hydro-electric Project—Stage IV. | 319,000* | 50.4 |
| 25 C.3 K. 1-M.10 | Patharpunj Project | 30,000 | 3.6 |
| 27 C.3 K. 1- M.12 | Gothana Project | 25,000 | 2.7 |
| 28 C.3 K. 1- M.13 | Kadvi Project | 132,000 | 24.0 |
| 29 C.3 K. 1-M.14 | Kasari Project | 367,000 | 48.9 |
| 30 C.3 K. 1 M.15 | Phonda Project | 70,000 | 12.6 |
| 31 C.3 K. 1 M.16 | Kumbhi Project | 290,000 | 33.9 |
| 33 C.3K. 1 M.18 | Vedganga Project | 100,000 | 15.2 |
| 34 C.3- K. 3-M.19 | Ajra Project | 262,500 | 30.5 |
| 37 C.3 K. 5-M.22 | Velholi Project | 30,000 | 4.7 |
| | Total | 697,500 | 226.5 |

* Additional installed capacity for westward diversion.

According to the information furnished, a small part of the tail race waters from each of the projects mentioned above will be used for developing irrigation in the west coast areas, for water supply to towns and villages and for industrial purposes.

14-23 The Upper Indravati Project (I23C.3-G.11-O.I) will divert 25·1 T.M.C. of water into the Mahanadi basin for an installed power capacity of 89,500 kW. The tail race waters are proposed to be used wholly for irrigation.

14-24 Some of the irrigation projects also aim at utilising the Krishna and the Godavari waters outside their drainage basins. These include

(a) *From the Krishna*

- (i) Nagarjunasagar Project—Stage II (Andhra Pradesh): about fifty per cent of the additional irrigation on the Left Bank Canal and 100 per cent of the additional irrigation on the Right Bank Canal would be outside the Krishna drainage basin.
- (ii) Pulichintala Project (Andhra Pradesh) : about 44 per cent of the irrigation would be outside the Krishna drainage basin.
- (iii) Tungabhadra High Level Canal—Stage II (Andhra Pradesh) : about 60 per cent of the additional irrigation would be outside the drainage basin of the Krishna.
- (iv) Sangameswaran Canal—Stages I and II (Andhra Pradesh) : all the irrigation would be outside the Krishna drainage basin.
- (v) Madras Canal (Madras) : all the irrigation would be outside the Krishna drainage basin.

(b) *From the Godavari*

- (i) Pochampad Project—Stage II (Andhra Pradesh) : about two-thirds of the additional irrigation would be in the Krishna drainage basin.
- (ii) Ippur Project (Andhra Pradesh): about 4/5th of the irrigation would be outside the Godavari drainage basin.
- (iii) Upper Indravati (Orissa) a power project (see paragraph 14-23); the tail race waters would be used for irrigation in the Mahanadi basin.

14-25 In connection with the projects described above, which would irrigate areas outside the Krishna and Godavari basins the Commission has not made any investigations about the availability of water, if any, from other sources for development of these areas. This did not appear particularly necessary in view of the general hydrologic features and history of water shortage in these areas, the diversions already made of Krishna waters for these areas and various projects mooted in the past for this purpose. In case of the Orissa project, referred to in paragraph 14-24 (b)(iii) above, there should be enough water in the Mahanadi basin but it

has been stated that the forest areas proposed to be developed cannot be commanded from the Mahanadi.

14-26 In connection with the proposal to use Krishna waters for water supply to Madras city, the Commission has examined the proposals, investigated by the Government of Madras, for getting water from sources other than the Krishna and are of the view that, taking all factors into consideration the best and most economical source of water supply for Madras city would be the Krishna.

Other uses

14-27 Of the projects described in this chapter, only two are intended for water supply; one is for water supply to Poona city (39C.3-K.5-M.24) and the other for water supply to Madras city (15C.3-K.7-Md.1). The former requires 3.45 T.M.C. and the latter 15.5 T.M.C. Two other projects Peddavagu (14C.2-G.9-A.6) and Kinnarsani (16C.2-G.10-A.8) provide 1.42 T.M.C. and 4.32 T.M.C. respectively for industrial use. While no other specific projects have been put forward for water supply to other parts of the two basins or for industrial use, the State Governments have stated that, in due course, supplies would be needed for these purposes.

Out of an estimated population of 60 million people in the two basins, about 80 percent live in villages and get their water supply from tanks and wells, etc. It is only for about 20 per cent of the population or for say 12 million people that specific water supply schemes would be necessary; some already exist. Assuming that this population of 12 million would gradually increase to about 20 million, at 40 gallons per head per day, about 50 T.M.C. of water would be required. This will not, however, be all consumptive use. A substantial part will return to the river system through drainage.

Regeneration

14-28 As indicated in paragraph 14-19 above the deltas proposed for different crops are on the high side. It has also been stated in paragraph 14-20 that the diversions for irrigation include an element of losses from irrigation canals and distributaries.

As stated in paragraph 11-26, excessive use of irrigation waters in the field and seepage from canals contribute to ground waters. It has further been stated in paragraph 11-27 that this accretion to ground waters unless withdrawn through wells, would seep into the rivers wherever there is good sub-surface drainage. In the absence of such drainage, this accretion would fill pockets, cause water-logging and call for artificial drainage operations.

14-29 It has also been stated in paragraph 14-20 that the losses from un-lined canals and distributaries may amount to about 25 per cent of the diversion at the head of a canal. A large part of this loss comprises seepage into the ground. As regard seepage from irrigated fields, this would depend on the difference between the water delivered to the fields and the consumptive use by crops.

“Consumptive use has been defined as the sum of the volumes of water used by vegetative growth of a given area in transpiration and building of plant tissue and that evaporated from adjacent soil, snow or intercepted precipitation. It is

the amount of water that is changed from a liquid to a gaseous state within an area because of evaporation and/or transpiration.....the source of the water, whether from natural rainfall, ground water, or surface irrigation, has little effect on the amount required to produce a good yield, providing fertility, disease, insects or other factors are not limiting growth and production. Therefore, the more useable rainfall, the less the need for irrigation. And, even though excess irrigation water is applied, actual consumption remains about the same. The excess either returns to the natural water supply of the basin or is consumed on lands other than those originally irrigated. This explains the great amount of "return flow" which occurs in many of our western river systems....."*

14-30 It would be recalled that most of the areas proposed to be provided with irrigation facilities already bear crops, supported by rain, or are under forests or scrub jungle. Thus the actual depletion from the water supply of the basin by new irrigation projects would be the difference between the consumptive use by irrigated crops and the consumptive use by un-irrigated crops, forests or scrub jungle.

14-31 It is difficult to give any quantitative idea of the difference between the proposed diversion at the head of canal and the net additional consumptive use by irrigated crops. This difference would largely be an accretion to ground waters in the first instance and would later appear as regeneration, except to the extent it is withdrawn through wells and pumps, or is used by crops on, or is lost by evaporation from, areas other than those originally irrigated.

Optimum use of varying river supply

14-32 In view of the large fluctuation in the river supplies available from year to year, the proposed annual diversions in most of the projects described in this chapter and related Annexures XI and XV have been limited, for irrigation projects, to the river flow estimated to be available, on the average, in three years out of four and, for power projects, on the average, in nine years out of ten.

14-33 Provision has been made in the case of some projects for a carry-over storage, largely to keep some water in reserve for use in case of a delay in the onset of the monsoon in the following June. Such a carry-over would be useful, however, only when such delay follows a year of high supply. It will not be of much use when such delay in the onset of monsoon rains follows a low supply year. On the other hand, if the rains break early in a year which follows a high supply year, the carry-over will remain unutilised.

14-34 The procedure described in paragraph 14-32 above would result in a substantial part of the average yield remaining unutilised. Also, since the total yield for any one year will not be known until about the end of September, or of October in some parts of the two basins, it is possible that a project in the upper reaches of a river may, in the early part of the flow season, utilise more water than its due share and leave the lower projects to suffer the consequences.

14-35 This subject was discussed by the Commission with the representatives of the State Governments concerned individually and jointly. At the inter-State meeting in Ootacamund, the general concensus of opinion which emerged was that, to use varying river supplies to best advantage, a limit should be imposed on the acreage of perennial and *kharif* crops on each project and that the supplies left over in the reservoir at the end of the flow season should be used for irrigating a varying area of *rabi* crop, depending on the actual supply available in any year. The exact limit to be placed on the area of the *kharif* crop would have to be determined for each project. It may be desirable to have this area based on a percentage availability of even more than 75 per cent. Such a limit on the sowings during *kharif*, followed by a *rabi* crop utilising the entire balance of the flow available in any year, would do no harm to upper projects; yet make for a maximum use of the water resources as well as their equitable distribution during years of low supply.

Relative merits of various projects

14-36 For a comparative study of the relative merits of various projects described in this chapter, it would be necessary to examine the diversions proposed from the point of view of

- (a) optimum use of water resources ;
- (b) increase in national production per T.M.C. of water diverted ; and
- (c) total benefits from a project as compared with the cost of development.

14-37 From the point of view of optimum use of water resources, the following considerations would be important :

- (a) for power projects,
 - (i) whether the tail race waters are returned to the river below the power-house, thus providing a source of regulated water supply for other uses lower down, *e.g.*, additional power generation, irrigation ;
 - (ii) whether the power-house is situated in the supply line of an irrigation work and the tail race waters are used wholly or partly for irrigation : and
 - (iii) whether after generating power, the tail race waters escape to the sea and the uses to which these can be put are severely limited or only of secondary importance.
- (b) for irrigation projects,
 - (i) whether they require a relatively low irrigation delta or a high irrigation delta;
 - (ii) whether any part of the total diversion for irrigation is likely to return to the river as regeneration, which regeneration can be used lower down ; and

(iii) whether the project is not likely to yield any useful return flow.

14-38 From the point of view of increased national production per T.M.C. of water diverted, the following considerations would be important :

(a) for power projects,

(i) those with a high head will produce more power per T.M.C. of water used than those with a low head ; and

(ii) whether they would produce firm power or seasonal power ;

(b) for irrigation projects, whether they are :

(i) for reclamation of lands which prior to introduction of irrigation do not produce any crops ; or

(ii) for conversion of rain-fed cultivation to irrigated agriculture in areas where a reasonably good un-irrigated crop can ordinarily be obtained year after year ; or

(iii) for conversion of rain-fed cultivation to irrigated agriculture in areas which are subject to "scarcity conditions" (see paragraph 8-22) ; or

(iv) for increasing the intensity of irrigation and cultivation in an area already irrigated or for changing the crop pattern of an irrigated project to another requiring larger quantities of water ; or

(v) for stabilising irrigation in an area already receiving some irrigation supplies which are either inadequate or not timely ; or

(vi) for conversion of forest lands to agricultural lands.

14-39 While every attempt is generally made to work out in detail an estimate of the total costs of development, before a project is sanctioned, little information is available, even for sanctioned projects, of the *total* benefits from a project. The methods now being followed for assessing the benefits from irrigation and power projects are not much different from those followed at the beginning of the present century. Apart from water rates, water cess and the increase in land revenue, on account of the introduction of irrigation, some projects make provision for a betterment levy. It is, however, not clear why a part of the sales tax collected by State Governments on commodities based on irrigated agriculture and a part of the excise duty on tobacco, sugar, cotton textiles, *etc.* based on agricultural produce, largely the result of irrigation projects, should not be regarded as a direct benefit from water resource development projects.

Similarly, there is no reason why an attempt should not be made to study and assess (even though approximately) some of the indirect benefits from irrigation and power projects and take them into account in considering the relative merits of various projects.

Further developments on pre-1951 projects

14-40 The particulars of projects of Category A, as given in Section 3 of Annexures VIII and XII, would show that the following further developments are contemplated on the projects named below :

| <i>Index number</i> | <i>Name of project</i> | <i>Additional irrigation contemplated</i> | <i>Additional diversion</i> |
|---------------------|-----------------------------------------|-------------------------------------------|-----------------------------|
| | Krishna River System | (acres) | (T.M.C.) |
| 1A-K. 7-A. 1 | Krishna Delta Scheme | 156,400 | 4.33 |
| 2A-K. 8-A. 2 | Kurnool Cuddapah Canal System | 170,000 | 5.27 |
| 3A-K. 7 -A. 3 | Dindi Project | 4,800 | 1.62 |
| 4A- K. 11-A. 4 | Palair Project | 2,100 | 0.19 |
| 5A-K. 12-A. 5 | Pakhal Lake | 1,100 | 0.16 |
| 6A- K. 12-A. 6 | Muneru System | 5,100 | 0.41 |
| 7A-K. 12-A. 7 | Wyra Project | 6,100 | 0.23 |
| 21A-K. 8-My. 3 | Anjanapur Reservoir | 1,500 | 0.31 |
| | Total | 348,500 | 12.60 |
| | Godavari River System | | |
| 1A-G. 5-A. 1 | Khanapur Channel | 7,200 | 1.33 |
| 3A-G. 4-A. 3 | Fateh Nehar | 1,000 | —0.15 |
| 4A-G. 4-A. 4 | Mahbub Nehar | 3,700 | —0.91 |
| 5A- G. 4-A. 5 | Nizamsagar Project | 109,400 | 13.65 |
| 6A-G. 4-A. 6 | Pocharam Project | 1,500 | 0.83 |
| 7A-G. 6-A. 7 | Manair Project | 5,900 | 0.88 |
| 8A-G. 10-A. 8 | Laknawaram Lake | 3,300 | 0.10 |
| 10A- G. 9-Ma. 2 | Roomal Tank | 1,100 | 0.05 |
| 11A-G. 9-Ma. 3 | Chichbund Tank | 900 | 0.04 |
| 12A-G. 9-Ma. 4 | Bori Tank | 2,100 | 0.30 |
| 13A-G. 9-Ma. 5 | Moorum Nalla Tank | 1,700 | 0.22 |
| 14A-G. 9-Ma. 6 | Sarathi Tank | 2,100 | 0.33 |
| 15A-G. 9-Ma. 7 | Jamunia Tank | 1,000 | 0.05 |
| | Total | 140,900 | 16.72 |

These developments may not involve much additional expense but would need to be examined in the light of the consideration set out in paragraphs 14-37 and 14-38 above.

Nature of the proposals for new works

14-41 As indicated in paragraph 14-2 above, the projects described in this chapter are in different stages of investigation and consideration. Field investigations have been, or are being, carried out for a relatively small number of projects. There are many projects which are based on a preliminary reconnaissance of the project site and topo-sheet studies while quite a large number are based merely on topo-sheet studies. The proposals, as submitted to the Commission, must therefore be regarded, in many cases, as of a preliminary nature and subject to considerable modification when the detailed investigations are carried out. Even though the State Governments seem to have put forward all likely projects, the Commission would not rule out the possibility of some other schemes being found necessary or feasible in due course.

14-42 It would be obvious that the engineering and economic feasibility of most of the projects have yet to be established. For the engineering feasibility considerable field investigations must first be carried out and the economic feasibility would depend on the circumstances at the time a project is to be undertaken. *Prima facie* some of the projects, which require the construction of dams two or three miles long, with large spillways, to store only one or two T. M. C. of water would not seem to be practical propositions, at least, at this stage.

For some irrigation projects, the Commission is doubtful whether the land would be capable of absorbing the quantity of water which is proposed to be put on it and yet remain healthy. Most projects do not make any provision for drainage works in the wake of irrigation and practically no studies have been carried out to assess the likely effect of irrigation on soil fertility.

On some of the power projects, a relatively large installed capacity has been proposed for "seasonal power" which would be available for about four months only.

14-43 It would not be incorrect to state that, by and large, the projects described in this chapter have been put forward by State Governments on the tacit assumption of unlimited funds being available and each project assuming for itself the highest priority on the available flow at the site of the project.

Joint projects

14-44 A number of projects on the Krishna and Godavari basins have already been sanctioned as joint undertakings of two States. These are the Tungabhadra Project, the Rajolibanda Diversion Scheme, the Tungabhadra Project High Level Canal, Stage I and the Tungabhadra Hydro-electric Project, Stage II between Andhra Pradesh and Mysore and the Machkund Hydro-electric Scheme between Andhra Pradesh and Orissa.

Andhra Pradesh and Orissa have agreed to have a common dam for the Gun-tewada/Balimela Hydro-electric scheme (4C.2-G. 12-A.4/0.1). Also, Andhra Pradesh and Mysore have agreed to co-operate on the Tungabhadra High Level Canal Stage II, when sanctioned.

14-45 According to the information supplied to the Commission, Madhya Pradesh and Maharashtra are willing to co-operate on the Bawanthari Project (32C.3-G. 9 Ma. 16/M. 34), the Bhoopalapatnam Project (41C. 3-G. 11 Ma. 25/M.45) and the Kotri-Nibra Hydel Scheme (55C. 3-G. 11-Ma. 39/M.46.). Similarly, Madhya Pradesh and Orissa are agreeable to undertake jointly the Sabari Multi-purpose Project (67C.3-G. 12-Ma. 51/0.12) and the Konta Project (68C. 3-G. 12-Ma. 52/0. 13).

Assistance needed by one State from another

14-46 A number of projects, though proposed for the benefit of one State, would submerge part of the territory of another. These are

- (a) the Swarna Project (2C. 1-G.5 A. 2) in Andhra Pradesh which would submerge some land in Maharashtra ;
- (b) the Upper Sileru Project of Andhra Pradesh (3C. 1-G. 12-A. 3), which would submerge large areas in Orissa ;
- (c) the Suddavagu Project of Andhra Pradesh (3C. 2-G. 5-A. 3) which would submerge some territory in Maharashtra;
- (d) the Inchampalli Project (3C. 3-G. 10-A. 3) of Andhra Pradesh which would submerge areas also in Maharashtra and Madhya Pradesh ;
- (e) the Ippur Reservoir Scheme (5C. 3-G. 10-A. 5) of Andhra Pradesh which will submerge some areas also in Madhya Pradesh and Orissa;
- (f) the Lower Machkund Project (15C. 3-G. 12-A. 15) and the Lower Sileru Hydro-electric Project (16 C. 3-G. 12-A. 16) which submerge areas both in Anhdra Pradesh and Orissa ; and
- (g) the Lower Wainganga Project (103C. 3-G. 9-M. 28) the Kanhan River Project (107C. 3-G. 9-M. 32) the Pench River Project (108C.3-G.9 M. 33) and the Kathani Project (115C.3-G.9 M.41),all of Maharashtra, which will submerge areas in Madhya Pradesh.

There are a number of medium schemes also for the benefit of one State which submerge area in another.

14-47 The schemes mentioned above can be executed only if one State comes to the assistance of the other in acquiring land for the benefit of the other.

Need for inter-State co-operation and adjustments

14-48 A number of projects in different States, as presented to the Commission, impinge on each other. For example, on the Krishna, Maharashtra intends to utilise part of the Koyna storage for Koyna Irrigation Scheme (6C.2-K.1-M.1) whereas Mysore is banking on the same water for use on its Upper Krishna Project Stage II (11C.2-K.2-My.2). The Ghataprabha Project of Mysore (11B-K.3-My.1) and the Ajra Project of Maharashtra (34C.3-K.3-M.19) are based on the same waters. The Madras Canal Project (15C.3 K.7-Md.1) should, it is stated, be treated as a part of the Nagarjunasagar Project (1C.1-A.7-A.1). Andhra Pradesh wants the Tungabhadra Low Level Left Bank Canal, which is now entirely in Mysore, to be extended into Andhra Pradesh, the water supply to be obtained from the Tungabhadra river or from the Upper Krishna Project, Stage II. Andhra Pradesh would also like the Upper Krishna Project, Stage I and the Bhima Irrigation Scheme (53C.3-K.6-My.10) to be extended into Andhra Pradesh for the benefit of areas now in Andhra Pradesh.

These projects can fructify only by close co-operation and mutual adjustments between the States concerned.

14-49 On the Godavari, the Bagh River Project of Maharashtra (10C.2-K.9-M.4) and the Bagh Right Bank Branch of Madhya Pradesh (30C.3-A.9-Ma.14) would need to be combined into a joint project. Similarly, the Devnoor Hydro-electric Project (8C.3-G.4-A.8) of Andhra Pradesh has to be combined with Maharashtra's Devnoor Project (86C.3-G.4-M.11); both depend on the same proposed reservoir. So do the Pranhita Project (13C.3-G.9-A.13) of Andhra Pradesh and the lowest of the chain of hydro-electric developments included in Maharashtra's Pranhita Project (104C.3-G.9-M.29).

The Inchampalli Project of Andhra Pradesh (3C.3-G.10-A.3), as proposed, will drown the Bhoopalapatnam Project (41C.3-G.11-Ma.25/M.45). Similarly, the Ippur Reservoir Scheme (5C.3-G.10-A.5) will drown the Konta Project (68C.3-G.12-Ma. 52/O.13). The Penganga Project of Andhra Pradesh (14C.3-G.7-A.14) and the Penganga Irrigation Project of Maharashtra (99C.3-G.7-M.24) depend in part on the same waters.

14-50 The lists of projects given in paragraphs 14-45 to 14-49 above are not exhaustive. There will be various other projects which will have direct inter-State impact.

In view of the position described in paragraphs 14-48 and 14-49 above it may be stated here that the totals of "proposed power installed," of "proposed annual irrigation" and of "proposed annual diversion" as given in Tables XXXII and XXXIII and in paragraphs 14-8 and 14-12, are likely to be substantially more than the practical potentialities of the system. In some cases a part of the area proposed to be irrigated by one project will be submerged by the reservoir proposed for another.

Need for an integrated basin-wide plan

14-51 Apart from the inter-State impacts of various projects, as described in the preceding paragraphs, there is the overall question of the adequacy of the available waters to meet the demands of all the projects, which have been put forward by the State Governments. This question needs to be examined first by sub-basins and this will be done in Chapter XV.

14-52 It may be stated here that there are, in the two basins, wet areas and dry areas and a big range in between. While it is necessary for a proper assessment and accounting of water resources, to study each sub-basin separately, as stated in paragraph 9-64, the overall hydrologic unity of the Krishna basin and of the Godavari basin must be kept in view. Accordingly, it is essential to ensure that no project should at any time reduce, in any way, the waters reasonably required by another. During years and periods within a year of low supplies, it would be important to regulate the river supplies in such manner as to make an equitable distribution of the available waters between all the projects on a river system.

14-53 It would have been noted from the earlier chapters of this report that work of soil conservation, like contour bunding, and withdrawals for irrigation from wells in one part of a river system would affect, to some extent, the river flow and the availability of supplies in other parts. On the other hand, irrigation developments in the upper parts of a river system would yield some return flow which would be available for use lower down.

14-54 Development of water resources on each river must, therefore, be in accordance with a basin-wide plan; new projects must be taken up in accordance with this plan and the actual regulation of supplies must at all times be carried out on an integrated basis, mutually satisfactory to all concerned.

CHAPTER XV

AVAILABILITY OF WATER SUPPLIES IN RELATION TO EXISTING AND CONTEMPLATED USES

Examination by sub-basins necessary

15-1 The Commission's conclusions about the availability of water supplies in the two basins have been set out in paragraphs 9-57 to 9-64. In the three preceding chapters and related Annexures, the water requirements of all projects, existing and proposed, have been described as presented to the Commission by the State Governments concerned.

It has been stated in paragraph 9-64 that the discharge data at Vijayawada and at Dowlashwaram would not, by themselves, be sufficient to determine the adequacy or otherwise of river supplies available at the sites of various projects upstream of these points. It is necessary to consider the question of availability and of the requirements of the projects, as put forward by the State Governments, first by sub-basins. The river flow available in each sub-basin, directly from its own catchment and from other sub-basins above it, has to be compared with the diversions being made and proposed from the sub-basin, together with the evaporation losses from reservoirs and tanks in the sub-basin.

Sub-basin K. 1 Upper Krishna

15-2 (a) *General* : The sub-basin (See Plate XI) comprises the catchment areas of the rivers Koyna, Yerla, Varna, Panchaganga, Dudhganga and that of Krishna from its source to its confluence with Dudhganga. The sub-basin extends over 6,939 square miles and lies mostly in Maharashtra; only a short length of the Dudhganga is in Mysore. The length of the sub-basin along the Western Ghats is 140 miles and the maximum width from west to east is about 70 miles.

Parts of Satara, Sangli and Kolhapur districts of Maharashtra and part of Belgaum district of Mysore lie in the sub-basin.

(b) *Topography and soil* : A major part of the sub-basin lies at an altitude between 3,000 feet and 2,000 feet; the higher reaches in the ghats are at an elevation of about 4,500 feet to 3,000 feet.

The soil in the sub-basin is medium black except along the river valleys where it is medium black to deep black.

(c) *Rainfall* : This sub-basin gets heavy rainfall from the south-west monsoon crossing the Western Ghats. A large part of the sub-basin receives about 3,000 mm to 1,000 mm (118 inches to 39.4 inches) annually. The western end

receives a rainfall of more than 3,000 mm while the catchment on the east of the line joining Kolhapur and Satara, gets only 1,000 mm to 600 mm (39·4 inches to 23·6 inches) annually.

The weighted average annual rainfall is 1,508 mm (59·5 inches).

There are 29 raingauge stations in this sub-basin but relatively few in the south-western part.

(d) *Evaporation* : The mean potential annual evaporation in this sub-basin varies from about 1,088 mm (62·5 inches) to about 2,540 mm (100 inches) ; the average is about 1,814, mm (81 inches).

(e) *River flow* : From the point of view of river flow, this sub-basin is very important as it drains about 140 miles length of the Western *Ghats*. Unfortunately, there are only six sites in this sub-basin for which some reliable data are available. Of these six, Helwak and Jalkewadi are very close to each other and the flow at Dhom is included in that at Khodshi weir. Yeralwadi has a small catchment in the low rainfall area and Radhanagari has a small catchment in a high rainfall area. As will be seen from Plate XI, the distribution of these river gauge stations is unsatisfactory from the point of view of assessing the overall yield of the sub-basin. No data exist for the runoff from the Varna, the Panchganga and the Dudhganga, all draining large areas of the Western Ghats. The useful data available (See Annexure II, Serial numbers 2, 9, 11 and 13) are as follows :

| Site | Catchment area | Weighted average monsoon rainfall | Number of years for calculating average yield | Average annual yield* |
|------------------------|----------------|-----------------------------------|-----------------------------------------------|-----------------------|
| | Square miles | (inches) | | (T.M.C.) |
| Khodshi weir | 1,322 | 42·6 | 12 | 79·7 |
| Jalkewadi | 356 | 128·3 | 12 | 127·7* |
| Yeralwadi | 274 | 15·0 | 12 | 2·9 |
| Radhanagari | 42·5 | 197·0 | 7 | 21·4 |

*Post-monsoon flows are assumed to be nil.

The total yield at Khodshi weir and at Jalkewadi is 207·4 T.M.C. for total area of 1,678 square miles or 124 M. Cft. per square mile. This has been assumed also as the yield from the corresponding part of the sub-basin south of the catchment at Khodshi and Jalkewadi. There is then an area of about 400 square miles in the head-reach of the Varna, Panchganga and Bhogavati where the monsoon rainfall is very much higher than the highest in the Jalkewadi-Khodshi region. The additional yield from this area may be taken as 40 T.M.C.

For the area on the east of the 600 mm isohyet (Map IV) a net yield of 5 M. cft. per square mile may be assumed, even though for Yeralwadi, a yield of about 10.6 M. cft. per square mile has been recorded. Yeralwadi has, however, a small catchment and its yield cannot be applied to a much larger catchment.

Accordingly the average annual yield from the sub-basin works out as follows :

| | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------------------------------------|
| 1,322 square miles above Khodshi weir | 79.7 | T.M.C. (See Annexure II, Serial number 2) |
| 356 square miles above Jalkewadi | 127.7 | T.M.C. (See Annexure II, Serial number 9) |
| 2,244 square miles of high rainfall catchment, west of 600 mm isohyet, at 124 M. cft per square mile | 288.3 | „ |
| Additional yield from the very high rainfall area in the upper reaches of Dudhganga, Panchganga and Varna (400 square miles) | 50.0 | „ |
| Net yield from low rainfall area (ignoring transit losses in the river) 3,017 square miles, east of the 600 mm isohyet at 9 M. cft per square mile | 27.2 | „ |
| TOTAL | 572.9 | T.M.C. |

For a long term average, the yield may be taken as 550 T.M.C.

Some idea of the annual variation in the yield from the sub-basin and its distribution within the year can be had from a study of the flow records at Khodshi and Jalkewadi discharge sites as given in Annexures II and III. However, it has to be noted that a large part of the catchment is in the low rainfall region and that the contribution to flow from this region will be only from rainfalls of relatively high intensities occurring at irregular intervals during the rainy season.

(f) Uses as in 1951 :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-----------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 2 Medium schemes | 9,800 | 1.5 |
| 4 Minor schemes | 2,642 | 0.2 |
| Small tanks and diversions | 665 | .. |
| Estimated evaporation losses from reservoirs and tanks. | .. | 0.5 |
| TOTAL | 13,107 | 2.2 |

(g) Power development:

There were no power projects existing in this sub-basin prior to the year 1951.

(h) Developments since 1951:

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|--------------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(i) Projects in operation</i> | | | |
| Radhanagari Project | 4,800 | 20,000 | 1.1 6.5 |
| 12 Minor schemes. | | 6,394 | 0.4 |
| Small tanks and diversions | | 1,670 | 0.1 |
| <i>(ii) Projects under construction</i> | | | |
| Koyna Hydro-electric Scheme (Stage I and II) | 580,000 | .. | 67.5 39.6 |
| 7 Minor schemes | | 13,813 | 1.5 |
| Small tanks and diversions | | 2,437 | 0.2 |
| <i>(iii) Improvements to existing works</i> | | 1,500 | 0.2 |
| <i>(iv) Estimated evaporation losses from reservoirs and tanks</i> | | | 10.4 |
| TOTAL | 584,800 | 45,814 | 86.8 |

(i) Proposed development :

| <i>Name or particulars of schemes</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Koyna Irrigation Scheme—Stage I (6C. 2-K, 1-M. 1) | .. | 104,200 | 29.4 |
| Dhom Project (16C. 3-K, 1-M. 1) | .. | 84,500 | 9.9 |
| Pathkal Project (17C. 3-K, 1-M. 2) | | 153,000 | 20.0 |
| Verna Project (18C. 3-K, 1-M. 3) | 7,500 | 25,000 | 3.2 |
| Koyna Hydro-electric Project (Stage III) | 60,000 | .. | 67.5 |
| Koyna Hydro-electric Project (Stage IV) (21C. 3-K, 1-M. 6) | 400,800 | .. | 50.4 53.8 |

(i) *Proposed developments—contd.*

| <i>Name or particulars of scheme</i> | <i>Power installed (k W.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|-------------------------------|------------------------------------------|----------------------------------------------------|
| Koyna irrigation scheme—Stage II (22C, 3-K, 1-M. 7) | .. | 144,600 | 8.8 |
| Wang Project (23C, 3-K, 1-M. 8) | .. | 69,500 | 8.7 |
| Patharpunj Project (25C, 3-K, 1-M. 10) | 30,000 | 6,000 | 3.6 |
| Khujgaon Project (26C, 2-K, 1-M, 11) | .. | 246,800 | 28.0 |
| Gothana Project (27C, 3-K, 1-M, 12) | 25,000 | 2,000 | 2.7 |
| Kadvi Project (28C, 3-K, 1-M. 13) | 1,32,000 | 10,000 | 24.0 |
| Kasari Project (29C, 3-K, 1-M. 14) | 3,67,000 | 4,000 | 48.9 |
| Phonda Project (30C, 3-K, 1-M, 15) | 70,000 | 64,000 | 12.6 |
| Kumbhi Project (31C, 3-K, 1-M, 16) | 2,90,300 | 5,000 | 33.9 |
| Dudhganga Project (32C, 3-K, 1-M. 17) | 13,000 | 190,000 | 22.1 |
| Vedganga Project (33C, 3-K, 1-M, 18) | 1,00,000 | 17,000 | 15.2 |
| 4 Medium Schemes | .. | 66,400 | 11.4 |
| Small tanks and diversions | .. | 343,380 | 22.8 |
| Estimated evaporation losses in reservoirs and tanks | .. | .. | 81.2 |
| TOTAL | 14,95,600 | 1,535,380 | 4,36.8 |

15-3 Sub-basin K. 2 Middle Krishna

(a) *General* : The Middle Krishna sub-basin (See plate XII) comprises the catchment area of river Krishna from its confluence with Dudhganga to its confluence with the Bhima and that of all its tributaries outfalling in this reach, except the Ghataprabha and the Malaprabha. It is 6,779 square miles in area and lies mostly in Mysore. Its elevation is from 2,000 feet to 1,000 feet.

A small part of the sub-basin lies in Sangli district of Maharashtra; the rest in Belgaum, Bijapur and Gulbarga districts of Mysore.

(b) *Topography and soil* : The sub-basin is mostly plain country and consists of fertile lands at an altitude of 2,000 feet to 1,000 feet.

The soil in this sub-basin varies from deep black soil to medium black soil.

(c) *Rainfall* : This sub-basin lies in a low rainfall area, 600 mm (23.6 inches) and less per annum. The weighted average annual rainfall is 565 mm (22.1 inches).

There are ten raingauge stations in the sub-basin, mostly in the southern half of the basin; the rainfall of the northern half is not well represented by the existing raingauge stations.

(d) *Evaporation* : The mean potential annual evaporation of the sub-basin varies from about 2,223 mm (87.5 inches) at its western end to about 3,493 mm (138 inches) at the eastern end ; the average is about 2,858 mm (113 inches).

(e) *River flow* : Unfortunately there is not a single reliable discharge site in the sub-basin. The rainfall during the south-west monsoon is less than 400 mm (16 inches). In the absence of recorded discharge data, the river flow in this sub-basin has to be assessed by a comparison of the yield characteristics of this and adjacent sub-basins and by a study of the isohyets, vegetal cover and other conditions existing in the sub-basin.

Taking all factors into consideration, it seems reasonable to assume a net yield of 5 M. Cft. per square mile, ignoring transit losses in the long length of the river. Hence the anticipated direct annual yield from this sub-basin of 6,779 square miles would be 33.9 T.M.C. say 35 T.M.C. This yield will be in the nature of irregular freshets during the rainy season.

The sub-basin will receive the inflow into it from K. 1 Upper Krishna sub-basin, K.3 Ghataprabha sub-basin, K. 4 Malaprabha sub-basin and, at its lower end, from K. 6 Lower Bhima sub-basin.

(f) *Uses as in 1951* :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|--------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 2 Minor schemes | 1,000 | 1.0 |
| Small tanks and diversions | 6,336 | |
| Estimated evaporation losses from reservoirs and tanks | .. | 0.8 |
| TOTAL | 7,336 | 1.8 |

(g) *Development since 1961* :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|--------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) <i>Projects in Operation</i> | | |
| 11 Minor schemes | 5,460 | 0.4 |
| Small tanks and diversions | 1,302 | 0.1 |
| (ii) <i>Projects under construction</i> | | |
| 6 Minor schemes | 10,117 | 1.0 |
| Small tanks and diversions | 4,789 | 0.4 |
| (iii) Estimated evaporation losses from reservoirs and tanks | .. | 2.9 |
| TOTAL | 21,668 | 4.8 |

(h) Power development:

There has so far been no hydro-power development in this sub-basin, nor is any proposed.

(i) Proposed developments :

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Upper Krishna Project Stage I (11C. 2-K. 2-My. 2) | 533,000 | 92.5 |
| Upper Krishna Project (Extension to Andhra Pradesh) (1C. 3-K, 2-A. 1) | 180,000 | 54.4 |
| Bijapur Lift Irrigation Scheme (44C. 3-K. 2-My. 1) | 850,000 | 120.2 |
| Upper Krishna Project Stage II. (45C. 3-K. 2-My. 2) | 667,000 | 115.0 |
| 1 Medium scheme | 25,000 | 2.7 |
| 5 Minor schemes | 8,030 | N.A. |
| Small tanks and diversions | 7,875 | 0.5 |
| Estimated evaporation losses from reservoirs and tanks | .. | 19.3 |
| TOTAL | 2,270,905 | 404.6 |

15-4 Sub-basin K. 3 Ghataprabha

(a) General : The Ghataprabha sub-basin (See plate XIII) extends over 3,409 square miles in area, most of it is in Mysore ; the uppermost part of the basin is in Maharashtra.

Portions of Ratnagiri and Kolhapur districts of Maharashtra and portions of Belgaum and Bijapur districts of Mysore lie in this sub-basin.

(b) Topography and soil : Greater part of the sub-basin has an altitude ranging from 3,000 feet to 2,000 feet ; the upper reaches going up to 4,500 feet ; the *ghat* area has dense and rich forests ;

Medium black soil and deep black soil are the major soil types in the sub-basin.

(c) Rainfall : Most of the rainfall in the basin is during the south-west monsoon period. The rainfall in the *ghat* area of the basin is heavy ranging from 3,500 mm to 1,000 mm (137.8 inches to 39.4 inches) per annum ; the *non-ghat* area receives less than 600 mm (23.6 inches).

The weighted average annual rainfall of the sub-basin is about 921 mm (36.2 inches).

There are seven rainauge stations in this sub-basin.

(d) *Evaporation* : The mean potential evaporation in the sub-basin varies from about 1,088 mm (62.5 inches) to about 3,015 mm (119 inches) ; the average is about 2,052 mm (90 inches).

(e) *River flow* : Of the four sites for which somewhat reliable data are available, Hadalga, Daddi and Ajra are situated in the uppermost part of the catchment and represent only a small part of it.

Since discharges at the fourth site, Dhupdal, include the discharges at the three upper sites, it is proposed to consider the data at Dhupdal for assessing the yield from this sub-basin. The data at Dhupdal (See Annexure II, serial number 16) are available for 23 years.

The catchment area of the river at Dhupdal is 1,080 square miles ; the contribution from the Markandeya catchment and the rest of the sub-basin, 2,329 square miles, is not gauged. The Markandeya catchment is similar in most respects to the catchment above Dhupdal and may be expected to give about the same yield per square mile. The rest of the sub-basin lies in the rain-shadow, has a much lower rainfall than the part above Dhupdal and is relatively flat country. Taking these facts into consideration and the actual or estimated runoff in the adjoining sub-basins, a net runoff of 6.0 M. Cft. per square mile of catchment (ignoring losses in the river channel below Dhupdal) has been assumed for this part of the sub-basin.

Approximate annual yield may now be worked out as follows :

| | | |
|--------------------------------------------------------------------------------------------------------|-------|--------|
| (i) Average annual flow at Dhupdal (1,080 square miles) | 141.0 | T.M.C. |
| (ii) Diversion by existing projects upstream | 0.1 | " |
| (iii) Total of (i) and (ii) | 141.1 | " |
| (iv) Average annual flow from Markandeya catchment (380 square miles @ say 120 M.Cft. per square mile) | 45.6 | " |
| (v) Anticipated net average annual contribution from 1,949 square miles at 6 M. Cft. per square mile | 11.7 | " |
| Total for the sub-basin] | 198.4 | " |
| say | 190 | " |

Some idea of the annual variation in the yield from this sub-basin and its distribution within the year can be had from a study of the flow records at Dhupdal as given Annexures II and III.

(f) Irrigation uses as in 1951:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 1 Medium scheme | 14,400 | 1.4 |
| 5 Minor schemes | 2,791 | 0.3 |
| Small tanks and diversions | 4,171 | 0.4 |
| Estimated evaporation losses from reservoirs and tanks | .. | 0.9 |
| TOTAL | 21,362 | 3.0 |

(g) Developments since 1951 :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Projects in operation | | |
| Ghataprabha Project (11B-K. 3-My. 1) | 298,000 | 34.8 |
| 3 Minor schemes | 2,349 | 0.2 |
| Small tanks and diversions | 543 | 0.05 |
| (ii) Projects under constructions | | |
| 3 Minor schemes | 3,300 | 0.2 |
| Small tanks and diversions | 3,494 | 0.3 |
| (iii) Estimated evaporation losses from reservoirs and tanks. | .. | 3.2 |
| TOTAL | 307,686 | 38.8 |

(h) Power development : There is so far no hydro-electric development in the sub-basin.

(i) *Proposed developments :*

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Ajra Project (34C. 3-K. 3-M. 19) | 262,500 | 8,000 | 30.5 |
| Ghataprabha Project-Stage III (46C. 3-K. 3-My. 3) | ... | 298,000 | 34.8 |
| Ghataprabha Project-Stage IV (47C. 3-K. 3-My. 4) | .. | 166,000 | 37.1 |
| Medium schemes | .. | 11,700 | 2.8 |
| Small tanks and diversions | .. | 29,900 | 2.0 |
| Estimated evaporation losses from reservoirs and tanks. | .. | .. | 9.6 |
| TOTAL | 262,500 | 513,600 | 116.8 |

15-5 Sub-basin K. 4 Malaprabha

(a) *General* : The Malaprabha sub-basin (See plate XIV) comprises the catchment area of the river Malaprabha and all its tributaries. It is 4,459 square miles in extent and is triangular in shape, the apex of the triangle corresponding to the confluence of the Malaprabha with the Krishna.

The sub-basin lies wholly in Mysore, in the districts of Belgaum, Bijapur and Dharwar.

(b) *Topography and soil* : The western part of the Malaprabha basin has an altitude ranging from 3,000 feet to 2,000 feet while the rest of the basin is at about 2,000 to 1,600 feet. The area in Western Ghats is covered with dense forests.

A greater part of the sub-basin is covered with red loamy soil.

(c) *Rainfall* : The catchment of the river in the Western Ghats receives fairly good rainfall of about 1,000 mm and more (40 inches and more) per annum ; the rest of the sub-basin has low rainfall of less than 700 mm (27.6 inches). The weighted average annual rainfall in the sub-basin is about 675 mm (26.6) inches.

There are 11 rainguage stations in the sub-basin.

(d) *Evaporation* : The mean potential evaporation in this basin is about 2,540 mm (100 inches) and it varies from about 1,088 mm (62.5 inches) to about 3,175 mm (125 inches) in the sub-basin.

(e) *River flow* : Fairly reliable discharge data are available for only two sites, viz. Asoga and Kolchi ; Asoga is situated a few miles below the source of the river and hence has a small catchment ; Kolchi is roughly in the middle of the catchment.

The catchment of Malaprabha at Kolchi is 1,140 square miles and the yield from the rest of the sub-basin, 3,319 square miles, is ungauged. In the lower part, the conditions are similar to those described for the lower part of the Ghataparabha catchment and a net run-off of 6 M Cft. per square mile, has been assumed for this part.

Approximate annual yield may be worked out as follows :

| | | |
|---------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------|
| (i) Average annual flow at Kolchi (1,140 square miles) | 55.4 | T.M.C. (See Annexure II, Serial number 23) |
| (ii) Diversion by existing projects upstream of Kolchi | 1.2 | „ |
| (iii) Total of (i) and (ii) | 56.6 | „ |
| (iv) Estimated net average annual contribution from 3,319 square miles catchment below Kolchi @ 6 M. Cft. per square mile | 19.9 | „ |
| Total for the sub-basin | 76.5 | „ |
| | say 70 | T.M.C. |

Some idea of the annual variation in the yield from the sub-basin, and its distribution can be had from a study of the flow records at Kolchi as given in Annexures II and III.

(f) *Irrigation uses as in 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion, or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------|-----------------------------------------------------|
| 3 minor schemes | 1,704 | 0.2 |
| Small tanks and diversions | 34,139 | 4.7 |
| Estimated evaporation losses in reservoirs and tanks | .. | 4.8 |
| Total | 35,843 | 9.7 |

(g) *Development since 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion, or losses (T.M.C.)</i> |
|------------------------------------------------------------|------------------------------------------|-----------------------------------------------------|
| <i>(i) Projects in operation</i> | | |
| 5 Minor schemes | 3,932 | 0.4 |
| Small tanks and diversions | 374 | .. |
| <i>(ii) Projects under construction</i> | | |
| 1 Medium scheme | 10,800 | 0.6 |
| 13 Minor schemes | 10,351 | 1.2 |
| Small tanks and diversions | 4,994 | 0.6 |
| (iii) Estimated evaporation losses in reservoirs and tanks | .. | 2.8 |
| Total | 30,451 | 5.6 |

(h) Power development :

There has so far been no hydro-electric development in the sub-basin, nor is any proposed.

(i) Proposed Developments:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Malaprabha Irrigation Scheme (10C, 2-K, 4-My. 1) | 300,000 | 30.9 |
| 2 Medium schemes | 50,800 | 8.4 |
| Minor schemes | 4,050 | N.A. |
| Small tanks and diversions | N.A. | N.A. |
| Estimated evaporation losses in reservoirs and tanks | | 6.60 |
| Total | 354,850 | 45.9 |

15-6 Sub-basin K.5. Upper Bhima

(a) General : The Upper Bhima sub-basin (See Plate XV) comprises the catchment area of the river Bhima from its source to its confluence with the Sina and that of all its tributaries which fall into it in this reach including the Sina. It is 17,786 square miles in extent and is approximately rectangular in shape.

Except for the southern-most part of the sub-basin, which lies in Mysore, the rest of the sub-basin is in Maharashtra. Parts of Poona, Satara, Ahmednagar, Sholapur, Osmanabad districts of Maharashtra, and part of Bijapur district of Mysore constitute the sub-basin.

(b) Topography and soil : The sub-basin has two distinct zones ; the Western Ghats portion, having an elevation of 4,500 feet to 2,000 feet, and the plains with an elevation of 2,000 feet to 1,000 feet. The hilly zone is covered with thick forests and receives heavy rainfall.

Medium black soil pre-dominates in the sub-basin ; the valley land, along the course of the rivers has deep black soil.

(c) Rainfall : The sub-basin has three distinct rainfall zones ; the western zone having heavy annual precipitation of about 3,000 mm to 1,000 mm (118 inches to 39.4 inches), the middle zone with annual rainfall of less than 600 mm (23.6 inches) and the eastern zone with rainfall of 600 mm to 800 mm (23.6 inches to 31.5 inches) per annum.

The weighted average annual rainfall for the sub-basin is about 676 mm (26.6 inches).

There are 35 rainguage stations in the sub-basin.

(d) *Evaporation* : The mean potential annual evaporation in this sub-basin is high and varies from about 2,223 mm (87.5 inches) at the western end to over 3,810 mm (150 inches) at the other ; the average is about 3,017 mm (119 inches).

(e) *River flow* : There are 10 sites in this sub-basin for which somewhat reliable discharge data are available. All of these are, however, located in the upper parts of the catchments of individual tributaries. Of these, seven sites are located on streams draining the Western Ghats. Chaskaman, Khadakwasla, Wadgaon, Nirgudsar and Vir are situated where the streams emerge from the heavy rain-fall zone, and Mulshi dam and Bhatgarh are higher up in the high rainfall area. The other three sites are in the rain shadow region. All the sites, however, have small catchments.

The data available (See Annexure II serial numbers 35, 34, 25, 32, 33, 42, 39, 37, 44 and 46) for the sites mentioned above are as below :

| <i>Name of site</i> | <i>Number of years for calculating average</i> | <i>Catchment area (square miles)</i> | <i>Average annual yield (T.M.C.)</i> | <i>Yield in M. Cft. per square mile</i> |
|-----------------------|------------------------------------------------|--------------------------------------|--------------------------------------|-----------------------------------------|
| Wadgaon | 12 | 78 | 5.2 | 66.6 |
| Nirgudsar | 21 | 284 | 30.2 | 106.3 |
| Chaskaman | 20 | 140 | 19.2 | 137.1 |
| Mulshi dam | 31 | 96 | 37.0 | 385.5 |
| Khadakwasla | 15 | 196 | 48.9 | 249.5 |
| Bhatgarh | 20 | 128 | 34.0 | 265.6 |
| Vir | 18 | 700 | 93.1 | 133.0 |
| Visapur | 10 | 154 | 1.2 | 7.8 |
| Hatwalan | 21 | 446 | 4.1 | 9.2 |
| Ekrak tank | 17 | 159 | 4.6 | 28.9 |

It will be observed that out of 17,786 square miles, which is the total catchment area of the sub-basin, gauged discharges are available only for 2,381 square miles; for the remaining area, there are no data to rely upon.

It is, however, noticed that the yield per square mile at Vir dam is 133 M.Cft per square mile against 124 M. Cft. per square mile for a large area south of it, represented by Khodshi weir and Jalkewadi in K. 1 Upper Krishna sub-basin (see paragraph 15—2). Bhatgarh is upstream of Vir and has relatively a large run-off. Similarly, Khadakwasla with a small catchment, has a relatively high run-off.

Mulshi dam has a very small catchment; it is in a very high rainfall zone.

There are no discharge sites for the Indrayani system and some other streams on both sides of it. These streams, however, drain a high rainfall area and should have a higher yield than that represented by Vir dam. However, north of this area, which is represented by Chaskaman, Nirgudsar and Wadgaon, the yield is relatively lower.

It would seem, therefore, that for the un-gauged area on the west of the 600 mm isohyet (see Map IV), it would be reasonable to assume a yield of 124 M. Cft. per square mile. For the large area on the east of the 600 mm isohyet, the run-off would be low and with no allowance for transit losses in the long length of the river up to the confluence of the Sina, a yield of 5 M.Cft. per square mile may be adopted.

The run-off from the sub-basin may thus be worked out as follows:

| | | |
|--------------------------------------------------------------------------------------------------------------------------------|-------|--------|
| (i) Total of average annual yields of catchments of Chaskaman, Mulshi dam Khadakwasla, Wadgaon and Bhatghar | 144.3 | T.M.C. |
| (ii) For the remaining catchment of 1,462 square miles, west of the 600 mm isohyet at 124 M. Cft. per square mile | 181.3 | „ |
| (iii) For the catchment area of 15,686 square miles, east of the 600 mm isohyet, at 5 M. Cft. per square mile | 78.4 | „ |
| Total | 404.0 | |
| say | 400 | T.M.C. |

Some idea of the annual variation in the yield from the sub-basin and its distribution within the year can be had from a study of the flow records at the discharge sites mentioned above, as given in Annexures II and III. It has to be borne in mind, however, that a large part of the catchment is in the low rainfall zone and that the contribution to flow from this zone will be only from rainfalls of relatively high intensities occurring at irregular intervals.

(f) *Uses as in 1951:*

| <i>Name or particulars of scheme</i> | <i>Power installed (k W.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------------------|---------------------------------------|------------------------------------------------------|--------------------------------------------------------------------|
| Tata Hydrel Power Supply Scheme | 70,000 | .. | 7.1 |
| Andhra Valley Power Supply Scheme | 72,000 | .. | 9.1 |
| Tata Power Scheme (Mulshi Dam) | 132,000 | .. | 21.8 |
| Nira Canals | 4,000 | 155,100 | 32.0 |
| 5 Medium schemes | .. | 38,400 | 8.4 |
| 15 Minor schemes | .. | 12,319 | 0.7 |
| Small tanks and diversions | .. | 6,646 | 0.8 |
| Estimated evaporation losses in reservoirs and tanks | .. | .. | 9.9 |
| Total | 278,000 | 212,465 | 89.8 |

(g) Development since 1951:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Projects in operation | | |
| Ghod Dam Project (7B-K, 5-M, 2) | 62,400 | 8.4 |
| 3 Medium schemes | 30,600 | 2.7 |
| 13 Minor schemes | 13,094 | 0.8 |
| Small tanks and diversions | 5,087 | 0.3 |
| (ii) Projects under construction | | |
| ·Khadakwasla Project—Stage I (5C.1-K, 5-M, 2) | 77,000 | 17.5 |
| Vir Dam Project (6C. 1-K, 5-M, 3) | 101,000 | 14.4 |
| 3 Medium schemes | 26,200 | 1.7 |
| 12 Minor schemes | 15,979 | 1.0 |
| Small tanks and diversions | 3,308 | 0.2 |
| (iii) Improvements to existing works | .. | 4.4 |
| (iv) Estimated evaporation losses from reservoirs and tanks | .. | 7.2 |
| Total | 334,668 | 58.6 |

(h) Power Developments:

No power project has been taken up since 1951.

(i) Proposed Developments:

| <i>Name or particulars of schemes</i> | <i>Power installed (k.W.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------------|-------------------------------|------------------------------------------|----------------------------------------------------|
| Bhima Lift Irrigation Project—Stage I (8C. 2-K, 5-M, 3) | 100,000 | 15.4 | |
| Kukdi Project—Stage I (16C. 2-K, 5-M, 6) | 122,800 | 17.4 | |
| Chaskaman Project (36C. 3-K, 5-M, 20) | 115,000 | 12.4 | |
| Bhima Lift Irrigation Project—Stage II (36C. 3-K, 5-M, 21) | 252,000 | 26.9 | |

Proposed Developments—(continued)

| <i>Name or particulars of schemes</i> | <i>Power installed (k W.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------------------------|-------------------------------|------------------------------------------|----------------------------------------------------|
| Velholi Hydel Scheme (37C. 3-K. 5-M. 22) | 30,000 | .. | 4.7 |
| Khadakwasla Project—Stage II (38C. 3-K. 5-M. 23) | .. | 85,600 | 14.0 |
| Poona City Water supply and power project (39C. 3-K. 5-M. 24) | 13,500 | .. | 21.1 |
| Kukdi Project—Stage II (40C. 3-K. 5-M. 25) | 14,500 | 184,600 | 22.1 |
| Nira Valley Project (41C. 3-K. 5-M. 26) | 15,000 | 249,700 | 17.0 |
| 2 Medium Schemes | .. | 64,000 | 5.6 |
| 7 Minor schemes | .. | 7,409 | 0.4 |
| Small tanks and diversions | .. | 361,827 | 22.6 |
| Estimated evaporation losses from reservoirs and tanks | .. | .. | 49.1 |
| Total | 73,000 | 1,542,936 | 207.6 |

15-7 Sub-basin K. 6 Lower Bhima

(a) *General*: The catchment area of the lower part of the river Bhima from its confluence with the Sina to the point where the Bhima joins the Krishna, and that of all its tributaries which fall into it in this reach constitute this sub-basin. (See plate XVI). It is 9,478 square miles in extent and is fairly rectangular in shape with a length of about 110 miles and a width of about 80 miles.

The upper part of the sub-basin in Maharashtra lies in the districts of Osmanabad, Sholapur and Sangli. Most of the sub-basin lies in the districts of Bidar, Gulbarga and Bijapur of Mysore. The lower part of the sub-basin extends into the districts of Medak, Hyderabad and Mahbubnagar of Andhra Pradesh.

(b) *Topography and soil*: Almost the whole of the sub-basin lies at an altitude of 2,000 feet to 1,000 feet and consists of valleys of several small rivers. The river Bhima flows about mid-way through the basin from west to east.

The greater part of the sub-basin is covered with deep black soil.

(c) *Rainfall*: This sub-basin gets an annual rainfall of about 600 mm to 800 mm (23.6 inches to 31.5 inches), the weighted average annual rainfall for the sub-basin is 661 mm or 26 inches.

There are only nine rain-gauge stations in the sub-basin.

(d) *Evaporation*: The mean potential annual evaporation in this sub-basin is as high as 3,810 mm or 150 inches, the maximum in the Krishna basin.

(e) *River flow*: There is no reliable discharge site in this sub-basin. The sub-basin lies in a low rainfall area; the monsoon rainfall, which contributes to the bulk of the river flow, is only about 400 mm to 600 mm (15·8 inches to 23·6 inches).

In the absence of gauged discharge data in the sub-basin, the run-off can only be estimated by a study of the flow characteristics of this and the adjacent sub-basins and by studying its rainfall distribution, vegetal cover, topography etc.

Taking note of all factors, and ignoring transit losses in the river, the net yield from 9,478 square miles has been assumed as 56·9 T.M.C., at the rate of 6·0 M.Cft. per square mile; say 55 T.M.C.

This sub-basin will receive the inflow into it from K. 5 Upper Bhima sub-basin.

The direct contribution from K. 6 lower Bhima catchment would be subject to wide fluctuations.

(f) *Uses as in 1951*:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 3 minor schemes | 170 } | |
| Small tanks and diversion | 19,130 } | 3·5 |
| Estimated evaporation losses in reservoirs and tanks | .. | 2·7 |
| Total | 19,130 | 6·2 |

(g) *Developments since 1951*:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Projects in operation | | |
| 3 Minor schemes | 172 | 0·14 |
| Small tanks and diversions | 497 | 0·04 |
| (ii) Projects under construction | | |
| 2 Medium schemes | 12,600 | 0·9 |
| 9 Minor schemes | 10,270 | 1·3 |
| Small tanks and diversions | 2,297 | 0·2 |
| (iii) Estimated evaporation losses in reservoirs and tanks | .. | 2·7 |
| Total | 25,836 | 5·3 |

(h) *Power development:* There has so far been no hydro-power development in this sub-basin, nor is any such development proposed.

(i) *Proposed Developments:*

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Bhima Project (7C. 3-K. 6-A. 7) | 400,000 | 100.7 |
| Bhima Lift Irrigation Scheme (52C. 3-K. 6-My. 9) | 100,000 | 14.3 |
| Bhima Irrigation Scheme (53C. 3-K. 6-My. 10) | 100,000 | 14.3 |
| Benithora Project (59C. 3-K. 6-My. 16) | 60,000 | 8.7 |
| 7 Medium schemes | 121,700 | 14.9 |
| 15 Minor schemes | 171,141 | 2.4 |
| Small tanks and diversions | 15,360 | 1.0 |
| Estimated evaporation losses in reservoirs and tanks | .. | 11.7 |
| Total | 814,201 | 168.0 |

15-8 Sub-basin K.7 Lower Krishna

(a) *General:* The Lower Krishna sub-basin (See plate XVII) comprises the catchment of the lower part of the river Krishna from its confluence with the Bhima to the sea; the sub-basin includes the direct catchment of the Krishna in this reach and of all its tributaries which fall into it in this reach except the Tungabhadra, the Musi, the Palleru and the Muneru.

The sub-basin has an area of 13,948 square miles. A large part of Mahbubnagar, parts of Nalgonda, Kurnool, Krishna and Guntur and a portion of Hyderabad district of Andhra Pradesh and a part of Raichur district of Mysore lie in this sub-basin.

(b) *Topography and soil:* The sub-basin may be divided into three parts; the western part in the Deccan Plateau; the central part where the river passes through the Eastern Ghats (a series of parallel ranges covered with thick forests) and the delta.

The valley land along the river has deep black soil; the remaining area has predominantly red sandy soil with a small portion having red and black soils.

(c) *Rainfall:* Most of the rainfall in the sub-basin is during the south-west monsoon but the eastern end gets some showers during the retreating monsoon, October-December. The annual rain-fall increases from the western end of the sub-basin eastwards, from 600 mm to 1,000 mm (23.6 inches to 39.4 inches). The weighted average annual rainfall in the sub-basin is 721 mm or 28.4 inches.

There are 13 rain-gauge stations in this sub-basin.

(d) *Evaporation*: The mean annual potential evaporation from this sub-basin is 2,540 mm or 100 inches.

(e) *River flow*: In this sub-basin there are two sites for which fairly reliable discharge data are available; one is the Siddeshwaram on the Krishna having five years data from 1948-49 to 1952-53 and the other is Vijayawada anicut for which long term data are available.

For purposes of estimating the yield, the sub-basin can be divided into three reaches, namely, the upper reach from the confluence of Bhima with Krishna to Siddeshwaram, a few miles below the confluence of Tungabhadra on the Krishna, the middle reach upto the beginning of the delta, that is upto Vijayawada anicut, and the lower reach below Vijayawada, in other words, the Krishna delta.

Since there is no discharge data recorded in the upper reach, the yield has to be calculated by a study of the yield characteristics of the adjacent basins and by studying the rainfall distribution, vegetal cover, topography etc. Considering all these factors, it appears reasonable to adopt a yield rate of 6 M.Cft. per square mile for this reach.

The average annual flow at Siddeshwaram during the period 1948-49 to 1952-53 is 1,558 T.M.C. (See Annexure II, serial number 6) and that at Vijayawada anicut during the same period is 1,804 T.M.C. (See Annexure II, serial number 8). The difference is 246 T.M.C.; this includes the inflow from Musi, Palleru and Muneru sub-basins as well as the direct yield from Lower Krishna sub-basin. The estimated inflow, from these sub-basins is 31.8 T.M.C.* Deducting this from 246 T.M.C., the estimated inflow between Siddeshwaram and Vijayawada would be 214 T.M.C. Adding the utilisation by and evaporation losses from minor tanks existing in the sub-basin, prior to 1951, the yield would be 234 T.M.C. On a long term basis, the average yield may be taken as 200 T.M.C.

The area below Vijayawada anicut receives higher rainfall. Considering other relevant factors also, a yield of 18 M.Cft. per square mile may be expected in this reach. This has, however, been ignored.

The run-off in this sub-basin, upto Vijayawada would accordingly be as follows:

| | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|-------|--------|
| 4,326 square miles between the confluence of Bhima with Krishna to the confluence of Tungabhadra with Krishna @ 6 M. Cft. per square mile | 17.3 | T.M.C. |
| 8,900 square miles between the confluence of Tungabhadra with Krishna and Vijayawada | 200.0 | „ |
| | 217.3 | „ |
| TOTAL | 217.3 | „ |
| say | 210 | T.M.C. |

The sub-basin will receive the inflow into it from K. 2 Middle Krishna, K. 8 Tungabhadra, K. 10 Musi, K. 11 Palleru and K. 12 Muneru.

*Estimated yield less uses as in 1951, see paragraphs 15-11 (e) and (f), 15-12 (e) and (f) and 15-13 (e) and (f),

(f) Irrigation uses as in 1951:

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Krishna Delta Scheme | 1,119,900 | 186.8 |
| 1 Medium scheme | 7,300 | 2.3 |
| 45 Minor schemes | 43,827 | } 39.0 |
| Small tanks and diversions | 190,000 | |
| Estimated evaporation losses in reservoirs and tanks | .. | 31.8 |
| TOTAL | 1,361,027 | 258.9 |

(g) Developments since 1951:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(i) Projects in operation</i> | | |
| 1 Medium project | 14,500 | 3.4 |
| 10 Minor schemes | 11,869 | } 5.5 |
| Small tanks and diversions | 22,000 | |
| <i>(ii) Projects under construction</i> | | |
| Nagarjunasagar Project (1C. 1-K. 7-A.1) | 2,000,000 | 263.6 |
| 1 Minor scheme | .. | .. |
| Small tanks and diversions | .. | .. |
| <i>(iii) Improvements to existing projects</i> | 106,100 | 23.6 |
| <i>(iv) Estimated evaporation losses in reservoirs and tanks</i> | .. | 19.0 |
| TOTAL | 2,154,469 | 315.1 |

(h) Power Development:

There are no power schemes existing or under construction in the sub-basin.

(i) Proposed Developments:

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Srisaïlam Hydro-electric Project (1C. 2-K. 7-A. 1) | 330,000 | 220,000 | 41.3 243.3 |
| Nagarjunasagar Hydro-electric Project (2C. 2-K. 7-A. 2) | 100,000 | .. | 149.1 |
| Sangameshwaram Canal scheme (2C. 3-K. 7-A. 2). | | 358,500 | 40.9 |
| Sangameshwaram Canal scheme—Stage II (3C. 3-K. 7-A. 3) | | 720,000 | 120.0 |
| Nagarjunasagar Project—Stage II (4C. 3-K. 7-A. 4) | 740,000 | 1,226,000 | 144.9 194.4 |
| Pulichintala Project (5C. 4-K. 7-A. 5) | 120,000 | 391,000 | 73.0 205.4 |
| Nagarjunasagar—Stage III (6C. 3-K. 7-A. 6) | | 2,013,000 | 595.2 |
| Madras Canal Project (15C. 3-K. 7-Md. 1) | | 1,783,000 | 206.3 |
| 3 Medium schemes | | 29,100 | 5.4 |
| 33 Minor schemes | | 39,467 | } 8.3 |
| Small tanks and diversions | | 10,000 | |
| Improvements to existing projects | | 161,200 | 6.0 |
| Estimated evaporation losses in reservoirs and tanks | | .. | 73.8 |
| TOTAL | 1,290,000 | 6,951,267 | 1,315.1 |

15-9 Sub-basin K.8. Tungabhadra

(a) General : The Tungabhadra sub-basin (See plate XVIII) includes the entire catchment of the Tungabhadra and of all its tributaries except the Vedavati (Hagari).

The sub-basin has an area of 18,466 square miles. It is about 100 miles long from east to west and 240 miles north to south. Parts of Shimoga, Chikmagalur, Chitradurga, Dharwar, Bellary and Raichur districts of Mysore and of Kurnool district of Andhra Pradesh lie in this sub-basin.

(b) *Topography and soil* : The south western parts of the sub-basin lie on the eastern slopes of the Western Ghats. The central portion is a great undulating plain varying in elevation from 2,000 feet to 500 feet. A series of isolated outcrops of hills are scattered in the entire sub-basin.

The upper portion of the sub-basin has red sandy to loamy soil; the lower portion has red soil and black to red sandy types. The valley land along the river has deep black soil.

(c) *Rainfall* : The sub-basin may be divided into two distinct rainfall zones, the heavy rainfall zone of the Western Ghats and the low rainfall zone in the central and north eastern parts of the sub-basin. The annual rainfall varies from 4,000 mm to 500 mm (157.5 inches to 19.7 inches).

The weighted average rainfall for the sub-basin is 884 mm (about 34.8 inches). There are 41 rain-gauge stations in the sub-basin.

(d) *Evaporation* : The mean potential evaporation in the sub-basin is 2,540 mm or 100 inches.

(e) *River flow* : Tungabhadra is perhaps the only "well observed river", in the Krishna and Godavari River systems. Regular discharge observations have been made at Sunkesula since 1904.

Reliable discharge data are available at six sites on the Tungabhadra, out of which three sites are upstream of the Tungabhadra Dam. The data at Rajolibanda are available for only one year. So the flow data at Tungabhadra Dam and at Sunkesula have been utilised for assessing the yield from the sub-basin.

The catchment area of Tungabhadra at Sunkesula is 24,915 square miles; at Tungabhadra Dam site it is 10,880 square miles as per project reports. Excluding the Vedavati catchment, the catchment between the dam and Sunkesula is 4,927 square miles.

The average annual flow at Sunkesula for the period 1950-51 to 1960-61 is 505.4 T.M.C. (See Annexure II serial number 53); that at the dam for the same period is 498.1 T.M.C. (See Annexure II serial number 54). Allowing for 15.0 T.M.C. as the diversion for irrigation in this reach and 14.0 T.M.C. for evaporation losses, taking the contribution from Vedavati as nil, and ignoring the losses in transit from the dam to Sunkesula, the net yield from the intermediate catchment of 4,927 square miles would be 36.3 T.M.C. or 7.3 M.C. ft. per square mile. It is assumed that the waters of the Vedavati are fully utilised in its sub-basin.

On the basis of 7 M.C.ft. per square mile as the average annual yield for the catchment below the dam, the net inflow from this catchment, 7,586 square miles, would be 53.1 T.M.C. and the total for the sub-basin 498.1 plus 53.1 plus 49 (existing diversions and losses above the dam)—600.2 T.M.C.

The long-term average flow at Sunkesula is 438.8 T.M.C. against the 11 years average of 505.4 T.M.C., 13 per cent less. Applying the same ratio the yield from sub-basin would be 522 T.M.C. say 520 T.M.C.

Some idea of the annual variation in the yield from the sub-basin and its distribution can be had from a study of the flow records of Tungabhadra dam and Sunkesula as given in Annexures II and III.

(f) *Irrigation uses as in 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Kurnool-Cuddapah canal | 97,800 | 33.0 |
| 3 medium schemes | 29,900 | 6.1 |
| 41 minor schemes | 50,076 | } 44.0 |
| Small tanks and diversions | 258,000 | |
| Estimated losses from reservoirs and tanks | .. | 41.3 |
| TOTAL | 435,776 | 124.4 |

(g) *Developments since 1951 :*

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Projects in operation | | | |
| Tungabhadra Project | 63,000 | 829,200 | 135.2 |
| Rajolibanda Diversion scheme (Left Side) | | 92,900 | 17.1 |
| Bhadra Reservoir Project | 33,200 | 241,600 | [56.8 29.6 |
| 1 medium scheme | | 27,200 | 8.8 |
| 9 minor schemes | | 5,719 | } 9.6 |
| Small tanks and diversions | | 1,000 | |

Developments since 1951—(continued)

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(ii) Projects under construction</i> | | | |
| Tungabhadra Project High Level Canal—Stage I (2C. 1-K. 8-A. 2/My. 3) | | 189,400 | 28·8 |
| Tungabhadra Hydro-electric Project—Stage II (2C. 1-K. 8-A. 3/My. 4) | 27,000 | | |
| 5 medium schemes | | 33,200 | 3 |
| 4 minor schemes | | 2,755 | 1·1 |
| Small tanks and diversion | | 5,000 | |
| <i>(iii) Improvements to existing works</i> | | 25,800 | 4·8 |
| <i>(iv) Estimated evaporation losses from reservoirs and tanks</i> | | | 25·8 |
| TOTAL | 1,23,200 | 1,413,774 | 292·3 |

(h) Proposed developments :

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Tungabhadra Project Left Bank Low Level Canal extension (9C. 3-K. 8-A. 9) | | 120,000 | 19·2 |
| Tungabhadra Project High Level Canal—Stage II (10C. 3-K. 8-A. 10/My. 20) | | 198,600 | 21·2 |
| Tungabhadra High level canal power Scheme (11C. 3-K. 8-A. 11) | 50,000 | | 20·9 |
| Upper Tungabhadra Project (60C. 3-K. 8-My. 17) | | 210,000 | 31·5 |
| Tunga Reservoir Project (61-C. 3-K. 8-My. 18) | | 250,000 | 37·4 |
| 6 medium schemes | | 117,200 | 27·1 |
| 6 minor schemes | | 12,665 | 2·1 |
| Small tanks and diversions | | 2,000 | |
| Improvements to existing projects | | 171,500 | 5·6 |
| Estimated losses in reservoirs and tanks | | | 17·5 |
| Total | 50,000 | 1,081,965 | 161·6 |

15-10 Sub-basin K. 9 Vedavati

(a) *General* : The Vedavati (Hagari) sub-basin (See plate XIX) comprises the entire catchment of the river Vedavati, from its source to its confluence with the Tungabhadra.

The sub-basin has an area of 9,108 square miles. Parts of Chikmagalur, Chitradurga, Tumkur, Hassan and Bellary districts of Mysore and parts of Anantapur and Kurnool districts of Andhra Pradesh lie in this sub-basin.

(b) *Topography and soil* : The entire catchment is a series of rolling plains with occasional outcrops of rocks ; varies in elevation from 3,000 feet to 1,000 feet.

The soil is predominantly red-loamy to red sandy except in the upper reaches of the river and its tributaries where it is medium to deep black.

(c) *Rainfall* : The sub-basin lies in the low rainfall zone; it varies from 700 mm to 500 mm (27·6 inches to 19·7 inches annual). The weighted average annual rainfall is 568 mm (22·4 inches). There are 19 raingauge stations in the sub-basin.

(d) *Evaporation* : The mean annual potential evaporation is fairly high. It is about 2,540 mm or 100 inches.

(e) *River flow* : Fairly reliable discharge data are available for three sites on the Vedavati. Of these, the data for Vanivilas Sagar are available for 43 years and that of Bhairavani thippa for four years; the data for Naranapur is for only one year and hence is of not much use in estimating the flow in the sub-basin.

The catchment area at Vanivilas sagar is 2,100 square miles and it receives fairly good rainfall. The average annual flow of 43 years at this site is 6·4 T.M.C. (See Annexure II serial number 58). The upstream utilisation by small tanks and diversions, and evaporation losses may be of the order of about 8 T.M.C. This works out to a yield of 7 M.Cft. per square mile for the catchment above Vanivilas Sagar.

The four years data at Bhairavanithippa gives an average yield of 14·8 T.M.C. The upstream utilisation and evaporation losses amount to about 30 T.M.C. Accordingly the total yield at Bhairavanithippa (catchment area about 5,625 square miles) would be 44·8 T.M.C. ; this gives a yield of about 8 M.C ft. per square mile.

Since the data for Bhairavanithippa are for four years only, the yield of 8 M. Cft. per square mile for the area above this site may not be reliable. Hence it would be reasonable to assume an average annual yield of 6 M.Cft. per square mile for the catchment area below Vanivilas sagar. Accordingly

The average annual yield from 2,100 square miles above Vanivilas Sagar . . . 14·4 T.M.C.

Anticipated average annual yield from the balance catchment of 7,008 square miles @ 6 M.Cft. per square mile 42·0 T.M.C.

Total . . . 56·4 T.M.C.
Say . . . 50 T.M.C.

(!) Irrigation uses as in 1951 :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 1 Medium scheme | 12,000 | 3.8 |
| 43 Minor schemes | 44,552 | } 21.7 |
| Small tanks and diversions | 108,000 | |
| Estimated losses from reservoirs and tanks | | 22.6 |
| Total | 156,552 | 48.1 |

(g) Developments since 1951:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(i) Projects in operation</i> | | |
| 2 Medium schemes | 17,000 | 4.1 |
| 7 Minor schemes | 8,425 | 1.2 |
| Small tanks and diversions | .. | |
| <i>(ii) Schemes under construction</i> | | |
| 2 Minor schemes | 500 | .. |
| Small tanks and diversions | 3,000 | 0.6 |
| <i>(iii) Estimated evaporation losses from reservoirs and tanks</i> | | 2.4 |
| Total | 28,925 | 8.3 |

(h) *Power developments*: No hydro-power projects have been developed in this sub-basin, nor are any proposed.

(i) *Proposed developments*: Nil.

15-11 Sub-basin K. 10 Musi

(a) *General*: The Musi sub-basin (See plate XX) comprises the entire catchment of the Musi river up to its confluence with the Krishna. It has an area of 4,329 square miles.

It lies wholly in Andhra Pradesh. Parts of Hyderabad and Nalgonda and portion of Medak, Mahbubnagar and Warangal districts lie in this sub-basin.

(b) *Topography and soil*: The sub-basin varies in elevation from about 2,000 feet to 500 feet. The lower part of the sub-basin has dense forests. Several outcrops of hills occur all over the sub-basin.

The soil is predominantly red-sandy.

(c) *Rainfall*: The sub-basin has low rainfall. The weighted average annual rainfall is 749 mm or 29.5 inches.

There are 14 rain gauge stations in the sub-basin; all in its upper part. The rainfall in the lower part of the sub-basin is not represented by the existing rain gauge stations.

(d) *Evaporation*: The mean annual potential evaporation is 2,800 mm or 110 inches.

(e) *River flow*: It is unfortunate that there is not a single reliable discharge site on the river Musi. The rainfall in this sub-basin is slightly less than that in the neighbouring Palleru sub-basin. The weighted average annual rainfall in this sub-basin is 749 mm against 810 mm in Palleru sub-basin. The yield in Palleru sub-basin has been worked out to be 13.5 M.Cft. per square mile [vide para 15-12(e) infra]. So it would be safe to assume that the yield from Musi sub-basin would be 11 M.Cft. per square mile or 47.6 T.M.C. for the entire sub-basin, say 50 T.M.C.

(f) *Irrigation uses as in 1951*:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|----------------------------------------------------|
| 22 Minor schemes | 22,232 | } 17.9 |
| Small tanks and diversions | 85,000 | |
| Estimated losses from tanks | | 14.3 |
| Total | 107,232 | 32.2 |

(g) *Developments since 1951:*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|----------------------------------------------------|
| <i>Schemes in operation</i> | | |
| Musi Project | 52,600 | 8.4 |
| 7 Minor schemes | 7,152 | } 3.9 |
| Small tanks and diversions | 16,000 | |
| Estimated losses from tanks | .. | 4.2 |
| Total | 75,752 | 16.5 |

(h) *Power development:* No hydro power project exists in this sub-basin nor is any proposed.

(i) *Proposed developments:*

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------|------------------------------------------|----------------------------------------------------|
| 6 Minor schemes | 4,528 | } 1.8 |
| Small tanks and diversions | 6,000 | |
| Estimated evaporation losses | | 1.4 |
| Total | 10,528 | 3.2 |

15-12 Sub-basin K. 11 Palleru

(a) *General:* The Palleru sub-basin (See plate XXI) comprises the entire catchment of the Palleru river upto its confluence with the Krishna river.

It has an area of 1,260 square miles and lies wholly in Andhra Pradesh. Parts of Warangal, Nalgonda and Khammam and a portion of Krishna district lie in this sub-basin.

(b) *Topography and soil*: The sub-basin has an elevation of less than 1,000 feet with occasional outcrops of hills. Dense forests cover most of the land.

The soil is predominantly red-sandy.

(c) *Rainfall*: The rainfall is low. The weighted average annual rainfall is 810 mm or 31.9 inches.

There are only two rain-gauge stations in the sub-basin, in its lower part. The upper part has no rain-gauge stations.

(d) *Evaporation*: The mean annual potential evaporation is 2,540 mm or 100 inches.

(e) *River flow*: Only three years data are available for the discharge site on the river Palleru. The catchment area at this place is 651 square miles. The average annual flow is 11.2 T.M.C. (range 18.4 T.M.C. to 2.0 T.M.C.) (See Annexure II serial number 62). Since the entire catchment of the sub-basin is only 1,260 square miles and the rainfall characteristics are almost the same throughout, a proportionate figure for the average annual flow for the whole sub-basin would be 21.7 T.M.C. The Commission has, however, assumed the long-term average yield as 17.0 T.M.C. (13.5 M.Cft. Per square mile).

(f) *Irrigation uses as in 1951:*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 1 Medium scheme | 11,000 | 3.0 |
| 1 Minor scheme | 2,500 | } 6.6 |
| Small tanks and diversions | 37,000 | |
| Estimated evaporation losses from tanks | | 5.9 |
| Total | 50,500 | 15.5 |

(g) *Developments since 1951:*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion of losses (T.M.C.)</i> |
|---------------------------------------------------|------------------------------------------|----------------------------------------------------|
| <i>Schemes in operation</i> | | |
| Small tanks and diversions | 7,000 | 1.2 |
| Estimated evaporation losses from tanks | | 0.9 |
| Total | 7,000 | 2.1 |

(h) *Power development:* No hydro power has so far been developed in this sub-basin; nor is any proposed.

(i) *Proposed development:*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 2 Minor schemes | 1,300 | } 0.6 |
| Small tanks and diversions | 2,000 | |
| Improvements to existing projects | 2,100 | 0.2 |
| Estimated evaporation losses from tanks | | 0.6 |
| Total | 5,400 | 1.2 |

15-13 Sub-basin K. 12 Muneru

(a) *General:* The Muneru sub-basin (See plate XXII) comprises the entire catchment of the Muneru river upto its confluence with Krishna.

It has an area of 4,019 square miles and lies wholly in Andhra Pradesh. Parts of Warangal, Khammam and Krishna districts lie in this sub-basin.

(b) *Topography and soil:* This sub-basin is a part of the Eastern Ghats region. A series of hills covered with dense forests is the predominant feature.

The soil is red-sandy.

(c) *Rainfall:* The sub-basin has medium rainfall varying from 800 mm to 1,050 mm. The weighted average annual rainfall is 954 mm or 37 inches.

There are 8 rain gauge stations in the sub-basin; the distribution is somewhat uneven.

(d) *Evaporation:* The mean annual potential evaporation is 2,235 mm or 88 inches.

(e) *River flow:* There is not a single discharge site on the river Muneru. The average annual yield has to be worked out on the basis of the yield in the neighbouring Palleru sub-basin. The yield in Palleru is 13.5 M.Cft. per square mile vide para 15-12(e). The rainfall in Muneru sub-basin is slightly higher than that of Palleru. The weighted average annual rainfall in the Muneru sub-basin is 954 mm against 810 mm in the Palleru sub-basin. So it may be reasonable to assume that the yield in Muneru would be 18 M.Cft. per square mile. On this basis, the total yield for the entire sub-basin would be 72.3 T.M.C., say 70 T.M.C.

(f) Irrigation uses as in 1951:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 3 Medium Schemes | 27,000 | 6.0 |
| 27 Minor schemes | 26,208 | } 27.7 |
| Small tanks and diversions | 140,000 | |
| Estimated evaporation losses from tanks | | 23.8 |
| Total | 193,208 | 57.5 |

(g) Developments since 1951:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Schemes in operation | | |
| 4 Minor schemes | 3,728 | } 3.0 |
| Small tanks and diversions | 14,000 | |
| (ii) Schemes under construction | | |
| Small tanks and diversions | 1,000 | 0.2 |
| (iii) Estimated evaporation losses from tanks | | 2.5 |
| Total | 18,728 | 5.7 |

(h) *Power development*: No hydro power project exists; nor is any proposed.

(i) *Proposed developments*:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------|------------------------------------------|----------------------------------------------------|
| 4 Medium schemes | 36,100 | 7.1 |
| 15 Minor schemes | 20,772 | } 5.1 |
| Small tanks and diversions | 10,000 | |
| Improvements to existing projects | 12,300 | 0.8 |
| Estimated evaporation losses from tanks | | 4.8 |
| Total | 79,172 | 17.8 |

15-14 Sub-basin G. 1 Upper Godavari

(a) *General*: The Upper Godavari sub-basin (See plate XXIII) comprises the catchment of the river Godavari from its source to its confluence with Manjra; the sub-basin excludes the catchment area of the Pravara, the Purna and the Manjra tributaries but includes that of all other tributaries which fall into the Godavari in this reach.

The sub-basin has an area of 12,935 square miles. It is about 320 miles long from east to west and has a maximum width of 65 miles.

The sub-basin lies wholly in Maharashtra. Portions of the districts of Ahmednagar, Aurangabad, Bhir, Nanded and Nasik lie in the sub-basin.

(b) *Topography and soil*: Except for the eastern slopes of the Western Ghats and the southern slopes of the Ajanta Hills on the Periphery, the sub-basin largely comprises rolling and undulating country, sloping down eastwards from the Western Ghats to an elevation of about 1,100 feet at its lower end.

A strip of land about 80 miles long and about 20 miles wide, along the western parts of the sub-basin, lies in the Western Ghats region, varying in elevation from 5,000 feet to 2,000 feet. This tract has ever-green forests and heavy torrential rainfall.

The low lying valley land has deep black soil; the rest of the sub-basin has medium black soil.

(e) *Rainfall*: There are three distinct rainfall zones in the sub-basin; the high rainfall zone (over 1,000 mm or 40 inches, annual) in its western part, the low rainfall zone (less than 600 mm or 24 inches, annual) in the west-central portion of the sub-basin and the medium rainfall zone (about 900 mm or 35 inches, annual) in the eastern part.

The weighted average annual rainfall for the entire sub-basin is 770 mm (about 30 inches).

There are 17 rain-gauge stations in the sub-basin of which 15 lie in the western half of the sub-basin; the rainfall of the eastern half is therefore not well represented by the existing rain-gauge stations.

(d) *Evaporation*: The mean potential annual evaporation in this sub-basin is high, especially in the Aurangabad region where it is 4,204 mm or 165·6 inches the highest in the Godavari basin.

(e) *River flow*: Out of the 10 sites for which fairly reliable discharge data are available, seven are above Nandur Madhmeshwar on the Godavari and, since flow data are available for 20 years for Nandur Madhmeshwar, it is proposed to consider the data at this site for assessing water availability up to this point.

Observations at the other two sites on the Godavari in this sub-basin below Nandur Madhmeshwar, namely Puntumba and Toka, the last named about 90 miles below Nandur Madhmeshwar, have been discontinued. Data for these two sites are available for nine years and six years respectively and are helpful to some extent. There are no reliable discharge data for any site between Toka and the Manjra confluence, a river length of about 320 miles.

The catchment of the river at Nandur Madhmeshwar is only 1,650 square miles. The flow from a major part of the sub-basin is, therefore, not measured at present. The only way to get some idea of the total supplies in the sub-basin is to fall back on known yields of catchments in the neighbourhood which are similar in topography and rainfall characteristics. Part of the un-gauged catchment of the Upper Godavari sub-basin is similar to the Purna catchment (paragraph 15-16) and the other part to the lower part of the Pravara catchment (paragraph 15-15).

Approximate average annual yield from the sub-basin has been worked out as follows:

| | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------------------------|
| (i) Average annual flow at Nandur Madhmeshwar (1,650 square miles) | 91·8 T.M.C. | (See Annexure, V Serial No. 2) |
| (ii) Diversion by existing projects upstream and reservoir losses | 14·1 T.M.C. | (See Annexure XIII) |
| (iii) Total of (i) and (ii) | 105·9 T.M.C. | |
| (iv) Anticipated average annual contribution from 11,285 square miles of catchment between Nandur-Madhmeshwar and Manjra confluence (excluding G. 2 and G. 3 sub-basins) @ 15 M.Cft. per square mile—(based on runoff rates of Purna and lower part of Pravara catchment—see paragraphs 15-15 and 15-16), say | 168·5 T.M.C. | |
| (v) Total for sub-basin, (iii) plus (iv) | 274·4 T.M.C. | |

Allowing for losses in the long reach of the river, it may be safe to assume an average annual yield of about 240·0 T.M.C. for the sub-basin.

To the direct runoff worked out above will, of course, be added the actual inflow into the river from G. 2 Pravara sub-basin, G. 3 Purna sub-basin and, at its lower end, from the G. 4 Manjra sub-basin.

Some idea of the annual variation in the yield from sub-basin G. 1, and its distribution within the year, can be had from a study of the flow records at Nandur, Madhmeshwar, Ozer and Siddeshwar as given in Annexures V and VI. It has to be remembered, however, that a large part of the catchment is in the low-rainfall zone and, as stated in paragraph 11-17, the contribution to flow from this zone will be only from rainfalls of relatively high intensities, which occur during the monsoon season at irregular intervals.

(f) *Irrigation uses as in 1951:*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|--------------------------------------------|------------------------------------------|----------------------------------------------------|
| Godavari canals | 46,600 | 10·3 |
| 1 medium scheme | 5,300 | 1·3 |
| 3 Minor schemes | 3,000 | } 0·4 |
| Small tanks and diversions | 3,000 | |
| Estimated losses from reservoirs | | 2·2 |
| Total | 57,900 | 14·2 |

(g) *Developments since 1951:*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|--------------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(i) Projects in operation</i> | | |
| Gangapur Project | 44,000 | 7·4 |
| 1 Medium scheme | 7,500 | 0·5 |
| Small tanks and diversions | 1,400 | 0·1 |

Developments since 1951—continued.

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (ii) Projects under construction | | |
| 4 medium projects | 34,300 | 2.8 |
| 10 minor schemes | 14,775 | } 1.0 |
| Small tanks and diversions | 2,000 | |
| (iii) Improvements on pre-1951 projects | 9,600 | 0.7 |
| (iv) Estimated losses from reservoirs and tanks | .. | 5.1 |
| Total | 113,575 | 17.6 |

(h) Power developments: There has so far been no hydro-electric power development in this sub-basin.

(i) Proposed developments:

| <i>Name or particulars of schemes</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Karanjwan Project—Stage I (17C. 2-G. 1-M. 7) | | 110,900 | 14.4 |
| Jayakwadi Project—Stage II (77C. 3-G. 1-M. 2) | | 620,300 | 55.8 |
| Upper Godavari Project (76C. 3-G. 1-M. 1) | 5,000 | 222,600 | 26.6 |
| 3 medium schemes | | 89,400 | 12.0 |
| 3 minor schemes | | 5,102 | } 10.0 |
| Small tanks and diversions | | 196,000 | |
| Improvements on existing works | | 20,000 | 1.9 |
| Estimated losses from reservoirs and tanks | | | 40.1 |
| Total | 5,000 | 1,264,302 | 160.8 |

15-15 Sub-basin G. 2 Pravara

(a) *General*: The Pravara sub-basin (See plate XXIV) comprises the entire catchment of the Pravara from source to its confluence with the Godavari.

The sub-basin has an area of 2,524 square miles. It is about 80 miles long from east to west and about 30 miles wide.

The sub-basin lies wholly in Maharashtra. A large part of the district of Ahmednagar and portions of Nasik and Poona districts lie in the sub-basin.

(b) *Topography and soil*: The western part of the sub-basin, about 20 miles by 20 miles lies in the Western Ghats region, varying in elevation from 3,500 feet to 2,000 feet. The rest of the sub-basin slopes eastward to an elevation of about 1,500 feet at its lower end.

The low lying valley land has deep black soil and the remaining part of the sub-basin medium black soil.

(c) *Rainfall*: There are two distinct rainfall zones in the sub-basin; the Western Ghats area has high rainfall (above 1,000 mm or 40 inches, annual) and the rest of the sub-basin has low rainfall (less than 600 mm or 23.6 inches, annual).

The weighted average annual rainfall in the sub-basin is 606 mm (about 24 inches).

There are only 4 rain-gauge stations in the sub-basin.

(d) *Evaporation*: The mean potential annual evaporation in this sub-basin is high, about 3,300 mm or 132 inches.

(e) *River flow*: There are three sites, two on the Pravara and one on the Mula, for which fairly reliable discharge data are available. Out of these, Bhandharadhara on the Pravara is upstream of Ozer on the same river. So the data at Ozer and at Chikalthan on the Mula has been considered for assessing the water supply in the sub-basin.

The catchment area at Ozer is 592 square miles and at Chikalthan 581 square miles. No data are available to assess directly the yield from the remaining 1,351 square miles of the catchment. The data recorded at Toka (catchment area 5,840 square miles) on the Godavari just below the confluence of Pravara with the Godavari, in association with the data at Nandur Madhmeshwar, at Ozer and at Chikalthan are the only records from which a rough estimate can be made of the likely yield from the remaining catchment.

Flow data at Toka are available for six years but, out of these six years, data are available at Chikalthan only for four years. So a study of the flow at all the

sites can be made for these four years only. (see Annexure V, serial numbers 2, 21, 23 and 4).

| | Annual flow during | | | | |
|--------------------------------------------------------------------------------------------------------------------|--------------------|---------|---------|------------------------|---------|
| | 1955-56 | 1956-57 | 1957-58 | 1959-60 | Average |
| |T.M.C..... | | | | |
| (i) at Nandur Madhmeshwar | 79.2 | 141.5 | 50.0 | 123.7 | 98.6 |
| (ii) at Ozer | 24.0 | 34.9 | 25.3 | 36.2 | 30.1 |
| (iii) at Chikalthan | 23.5 | 33.7 | 19.1 | 42.7 | 29.8 |
| (iv) total of (i) plus (ii) plus (iii) | 126.7 | 210.1 | 94.4 | 202.6 | 158.5 |
| (v) at Toka | 134.3 | 254.5 | 83.7 | 220.8 | 173.3 |
| (vi) Diversions above Toka | 28.3 | 26.0 | 30.8 | 29.8 | 28.7 |
| (vii) total of (v) plus (vi) | 162.6 | 280.5 | 114.5 | 250.6 | 202.0 |
| (viii) Yield from the catchment below Nandur Madhmeshwar Ozer and Chikalthan upto Toka (viii)—(iv) | 35.9 | 70.4 | 20.1 | 48.0 | 43.5 |
| Catchment area below Nandhur Madmeshwar Ozer and Chikalthan up to Toka | | | | 3,017 square miles | |
| Average annual yield per square mile of catchment | | | | 43.5 T.M.C. ÷ 3,017 | |
| | | | Say | 14.5 M. Cft. | |

The yield calculated above is based on a study of only four years data. A reference to Annexure V will show that the 4 years' average at Nandur Madhmeshwar is about 7.4 per cent higher than the long term average. Similarly, the 4 years' average at Ozer is about 18 per cent higher than the long term average. Accordingly, it would not be safe to assume the long term average yield from the intermediate catchment at more than, say, 13 M. Cft. per square mile.

The yield from the Pravara sub-basin may now be worked out as follows :

| | |
|--------------------------------------------------------------------------------------------|---------------------------------------------|
| Average annual flow at Ozer | 25.6 T.M.C. (see Annexure V, Serial No. 21) |
| Average annual flow at Chikalthan | 30.7 " (see Annexure V, Serial No. 23) |
| Estimated losses from reservoir | 0.9 |
| Yield from the remaining catchment of 1,351 miles @ 13 M.Cft. per square mile | 17.6 |
| Total | 74.8 Say 70 T.M.C. |

The annual variation in the yield from this sub-basin and its distribution within the year should be somewhat similar to the variation and distribution of flow at some of the sites in the sub-basin for which the 10—daily and monthly averages are given in Annexures V and VI.

(f) *Irrigation uses as in 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Pravara canals | 58,000 | 15.3 |
| Small tanks and diversions | 1,800 | 0.1 |
| Estimated losses from reservoirs and tanks | | 1.1 |
| Total | 59,800 | 16.5 |

(g) *Developments since 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(i) Projects in operation</i> | | |
| Small tanks and diversions | 700 | |
| <i>(ii) Projects under construction</i> | | |
| Mula Project | 231,400 | 31.8 |
| 1 minor scheme | 512 | |
| <i>(iii) Estimated losses from reservoirs and tanks</i> | | 2.9 |
| Total | 232,612 | 34.7 |

(h) *Power developments* : There is no hydro-electric power station in this sub-basin ; nor is any under construction.

(i) Proposed developments :

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Pravara river Project | | | |
| (80C.3-G. 2-M.5) | 27,000 | 143,200 | 9.5 |
| 1 minor scheme | | 1,230 | } 1.2 |
| Small tanks and diversions | | 19,600 | |
| Estimated losses from reservoirs and tanks | | | 3.8 |
| Total | 27,000 | 164,030 | 14.5 |

15-16 Sub-basin, G. 3 Purna

(a) *General* : The Purna sub-basin (See plate XXV) comprises the catchment of the river Purna from source to its confluence with the Godavari.

The sub-basin has an area of 6,015 square miles and is about 140 miles long and 40 miles wide.

The sub-basin lies wholly in Maharashtra. Portions of the districts of Akola, Aurangabad, Buldana and Parbhani lie in the sub-basin.

(b) *Topography and soil* : The north-western portion of the sub-basin lies on the southern slope of the Ajanta Hills and the sub-basin gradually slopes south-eastwards from an elevation of 2,000 feet to 1,220 feet.

The soil in the sub-basin is medium black.

(c) *Rainfall* : The sub-basin lies in a low to medium rainfall zone (700 to 900 mm annual). The weighted average annual rainfall is 797 mm or 32 inches. There are only three rain-gauge stations in the sub-basin, which do not adequately represent the rainfall conditions of the sub-basin.

(d) *Evaporation* : The mean potential annual evaporation of the sub-basin is about 3,800 mm or 150 inches.

(e) *River flow* : There is only one site on the river Purna for which fairly reliable discharge data are available, but only for three years. The catchment area at this site is only 3,000 square miles.

The total yield from the sub-basin has been worked out as follows :

| | |
|--------------------------------------------------------------------------------------------|---------------------|
| (i) Average annual flow at Siddeswar | 88.3 T.M.C. |
| (ii) Contribution from the remaining catchment in a slightly lower rainfall area | 61.7 T.M.C. |
| Total | 150.0 T.M.C. |

Data for a much longer period are, however, required to be observed before any firm conclusion can be drawn. It would be advisable for the time being, to assume that the long-term average yield from the sub-basin would be about 100.0 T.M.C.

The observed flow at Siddeshwar varies from a maximum of 125.5 T.M.C. to 40.8 T.M.C.

(f) *Irrigation uses as in 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|--------------------------------------|------------------------------------------|----------------------------------------------------|
| Small tanks or diversions | 300 | .. |

(g) *Developments since 1951 :*

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(i) Schemes in operation</i> | | | |
| Small tanks and diversions | | 200 | .. |
| <i>(ii) Schemes under construction</i> | | | |
| Purna Project (11C. 1-G. 3-M. 5) | 15,000 | 152,000 | 28.1 |
| 4 medium Schemes | | 33,500 | 2.7 |
| 4 minor Schemes | | 9,050 | 0.6 |
| <i>(iii) Estimated losses from reservoirs and tanks</i> | | | 7.9 |
| Total | 15,000 | 194,750 | 39.3 |

(h) *Proposed developments:*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Lower Dudna Project (84C.3-G. 3-M.9) | 123,000 | 12.5 |
| 3 medium schemes | 48,500 | 4.1 |
| 1 minor scheme | 760 | } 5.0 |
| Small tanks and diversions. | 78,900 | |
| Estimated losses from reservoirs and tanks | | 12.7 |
| Total | 251,160 | 34.3 |

There is no scheme for any further development of hydro-power.

15-17 Sub-basin G. 4 Manjra

(a) *General* : The Manjra sub-basin (See plate XXVI) comprises the entire catchment of the Manjra river from its source to its confluence with the Godavari.

The sub-basin has an area of 11,909 square miles. The sub-basin lies in the States of Maharashtra, Mysore and Andhra Pradesh. Parts of Bhir, Osmanabad and Nanded and portions of Ahmednagar and Sholapur districts of Maharashtra; part of Bidar district of Mysore and parts of Medak and Nizamabad and a portion of Hyderabad district of Andhra Pradesh lie in this sub-basin.

(b) *Topography and soil*: The upper triangular part of the sub-basin, about 150 miles along the meridian, lies at an altitude of 3,000 feet to 2,000 feet; the sub-basin then slopes generally towards east and north-east until it is about 1,000 feet at its lower end.

Except for a small area to the south of the sub-basin which has laterite to red sandy soil, the predominant soil in the sub-basin is medium black.

(c) *Rainfall* : The sub-basin lies in the medium rainfall zone, from 800 mm (31·5 inches) at its western end to 1,000 mm (39·4 inches) in its north eastern part. The weighted average annual rainfall for the sub-basin is 846 mm or about 34 inches.

There are 15 rain-gauge stations in the sub-basin out of which 12 are in the eastern part of the sub-basin; the rainfall in the western part is not properly represented by the existing rain-gauge stations.

(d) *Evaporation* : The mean potential evaporation in the sub-basin is high, about 3,810 mm or 150 inches.

(e) *River flow* : There are three sites, two on the Manjra at Ghanpur and Nizamsagar and the third at Pocharam on the Alair, a sub-tributary of Manjra for which fairly reliable data are available. Since Ghanpur and Pocharam are upstream of Nizamsagar, the data at Nizamsagar only are considered for assessing the yield of this sub-basin.

The catchment area of the Manjra at Nizamsagar is 8,376 square miles. No data are available for 3,533 square miles of the catchment below Nizamsagar. However, this area is similar to the catchment above Nizamsagar; it has a slightly higher

rainfall than the upper catchment. A proportionate figure of yield has been taken for this area and the total supply for the sub-basin is worked out as follows :

| | <i>Average annual flow (T.M.C)</i> |
|---------------------------------------------------------|------------------------------------------------|
| (i) Flow at Nizamsagar | 151.1 |
| (ii) Uses upstream | 25.5 |
| (iii) Estimated losses from tanks | 16.2 |
| (iv) total of (i) to (iii) | 192.8 |
| (v) Contribution from the remaining catchment | 81.3 |
| Total Say | 274.1 270 T.M.C. |

Some idea of the annual variation in the yield from the sub-basin, and its distribution within the year, can be had from a study of the flow data at Nizamsagar, as given in Annexure V, serial number 28.

(f) *Irrigation uses as in 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------|
| Nizamsagar Project | 128,000 | 40.0 |
| 3 Medium schemes | 24,000 | 8.5 |
| 24 Minor schemes | 14,093 | } 25.0 |
| Small tanks and diversions | 151,800 | |
| Estimated losses from reservoirs and tanks | | 28.7 |
| Total | 317,893 | 102.2 |

There was no hydro-electric development in the sub-basin.

(g) Developments since 1951 :

| <i>Name or particulars of schemes</i> | <i>Power: installed (k.W.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|--------------------------------------------------------|----------------------------------------|------------------------------------------------------|--------------------------------------------------------------------|
| (i) Projects in operation | | | |
| Nizamsagar Hydro-electric Project | 15,000 | .. | .. |
| 14 Small tanks and diversion projects | | 1,146 | 0·1 |
| (ii) Projects under construction | | | |
| 3 Medium schemes | | 29,800 | 3·7 |
| 2 Minor schemes | | 6,000 | } 1·0 |
| Small tanks and diversion projects | | 500 | |
| (iii) Improvements to existing projects | | 40,700 | 3·1 |
| (iv) Estimated losses from reservoirs and tanks | | | 2·7 |
| Total | | 78,146 | 10·6 |

(h) Proposed development :

| <i>Name or particulars of schemes</i> | <i>Power installed (k.W.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion losses (T.M.C.)</i> |
|---------------------------------------------------------------------|---------------------------------------|------------------------------------------------------|-----------------------------------------------------------------|
| Dhanegaon Project (85C.3-G.4-M-10) | | 51,000 | 6·0 35·8 |
| Devnoor Project* (86C.3-G. 4-M. 11 and 8C. 3-G 4-A .8) | 33,000 | 53,000 | 9·2 |
| Tirna Project (88C.3-G. 4-M. 13) | | 73,900 | 7·3 |
| Lendi Project (89C. 3-G. 4-M14) | | 89,000 | 7·5 |
| 7 Medium Projects | | 146,800 | 18·4 |
| 24 Minor schmes | | 29,789 | } 30·4 |
| Small tanks and diversions | | 157,500 | |
| Improvements to existing projects | | 115,600 | 13·4 |
| Estimated losses from reservoirs and tanks | | | 41·0 |
| Total | 33,000 | 716,589 | 133·2 |

*See Paragraph 14—49.

15-18 Sub-basin G-5 Middle Godavari

(a) *General*: The middle Godavari sub-basin (See plate XXVII) comprises the catchment of the river Godavari from its confluence with the Manjra to its confluence with the Pranhita ; the sub-basin includes the direct catchment of the Godavari in this reach as well as of its tributaries out-falling in this reach except the Maner and the Pranhita.

The sub-basin has an area of 6,643 square miles. It is about 130 miles from east to west at the longest and about 70 miles from north to south at the widest. Parts of the districts of Adilabad, Karimnagar, and Nizamabad in Andhra Pradesh and a small portion of Nanded district in Maharashtra lie in the sub-basin.

(b) *Topography and soil* : The entire sub-basin comprises plains varying in elevation from 1,100 feet to 400 feet with occasional out-crops of hills scattered all-over.

The valley land of the sub-basin has deep black soil. The remaining portion has medium black soil. A relatively small portion towards the south has red soil.

(c) *Rainfall* : The sub-basin lies in medium rainfall zone 900 mm to 1,200 mm (36 inches to 47.3 inches). The weighted average rainfall is 955 mm (37.6 inches). There are 15 rain-gauge stations in the sub-basin.

(d) *Evaporation* : The mean annual potential evaporation is about 2,900 mm or 114.26 inches.

(e) *River flow* : There is no discharge site in this sub-basin for which reliable data exist. Accordingly a rough estimate has been made in Appendix C; the average annual yield from this sub-basin may be 100 T.M.C.

To the estimated run-off stated above, will be added the inflow from G. 1 (inclusive of the inflow into G. 1 from G. 2, G. 3 and G. 4) and G. 6 sub-basins.

(f) *Irrigation uses as in 1951* :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C)</i> |
|---------------------------------------|------------------------------------------|---------------------------------------------------|
| 1 Medium scheme | 8,700 | 2.4 |
| 16 Minor schemes | 24,887 | 20.5 |
| Small tanks and diversions | 108,000 | |
| Estimated losses from tanks | .. | 16.4 |
| Total | 141,587 | 39.3 |

(g) Developments since 1951:

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Projects in operation | | |
| Kaddam project | 85,000 | 16.2 |
| 2 Minor schemes | 747 | } 3.1 |
| Small tanks and diversions | 18,100 | |
| (ii) Projects under construction | | |
| 1 Medium scheme | 9,100 | 1.7 |
| 3 Minor schemes | 12,000 | } 2.1 |
| Small tanks and diversions | 200 | |
| (iii) Improvements to existing works | 1,500 | 0.4 |
| (iv) Estimated losses from reservoirs and tanks | | 5.5 |
| TOTAL | 126,547 | 29.0 |

(h) Power developments : No hydro-electric power project exists in this sub-basin; nor is any under construction.

(i) Proposed developments :

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Godavari canals project (Pochampad) Stage I (1C. 2-G. 5-A. 1) | | 340,000 | 65.8 |
| Godavari canals project (Pochampad) Stage II (1C. 3-G. 5-A. 1) | 128,500 | 1,593,000 | 229.2 |
| Godavari canals project (Pochampad) Stage III (2C. 3-G. 5-A. 2) | | 300,000 | 170.2 |
| Kuntala Hydro-electric scheme (11C. 3-G. 5-A. 11) | 9,000 | | 3.9 |
| 3 medium schemes | | 35,400 | 6.1 |
| 24 minor schemes | | 25,833 | } 5.4 |
| Small tanks and diversions | | 6,500 | |
| Improvements to existing works | | 7,200 | 1.3 |
| Estimated losses from reservoirs and tanks | | | 22.0 |
| Total | 137,500 | 2,307,933 | 500.0 |

(j) Since the Godavari canals projects Stage I, Stage II and Stage III take off from the upper end of the sub-basin, these projects, if executed, will have to depend for their water supplies almost entirely on the inflow from sub-basin G. 1.

15—19 Sub-basin G. 6 Maner

(a) *General* : The Maner sub-basin (See plate XVIII) comprises the entire catchment of the Maner from source to its confluence with the Godavari.

The sub-basin has an area of 5,060 square miles. It is about 110 miles long from east to west and about 45 miles wide. The sub-basin lies wholly in Andhra Pradesh ; parts of Medak, Karimnagar and Warangal districts and a small portion of Nizamabad district lie in the sub-basin.

(b) *Topography and soil* : The sub-basin consists largely of undulating plains with elevation from 2,000 feet to 500 feet. The general slope is north-eastwards.

The soil of the sub-basin is predominantly red sandy ; relatively small portions at the lower end have deep black soil.

(c) *Rainfall* : The sub-basin lies in the medium rainfall zone, about 800 to 1,000 mm (32 to 39 inches) annual. The weighted average annual rainfall in the sub-basin is 932 mm (about 37 inches).

There are 5 rain gauge stations in the sub-basin.

(d) *Evaporation* : The mean potential annual evaporation in the sub-basin is about 2,800 mm or 112 inches.

(e) *River flow* : There are four sites, one on the Maner and three on its tributaries for which fairly reliable discharge data are available. However, these sites are situated in the upper valley of the sub-basin and no information is available about the flow from a large part, about 80 per cent of the sub-basin. Three of the four sites for which data are available have small catchments. The data recorded at Maner has had, therefore, to be utilised in making a rough assessment of total supplies in the sub-basin on a proportionate basis.

T.M.C.

| | |
|--------------------------------------------------------------------------------------------------|-------|
| (i) Average annual flow at Maner (836 square miles) | 12.8 |
| (ii) Estimated diversions and losses upstream on a proportionate basis | 9.4 |
| (iii) Total of (i) and (ii) | 22.2 |
| (iv) Likely yield from the ungauged catchment (4,224 square miles) on a proportionate basis, Say | 111.0 |
| Total | 133.2 |

Since the data available are for 10 years only and for a small part of the catchment it would be reasonable to take 90 T.M.C. as the long term average.

(f) Irrigation uses as in 1951 :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|----------------------------------------------------|
| 1 medium scheme | 2,400 | 0.4 |
| 61 minor schemes | 33,976 | } 31.0 |
| Small tanks and diversions | 151,900 | |
| Estimated losses from tanks | | 25.4 |
| TOTAL | 188,276 | 56.8 |

(g) Developments since 1951 :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Projects in operation | | |
| 1 minor scheme | 1,305 | 0.3 |
| Small tanks and diversions | 23,100 | 4.0 |
| (ii) Projects under construction | | |
| 2 minor schemes | 5,050 | } 2.3 |
| Small tanks and diversions | 400 | |
| (iii) Improvements to existing tanks | 9,000 | 2.3 |
| (iv) Estimated losses from tanks | | 4.0 |
| TOTAL | 38,855 | 10.6 |

(h) Power development : There is so far no hydro-electric development in the sub-basin.

(i) *Proposed developments :*

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average Annual diversion or losses (T.M.C.)</i> |
|-----------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Lower Maner Project (12C. 3-G. 6-A. 12) | 2,000 | 71,000 | 12.2 |
| 21 minor schemes | | 27,152 | } 9.0 |
| Small tanks and diversions | | 9,500 | |
| Improvements to existing works | | 5,900 | 0.9 |
| Estimated losses from reservoir and tanks | | | 7.2 |
| TOTAL | 2,000 | 113,552 | 29.3 |

15—20 Sub-basin G. 7 Penganga

(a) *General* : The Penganga sub-basin (See plate XXIX) comprises the entire catchment of the Penganga river from its source to its confluence with the Wardha.

The sub-basin has an area of 9,297 square miles. It is about 160 miles long from east to west and has a maximum width from north to south of 80 miles. Almost the entire sub-basin lies in Maharashtra with only a small portion in Adilabad district of Andhra Pradesh. Parts of Parbhani, Buldhana, Akola, Yeotmal and Nanded districts lie in this sub-basin.

(b) *Topography and soil* : The north-western part of the sub-basin lies along the southern slope of the Ajanta Range. The rest of the sub-basin is a great undulating plain between elevation 2,000 feet to 500 feet and with a general slope towards east-southeast.

The sub-basin has predominantly medium black soil except in some portion in the east which has mixed red and black soil.

(c) *Rainfall* : The sub-basin lies in the medium rainfall zone, 800 mm to 1,100 mm (32 inches to 43.3 inches) annual. The weighted average annual rainfall in the sub-basin is about 960 mm or 38 inches.

There are 14 rain gauge stations in the sub-basin.

(d) *Evaporation* : The mean potential evaporation in the sub-basin is about 3,175 mm or 125 inches.

(e) *River flow* : There is no discharge site in the sub-basin for which reliable data exist. Accordingly a rough estimate has been made in Appendix C; the average annual yield for this sub-basin may be 180 T.M.C.

(f) Irrigation Uses as in 1951 :

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|----------------------------------------------------|
| Small tanks and diversions | 3,700 | 0.2 |
| Estimated losses from tanks | | 0.5 |
| Total | 3,700 | 0.7 |

(g) Developments since 1951 :

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Projects in operation | | |
| Small tanks and diversions | 1,500 | 0.1 |
| (ii) Projects under construction | | |
| 1 medium project | 5,400 | 0.5 |
| 2 minor schemes | 4,045 | } 0.3 |
| Small tanks and diversions | 1,600 | |
| (iii) Estimated losses from tanks | | 1.0 |
| Total | 12,545 | 1.9 |

(h) Power developments : No hydro-power project exists ; nor is any under construction.

(i) Proposed developments :

| <i>Name or particulars of schemes</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Penganga hydro-electric Project (8C. 2-G. 7-M. 2) | 37,500 | | 25.2 |
| Kayadhu Project (21C. 2-G. 7-M. 11) | | 79,800 | 7.2 |
| Dongargaon project (98C. 3-G. 7-M. 23) | | 98,000 | 8.2 |
| Penganga project* (99C. 3-G. 7-M. 24) | | 375,000 | 45.6 |
| 7 medium projects | | 185,400 | 19.5 |
| 21 minor schemes | | 20,252 | } 7.5 |
| Small tanks and diversions | | 94,400 | |
| Estimated losses from reservoirs and tanks | | | 32.8 |
| Total | 37,500 | 852,852 | 120.8 |

*See paragraph 14-49.

15—21 Sub-basin G. 8 Wardha

(a) *General* : The Wardha sub-basin (See plate XXX) comprises the entire catchment of the Wardha river from its source to its confluence with the Wainganga excluding the catchment of the Penganga.

The sub-basin has an area of 9,300 square miles. Parts of Amravati, Chanda, Wardha, Yeotmal and Nagpur and a small portion of Akola districts of Maharashtra and part of Betul and a portion of Chhindwara of Madhya Pradesh lie in this sub-basin.

(b) *Topography and soil* : The northern half of the sub-basin lies on a table land varying in elevation from 4,000 feet to 2,000 feet. The southern half is a stretch of plain land varying in elevation from about 2,000 feet to 1,000 feet with several out crops of hills. A large part of the sub-basin is covered with forests.

The sub-basin has predominantly medium black soil except a small portion in the north which has shallow black soil.

(c) *Rainfall* : The sub-basin lies in medium rainfall zone 900 mm to 1,300 mm (35.4 inches to 50.2 inches). The weighted average annual rainfall is 1,055 mm (39.62 inches). There are 13 rain-gauge stations in the sub-basin.

(d) *Evaporation* : The mean annual potential evaporation is about 3,000 mm or 118.2 inches.

(e) *River flow* : There is no discharge site in the sub-basin for which reliable data exist. Accordingly a rough estimate has been made in Appendix C ; the average annual yield for this sub-basin may be 240 T.M.C.

To this will be added the inflow from G. 7 sub-basin.

(f) *Irrigation uses in as 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|----------------------------------------------------|
| Small tanks and diversions | 22,500 | 1.5 |
| Estimated losses from tanks | .. | 3.0 |
| Total | 22,500 | 4.5 |

(g) *Developments since 1951 :*

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Projects in operation | | |
| 3 minor schemes | 243 | .. |
| small tanks and diversions | 300 | .. |
| (ii) Projects under construction | | |
| 1 medium scheme | 42,600 | 3.9 |
| 5 minor schemes | 4,408 | } 0.4 |
| small tanks and diversions | 1,200 | |
| (iii) Improvements on pre 1951 works | 1,000 | 0.1 |
| (iv) Estimated losses from tanks | .. | 1.1 |
| Total | 47,751 | 5.3 |

(h) *Power development* : No hydro-power project exists in the sub-basin ; nor is any under construction.

(i) *Proposed developments* :

| <i>Name or particulars of schemes</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|--------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Upper Wardha Stage I (20C.2-G.8-M.10) | .. | 68,000 | 14.1 |
| Bembala project (92C.3-G.8-M.17) | .. | 76,000 | 5.1 |
| Lower Wunna Project (94C.3-G.8-M.19) | .. | 120,000 | 13.6 |
| Wardha scheme (17C. 3-G.8-Ma. 1) | 2,000 | | 0.5 |
| | | 6,300 | 0.5 |
| 6 medium schemes | .. | 106,000 | 7.7 |
| 26 minor schemes | .. | 36,932 | } 10.8 |
| Small tanks and diversions | .. | 155,800 | |
| Estimated losses from reservoirs and tanks | .. | .. | 38.7 |
| Total | 2,000 | 569,030 | 90.5 |

15—22 Sub-basin G-9 Pranhita

(a) *General* : The Pranhita sub-basin (See plate XXXI) comprises the catchment of the river Wainganga from its source to its confluence with the Wardha and the Pranhita up to its confluence with the Godavari ; the sub-basin includes all the tributaries of the Wainganga and the Pranhita except the Penganga and the Wardha.

The sub-basin has an area of 23,588 square miles. It is about 268 miles long from north to south and about 176 miles from east to west at the widest point. Parts of Balaghat, Chhindwara, Seoni and portions of Betul and Mandla districts of Madhya Pradesh, parts of Bhandara, Chanda and Nagpur and a small portion of Nanded district of Maharashtra and part of Adilabad district of Andhra Pradesh lie in this sub-basin.

(b) *Topography and soil* : The northern part of the sub-basin lies along the southern slopes of the Mahadeo hills and varies in elevation from 4,000 feet to 2,000 feet. The southern part of the sub-basin varies in elevation from 2,000 feet to 400 feet, interspersed with numerous hill ranges and forests.

The sub-basin has predominantly medium black soil with small patches of red soil and red and yellow soil in some parts.

(c) *Rainfall* : The sub-basin lies in a fairly heavy rainfall zone 1,100 mm to 1,600 mm (43.3 inches to 65.0 inches). The weighted average rainfall is 1,363 mm of 53.86 inches. There are 56 rain-gauge stations in the sub-basin.

(d) *Evaporation* : The mean annual potential evaporation is about 2,800 mm or about 110.32 inches.

(e) *River flow* : There are no useful discharge data for the sub-basin. Accordingly a rough estimate has been made in Appendix C ; the yield from this sub-basin may be 1,300 T.M.C.

To this will, of course, be added the inflow of G. 8 sub-basin inclusive of the inflow of G. 7 sub-basin.

(g) *Irrigation uses as in 1951* :

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| Wainganga canal | 52,100 | 5.9 |
| 13 medium schemes | 106,500 | 7.8 |
| 53 minor schemes | 47,763 | } 29.0 |
| small tanks and diversions | 400,200 | |
| estimated losses from reservoirs and tanks | .. | 61.0 |
| Total | 606,563 | 103.7 |

(g) *Developments since 1951* :

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-----------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) <i>schemes in operation</i> | .. | .. |
| 3 medium schemes | 23,800 | 1.8 |
| 8 minor schemes | 3,472 | } 0.4 |
| Small tanks and diversions | 3,900 | |
| (ii) <i>schemes under construction</i> | .. | .. |
| 4 medium schemes | 37,400 | 2.9 |
| 10 minor schemes | 11,918 | } 1.0 |
| small tanks and diversions ; | 1,900 | |
| (iii) improvements on existing works | 26,000 | -0.4 |
| (iv) estimated losses from reservoirs and tanks | .. | 3.6 |
| Total | 108,390 | 9.3 |

(h) *Power developments :*

No hydro power project exists; nor is any under construction.

(i) *Proposed developments :*

| <i>Name or particulars of schemes</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-----------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Bagh River Project (10C.2-G.9-M.4) | .. | 110,000 | 8.3 |
| Itiadoh Project (11C.2-G.9-M.5) | .. | 134,000 | 12.3 |
| Pranhita Project *(13C.3-G.9-A.13) | .. | 250,000 | 57.7 |
| | 300,000 | .. | 455.3 |
| Upper Wainganga Project (18C.3-G.9-Ma.2) | 7,500 | 178,700 | 19.7 |
| Bijna Project (20C.3-G.9-Ma.4) | .. | 61,500 | 6.5 |
| Uskel Scheme (27G.3-G.9-Ma. 11) | 2,000 | 6,000 | 0.5 |
| | | .. | 0.1 |
| Nahara Hydrel Scheme (28C. 3-G.9-Ma. 12) | 7,700 | .. | 3.7 |
| | .. | 25,000 | 2.9 |
| Dzo-Ama-Son Scheme (31-C.3-G.9-Ma. 15) | 20,200 | .. | 2.0 |
| | .. | 10,000 | 3.7 |
| Bawanthari Project (32C.3-G. 49.-Ma. 16 M.34) | .. | 134,000 | 12.0 |
| Pench Diversion Scheme (37C.3-G.9-Ma. 21); | .. | 307,700 | 29.7 |
| Kulbehra Scheme (38C.3-G.9-Ma.22) | 27,500 | .. | 9.8 |
| | .. | 9,000 | 0.9 |
| Lower Wainganga Project (103C.3-G.9-M.28) | .. | 240,000 | 19.0 |
| Pranhita Project (104C.3-G.9-M.29) | 217,000 | .. | 189.9 |
| Kanhan River Project (107C.3-G.9-M.32) | 36,000 | 331,200 | 38.1 |
| Pench River Project (108C.3-G.9-M.33) | 66,700 | .. | 23.4 |
| | .. | 232,500 | 21.2 |
| Tultuli Project (113C.3-G.9-M.39) | .. | 76,000 | 6.3 |
| Kathani Project (115C.3-G.9-M.41) | .. | 94,000 | 7.8 |
| Andhari Project (118C.3-G.9-M.44) | .. | 72,000 | 5.6 |
| 26 medium schemes | .. | 458,400 | 43.1 |
| 260 minor schemes | .. | 382,096 | 100.0 |
| small tanks and diversions | .. | 936,000 | |
| improvements on existing works | .. | 8,900 | 1.0 |
| estimated losses from reservoirs and tanks | .. | .. | 317.2 |
| Total | 702,600 | 4,056,996 | 713.5 |

*See paragraph 14-49

15-23 Sub-basin G. 10 Lower Godavari

(a) *General* : The lower Godavari sub-basin (See Plate XXXII) comprises the lower part of the river Godavari from its confluence with the Pranhita to the sea; the sub-basin includes the direct catchment of the Godavari in this reach and of all its tributaries which fall into it in this reach except the Indravati and the Sabari.

The sub-basin has an area of 9,602 square miles. It is about 210 miles long from west to east. The sub-basin lies in part of East Godavari, Karimnagar, Khammam, Warangal and West Godavari and a small portion of Visakhapatnam district of Andhra Pradesh, part of Bastar district in Madhya Pradesh and a small part of Chanda district in Maharashtra.

(b) *Topography and soil*: There are two distinct zones in the sub-basin. The western half of the sub-basin is interspersed with numerous hills and ranges of the Eastern Ghats and the eastern half is the fertile delta of the Godavari. The hill ranges are covered with forests. The valley land is a fertile plain varying in elevation from 500 feet to about 50 feet above sea level.

Along the north-west south-east direction, the sub-basin has deep black soil except the valley land along the Godavari river which has red loamy soil. Some portions up to the confluence of the Godavari and the Sabari also have red sandy soil.

(c) *Rainfall* : The sub-basin lies in fairly heavy rainfall zone varying from 1,100 mm to 1,400 mm (43·3 inches to 55·1 inches). Although most of the rain precipitates during the south-west monsoon, a part is received during the retreating monsoon—October to December. The weighted average annual rainfall is 1,208 mm or 47·5 inches.

There are 13 rain-gauge stations in the sub-basin.

(d) *Evaporation* : The mean annual potential evaporation is about 2,300 mm or 90 inches.

(e) *River flow* : There are no discharge statistics available from which the direct run-off from this sub-basin could be worked out. Accordingly a rough estimate has been made in Appendix C; the average annual yield for this sub-basin may be 400 T.M.C.

To this will be added the inflow from G·5 (inclusive of the inflow from G·1 and G·6), G·9, G·11 and G·12.

(f) Irrigation uses as in 1951:

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|----------------------------------------------------|
| Godavari Delta System | 1,221,500 | 253.0 |
| 1 medium scheme | 5,600 | 1.8 |
| 14 minor schemes | 5,919 | } 1.2 |
| small tanks and diversions | 1,200 | |
| estimated losses from tanks | | 1.6 |
| Total | 1,234,219 | 257.6 |

(g) Developments since 1951 :

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|-------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(i) Schemes in operation]</i> | | |
| small tanks and diversions | 23,000 | 3.9 |
| <i>(ii) Schemes under construction</i> | | |
| 1 Medium scheme | 15,400 | 2.4 |
| 1 minor scheme | 1,000 | } 0.2 |
| small tanks and diversions | 400 | |
| <i>(iii) improvements to existing works</i> | 54,800 | —21.4 |
| <i>(iv) estimated losses from tanks</i> | | 3.3 |
| Total | 94,600 | —11.6 |

(h) Power development :

No hydro-power project exists; nor is any under construction.

(i) Proposed developments :

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| Inchampalli Project (3C. 3-G, 10-A.3) | 600,000 | 450,000 | 110.0 |
| Singareddy Hydro-electric scheme (4C. 3-G. 10 A.4) | 210,000 | | 669.4 |
| Ippur reservoir scheme* (5C. 3-G. 10-A.5) | 420,000 | 1,676,000 | 371.2 |
| Providing, 6, drumgates to Godavari Anicut (7C. 3-G. 10-A.7) | | 249,600 | 57.4 |
| Mukpara project (63C, 3-G.10-Ma.47) | 7,000 | 15,000 | 1.4 1.8 |
| Kormanar Scheme (64C. 3-G. 10-Ma. 48) | 1,000 | 4,800 | 0.4 0.3 |
| 5 Medium schemes | | 49,800 | 12.7 |
| 49 Minor schemes | | 72,357 | 18.4 |
| Small tanks and diversions | | 38,200 | |
| Improvements on existing works | | 3,300 | 0.1 |
| Estimated losses from reservoirs and tanks | | | 140.7 |
| Total | 1,238,000 | 2,559,057 | 712.6 |

15-24 Sub-basin G-11 Indravati

(a) General : The Indravati sub-basin (See plate XXXIII) comprises entire catchment of the Indravati from its source to its confluence with the Godavari.

The sub-basin has an area of 16,087 square miles. Parts of Koraput and Kalahandi districts of Orissa, part of Bastar and portion of Raipur and Durg districts of Madhya Pradesh and part of Chanda district of Maharashtra lie in this sub-basin.

(b) Topography and soil : The entire sub-basin forms part of the Eastern Ghats which are a series of broken hills and table land varying in elevation from 4,500 feet to 2,000 feet. Most of the land is covered by forests. Part of Dandakaranya lies in this sub-basin.

*See paragraph 14-49.

The sub-basin has predominantly red loamy soil.

(c) *Rainfall* : The sub-basin lies in a fairly heavy rainfall zone 1,400 mm to 1,600 mm (55.1 inches to 65.0 inches). The weighted average annual rainfall is 1,588 mm or 61.70 inches.

There are only 12 rain-gauge stations in this large sub-basin; these are inadequate for such a large catchment.

(d) *Evaporation* : The mean annual potential evaporation is about 2,200 mm or about 86.7 inches.

(e) *River flow* : There is no discharge site in the sub-basin for which reliable data exist. Accordingly a rough estimate has been made in Appendix C; the average annual yield from this sub-basin may be 1,160 . . .C.

(f) *Irrigation uses as in 1951* :

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|----------------------------------------------------|
| 15 minor schemes | | |
| Small tanks and diversions | 58,000 | 4.8 |
| Estimated losses from tanks | | 3.2 |
| Total | 58,000 | 8.0 |

(g) *Developments since 1951* :

| <i>Name or particulars of schemes</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------------|------------------------------------------|----------------------------------------------------|
| (i) Schemes in operation | | |
| 8 minor schemes | 5,411 | 0.8 |
| Small tanks and diversions | | |
| (ii) Schemes under construction | | |
| 1 medium project | 18,600 | 1.3 |
| 8 Minor schemes | 10,440 | 1.3 |
| Small tanks and diversions | | |
| (iii) Estimated losses from reservoirs and tanks | .. | 3.5 |
| Total | 47,851 | 6.9 |

(h) Proposed developments :

| <i>Name or particulars of schemes</i> | <i>Power installed k. W.</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|------------------------------------------------------------|----------------------------------|----------------------------------------------|--------------------------------------------------------|
| Indravati Hydrel Project. (40C. 3-G. 11-Ma. 24) . . . | 541,000 | | 189.2 |
| Bhoopalapatnam* (41-C. 3-G. 11-Ma. 25/M.45) . . . | | 128,000 | 10.0 |
| Baroda-waler and Upper Nibra Scheme (47C. 3-G, 11-Ma.31) . | 170,000 | | 252.3 |
| Gudra Hydrel Project (48C. 3-G. 11-Ma. 32) . . . | 53,000 | 22,000 | 2.7 |
| Berudi Project (53C. 3-G. 11-Ma. 37) . . . | 10,000 | .. | 16.3 |
| Kotri-Nibra Hydrel Scheme (55C. 3-G. 11-Ma. 39/M.46) | 15,000 | 10,000 | 12.6 |
| Kokral scheme (60C. 30G. 11-Ma. 44) . . . | 93,000 | .. | 14.2 |
| Jallavagu Scheme (61C. 3-G. 11-Ma. 45) . . . | 3,000 | 5,000 | 1.4 |
| Bandia Hydro-electric Scheme (119C. 3-G. 11-M. 47) . . . | 2,700 | 12,500 | 0.7 |
| Upper Indravati Project (123C. 3-G. 11-0.1) . . . | 16,000 | .. | 1.4 |
| Indravati Kolab Project (124C. 3-G. 11-0.2) . . . | 89,500 | 187,200 | 0.4 |
| Bhaskel Project (126C. 3-G. 11-0.4) . . . | | 408,900 | 24.9 |
| 22 medium projects . . . | | 61,800 | 25.1 |
| 150 minor schemes . . . | | 326,300 | 63.3 |
| Small tanks and diversions . . . | | 224,850 | 8.7 |
| Estimated losses from reservoirs and tanks . . . | | 353,200 | 33.6 |
| Total . . . | 993,200 | 1,739,750 | 48.8 |
| | | | 182.0 |
| | | | 377.5 |

*See paragraph 14-49.

15-25 Sub-basin G-12 Sabari

(a) *General* : The Sabari sub-basin (See plate XXXIV) comprises the entire catchment of the Sabari river from its source to its confluence with the Godavari. It has an area of 7,887 square miles. Part of Koraput district of Orissa, part of Bastar district of Madhya Pradesh and part of East Godavari and Visakhapatnam districts of Andhra Pradesh lie in this sub-basin.

(b) *Topography and soil* : The Eastern Ghats criss-cross the entire sub-basin. There are a series of parallel ranges and table lands varying in elevation from 4,500 feet to 2,000 feet, with dense forests covering almost the entire sub-basin. Part of the Dandakaranya lies in this sub-basin.

Red loamy soil covers the entire sub-basin.

(c) *Rainfall*: The sub-basin lies in fairly heavy rainfall zone 1,200 mm to 1,600 mm (47.3 inches to 65.0 inches) annual. The weighted average annual rainfall is 1,433 mm or 56.46 inches. Although a major part of this rainfall precipitates during the south-west monsoon a substantial portion, about 11 per cent, falls during October to December.

There are 8 rain-gauge stations in the sub-basin.

(d) *Evaporation* : The mean annual potential evaporation is about 2,000 mm or 78.8 inches.

(e) *River flow* : There are two sites for which fairly reliable discharge data are available but they represent only a small part of the sub-basin. Accordingly a rough estimate has been made in Appendix C; the average annual yield from this sub-basin may be 480 T.M.C.

(f) *Irrigation uses as in 1951* :

| <i>Name or particulars of scheme</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------|------------------------------------------|----------------------------------------------------|
| Small tanks and diversions | 15,700 | 1.5 |
| Estimated losses from tanks | | 2.1 |
| Total | 15,700 | 3.6 |

(g) *Developments since 1951* :

| <i>Name or particulars of scheme</i> | <i>Power installed (kW.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|---------------------------------------------------------|------------------------------|------------------------------------------|----------------------------------------------------|
| <i>(i) Schemes in operation</i> | | | |
| Machkund Hydro-electric Project | 114,750 | | 44.2 |
| Small tanks and diversions | | 8,200 | 0.8 |
| <i>(ii) schemes under construction</i> | | | |
| Upper Sileru Hydro-electric Project Stage I | 120,000 | | 56.8 |
| 16 Minor schemes | 19,140 | | |
| Small tanks and diversions | 5,200 | | 2.0 |
| <i>(iii) Estimated losses from reservoirs and tanks</i> | | | |
| | | | 8.3 |
| Total | 234,750 | 32,540 | 11.1 |

(h) Proposed developments :

| <i>Name or particulars of scheme</i> | <i>Power installed (k.W.)</i> | <i>Average annual irrigation (acres)</i> | <i>Average annual diversion or losses (T.M.C.)</i> |
|----------------------------------------------------------------|-------------------------------|------------------------------------------|----------------------------------------------------|
| Guntewada-Balimela Hydro-electric Project (4C.2-G. 12-A.4/0.1) | 420,000 | | 131.0 |
| Lower Machkund Hydro-electric Project (15C. 3-G. 12-A. 15) | 30,000 | | 46.7 |
| Lower Sileru Hydro-electric Project (16C. 3-G. 12-A. 16) | 210,000 | | 84.4 |
| Sabari Multipurpose project (67C. 3-G. 12-Ma. 51/0.12) | 250,000 | 1,060,000 | 113.2 |
| Konta Project* (68C. 3-G. 12-Ma. 52/0.13) | 50,000 | 30,000 | 78.8 4.0 |
| Kaklur-mupari Scheme (70C. 3-G. 12-Ma. 54) | 7,300 | 20,000 | 1.5 2.5 |
| Upper Kolab Hydel (132C. 3-G. 12-0.10) | 101,000 | | 34.7 |
| Balimela Irrigation Project (134C. 3-G. 12-0.14) | | 319,200 | 62.8 |
| 7 medium schemes | | 129,700 | 12.7 |
| 48 minor schemes | | 66,200 | } 19.2 |
| small tanks and diversions | | 163,100 | |
| estimated losses from reservoirs and tanks | | | 55.0 |
| Total | 1,068,300 | 1,788,200 | 269.4 |

*See paragraph 14-49

Comments on sub-basin studies

15-26 In the studies made in paragraphs 15-2 to 15-25 above, the reservoir losses from major and medium schemes have been taken from the particulars of various projects as furnished by the State Governments concerned and given in the relevant Annexures (also see paragraph 5-35). For minor schemes and small tanks and diversions, these losses have been worked out in accordance with the procedure adopted in paragraph 12-25 where it has been shown that the water spread of these tanks is about 87.5 per cent of the irrigated area. This assumption is based on a study of tanks in Andhra Pradesh. The evaporation losses have been taken as 3.5 feet depth of water. Obviously, losses in other parts of the two basins would vary depending not only on the local evaporation rates but also on the water spread of the tanks in relation to their capacity. In the absence of detailed particulars for other areas, the Commission has adopted the results obtained from the study of tanks in Andhra Pradesh for all the sub-basins and, to this extent, the picture presented is approximate.

15-27 Apart from irrigation and power uses, shown in the sub-basin studies in paragraphs 15-2 to 15-25 above, Mysore has 1.3 million acres to develop by minor schemes and small tanks and diversions. Distribution of this area by sub-basins has, however, not been furnished. Hence, the requirements of water for this development have not been included in the sub-basin studies. Irrigation of this area of 1.3 million acres in Mysore would require about 186 T.M.C. of water and it may involve evaporation losses of about 173 T.M.C.

The sub-basin studies have also not taken into account any industrial use of water and water supply for cities except to the extent these have been included in the projects described in Chapters XII, XIII and XIV. These, as stated in paragraph 14-27, may require 50 T.M.C. of water.

15-28 With regard to the totals of "proposed power installed", of "proposed annual irrigation" and of "proposed annual diversion", as given for different sub-basins in paragraphs 15-2 to 15-25, attention may be drawn to paragraph 14-50, in which it has been stated that these totals would, in case of some sub-basins, indicate figures higher than the overall potentialities of the system. These totals should, therefore, be taken only as indicative of the general trend of the possibilities of each sub-basin.

Hydrologic characteristics of different sub-basins

15-29 Table XXXIV shows some of the important hydrologic characteristics of different sub-basins on the Krishna and Godavari river systems. The catchment area of each sub-basin, its weighted average rainfall for the year as a whole and for the south-west monsoon period, June to September, are shown against the rough estimate of the average annual yield for the sub-basin, determined in accordance with the procedure outlined in paragraphs 15-2 to 15-25 above.

Because of varying conditions in each sub-basin, as indicated in paragraphs 15-2 to 15-25, the yields from different sub-basins do not show any constant relation with either the annual, or the south-west monsoon, rainfall. While some explanation can be suggested for differences in this relationship for most sub-basins, the yields from K. 3 Ghataprabha sub-basin and G. 2 Pravara sub-basin when compared with the Isohyets, show a disparity which cannot be adequately explained on the basis of the data available.

15-30 The aggregate yield of all the sub-basins on the Krishna works out to 2,217 T.M.C. In determining the yield of each sub-basin some allowance has been made for transit losses in the rivers. As against this aggregate average yield of 2,217 T.M.C., the average *recorded* flow at Vijayawada was 1,911 T.M.C. during the period 1901-02 to 1930-31 and 2,000 T.M.C. during the period 1931-32 to 1960-61; the total diversion upstream, as of 1951, was 224.6 T.M.C. and estimated annual evaporation losses from reservoirs and tanks 118.3 T.M.C. The disparity in these estimates indicates the range of approximation in which one has to work in the absence of a comprehensive record of scientifically observed river flow data.

TABLE XXXIV

IMPORTANT HYDROLOGIC CHARACTERISTICS

| Name of sub-basin | Direct catchment area (Square miles) | Weighted average rainfall | | Rough estimate of average annual yield | | | | |
|-------------------------------|--------------------------------------------------|------------------------------|-------------------------------|-------------------------------------------|---------------------------------------------|--------------------|--|--|
| | | Annual (inches) | June September (inches) | T.M.C. | M.Cft per square mile of catchment | Inches of depth | | |
| Krishna River System | | | | | | | | |
| K-1 Upper Krishna | 6,939 | 59.4 | 50.6 | 550 | 79.3 | 34.1 | | |
| K-2 Middle Krishna | 6,779 | 22.2 | 14.4 | 35 | 5.2 | 2.2 | | |
| K-3 Ghataprabha | 3,409 | 36.3 | 26.4 | 190 | 55.7 | 24.0 | | |
| K-4 Malaprabha | 4,459 | 26.6 | 17.0 | 70 | 15.7 | 6.8 | | |
| K-5 Upper Bhima | 17,786 | 26.6 | 20.7 | 400 | 22.5 | 9.7 | | |
| K-6 Lower Bhima | 9,478 | 26.0 | 19.6 | 55 | 5.8 | 2.5 | | |
| K-7 Lower Krishna | 13,948 | 28.4 | 20.0 | 210 | 15.1 | 6.5 | | |
| K-8 Tungabhadra | 18,466 | 34.8 | 24.5 | 520 | 28.2 | 12.1 | | |
| K-9 Vedavati | 9,108 | 22.4 | 11.3 | 50 | 5.5 | 2.4 | | |
| K-10 Musi | 4,329 | 29.5 | 21.5 | 50 | 11.6 | 5.0 | | |
| K-11 Palleru | 1,260 | 31.9 | 23.8 | 17 | 13.5 | 5.8 | | |
| K-12 Muneru | 4,019 | 37.6 | 28.5 | 70 | 17.4 | 7.5 | | |
| Godavari River System | | | | | | | | |
| G-1 Upper Godavari | 12,935 | 30.3 | 25.4 | 240 | 18.5 | 8.0 | | |
| G-2 Pravara | 2,524 | 23.9 | 18.8 | 70 | 27.7 | 12.0 | | |
| G-3 Purna | 6,015 | 31.4 | 26.0 | 100 | 16.6 | 7.2 | | |
| G-4 Manjra | 11,909 | 33.2 | 27.4 | 270 | 22.7 | 9.8 | | |
| G-5 Middle Godavari | 6,643 | 37.6 | 31.8 | 100 | 15.1 | 6.5 | | |
| G-6 Maner | 5,060 | 36.7 | 30.0 | 90 | 17.8 | 7.7 | | |
| G-7 Penganga | 9,227 | 37.8 | 32.3 | 180 | 19.5 | 8.4 | | |
| G-8 Wardha | 9,300 | 39.6 | 35.7 | 240 | 25.8 | 11.1 | | |
| G-9 Pranhita | 23,588 | 53.9 | 47.1 | 1,300 | 55.1 | 23.7 | | |
| G-10 Lower Godavari | 9,602 | 47.6 | 36.6 | 400 | 41.7 | 17.9 | | |
| G-11 Indravati | 16,087 | 61.7 | 53.8 | 1,160 | 72.1 | 31.0 | | |
| G-12 Sabari | 7,887 | 56.5 | 44.8 | 480 | 60.8 | 26.2 | | |

217

A similar examination of the yields from the Godavari sub-basins has been made in paragraph 9 of Appendix C.

Limitations on estimates of sub-basin flow

15-31 Attention may be drawn here to the fact that, in general, the flow data available for all sites on the Krishna and the Godavari rivers (except Vijayawada and Dowlashwaram) have been assumed as correct within 20 per cent, plus or minus, of the actuals (see Chapter IX). As such, the estimates of river flow in each sub-basin, as made in paragraphs 15-2 to 15-25 above, must also be regarded as subject to the same limitation.

15-32 It must also be clear that the estimates of river flow given in paragraphs 15-2 to 15-25 are for *average annual* flow. As stated in paragraph 9-27, about 95 per cent of the annual flow appears during six months, June to November. Apart from this, there is large fluctuation in the available supplies from year to year. This has to be kept in view in project planning. This fluctuation would be more marked in those sub-basins where the rainfall is relatively low than where the river flow is derived largely from the Western *Ghats* or from the forest-covered hills in the north-east of the Godavari basin.

15-33 As explained in paragraph 14-31, there will be some return flow into the rivers in each sub-basin from new irrigation developments in the sub-basin or in the upper sub-basins. As already stated, it is difficult to give any quantitative values for the anticipated regeneration. Withdrawals for irrigation from new surface wells or by tubewells would reduce this regeneration. There would also be the effect on river flow of land treatment like contour bunding, levelling of land for irrigation and construction of new field dowsels *etc.* Further, as stated in paragraph 9-40, additional withdrawals from the upper reaches of a river would result in the salvage of losses which would otherwise occur in transit to a lower site on the river. All these factors will play their part, but it is not possible at this stage to allot any quantitative values to the overall likely effect on the supplies available at a particular point.

Need for caution

15-34 It may be emphasised here that the Commission regards the rough estimate of river flow made by it for each sub-basin as no better than an informed guess. In general, only a small part* of the quantity estimated is based on observed data which themselves are subject to the limitations described in paragraph 15-31. The major part of the quantities assessed are, however, based on general hydrologic considerations, rainfall data, annual and seasonal—and analogy of nearby catchments. While the figures indicated should give a general idea of the likely average yield from each sub-basin, these estimates in the Commission's view are not enough to form the basis of big projects involving large sums of public money. Accordingly, considerable caution must be exercised in sanctioning any further projects; even some of those, already under construction, may well be reviewed in the light of the studies made in paragraphs 15-2 to 15-25 above.

*About 50 per cent on the Krishna but 5 per cent on the Godavari.

TABLE XXXV
REVIEW OF ESTIMATED YIELD AND PROJECT REQUIREMENTS AS PROPOSED BY
STATE GOVERNMENTS

| Name of sub-basin | Estimated direct annual yield from sub-basin | Receives inflow from | Diversion and losses by projects* | | | | |
|------------------------------------------|----------------------------------------------|---------------------------------|-----------------------------------|-----------------------|--------------------------|----------|--|
| | | | as in 1951 | Undertaken since 1951 | sum of col. 4 and col. 5 | Proposed | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| | | T.M.C. | | | T.M.C..... | | |
| | | Krishna River System | | | | | |
| K.1 Upper Krishna | 550.0 | .. | 2.2 | 86.6 | 88.8 | 436.8 | |
| K.2 Middle Krishna | 35.0 | K.1, K.3, K.4 | 1.8 | 4.8 | 6.6 | 404.6 | |
| K.3 Ghataprabha | 190.0 | .. | 3.0 | 38.8 | 41.8 | 116.8 | |
| K.4 Malaprabha | 70.0 | .. | 9.7 | 5.6 | 15.3 | 45.9 | |
| K.5 Upper Bhima | 400.0 | .. | 89.8 | 58.6 | 148.4 | 207.6 | |
| K.6 Lower Bhima | 55.0 | K.5 | 6.2 | 5.3 | 11.5 | 168.0 | |
| K.7 Lower Krishna (upto Vijayawada) | 210.0 | K.2, K.6, K.8, K.10, K.11, K.12 | 258.9 | 315.1 | 574.0 | 1,315.1 | |
| K.8 Tungabhadra | 520.0 | K.9 | 124.4 | 292.3 | 416.7 | 161.6 | |
| K.9 Vedavati | 50.0 | .. | 48.1 | 8.3 | 56.4 | .. | |
| K.10 Musi | 50.0 | .. | 32.2 | 16.5 | 48.7 | 3.2 | |
| K.11 Palleru | 17.0 | .. | 15.5 | 2.1 | 17.6 | 1.2 | |
| K.12 Maneru | 70.0 | .. | 57.5 | 5.7 | 63.2 | 17.80 | |
| | | Godavari River System | | | | | |
| G.1 Upper Godavari | 240.0 | G.2 and G.3 | 14.0 | 18.0 | 32.0 | 161.0 | |
| G.2 Pravara | 70.0 | .. | 17.0 | 35.0 | 52.0 | 15.0 | |
| G.3 Purna | 100.0 | .. | .. | 39.0 | 39.0 | 34.0 | |
| G.4 Manjra | 270.0 | .. | 102.0 | 11.0 | 113.0 | 133.0 | |
| G.5 Middle Godavari | 100.0 | G.1, G.4 and G.6 | 39.0 | 29.0 | 68.0 | 500.0 | |
| G.6 Maner | 90 | .. | 57.0 | 11.0 | 68.0 | 29.0 | |
| G.7 Penganga | 180 | .. | 1.0 | 2.0 | 3.0 | 121.0 | |
| G.8 Wardha | 240 | G.7 | 5.0 | 5.0 | 10.0 | 91.0 | |
| G.9 Pranhita | 1,300 | G.8 | 104.0 | 9.0 | 113.0 | 714.0 | |
| G.10 Lower Godavari (upto Dowlaishwaram) | 400 | G.5, G.9, G.11 and G.12 | 258.0 | 12.0 | 270.0 | 713.0 | |
| G-11 Indravati | 1,160 | .. | 8.0 | 7.0 | 15.0 | 378.0 | |
| G-12 Sabari | 480 | .. | 4.0 | 11.0 | 15.0 | 269.0 | |

* See paragraph 15-28.

15-35 It would be obvious that within each sub-basin a more intensive study would have to be made because the adequacy of river supply for any project has to be gauged by supplies available at the site of the proposed diversion and not on the yield of the sub-basin as a whole. Such a study will have to be taken up in connection with each individual project and would require more exact particulars of minor schemes and small tanks and diversions and of the evaporation losses than are available to the Commission. For the purpose of this report, however, the examinations made by sub-basins should give a fairly good picture.

Some general conclusions

15-36 Table XXXV gives, in brief, a comparison of the estimated yield from each sub-basin and the diversions and losses by projects of various categories. The information in this Table should be examined in the light of the considerations set out in paragraphs 15-26 to 15-34 above and the particulars for each sub-basin given in paragraphs 15-2 to 15-25 above. The following general conclusions emerge:

(a) *On the Krishna*

- (i) Until river flow data have been observed for a number of years in accordance with the recommendations made in paragraph 9-44, it would not be advisable to undertake any further major or medium project in sub-basins K. 8, K. 9, K. 10, K. 11 and K. 12.
- (ii) There has not been much development so far in sub-basins K. 2 Middle Krishna, K. 4 Malaprabha and K. 6 Lower Bhima.
- (iii) The surplus waters available after meeting the requirements of pre-1951 projects and those undertaken since then in sub-basins K. 1, K. 3 and K. 4 have to be utilised not only for the development of projects proposed in these sub-basins but also for the projects proposed in sub-basins K. 2 and K. 7.
- (iv) If any surplus waters are found in sub-basin K. 8, these have to be utilised not only for the development of projects proposed in this sub-basin but also for the projects proposed in sub-basin K. 7.
- (v) The surplus waters available after meeting the requirements of pre-1951 projects and those undertaken since then in sub-basin K. 5 have to be utilised not only for the development of projects proposed in this sub-basin but also for the projects proposed in sub-basins K. 6 and K. 7.
- (vi) The requirements of all the projects in sub-basins K. 1 to K. 8, as indicated by the State Governments, cannot be met by the available supplies even if these can be made fully utilisable; the maximum shortage is in sub-basin K. 7 Lower Krishna.

(b) *On the Godavari*

- (i) Until river flow data have been observed for a number of years in accordance with the recommendations made in paragraph 9-44, it would not be advisable to undertake any further major or medium project in sub-basins, G. 2

G. 3 and G. 6 and on the tributaries (other than Manjra and Maner) out-falling into the Godavari in G. 5 Middle Godavari sub-basin.

- (ii) The surplus supplies available from sub-basins G. 1 and G. 4 (and ultimately also from G. 2 and G. 3) after meeting present commitments have to be utilised not only for the development of the projects proposed in these sub-basins but also for those based on the supplies in the main river in G. 5 sub-basin.
- (iii) It is unlikely that any dependable supplies would ultimately flow down from the Middle Godavari sub-basin.
- (iv) There has not been much development so far in sub-basins G. 7, G. 8, G. 9, G. 11 and G. 12 and there is likely to be surplus waters in sub-basins G. 8, G. 9, G. 11 and G. 12. According to the proposals made by the State Governments, minimum regulated flows (from power projects) of 190 T.M.C. and 252 T.M.C. should be available in the rivers Pranhita and Indravati respectively near their confluence with the Godavari. This would amount to more than 10 M.A.F.

Integrated project for lower Godavari

15-37 One of the most urgent tasks in the Godavari basin would appear to be the preparation of an integrated plan incorporating the developments proposed under the following projects:

| | |
|---------------------------|----------------------------------|
| 13C. 3-G. 9-A. 13 | Pranhita Project |
| 104C. 3-G. 9-M. 29 | Pranhita Project |
| 40C. 3-G. 11-Ma. 24 | Indravati Hydel Project |
| 41C. 3-G. 11-Ma. 25/M. 45 | Bhopalapatnam Project |
| 55C. 3-G. 11-Ma. 39/M. 46 | Kotri Nibra Project |
| 68C. 3-G. 12-Ma. 52/O. 13 | Konta Project |
| 3C. 3-G. 10-A. 3 | Inchamapalli Project |
| 4C. 3-G. 10-A. 4 | Singareddy Hydro-electric Scheme |
| 5C. 3-G. 10-A. 5 | Ippur reservoir scheme |

Three of these projects have been proposed as joint projects; some others impinge on each other (see paragraph 14-49). These projects have a large hydro-electric potential; only an integrated scheme can develop this potential to best advantage. A regulated supply of water from an upper power project can successively be used on a number of downstream power projects. The full reservoir levels and tail race levels at each project site have to be so fixed as to get maximum benefit of the gross head available.

The Ippur reservoir scheme would have available to it considerable additional flow, partly regulated by power projects, from sub-basin G. 12.

15-38 A large part of the regulated flow available in the river Godavari from the power projects referred to above, which would amount to much more than 10 M.A.F., would be surplus to the requirements of projects on the Godavari and can be diverted to the Krishna basin, to meet in part the shortage in sub-basin K. 7 Lower Krishna [See paragraph 15-36 (a) (vi) above].

Pochampad Project

15-39 In view of the remarks in paragraph 15-36 (b)(iii) above, there would appear to be little possibility of generating any power at Pochampad, as provided in Pochampad Project, Stage II. Also, in the light of the hydrologic features of the river system above Pochampad, it would be clear that the proposed Pochampad Canal could not get continuous supply even during the monsoon period without storage to regulate the spasmodic flow into the river from catchments in a fairly dry zone. Accordingly, Pochampad Project Stage I, as proposed, would not be feasible and for the irrigation of the area south of the Godavari, it would be necessary to include in Stage I itself a storage reservoir as proposed in Pochampad Project Stage II, with appropriate modifications in the scope of the project.

CHAPTER XVI

DIVERSION OF GODAVARI WATERS TO THE KRISHNA

16-1 Under its terms of reference, the Commission has been asked to report on the feasibility of diverting any surplus supplies in the Godavari to the Krishna, indicating the quantity to be diverted and the order of the cost involved.

Physical possibilities

16-2 As a first step, the Commission examined the physical possibility of diverting the waters of the Godavari into the Krishna, irrespective of the availability of any surplus waters in the Godavari.

As stated in paragraph 4-32 and as can be seen from Plate I, the upper reach of the Godavari valley is lower than the corresponding reach of the Krishna valley. It is, therefore, not possible to divert, by flow, any waters from the upper reaches of the Godavari into the upper reaches of the Krishna. The highest suitable point on the Godavari from where its waters can be transferred to the Krishna is at or near the site of the proposed Pochampad reservoir. If sufficient waters were available at this site, it would be possible to construct a diversion canal in conjunction with, or parallel to, the Pochampad South Canal and to drop Godavari waters into the Nagarjunasagar reservoir. The alignment of this diversion canal is shown in Plate X. As stated in paragraph 14-24 (b)(i), the Pochampad South Canal itself will transfer Godavari waters into the Krishna basin.

16-3 Lower down the Godavari, there are possibilities of diverting the Godavari waters into the Krishna from two places; one from near Albaka along the alignment of the Godavari-Pulichintala Link and the other from the proposed Polavaram barrage to Vijayawada. The alignment of both these link canals is shown in Plate X and on Map VI. The former link canal will outfall into the proposed Pulichintala reservoir and the latter above the Krishna barrage at Vijayawada.

16-4 An attempt was also made to examine whether the waters of any of the tributaries of the Godavari could be diverted into the Godavari upstream of its normal outfall into the Godavari and then into the Krishna basin. One possibility along this line is the Penganga-Pochampad Link shown on Plate X. This will divert the waters of the upper part of the Penganga river into the Godavari by a short link canal. Another possibility is a diversion from the Manjra to the Bhima.

Pochampad—Nagarjunasagar Link

16-5 It would appear from paragraphs 15-36(b)(iii) and 15-39 that there would hardly be any surplus waters available in the Godavari at Pochampad after meeting the requirements of the areas which can be irrigated from the Godavari at and above Pochampad. As such, no further consideration has been given to this possible link

canal, at this stage. If it is found later, when sufficient data of river gaugings become available, that some surplus waters are available at Pochampad, this link may be investigated. The total length of the link would be about 286 miles.

For similar reasons, no further consideration has been given to the Manjra-Bhima diversion.

Polavaram—Vijayawada Link

16-6 A perusal of Plate X would show that of the different possible link canals to the Krishna, the shortest and, therefore, likely to be the cheapest is the Polavaram-Vijayawada Link. This link canal will be about 110 miles long. The full reservoir level proposed at the Polavaram barrage (5C-3-G.10-A.5) is about R.L. 145 and there is ample command available to drop the waters of the link canal upstream of the Krishna barrage at Vijayawada where the full pond level is R.L. 57.05. It may be possible to generate some power at the outfall. The alignment of the link canal will approximately be the same as that of the Right Bank Canal ex-Polavaram Barrage (5C-3-G.10-A.5).

16-7 This link canal (*see* Map VI) can command the entire irrigation of the Krishan Delta System and the New Krishna West Canal, proposed under the Nagarjunasagar Project (1C.1-K.7-A.1), as well as the irrigation proposed on the Right Bank Canal under the Ippur reservoir scheme (5C.3-G.10-A.5).

The Ayacut of the Krishna Delta Canals, as now proposed is 1,225,000 acres; that of the New Krishna West Canal 150,000 acres. The Ayacut on the Right Bank Canal as provided in the Ippur reservoir scheme is 300,000 acres. All this area could get its water supply from the Godavari and, in view of paragraph 15-36(b)(iv), a much more assured supply would be available for this area from the Godavari, through the Polavaram—Vijayawada Link, than at present from the Krishna.

16-8 A link canal with sufficient capacity to deliver about 11,500 cusecs above the Krishna Barrage would meet the proposed withdrawals* in full of both the Krishna Delta Canals and the New Krishna West Canals from mid-October to end June. During the rainy season, additional supply would be available from the inflow into the river below Pulichintala supplemented by adequate releases from the proposed Pulichintala reservoir. The annual supply to be diverted from the Godavari on this basis would be about 211 T.M.C.; the additional supply required from the Krishna would be about 25.0 T.M.C.

In view of the regulated supplies that would be available all the year round from the Godavari, it would be possible to improve considerably upon the crop pattern and intensity of irrigation in the areas irrigated from the Krishan Delta Canals and those proposed to be irrigated from the New Krishna West Canal.

* See column 11 of item 10 of the particulars of Krishna Delta Canals (1A-K.7-A.1) in Annexure VIII and column 5 of item 11 (iii) of the particulars of the Nagarjunasagar dam (1C.1-K.7-A.1) in Annexure X.

6-9 This link canal formed part of the Ramapadasagar Project (1950). For a capacity of about 21,400 cusecs at head, then proposed for this link canal, its estimated cost was about Rs. 17 crores. For a capacity at tail of 11,500 cusecs, the present cost may be of the order of Rs. 40 crores, excluding the cost of the Polavaram Barrage.

Godavari-Pulichintala Link

16-10 This link canal will take off from the Godavari above a diversion dam near Albaka. It will be about 153 miles long upto the proposed Pulichintala reservoir and will cross the main ridge between the Godavari and the Krishna through a tunnel about 17 miles long. A longitudinal section of the link canal is shown in Plate XXXVII.

16-11 This link canal will command the entire Pulichintala block (Ayacut 600,000 acres) partly under the Nagarjunasagar Right Bank Canal and partly under the proposed Pulichintala Project (5C.3-K.7-A.5) about 70,000 acres of the Ayacut under the Left Bank Canal of the Nagarjunasagar Project and may be able to take up another 230,000 acres proposed to be covered by an extension of the Nagarjuna sagar Left Bank Canal in Nagarjunasagar Project Stage II. This link will thus irrigate an area of about 900,000 acres. It can get regulated supply, all the year round, from the tail race waters of the proposed power projects on the Pranhita and the Indravati, see paragraph 15-36 (b)(iv). The crop pattern for this area should therefore, be worked out, not on the basis of 4 to 5 months supply as in the Krishna delta, but on the basis of 12 months supply. Assuming a fairly liberal allowance of about 4 cusecs per thousand acres of irrigated area, the capacity required at distributary heads would be 3,600 cusecs. Adding 400 cusecs for losses, the total capacity of the link canal, at head, would be 4,000 cusecs.

This link will transfer from the Godavari about 95 T.M.C.* of water annually for use in areas proposed to be developed from the Krishna.

16-12 The cost of this link canal including the cost of the tunnel but excluding the cost of the diversion dam would be of the order of Rs. 40 crores.

16-13 The exact location of the headworks of the Godavari-Pulichintala link will have to be examined in relation to other works that may be built on the Godavari in this reach (see paragraph 15-37). Andhra Pradesh has proposed a dam at Inchampalli (3C.3-G.10-A.3) about 50 miles above Albaka, and another at Singareddi, about 10 miles below Albaka. It should be possible either to move up the proposed dam at Singareddi to Albaka, or to move the headworks of the Godavari-Pulichintala link to Singareddi, thus avoiding another dam on the Godavari for the proposed link.

16-14 It is also possible to take off this link from above the proposed dam at Inchampalli along the alignment shown in Plate X of the Inchampalli-Pulichintala Link, but that would only mean an unnecessary extension of the link canal by about 50 miles.

* Assuming an annual capacity factor of 0.75.

The Penganga-Pochampad Link

16-15 In paragraph 15-20, the average annual run-off for G.7 Penganga sub-basin has been assumed as 19.5 M. Cft. per square mile. The catchment area of the Penganga above the site of the diversion for this link canal is 3,428 square miles and has a lower rainfall than the portion below this site. Taking a yield of 15 M. Cft. per square mile for this catchment, the annual yield at the diversion site may be of the order of 50 T.M.C. The possibility should be examined of diverting 25-30 T.M.C. of this yield to the Godavari to reduce the shortage in sub-basin G.5. It may be possible to develop some hydro-power on this link.

Consequential changes in various projects

16-16 (a) *Proposed Pulichintala Project (5C.3-K-7-A.5)* : Since the entire irrigation of the Krishna Delta Canals, the proposed New Krishna West Canal and the proposed Pulichintala Project will be taken over by the proposed link canals from the Godavari, the proposed Pulichintala reservoir would function only as a balancing reservoir to catch the inflow from the Krishna catchment below Nagarjunasagar and to release it as required to meet the demands of the canals at Vijayawada over and above 11,500 cusecs, to be delivered at Vijayawada by the Polavaram-Vijayawada Link. It may be not possible, therefore, to generate any firm power at Pulichintala. The proposed Pulichintala Project will thus have to be designed accordingly.

(b) *Nagarjunasagar Hydro-electric Project (2C.2-K.7-A.2)* : Since no supplies will need to be let down into the river below Nagarjunasagar, the hydro-electric development proposed at Nagarjunasagar will have to be abandoned.

(c) *Nagarjunasagar Project (1C.1-K.7-A.1)* : The proposed New Krishna West Canal will get its water supply from the Polavaram-Vijayawada Link; about 200,000 acres of the Pulichintala block included in Nagarjunasagar Right Canal and about 70,000 acres included in the Ayacut of the Nagarjunasagar Left Canal will get their water supply from the Godavari-Pulichintala Link. It will also not be necessary to release water from Nagarjunasagar storage for the second crop in the Krishna Delta; about 34.5 T.M.C. of stored water thus saved can be put to some other use. The Nagarjunasagar Project must, therefore, be reviewed in the light of these possibilities. Also, in view of (d) below the Nagarjunasagar dam will function largely as a diversion dam and should be built accordingly.

(d) *Srisailem Project (1C.2-K.7-A.1)* : Since the supplies to be let down below Srisailem would be limited to the requirements of the canals at Nagarjunasagar, as may be determined *vide* (c) above, the Srisailem hydro-electric project would need to be revised and the power releases below Srisailem determined accordingly. Since any flood waters released into the Krishna below Srisailem could not be put to any use in the Krishna Lower down, the possibility should be examined of escaping surplus flood waters reaching Srisailem reservoir into the Pennar through Sangameshwaram canal, from where it should be possible to put even undependable supplies into productive use.

(e) *Penganga hydro-electric Project (8C.2-G.7-M.2)* : If the diversion of 25-30 T.M.C. of Penganga waters to the Godavari near Pochampad is found feasible it will be necessary to abandon Penganga hydro-electric Project.

Overall effect of the proposed diversions

16-17 (a) It would appear from paragraphs 16-8 and 16-11 above that the Polavaram-Vijayawada Link and the Godavari-Pulichintala Link would be able to transfer from the Godavari to the Krishna about 211 T.M.C. and 95 T.M.C. respectively (in all about 7 M.A.F.) for the use of all the area developed, or proposed to be developed, from the Krishna below Nagarjunasagar and a part of the area proposed to be irrigated by Nagarjunasagar canals. It will not be necessary to let down any Krishna water into the river below Nagarjunasagar. Accordingly, the entire flow of the Krishna river system available upto Nagarjunasagar can be utilised at and above Nagarjunasagar.

(b) For the areas already developed from the Krishna below Nagarjunasagar and those proposed to be developed from the waters in this reach, a much more assured supply would be available from the Godavari than can be provided from the Krishna and considerable improvement would be possible in the intensity and type of irrigation.

(c) The hydro-electric development proposed at Pulichintala and Nagarjunasagar will have to be abandoned and that at Srisailem will have to be reduced in accordance with the requirements of the canals at Nagarjunasagar. There is, however, a large hydro power potential in the lower Godavari region which should be developed expeditiously.

(d) The proposed link from the Penganga into the Godavari can augment supplies available in the Godavari for the benefit of areas proposed to be developed by Andhra Pradesh and Maharashtra from G.1 and G.5 sub-basins.

(e) The proposed Pochampad Project will divert some Godavari waters for irrigation in the Krishna basin.

16-18 It may be stated here that the Commission did not undertake any field work in connection with the proposals made above regarding the Polavaram-Vijayawada Link and the Godavari -Pulichintala Link. These proposals are based only on a study of the topo-sheets of the area as well as of the particulars of various projects in the region as furnished by the State Governments. It may be necessary to modify these proposals in various ways as a result of detailed field investigations and overall planning.

It would have been noted that no separate dam or barrage would be required for either of the two links mentioned above.

Technically, it is possible to do away with the Polavaram-Vijayawada Link by increasing adequately the capacity of the proposed Godavari-Pulichintala Link but it would appear from a study of the maps and other data available that it would be cheaper to have two link canals than one. With two links, as proposed, the supplies to be diverted from Polavaram could be used also for generation of power both at Singareddi and Ippur.

CHAPTER XVII

IRRIGATION PRACTICES, POLICY AND ADMINISTRATION

Important for optimum development

17-1 Irrigation practices, that is, the technique of design and operation of irrigation works, the system of distribution of available supplies and the habits of cultivators, and the allocation to different departments and individuals of various functions relating to the development of irrigation works, their administration and management, play an important role in the optimum utilisation of the available water resources of any river system. Accordingly, the Commission felt it necessary to make a brief survey of these aspects with regard to irrigation works and projects in the Krishna and Godavari basins.

17-2 Annexure XVI gives a resume of the existing legislation in respect of irrigation works, as in force in different States and regions within a State. It indicates the manner in which different departments of the State Governments have been entrusted with different responsibilities with regard to the construction, operation and management of irrigation works of various classes and development thereon. The varying control exercised by Government on the crops irrigated, the charges levied for the supply of water and the system of assessment of these charges are also described. For facility of reference, the information furnished in Annexure XVI has been classified by sections.

Existing legislation

17-3 Different Irrigation Acts are in force in different States and, because of the political re-organizations described in paragraphs 2-6 to 2-10, even in different regions of a State. Although State boundaries were materially altered between 1953 and 1956, in most cases, irrigation works continue to be administered in accordance with the Acts and Rules thereunder which were applicable to them in the original province or State.

A study of the main provisions of the Irrigation Acts, applicable to different parts of the Krishna and Godavari basins, as described in Annexure XVI, would show that the Acts and the Rules thereunder differ widely in their scope, in powers and privileges of Government and in the rights and obligations of the irrigators.

17-4 The Bombay Irrigation Act, 1879, the Central Provinces Irrigation Act, 1931, and the Hyderabad Irrigation Act, 1948, empower the State Government to declare that the waters of a natural stream, or any other natural collection of water, shall be used by Government for the purpose of an irrigation work. This declaration becomes effective after due notification in the Gazette, and in case of the Central

Provinces Irrigation Act, after payment of compensation where such declaration interferes with vested rights. On the other hand, the Madras Irrigation Cess Act, 1865, the Mysore Irrigation Act, 1932, and the Orissa Irrigation Act, 1959, make no such provision. It is important that Government should have full powers to control, for public use, the water supplies in all rivers, streams, natural lakes and reservoirs. Any lacuna in this respect in Irrigation Acts may lead to embarrassing situations or difficulties as developments proceed.

17-5 In Maharashtra, the Bombay Land Revenue Code authorises the Collector of a district to permit land holders and other persons to use the waters of natural streams, subject to such water-rates as he may deem fit to impose. Since 1939, however, no charges are being levied where water is taken from a source on which no expenditure has been incurred by Government at any time or where land is irrigated by means of a pumping plant.

The Central Provinces Irrigation Act authorises Government to permit the construction of private irrigation works, subject to such conditions and payment of charges as the State Government may decide.

It has not been possible to ascertain the position in this respect in other States.

17-6 In general, cultivators acquire the right to the use of waters from a Government irrigation work,

(a) in Andhra Pradesh and Mysore,

(i) by usage, in which case the right to irrigate a field from a particular source is entered in the settlement records;

(ii) by inclusion of specified areas in a "localization" scheme approved by the Collector;

(b) in Maharashtra and Madhya Pradesh, by entering into agreement with Government for a specified period under terms and conditions defined in the agreement; and

(c) in all States, by special permission, on application, for specified periods or for single waterings.

While every field, irrigable from a project in Maharashtra and Madhya Pradesh, can by application acquire the right to get irrigation supplies limited only to availability of water, this is not so in Andhra Pradesh and Mysore where fields not included in a 'localization scheme' are in-eligible for getting irrigation waters even though they may physically be in a position to get water from an irrigation project.

17-7 In general, the principal obligation of the cultivators is to pay such water-rates as may be levied by Government from time to time,

The Bombay Irrigation Act, 1879, which applies to Western Maharashtra, provides for the division of fields into half-acre plots for perennial irrigation and one acre plots for irrigation of dry crops and for a system of field channels to be maintained in such manner as to ensure that water required for irrigating any field can be supplied directly to it through a channel and not by passing water from one field to another. There are no such obligations imposed by the Acts applicable to other parts of the Krishna and Godavari basins.

The Madras Irrigation Cess Act, 1865, applicable to Andhra region of Andhra Pradesh, provides for routine repairs and maintenance of bunds etc. by cultivators but these provision are practically obsolete. In Mysore, the irrigators are required to carry out routine repairs and the responsibility for this rests on the *patel* of each village.

17-8 There is no legislation in any State regarding developments from ground waters, *i.e.*, by surface wells or tube wells.

Multiplicity of departments dealing with irrigation development

17-9 Irrigation works in the Krishna and Godavari basins are, in general, divided into the following classes :

- (a) Private irrigation works;
- (b) Tanks and minor works entirely under the control of the Revenue Department; and
- (c) Major and medium irrigation works which are
 - (i) under the complete control of the Public Works Department in Maharashtra and Madhya Pradesh; and
 - (ii) only constructed and operated by the Public Works Department in Andhra Pradesh, Mysore and Orissa but all development work thereon and assessment of water-charges *etc.* are under the control of the Revenue Department.
- (d) Wells and tube-wells.

17-10 Private irrigation works are generally small in scope ; there is little control by Government ; no water-charges are paid; no operational statistics are available,

17-11 The definition of tanks and minor works, which are under the control of the Revenue Department, varies in different parts of the Krishna and Godavari basins as follows:

- (a) In Andhra region of Andhra Pradesh and Madhya Pradesh these works have an Ayacut or C.C.A. of 200 acres or less.
- (b) In the Talengana region of Andhra Pradesh these works have an Ayacut of 100 acres or less.

- (c) In Maharashtra these works have C.C.A. of 250 acres or less.
- (d) In the old Mysore State region of Mysore, all tanks fall in this category until specifically transferred to the Public Works Department.
- (e) In the Hyderabad Karnatak region of Mysore, these tanks have an Ayacut of 10 acres or less.
- (f) In Orissa these works have an Ayacut of 4,000 acres or less and must cost less than Rs. 10,00,000 each and not more than Rs. 250 per acre in case of diversion works and not more than Rs. 450 per acre in case of tanks.

17-12 Since the formation of *Zila Parishads* in Andhra Pradesh, tanks and minor works of class (b) of paragraph 17-9 have been transferred to these bodies. Technical maintenance, with funds provided by *Zila Parishads* is with the Superintending Engineer, Local Administration, working under the Chief Engineer Buildings and Public Health Department.

In Maharashtra, it is obligatory on the irrigators on class (b) works (called Second-class Irrigation Works) to maintain them in proper order.

In Mysore, the maintenance and up-keep of these works has been entrusted to Irrigation *Panchayats*, and Irrigation Boards.

In Orissa, the Collector is in-charge of the maintenance and repairs of all works of this class and may have an irrigation officer working under him.

17-13 The entire management of major and medium irrigation works in Maharashtra and Madhya Pradesh rests with the Public Works Departments, who conclude agreements for the use of water by cultivators or accord short term sanctions, deal with all problems regarding the distribution of water among cultivators and up-keep of the water courses and assess the water charges due from the irrigators.

In Madhya Pradesh, irrigation officers are assisted in their work by Village *Panchayats*.

17-14 In Andhra Pradesh and Mysore while all major and medium irrigation works are constructed, maintained and operated by the Public Works Department, all development work, assessment of water charges and disputes between cultivators are dealt by the Revenue Department. Irrigation Officers are not in touch with the ultimate results of irrigation.

17-15 In Orissa, there are so far no major and medium irrigation works in the Godavari basin and the Public Works Department has no function to perform with regard to existing irrigation in that basin. Recently the Dandakaranya Development Authority has taken up construction of some tanks and one or two dams independent of the departments of the State Government.

17-16 Wells and tube-wells are generally the result of landholder's own efforts. Some assistance is of late being given by Government through the Revenue Department, for digging new wells or repairing old dilapidated wells but there is no Governmental control or co-ordination or watch of any kind on their development. Little information is available regarding their operation or performance.

For some of the new projects in Maharashtra, it is proposed to use well waters in conjunction with canal waters.

Regulation and distribution of water

17-17 On most tanks, under the control of the Revenue Department or the Public Works Department, the only crop irrigated is paddy, the water is let out through the tank sluice and allowed to flow from one field to another. There is no question of any distribution between cultivators and no regulation except to open or close the tank sluice.

There are no water courses. The tank itself and the Ayacut below are, during the crop season, just two sheets of water.

17-18 In the delta canals, in Andhra Pradesh, available supplies are distributed proportionately to all the distributaries by the operation of sluice gates at their heads. Distributaries are seldom run in rotation. Small outlets consist of pipes ; large outlets are fitted with sluice gates. Irrigation conservancy subordinates and delta *laskars* are employed under overseers to ensure proper distribution of supplies. There are not many water courses, water flows from one field to another. That there is no serious trouble is largely due to the fact that there is ample water around during the crop season.

17-19 On the Godavari, Pravara and Nira Canals in Maharashtra, the amount of water to be given for any crop is determined by Government. Distributaries are generally run full supply, when necessary in rotation. Distribution of supplies among different cultivators on an outlet is carried out by an irrigation official called *patkari*. Each time a cultivator is given water, the pass issued to him is marked with the date of watering and punched. That the system works under the control of petty officials is largely due to the fact that sanctions for the use of water are severely limited to the available supplies in each season and there is seldom any 'shortage' so far as standing crops are concerned.

17-20 On the new projects like Tungabhadra, the amount of water to be given for wet crops, dry crops or perennials is determined by Government. Water courses, provided by Government, extend to each field which will bear dry crops and, for wet cropped land, to each 25 acre plot. A similar procedure is proposed to be followed on the Nagarjunasagar project.

17-21 In Madhya Pradesh water courses are generally provided by Government and the Irrigation *Panchayats* look after their maintenance.

Government control on crops to be irrigated

17-22 On most tanks, the entire Ayacut or irrigable area bears a paddy crop between June and November. If some water is left in the tank at the end of *abi* or *kharif* season, part of the area bears a second crop of paddy. There is no other crop and there is no question of any control by Government on the crop pattern,

On the delta canals in Andhra Pradesh, practically the entire area is under *abi* paddy and a small part gets a second crop of paddy. There again, there is no question of any crop pattern.

In either case, the same field, year after year, grows a paddy crop in *abi* or *kharif* and a small part of the area bears a second crop, also of paddy. On the delta canals, fodder or green manure is sometimes grown after *abi* paddy ; no water charges are levied, no statistics are available.

17-23 In Maharashtra, a diversified crop pattern is in vogue. This crop pattern is almost entirely controlled by Government under the terms of agreements reached or of sanction accorded. In Western Maharashtra, such sanctions are by blocks covering an area of 4 to 16 acres, according to the types of crops grown. For large farms attached to sugar factories, agreements extend over a period of about 30 years.

In addition to the supplies delivered under agreements, on the basis of the quantity of water known to be available in storage at the end of *kharif* season, the cultivators are issued permits to use the water for specified crops or specified number of waterings.

17-24 On some of the new projects like Tungabhadra, a system of 'localization' has been introduced in which Government determines not only the area that will receive the benefit of irrigation supplies but also the class of crops that may be grown. There are three principal classes (i) paddy (ii) sugarcane, plantains or gardens and (iii) dry crops like *jowar*, *bajra*, cotton, ground-nuts.

It is difficult to say how far the system will be successful. A similar system is, however, planned on the Nagarjunsagar project.

In Mysore, a special feature of 'localisation' is that dry crops shall be irrigated during the day and wet crops during the night.

17-25 In brief, under the system in vogue in Maharashtra and Madhya Pradesh, every cultivator, whose area is included in the C. C. A. of a canal, is entitled to apply and get water, if available, and grow such crops as may be approved by Government. Under the 'localisation' procedure introduced in Andhra Pradesh and Mysore, areas are being selected to which irrigation water will be supplied for growing either a wet crop or a dry crop or a perennial ; other areas, even though included in the C. C. A. of a canal, will be ineligible to get the benefits of irrigation supplies.

The Commission is unable to see the justification of depriving certain areas of the right to get water while giving a large dose of water to some areas and a small dose to others. The considerations pertinent to the system of 'localisation' and the procedure adopted have been explained in paragraphs 5-2 to 5-4 and 5-19 to 5-21 of Annexure XVI. It cannot be held that the areas excluded from a 'localisation' scheme would not have benefitted from irrigation supplies, if made available to them.

Water rates

17-26 For irrigation from the delta canals in Andhra Pradesh and tanks in Andhra Pradesh, Mysore and Orissa, there is no separate water rate. A consolidated land rate, inclusive of an element of water rate, is levied. These consolidated rates were determined at the last settlement, in case of most districts, 20 or 30 years ago.

17-27 Water rates for irrigation from other works in the Krishna and Godavari basins vary enormously, not only from State to State, but even from region to region and from project to project. A perusal of Schedules I to V of Annexure XVI, showing the current water charges in various States in the Krishna and Godavari basins, would indicate the following large variation in these charges :

| <i>Name of Crop</i> | <i>Range of water-rates rupees per acre</i> |
|----------------------------------|-------------------------------------------------|
| (i) Paddy (<i>kharif</i>) | 2 to 15 |
| (ii) Jowar, bajra and maize | 1 to 10 |
| (iii) Cotton | 1 to 18 |
| (iv) Groundnut | 4 to 17.50 |
| (v) Paddy (<i>rabi</i>) | 2 to 20 |
| (vi) Sugarcane and fruit orchard | 6.25 to 160 plus cess 30 |
| (vii) Pans and plantains | 15 to 170.50 plus cess 30 |
| (viii) Vegetables | 4 to 10 |
| (ix) Wheat | 1.50 to 12 |
| (x) Pulses | 1 to 10 |
| (xi) Fodder | nil to 10 |

17-28 In Madhya Pradesh, the rates for areas under agreements are low as compared to those for irrigation on demand. In Andhra Pradesh, rates for *tabi* paddy are lower than those for *abi* paddy. In Mysore, the rates for irrigation on the Tungabhadra Left Bank Canal are substantially more than those for irrigation on the Tungabhadra Right Bank Canal.

On pumping schemes in Andhra Pradesh the cost of pumping water is recovered from the cultivators in addition to the usual water-rates.

17-29 In Orissa, according to the rules which have come into force only in September, 1961, for all staple crops, mainly paddy and wheat, the rate varies from Rs. 8 per acre to Rs. 2 per acre, depending on the guaranteed quantity of irrigation water to be given. For other crops, varying rates have been fixed.

17-30 Because of the varying political structure of different parts of the two basins and because of the different values attached, in the past, to irrigation in different regions, one can understand the present variation in the charges levied for the supply of irrigation water in the two basins. There is, however, no reason why these variations and disparities should now continue to exist. Politically, the entire country has one constitution. Irrigation supplies are equally in demand everywhere. The prices of agricultural produce in different parts of the two basins do not vary much. It seems necessary, therefore, that all the States concerned should determine the water

rates afresh on the basis of uniform and rational principles so that the beneficiaries from irrigation projects are required to pay a reasonable sum for the irrigation waters provided to them at public cost. It may be added that economic use of water supplies would not be practicable without a reasonable level of water charges.

17-31 In Madhya Pradesh, Maharashtra and Orissa, water rates are assessed by the Public Works Department. In Andhra Pradesh and Mysore, the assessment is made by the Revenue Department.

17-32 The Betterment Levy Acts, as adopted in various States (see Section XII of Annexure XVI), have different basis for the betterment charges. No recovery has, however, yet been made of these charges, except to some extent in Andhra Pradesh, and the policy advocated by the Planning Commission, in this respect, in the First Five Year Plan, has largely remained un-implemented.

Economic use of water

17-33 The oldest and the largest irrigation works in the Krishna and Godavari basins are the two delta canals systems. They have been in operation for over a hundred years and now irrigate more than a million acres each. Situated at the lower ends of the two river systems, they have so far had abundant supplies during the rainy season, from about mid-June to mid-September and adequate supplies for two or three months afterwards for maturing the crops grown. Under these conditions of river supplies and the fact that there was a fair amount of rainfall from June to October, paddy was the most suitable crop to grow and there was no need to practice any economy in water use. However, it became necessary to build a large number of drains, but the quantities of water removed by these drains are not known. Whether water flowed to the sea directly through river channels or through canals, paddy fields and drains did not make much difference.

17-34 In the upper reaches of the two rivers are three canal systems in Maharashtra—the Godavari Canals, the Pravara Canals and the Nira Canals. These canals serve an area of low and undependable rainfall. They were intended to afford protection to famine and scarcity areas and the water available were originally intended to be spread over a large area for the cultivation of dry crops. Mainly because of the low price level of food crops, these canals were, to begin with, a virtual failure. Cultivators liked to gamble on rain rather than take canal water and thus have to pay water charges. As a result, the available water supplies were restricted to a relatively small area and sugarcane cultivation was encouraged. As explained in paragraphs 17-19 to 17-25 above, the area to be irrigated, the crops to be grown and the quantity of irrigation water are all fixed by Government. The cultivators have no inducement to try to use the waters more economically, in fact that would be illegal.

17-35 The rest of the irrigation in the Krishna and Godavari basins is largely confined to tanks where again the nature of water supply available and the position (in the bottom of the valley) of the area to be irrigated also claimed paddy as the most suitable crop. Each tank is a relatively small unit and its operation is largely left to the cultivators themselves. Here again there was not much scope for eco-

economy in water use. The fact that the evaporation losses from these shallow tanks are almost equal to, or more than, the water applied to irrigation has so far received scant attention. For every acre irrigated there is almost an equal area submerged under the tank.

It is high time that some effort was made to put an end, wherever possible, to this waste of valuable water and land.

17-36 In Madhya Pradesh and Vidarbha, until recently, irrigation was not popular. Cultivators had to be induced to use canal water; there was no question of any economy in water use.

17-37 Conditions described above naturally led to the use of high deltas and low capacity factors, the present variations in water-rates described above, in system of administration and management, assessment of water-charges, etc. prevalent in different parts of the two basins.

17-38 As explained in Chapter XIII, since Independence, a large number of new irrigation works have been sanctioned and are under construction or development in various parts of the two basins. There is demand for many more. Except in the lower Godavari region, water would no longer be abundant; in all areas irrigation would no more be unpopular. During the Commission's visit to various parts of the two basins, there was ample evidence every where of the enthusiasm for new irrigation developments. It is unfortunate, however, that in the changed circumstances of to-day irrigation projects are being conceived largely along the lines of earlier developments; project planning must be oriented to the changed circumstances.

17-39 It is high time that the whole policy of Government under which irrigation works are managed or supervised by different Government Departments should be reviewed, water-rates revised and some uniform procedures established which should lead to economy in water use and efficiency and expedition in all developments. It is after the outlet that the use of irrigation waters begin, it is exactly at that point in some States that the role of an irrigation officer ends.

Drainage

17-40 Little attention is being paid to the need for drainage in the wake of new irrigation developments. The necessity for such drainage having been felt in the past in the two delta systems and in the irrigation developments in Maharashtra should be a clear indicator that drainage problems will have to be faced in all big irrigation projects in the two basins.

17-41 In particular, the Commission would like to draw attention about the policy with regard to existing tanks which fall in the C.C.A. or Ayacut of new major projects. According to the information furnished to the Commission, 1,250 existing tanks are proposed to be breached and the areas irrigated therefrom merged in the new projects; but nearly 17,000 tanks, irrigating about 575,000 acres, are proposed to be retained. These tanks are essentially in the nature of obstructions to the natural drainage of the areas which will come under irrigation. Standing as isolated units and each irrigating a small area in the valley bottom below it, the effect of such

obstructions was not significant. Now when the country around these tanks will receive irrigation waters, these tanks, which obstruct the natural drainage of the area, would create difficulties. It seems necessary that this practice should receive an early re-appraisal.

Method of paddy cultivation

17-42 Since paddy is the principal irrigated crop in the two basins and gets large doses of irrigation supplies, it appears necessary to examine here briefly the methods of its cultivation.

17-43 Different varieties of paddy are grown depending on the time of sowing, period of growth, suitability to different conditions of soil, rainfall, temperature, altitude and adaptability to such special environments as flooded land, alkalinity and salinity, acidity, depth of standing water *etc.*

Low-lying clay soils are preferred for long duration varieties and relatively high lying loams and lighter soils for quick maturing types.

Paddy can be grown practically throughout the year in both the basins. In case of 'double cropping', a quick maturing variety is followed by a long duration type, or *vice versa*.

17-44 Paddy is grown as a semi-aquatic plant on lands which are ploughed and brought to good tilth by repeated ploughing or harrowing soon after the rains set in. Before sowing, the land is irrigated and ploughed in standing water. After sowing, ploughing is repeated in wet condition three or four times, at short intervals, to stir up and puddle the soil thoroughly. The puddle is finally levelled by passing a levelling board over the field. To hold irrigation water evenly, the levelling of paddy fields is essential, therefore in undulating tracts and on hill slopes, the land is thrown into bench-type terraces. The size of each terrace is generally small, it seldom exceeds 1/10th acre and is frequently as small as 1/40th acre. Each plot is provided with water-tight *bunds* and the plots are so arranged and graded that irrigation water from a plot flows into the one below it without causing any scouring.

Sowing may be broad-cast or by transplantation.

Before broad-casting, the seed is sometimes allowed to sprout. After sowing the field is lightly irrigated on alternate days for a week or so to assist germination.

When transplanted, until the seedlings are well-established, water is allowed to stand in the field to a depth of one-half or one inch.

Thereafter, about two to three inches of water is made to stand more or less continuously up to the dough stage of the crop, the supply of water being given continuously or at short intervals. A week or two before harvesting, water is drained off the field to encourage quick and uniform maturing of grain.

17-45 An alternate method, which is being increasingly encouraged and is known as the Japanese method of cultivation, involves among other things, mulching the field and applying top dressing of manure before each mulching. Irrigation is not

continuous and water is not required to stand in the field throughout the crop season. Instead, water is applied, as in other crops, as and when necessary.

The following advantages are claimed for this method :

- (a) increase in the oxidation-reduction potential of soil,
- (b) roots show increased growth *i.e.*, extend downwards and not merely horizontally, thus ensuring plant food from lower depths and resulting in heavier and richer grains and higher yield,
- (c) stalks become stiff and hardy as they do not remain immersed in water,
- (d) there is saving of water used for irrigation and thus water logging is avoided, and
- (e) weeding is not necessary.

CHAPTER XVIII

SUMMARY AND RECOMMENDATIONS*

General

18-1 The Krishna and Godavari basins (see Plates I and II) extend over an area larger than France. They cover about 221,000 square miles, more than one sixth of the entire area of India. They include almost one-fourth (23 per cent) of the culturable area of the country.

Approximately, 72 per cent of the area of the State of Maharashtra, 61 per cent of Mysore, 43 per cent of Andhra Pradesh, 15 per cent of Madhya Pradesh and 11 per cent of Orissa lie in the two basins.

18-2 The Krishna river system has a drainage area of about 100,000 square miles. Together with its tributaries, it drains about 440 miles length of the Western Ghats—the chief source of the Krishna waters. The main river is about 870 miles long. Two of its tributaries, the Bhima, over 500 miles long, and the Tungabhadra, over 300 miles long, are major rivers in their own rights.

About 44,000 square miles of the drainage basin lies in Mysore, 29,000 square miles in Andhra Pradesh and 27,000 square miles in Maharashtra.

18-3 The Godavari river system has a drainage area of about 121,000 square miles. Its principal source of supply, in its upper reach, is the relatively small catchment in the Western Ghats and, in its lower reach, the forest covered hills and tablelands in the north-east of the basin. The main river is about 910 miles long. The Manjra and the Pranhita, each nearly 450 miles long, the Indravati, over 350 miles long, and the Sabari, about 260 miles long, are four principal tributaries of the Godavari, each a major river in its own right.

Approximately, 59,000 square miles of the drainage basin lies in Maharashtra, 28,000 square miles in Andhra Pradesh, 25,000 square miles in Madhya Pradesh, 7,000 square miles in Orissa and 2,000 square miles in Mysore.

18-4 For detailed studies, each river system has been divided into 12 sub-basins (see Plate II and paragraphs 3-22 and 4-27).

18-5 The political distribution of the drainage basins, as described above, came into effect only from 1st November, 1956 (see paragraphs 2-6 to 2-10).

**This Chapter is not intended to replace Chapters I to XVII; only the more important aspects have been summarised here.*

The portion of the two basins, now in Andhra Pradesh, was, prior to Independence, under the control of the former Madras Presidency, the erstwhile Hyderabad State, a former princely State and a number of *jagirdars* ; that in Madhya Pradesh was under the former Central Provinces and the erstwhile Bastar State. The areas now in Maharashtra formed parts of the former Bombay Presidency, the former Central Provinces, the erstwhile Hyderabad State and a number of now defunct princely States. Likewise, the part of the two basins now in Mysore was then distributed between the former Madras Presidency, the erstwhile Hyderabad State, the former Bombay Presidency, the former Mysore State and some defunct princely states. The areas in Orissa were largely in the erstwhile Kalahandi State and in the now defunct Jeypore estate.

18-6 A serious difficulty which the Commission had to encounter, at all stages of its work, arose out of the fact that general statistics, collected with the district as a unit could not be applied directly to hydrologic units, river basins and sub-basins. The Commission had in such cases to work out appropriate figures based on the proportion which the area of a district within the basin bears to the total area of the district. Apart from this, the Commission found an almost complete absence of published statistics relating to the Krishna and Godavari basins. Most of the important data and information relating to water resources development in the two basins were either non-existent or had not been compiled and analysed before. The Commission thus found that one of its important tasks was to get together and compile whatever data it could obtain.

Except, where specifically indicated, the report of the Commission is based on the technical data and other information supplied by the State Governments concerned. The Commission has not carried out any physical verification of these data nor was this considered necessary. The responsibility for the accuracy of these data rests with the State Governments.

18-7 Geologically, (see Plate III) the two basins consist largely of Archaean formations, parts of which are covered over by Deccan trap lavas, Cuddapah and Vindhyan basins and faulted blocks of the Gondwanas.

While the mountains are mere outstanding portions of the old plateau that have escaped the weathering of ages, the rivers have flat shallow valleys with relatively low gradients, the channels having approached the base level of erosion.

Apart from the slopes of the Western *Ghats*, the irregular ranges of the Eastern *Ghats* and the table-lands in the north-east of the Godavari basin, the entire drainage basin of the two rivers, comprises undulating country, a series of ridges and valleys interspersed with low hill ranges.

18-8 The soils are, in general, relatively shallow specially where they are formed *in situ*. Deep soils are found mainly along the banks of streams and rivers where they have been formed by eroded material brought by and deposited during floods. The typical soil features, in the two basins and the texture and properties of the top soil as well as of the sub-grade have been described in Chapter VI (also see Plate VI).

18-9 The total population of the two basins is about 60 million people; about 80 per cent live in rural areas.

18-10 The gross area of the two basins (see paragraph 7-3 and tables XII and XIII), as per village papers, is about 141 million acres. Of this, about 29 million acres are forests, largely undeveloped. About 99 million acres are culturable, out of which 73 million acres are under cultivation. The area cropped annually is about 76 million acres. The irrigated area is about 7.7 million acres, the irrigated cropped area is about 9 million acres. The latter includes about 1.9 million acres irrigated from the two rivers outside their drainage basins.

18-11 Of the irrigated area of about 7.7 million acres, about 1.9 million acres are irrigated by wells and other sources, about 2.5 million acres by tanks and 3.3 million acres by canals.

18-12 The major crops grown in the two basins, in descending order of the acreage covered, are *jowar* (23 million acres), paddy (9 million acres), cotton (7 million acres), ground-nut (6 million acres), *bajra* (5 million acres), wheat (3 million acres), and sugarcane and perennials (1 million acres).

Under irrigated conditions, paddy is the principal crop (6 million acres).

18-13 The total installed capacity of hydro-electric generating plants in the two basins, as in March 1961, is about 500,000 kW, that of thermal plants about 100,000 kW. The basins are rich in minerals but the level of exploitation is relatively modest.

18-14 The enormous forest wealth in the Krishna and Godavari basins has largely remained neglected; the level of exploitation is low. The development of power has so far been poor and the present industrial development is only a modest indication of the large potential which remains to be developed. Under these conditions (see Chapter VIII), the economy of the two basins and adjoining areas depends largely on agriculture, which provides a low level of subsistence except in a small part, where facilities for irrigation have been provided. The well-being and prosperity of the entire Krishna-Godavari region is closely related to the development of water resources of the two river basins.

18-15 Some parts of the Krishna and Godavari basins suffer from frequent failure of rainfall during critical periods in the agricultural rotation. Scarcity conditions then prevail, land revenue is suspended and other relief measures are taken. A study of these areas has been made, *taluk-wise*, in paragraphs 8-15 to 8-25.

The Commission has found that there are 34 *taluks* in which 75 per cent or more of the annual land revenue was suspended at least twice in a 10-year period or 50 to 75 per cent of the annual land revenue was suspended at least thrice in a 10-year period. The normal-annual yield of crops in these *taluks* is also low.

18-16 The Commission suggests that the possibilities be examined of collecting general statistics, particularly data of land utilisation, by river basins and sub-basins.

Rainfall

18-17 The source of all water in the Krishna and Godavari basins, whether in stream flow or in the form of ground waters, is the rain which falls within each basin. There is no evidence of any sub-soil flow getting into the basin from outside or of any subsoil flow escaping from either of the two basins.

18-18 There are 374 rain-gauge stations in the Krishna and Godavari basins for most of which rainfall data over a period of 50 years are available. An examination of the distribution of these raingauge stations, sub-basin-wise (see Plates XI to XXXIV), shows that there are large tracts with no rain-gauge station at all.

18-19 It is necessary to review the number and distribution of rain-gauge stations in the two basins and to establish new stations to fill in such gaps as exist. It is also important that the daily rainfall data for all these stations should be published on a monthly basis by sub-basins. Machinery should be established for a regular study and analysis of these data.

18-20 The Krishna and Godavari basins receive most of their rainfall during the south-west monsoon, from June to September. The high rainfall zone along the Western *Ghats* (see Plate IV) forms the western boundary of the two basins for more than 500 miles. The other high rainfall area is the forest covered hills and table-lands in the north-east of the Godavari basin. For the rest, the two basins constitute low rainfall zones. There is a large belt, about 45,000 square miles in area, a short distance east of the Western *Ghats*, varying in width from about 160 miles in the south of the Krishna basin to about 60 miles in the north of the Godavari basin, where the normal annual rainfall is less than 600 mm (about 24 inches).

Maps I to V show in detail the seasonal and annual normal rainfall, incidence and distribution, over the two basins.

18-21 The weighted average annual rainfall of the Krishna basin is about 31 inches and about three-fourths of it occurs during the four months, June to September (see Table IV).

The weighted average annual rainfall of the Godavari basin is about 45 inches, of which as much as 84 per cent occurs during the four months, June to September (see Table IV).

18-22 Apart from the fact that most of the rainfall is concentrated in the four months, June to September, there is a wide variation in its incidence in time and space. This variation is more marked in the low rainfall zone than in areas of high rainfall and more in the relatively dry part of the year than in the wet months (see Table VI). The north-east monsoon is much less dependable than the south-west monsoon.

The areas lying towards the south-east of the Krishna basin receive a large proportion of their annual rainfall during the north-east monsoon. They do not get any dependable rainfall from either the south-west or the north-east monsoon.

Evaporation¹

18-23 Little observed data is available regarding evaporation but, from the prevailing meteorological features, it is known that both the basins are areas of very high evaporation (see Plate V). During the three months preceding the rainy season, March to May, evaporation rates are very high and the potential evaporation for this period is almost half of the total annual potential evaporation.

18-24 It is necessary to establish an extensive net work of evaporation measuring stations, throughout the two basins, particularly at the sites of existing and proposed reservoirs.

18-25 No information is available about evapo-transpiration in this region. Since this is the most important element in the water requirements of crops, the lack of this data is a serious lacuna in the data required for the optimum development of the water resources of the two basins.

18-26 Systematic observation of evapo-transpiration under various crops needs to be carried out in selected stations throughout the two basins.

River flow

18-27 In general, the rivers rise in the later half of June. July and August are the months of maximum discharge; the volume of flow in these two months varies from 40 to 85 per cent of the annual flow.

The volume of flow during the six months, June to November, is 90 to 100 per cent of the annual flow; after January the rivers are practically dry.

18-28 There has so far been no planned and systematic observation of discharges on either the Krishna or the Godavari river systems and the position with regard to sediment data is worse. In general, the only systematic records that are available pertain to existing anicuts or reservoirs where river flow is calculated on the basis of gauge readings observed from different parts of the works.

18-29 Since the reliability of river discharge data is closely related to the methods of observation and/or estimation of discharge, the Commission made special efforts to ascertain these methods. The information obtained has been set out fully in the relevant Annexures along with the data.

At some of the sites for which data are available, the method of observation indicates that these data cannot be relied upon for any purpose. At other sites, the data can be taken as approximately correct, within 20 per cent, plus or minus, of the actual (see Chapter IX).

18-30 Of the 62 sites on the Krishna river system for which some data have been supplied, useful data are available for a period of 10 years or more for only 15 sites and for a period of 20 years or more for only 5 sites (see paragraph 9-3).

On the Godavari river system, out of 44 sites for which data have been made available, useful data for a period of 10 years or more are available for only 16 sites and for a period of 20 years or more for only 7 sites (see paragraph 9-4).

It is surprising to note that the observations being made at some of these sites were discontinued only during 1959 and 1960.

18-31 Because of the un-even distribution of the discharge sites (see Plate VIII), there are many sub-basins in which no river flow data exist (see paragraph 9-25). On a large river system like the Krishna or the Godavari, transit losses, regeneration and time-lag are important considerations from the point of view of developments on the river. It is, however, not possible to study these features on the two river systems unless a comprehensive system of discharge observations is established and data for a fairly long period collected.

18-32 As a result of new irrigation developments, some additional regeneration is bound to appear in the rivers. The exact quantity cannot be stated at this stage (see paragraphs 14-28 to 14-31). In addition, there will be some salvage of the transit losses, which now occur. No quantitative values can, however, be assigned at this stage.

18-33 As regards the measure of dependability to be adopted reference may be made to paragraph 14-35. If the proposals made therein are adopted, the average annual use would not be far from the average river flow.

18-34 The Commission strongly recommends, as a matter of first urgency, the establishment on a permanent basis and on scientific lines, of daily discharge observations at 38 sites on the Krishna River System and 38 sites on the Godavari River System (see Tables XXI and XXII and Plate IX). The river flow data to be obtained at these sites are essential for the preparation of individual projects, for the preparation of an integrated basin-wide plan, for the subsequent operation of such a plan and the regulation, to best advantage, of the available river waters in any year (see paragraphs 9-39 to 9-45).

18-35 As a number of dams are being constructed in these river basins, it is necessary that, besides taking discharge observations, systematic data should also be collected with regard to the sediment carried by river waters. These data would be of considerable use in working out dead storage, life of reservoirs etc.

18-36 The Commission regards the collection of river discharge and sediment data as a fundamental work of national stock-taking and recommends that, like meteorological data and general surveys, the Central Government should assume the responsibility for this important work and set up a special organisation for this purpose under the Ministry of Irrigation and Power (see paragraphs 9-50 to 9-56).

18-37 It is unfortunate that no attempt has so far been made to undertake regular discharge observations at the sites of proposed projects. Even for the projects under construction, little attention has been paid to the observation and compilation of accurate flow data.

For project planning, river flow is estimated by various empirical formulae (see paragraph 9-31). The Commission is unable to support this procedure and consider this practice unsound.

Considerable caution is called for in undertaking any new project on this basis.

18-38 It needs to be stated that for most projects it is not enough to know the average annual yield at the point of diversion; its distribution during the year and its variation, from year to year, are equally important.

Because of this it is necessary to formulate detailed rules for each project laying down the manner in which river flow will be withdrawn, or abstracted for storage, during any 10-day period, under varying conditions of river supply. The operation of all projects in different States will have to be carried on in a co-ordinated manner (see paragraph 13-40 and 13-41).

18-39 The Commission regards it indispensable that, in addition to the work outlined in paragraphs 18-34 to 18-36, arrangements should be made by each State Government

- (a) to make accurate measurements of the daily withdrawals by all major irrigation canals and power channels and an estimate, from gauge discharge curves of the withdrawals by other canals and power channels; such gauge discharge curves to be regularly checked and kept up-to date;**
- (b) to measure river flow and prepare "water accounts" at the sites of all storage projects and diversion weirs in operation; and**
- (c) as soon as a new project is conceived, to set up as a first priority, regular discharge and sediment observations at that site.**

It will be necessary to establish a close co-ordination between the above work to be done by the State Governments and the work to be done by the Central Organisation proposed in paragraph 18-36.

Ground waters

18-40 No systematic ground surveys of the Krishna and Godavari basins appear to have been carried out so far. No data and statistics in this respect are, therefore, available. There are, however, 335,000 wells in the Krishna basin irrigating about 1·13 million acres and 303,000 wells in the Godavari basin irrigating about 0·73 million acres. There are indications (see Plate VII) of good ground water characteristics in the sub-soil in the coastal belt and along the lower Godavari Valley and the lower Pranhita. Another important source of ground waters would be the seepage from canals and from irrigated fields (see paragraphs 11-26 to 11-28).

18-41 There is a water balance between the rainfall on the one hand and stream flow, ground waters, evaporation and transpiration by crops and native vegetation on the other. Also, accretions to ground water from rainfall, from seepage from irrigation channels and from irrigated fields, unless withdrawn through wells or by pumps will, under good sub-surface drainage conditions, seep into the rivers; under other conditions, these waters will fill pockets, form perched water-tables and may cause local water-logging.

18-42 It is important that regular observations should be made by all State Governments of the position of the ground waters and their fluctuations during the year. The methods to be adopted would vary in different parts according to local conditions. This information is necessary to maintain a close watch on the behaviour of ground waters, particularly in view of the large scale new developments undertaken and contemplated, and for the due exploitation of ground waters, separately or in conjunction with canals.

Developments up to 1951

18-43 Tables XXVI and XXVII show the nature and extent of irrigation developments in the Krishna and Godavari basins respectively. It will be seen that there were only three major schemes and 17 medium schemes in the Krishna basin and five major schemes and 20 medium schemes in the Godavari basin in operation in 1951.

There were, in addition, a large number of minor schemes and numerous tanks and small diversions in each basin.

Important particulars, to the extent available, of each major and medium scheme are given in Annexures VIII and XII. These Annexures also show the available particulars of each minor scheme and district-wise figures for small tanks and diversions. Also see Map VI.

18-44 The withdrawals by major and medium schemes, as supplied by the State Governments, are shown in Annexures IV and VII. No information is available regarding the amount of water diverted by small tanks and diversions. The Commission has, therefore, made rough estimates of the diversions by these small works.

18-45 The State-wise developments of irrigation in the two basins, in 1951, was as follows :—

| State | Average annual irrigation | | | Average annual diversion | | |
|--------------------------|-----------------------------|---------------------------|-------------|--------------------------|----------------------------|--------------|
| | Major and medium schemes | Minor schemes, tanks etc. | Total | Major and medium schemes | Minor schemes, tanks, etc. | Total |
| |Million acres..... | | |T.M.C..... | | |
| | Krishna River System | | | | | |
| Andhra Pradesh | 1.26 | 0.35 | 1.61 | 231.1 | 59.0 | 290.1 |
| Maharashtra | 0.20 | 0.02 | 0.22 | 41.9 | 1.1 | 43.0 |
| Mysore | 0.06 | 0.41 | 0.47 | 11.3 | 67.0 | 78.3 |
| Total | 1.52 | 0.78 | 2.30 | 284.3 | 127.1 | 411.4 |

| State | Average annual irrigation | | | Average annual diversion | | |
|-------------------------------------------------------|---------------------------|----------------------------|-------------|--------------------------|----------------------------|--------------|
| | Major and medium schemes | Minor schemes, tanks, etc. | Total | Major and medium schemes | Minor schemes, tanks, etc. | Total |
| Godavari River System | | | | | | |
| Andhra Pradesh | 1.39 | 0.52 | 1.91 | 306.3 | 86.5 | 392.8 |
| Madhya Pradesh | 0.08 | 0.12 | 0.20 | 7.9 | 12.3 | 20.2 |
| Maharashtra | 0.19 | 0.42 | 0.61 | 32.7 | 23.3 | 56.0 |
| Mysore | .. | .. | .. | .. | 0.2 | 0.2 |
| Orissa | .. | 0.02 | 0.02 | .. | 1.4 | 1.4 |
| Total | 1.66 | 1.08 | 2.74 | 346.9 | 123.7 | 470.6 |
| Grand Total Krishna and Godavari River Systems | 3.18 | 1.86 | 5.04 | 631.2 | 250.8 | 882.0 |

18-46 Three hydro-electric projects in Maharashtra, owned by private companies and having an installed capacity of 274,000 kW. used 38.0 T.M.C. of water which was diverted into the Arabian Sea. On the Godavari, there was no hydro-electric power development.

18-47 Evaporation losses from reservoirs (see paragraphs 12-24 to 12-26) take a substantial toll from the available river supplies in the Krishna and Godavari basins. In comparison with the diversions for irrigation, these losses are comparatively very high where the tanks are shallow as generally happens to be the case.

For the major and medium schemes in operation in 1951, the estimated reservoir losses were 13.3 T.M.C. on the Krishna and 12.8 T.M.C. on the Godavari. For minor schemes, these losses have been estimated as 105 T.M.C. on the Krishna and 145 T.M.C. on the Godavari; these are more than the waters applied to irrigation by these schemes.

18-48 The position regarding statistics for tanks is far from satisfactory. There are nearly 60,000 tanks in the two basins irrigating approximately 1.66 million acres and the estimated diversions by them are of the order of 220 T.M.C. Unless systematic long term data regarding these tanks are collected, their effect on river flow cannot be determined.

The Commission recommends that important data for individual tanks should be collected and an up-to-date record maintained. The area irrigated annually by each tank should be measured and recorded, together with an estimate of the quantity of water applied to irrigation.

A survey of each tank should be carried out periodically, say, every five years, to watch the loss in capacity, if any.

18-49 A number of drains had been constructed in the two deltas as well as on some of the major projects in Maharashtra (see paragraphs 12-27 to 12-34)

No discharge data are, however, available for these drains.

The Commission recommends that discharges of drains should be observed regularly and the data compiled.

Working statistics of canals and distributaries

18-50 There is no system of maintaining operation statistics of canals and distributaries as a permanent record. These statistics are absolutely necessary for watching their performance and efficiency.

The Commission is of the view that complete working statistics of canals and distributaries should be compiled annually and printed in a suitable form so as to be available as a permanent record for future reference.

Development since 1951

18-51 Developments since 1951 fall into two categories: Projects and Schemes which have come into operation before March 1961 even though partially, have been described in Annexure IX and XIII and an abstract is given in Tables XXVIII and XXIX. In addition, there have been some improvement on pre-1951 projects; these have been mentioned in paragraphs 13-5 to 13-9. Projects and schemes, under construction, have been described in Annexure X and XIV and an abstract has been given in Tables XXX and XXXI. Also see Map VI.

18-52 The overall, State-wise, position* of the developments undertaken since 1951, as compared with the developments up to 1951, is as follows :

*See paragraph 14-16 and footnote thereto

| State | Average annual irrigation | | | Power installed | | | average annual Diversion | | |
|-----------------------------------------|---------------------------|----------------|--------------|---------------------|---------------|--------------|--------------------------|---------------|----------------|
| | up to 1951 | since 1951* | Total | upto 1951 | since 1951 | Total | upto 1951 | since 1951 | Total |
| | .. Million acres.... | | | Megawatts..... | | | T.M.C..... | | |
| Krishna River System | | | | | | | | | |
| Andhra Pradesh | 1.61 | 2.74† | 4.35 | .. | 90‡ | 90 | 290.1 | 503.5§ | 793.6 |
| Maharashtra | 0.22 | 0.42 | 0.64 | 274 | 585 | 859 | 81.0 | 129.9 | 210.9 |
| Mysore | 0.47 | 1.40 | 1.87 | .. | 33 | 33 | 78.3 | 120.4 | 198.7 |
| Total | 2.30 | 4.56 | 6.86 | 274 | 708 | 982 | 449.4 | 753.8 | 1,203.2 |
| Godavari River System | | | | | | | | | |
| Andhra Pradesh | 1.91 | 0.35 | 2.26 | .. | 250 | 250 | 392.8 | 27.5 | 420.3 |
| Madhya Pradesh | 0.20 | 0.09 | 0.29 | .. | .. | .. | 20.2 | 4.9 | 25.1 |
| Maharashtra | 0.61 | 0.68 | 1.29 | .. | 15 | 15 | 56.0 | 87.5 | 143.5 |
| Mysore | .. | .. | .. | .. | .. | .. | 0.2 | .. | 0.2 |
| Orissa | 0.02 | 0.08 | 0.10 | .. | .. | .. | 1.4 | 7.8 | 9.2 |
| Total | 2.74 | 1.20 | 3.94 | .. | 265 | 265 | 470.6 | 127.7 | 598.3 |
| Grand Total Krishna and Godavari | 5.04 | 5.76 | 10.80 | 274 | 973 | 1,247 | 920.0 | 881.5 | 1,801.5 |

18-53 It would appear from the above that the works undertaken since 1951 will create an irrigation potential much more than had been built up to 1951, during the previous 100 years or more. On the Krishna, the annual irrigation from projects and schemes undertaken since 1951 would be twice the area irrigated as in 1951; on the Godavari these works will increase the irrigated acreage by about 44 per cent.

*includes improvements effected up to 1961 on pre-1951 projects.

†includes Mysore's share of irrigation in Tungabhadra High Level Canal—Stage I

‡includes Mysore's share of power in Tungabhadra Project and Tungabhadra Hydro-electric Scheme—Stage II..

§includes Mysore's share of annual diversion in Tungabhadra, Rajolibanda and Tungabhadra High Level Canal—Stage I.

The hydro-electric potential to be developed by these projects, though more than in 1951, is still relatively small, particularly on the Godavari.

18-54 It will, however take many years more* before the potential being created by the developments undertaken since 1951 will be fully developed (see paragraphs 13-50 and 13-51). Against a total annual irrigation of 5.43 million acres to be developed by these works the area actually irrigated in 1961 was only 0.71 million acres or about 13 per cent. Considerable work has yet to be done and a vast expenditure to be incurred first on the construction of the engineering works and then on the development of the land.

In the view of the Commission, construction work is not proceeding at the optimum rate and relatively little effort is being made for speeding up development. Meanwhile interest charges on the expenditure already incurred keep on accumulating and adding to the cost of development.

18-55 The Commission recommends strongly that an immediate review be made of the developments undertaken since 1951, in each State, in order to ascertain how the construction of the engineering works can be expedited to attain the optimum rate of development on each work. Such additional funds (including foreign exchange) and such other personnel, as may be required should be allocated to these projects in preference to any new project. New projects should be sanctioned only if men, material and money are available surplus to the requirements of the projects already undertaken.†

18-56 The cost of irrigation development in the Krishna and Godavari basins is relatively high, varying from about Rs. 500 to Rs. 1,300 per acre irrigated (see paragraph 13-48). This high cost is attributable in part to the fact that the supplies made available are proposed to be utilised over a relatively small area or canals are proposed to be run with full capacity or near full capacity only for a few months during the year.

It is necessary that the crop pattern on these projects should be reviewed and the irrigation facilities provided spread over a larger area and to a larger number of cultivators (also see paragraph 18-74).

18-57 From the point of view of river supplies, most projects undertaken since 1951 have been planned and are being executed as independent units without regard to other projects, existing or proposed, in the basin. Accordingly, each such project assumes for itself the highest priority on all waters reaching the project site and there has been no examination of the hydrological consequences of its operation on the works downstream (see paragraphs 13-40 and 13-41).

*For instance, (i) Rajolibanda Diversion Scheme costing Rs. 4.5 crores was taken up in 1944, and came into partial operation 14 years late in 1958. Irrigation developed upto 1961 was only 21 per cent; (ii) Bhadra Reservoir scheme costing nearly Rs. 36 crores was taken up in 1947 and came into partial operation in 1957. Development upto 1960-61 was only 7 per cent; (iii) Gangapur Scheme, costing nearly Rs. 5 crores, was taken up in 1948. It came into partial operation in 1957. Development upto 1961 was only 12 per cent.

†For proposals to increase the speed of development, see paragraphs 18-74 and 18-78 to 18-81.

18-58 The Commission recommends that the effect of each project undertaken since 1951 on the supplies available for projects downstream of it should be examined, the relative priorities on river flow for each project determined and, where necessary and to the extent now possible, the design of each project should be revised to comply with the requirements of integrated operation.

18-59 Not much attention has been paid to the requirements of drainage operations that may be required in the wake of new irrigation developments.

New projects and adequacy of river supplies therefor

18-60 A large number of new projects and schemes have been put forward by the State Governments concerned. These fall in two categories : those which have been referred to in III Plan (some are included in III Plan, others are still under consideration) and those not referred to in III Plan. All these have been described in Annexures XI and XV ; important particulars are given in Tables XXXII and XXXIII. The overall position, State-wise, is stated in paragraphs 14-8 and 14-12. Also see Map VI.

In all, the Commission has received particulars of 81 proposed major and medium projects on the Krishna and of 156 such projects on the Godavari ; 92 minor schemes on the Krishna and 632 minor schemes on the Godavari are contemplated. There are, of course, a number of small tanks and diversions in addition.

18-61 While most of the projects and schemes mentioned above are based on topo-sheet studies only, in some cases with preliminary reconnaissance of the diversion or storage site, they differ widely in their concept and the diversions proposed are not directly comparable.

So far as irrigation projects are concerned, this concept can best be indicated by the large range in the following figures of average* delta or the quantity of water proposed to be diverted per acre irrigated :

| | <i>Krishna River System</i> | <i>Godavari River System</i> |
|--------------------------|-------------------------------------|--------------------------------------|
| Andhra Pradesh | 4.8 | 5.0 |
| Madhya Pradesh | .. | 2.2 |
| Madras | 2.7** | .. |
| Maharashtra | 2.4 | 2.1 |
| Mysore | 3.4 | 4.0 |
| Orissa | .. | 3.4 |

*Average for all irrigation projects proposed by each State.

**Excludes the supplies to be received from the existing source of supply, mainly local tanks, for part of the area.

This range is even wider when one examines individual projects of each State.

So far as power projects are concerned, they are, in some cases, situated in the supply line of an irrigation canal, requiring no additional diversion; in other cases, they would deliver into the river below the power house a regulated supply of water from the tail-race. There are, however, 10 power projects of Maharashtra (paragraph 14-22) which would divert to the Arabian Sea 226.5 T.M.C. of water out of the Krishna basin and one power project of Orissa (paragraph 14-23) which will divert 25.1 T.M.C. of water from the Godavari basin.

18-62 The engineering and economic feasibility of most of the projects has yet to be established; detailed field investigations would have to be undertaken for each such project. *Prima-facie* some of the projects which require the construction of dams, two or three miles long, and large spillways to store only one or two T.M.C. of water would not seem to be practical propositions. In case of some projects, it is doubtful whether it would be possible for the land to deal with all the water proposed to be put on it.

By and large, the State Governments have put forward these projects on the tacit assumption of unlimited funds being available and assuming for each project the highest priority on the available flow at the site of the project without consideration of the requirements of other projects on the river system.

18-63 A number of projects have been put forward jointly by two State Governments (see paragraphs 14-44 and 14-45). There are others which, although sponsored by only one State Government, would submerge large areas in the territory of another State (see paragraph 14-46). There is still another class of projects put forward by different States, which impinge on each other (see paragraphs 14-48 and 14-49). Some of these are dependant on the same supply of water; others on the same storage site and still others, if executed, would drown the tail-race waters of an upper power project.

18-64 The requirements of the new projects and schemes, as put forward by the State Governments, have been examined sub-basin-wise, in paragraphs 15-2 to 15-25 along with a rough estimate of the river supplies likely to be available in the sub-basin and the diversions by projects in operation or those undertaken since 1951. The overall result is presented in Table XXXV and the general conclusions in paragraphs 15-34 to 15-36. Also see paragraph 18-75.

18-65 Briefly stated, the supplies available in the Krishna basin and in the upper part of the Godavari basin (sub-basins G.1 to G.5) are inadequate to meet the demands of the projects put forward by the State Governments; the supplies available in the lower part of the Godavari basin (sub-basin G.7 to G.12) are in excess of the demands.

18-66 The shortage in the Krishna basin can be made up partly by the transfer of such surplus supplies from the lower Godavari area as can be utilised in the Krishna basin by the following two link canals:

- (a) A link canal from the Godavari at Polavaram to Vijayawada (see paragraphs 16-6 to 16-9), at a cost of about Rs. 40 crores. This will transfer about 211 T.M.C. (4.8 M.A.F.) of water to the Krishna.
- (b) A link canal from the Godavari near Albaka or Singaraddi to Pulichintala on the Krishna (see paragraphs 16-10 to 16-13) at a cost of about Rs. 40 crores. This link canal will transfer about 95 T.M.C. (2.2. M.A.F.) of water to the Krishna.

18-67 It may be possible to make up the shortage in the upper Godavari area, to some extent, by the transfer of about 25 to 30 T.M.C. of water from the Penganga to the Godavari (see paragraph 16-15). The cost of this link canal has not been estimated.

18-68 These diversions, if executed, would call for modifications in some of the projects under execution and in some of those proposed. These modifications have been described in paragraph 16-16 and the overall effect of the transfer of water in paragraph 16-17.

18-69 In the light of the facts and considerations set out in paragraphs 18-56 to 18-61 and of the relevant portions of Chapters XIV to XVI, the Commission recommends as follows:

- (a) Immediate steps be taken to prepare an integrated plan incorporating the power and irrigation developments proposed by different States in the lower Godavari area (see paragraphs 15-37), Polavaram-Vijayawada Link and the Godavari-Pulichintala Link (See paragraphs 16-6 to 16-13). It should be possible, on the basis of the information contained in this report, field reconnaissance and some preliminary surveys to be carried out, to prepare a preliminary project report in about six months and establish the feasibility, or otherwise, and scope of the proposed diversions from the Godavari to the Krishna.

As soon as this preliminary project report has been prepared, final decision can be taken in accordance with it, in regard to :

- (i) the scope of the Nagarjunasagar Project [see paragraph 16-16 (c)];
- (ii) sanction to or abandonment of the Nagarjunasagar Hydro-electric Project [see paragraph 16-16 (b)]; and
- (iii) the scope of the Srisaïlam Project [see paragraph 16-16 (d)].

It is clear that the Srisaïlam Project would fit in any scheme and from this point of view, there should be no objection to starting work on the Srisaïlam Project, the only hydro-electric development left in the lower Krishna area. The scope of the project would, however, have to be reviewed as soon as the preliminary plan mentioned above has been prepared.

In view of the regulated supplies that would be available to the projects, existing and proposed, on the Krishna below Nagarjunasagar, from the Godavari diversions, and to the canals at Nagarjunasagar, from Srisailam, the crop pattern now proposed on the basis of 4 to 6 months' supply should be revised to take advantage of the regulated flow.

- (b) A preliminary survey be made of the proposed Penganga-Pochampad Link (see paragraph 16-15) and this survey be taken into account before according sanction to the Penganga Hydro-electric Project [see paragraph 16-16(e).]

Administration and management

18-70 There are wide variations in the scope and the provisions of existing legislation on irrigation development applicable to different States and different regions of each State in the Krishna and Godavari basins. Apart from the lack of uniformity, there are serious lacunae in some of the Irrigation Acts, both with regard to the powers necessary for Government for the optimum utilisation, in the public interest, of the available water resources as well as in the obligations of the cultivators, with regard to construction and maintenance of water-courses (see paragraphs 17-3 to 17-8). An important provision, which does not appear adequately in any existing legislation, is with regard to the obligation of the irrigator to prepare his land for receiving irrigation waters. As stated in paragraphs 7-25 and 7-26 such a provision is important for the Krishna and Godavari basins.

18-71 There is a multiplicity of departments under the State Government dealing with irrigation development. The Public Works Department, the Revenue Department, the Agricultural Department, Village *Panchayats*, etc., (see paragraphs 17-9 to 17-15) all have some role to play. The Dandakaranya Development Authority has its own independent organisation. This division of responsibility ignores the hydrologic unity of river basin and the need of close coordination between inter-dependent developments by works of different classes.

The Public Works Department, required to construct and operate all major and medium works, do not in some States have any real contact with the irrigators. Development is slow and the overall water use not efficient.

18-72 Because of the history and nature of development of irrigation in the Krishna and Godavari basins and the relatively large quantities of water so far available when compared with the uses developed, there has not been any urge in the past towards an economic use of river supplies (see paragraphs 17-33 to 17-37). The control exercised by Government in sanctioning the use of water and in regulating crop pattern themselves stand in the way of economy in water use. Irrigation practices are such as consume a large quantity of water (see paragraphs 17-42 to 17-44).

The system of 'localisation' introduced in some States is inequitable in as much as it deprives some eligible cultivators from the right to benefit from irrigation facilities while enabling others to use relatively large quantities (see Annexure XVI).

Even at the Centre, the major and medium projects are dealt in the Ministry of Irrigation and Power and minor projects in the Ministry of Agriculture. The Dandakaranya Development Authority is under the supervisory control of the Ministry of Works, Housing and Supply.

Water-rates vary enormously and are, in most States, un-related both to the present-day costs of construction and maintenance of irrigation works and to the present-day benefits derived by the cultivators from the use of irrigation waters. These rates are in strange contrast to the keenness and the enthusiasm with which more and more irrigation works are in demand in the two basins.

Need for a new policy

18-73 In the entire Krishna basin and the upper part of the Godavari valley, **water is a scarce natural resource.** Water is also scarce in the adjoining areas lying towards the south-east of the Krishna basin. At the same time, **irrigation waters are an expensive commodity.** Because of the hydrological features of the two rivers, almost every project has to be based on storage. Because of the terrain, canal construction is more expensive than in the Indo-Gangetic plains or the coastal belts:

Evaporation losses from storage reservoirs and tanks are usually **high in the two basins**, particularly during the three months preceding the south-west monsoon. The problem is very serious on small shallow tanks, where the water lost by **evaporation may equal or exceed that applied to crops.**

Most of the land in the two basins is either cropped or bears forests and **natural vegetation.** The benefits from an irrigation project would, therefore, be the difference between the value of crops sown after irrigation supplies are made available and the value of forests or crops under un-irrigated conditions. Correspondingly, **consumptive use on account of irrigation would be the difference between the evapo-transpiration from the area respectively under irrigated and un-irrigated conditions.**

Because of the rolling terrain and spasmodic rainfall of high intensity, **soil conservation and proper land utilization must be regarded as important activities in the two basins**, having a significant effect also on their water supplies.

Land treatment is an essential pre-requisite to the introduction of irrigation in most parts of the two basins.

The structure and nature of the soil varies widely in different parts of the two basins and within each river valley. A change-over from un-irrigated to irrigated conditions, therefore, requires expert supervision.

Hydrologically, river flow and ground waters are both parts of a common source of supply and there must, therefore, be a close co-ordination between the developments from surface waters and ground waters.

Minor schemes and small tanks may not be as spectacular as major and medium projects but they are as much an engineering problem as major and medium projects. Under present conditions, they are extravagant in water use and virtually not maintained until they fall into dis-use. With the development of new major works, they will create serious drainage problems. Minor schemes and tanks, therefore, now require expert supervision as much as major and medium schemes; and they have to be merged, wherever possible, into new major projects.

The developments undertaken since 1951 and those proposed, exceed by far, in magnitude and overall effect, the developments undertaken up to 1951. The latter were largely confined to small valleys and the delta areas ; the development of the uplands is now being undertaken on an extensive scale for the first time and these will create many new problems.

18-74 In view of the facts and considerations set out above,

the Commission recommends that the State Governments concerned should all agree to tune their policy regarding irrigation and the administration and management of irrigation works to the requirements of optimum development of a scarce and expensive natural resource.

Some of the steps which should be undertaken immediately in furtherance of this objective are as follows :

- (a) Limit the irrigation of paddy to the rainy season, in order to reduce the use of irrigation supplies to the minimum and (i) to areas of high rainfall such as sub-basins G. 8, G. 9, G. 10, G. 11 and G. 12 and the narrow strip along the Western Ghats where the delta for paddy should not be more than about 2.0 feet (ii) valley-bottoms and low-lying areas where, because of the seepage from upland irrigation no other crop can be grown and paddy can be grown with advantage or (iii) to the delta lands.
- (b) Adopt a crop pattern which would (i) take full advantage of seasonal rainfall and (ii) not require any stored water after February, so that the reservoirs are emptied by that date. This will save the high evaporation loss from March to May.
- (c) Develop the use of ground waters to the maximum ; investigate the likely sites and develop the use of under-ground reservoirs, artificially charged during the rainy season.
- (d) Limit perennial crops to (i) only those areas where the irrigation supplies required between, say, January, to May can be obtained from ground waters or from artificially charged under-ground reservoirs or (ii) to those areas where irrigation waters are obtained from the regulated flow below a power project. In such cases, the perennial areas should be in convenient blocks, so that it is not necessary to run any irrigation channel with a capacity factor of less than 0.5 in any month.
- (e) In case of multipurpose projects, the crop pattern should be such as would require irrigation supplies more or less uniformly all the year round.
- (f) Reorganise the Public Works Department, where necessary, to enable it to manage all irrigation projects, major, medium, minor or small tanks, and all stages of planning, construction, operation and development including the assessment of water charges. It is necessary that all aspects of the development of water resources for irrigation and of their ultimate use should be under unified control.

- (g) While no control need be exercised, at this stage, with regard to development of irrigation from wells except where such development is an integral part of a canal system, it is necessary to have in the Irrigation Department, officers to advise cultivators with regard to developments from wells and who should maintain a record of well operations. These officers should also maintain records of the operation of private irrigation works and watch the effect, on the hydrology of the basin, of contour bunding and land treatment in non-irrigated areas.
- (h) Introduce necessary legislation along uniform set of principles to facilitate optimum development of the water resources of the two river basins, laying down appropriate powers for Government and the rights and obligations of the cultivators. A more or less uniform basis for charges for irrigation water supplies and betterment levy etc., should be established.
- (i) The present system of administrative account of irrigation projects should be reviewed and revised to take note of the changed conditions, such as the new direct receipts from agricultural commodities or the processing of agricultural produce. An appropriate basis should be established for taking note of indirect benefits in the administrative accounts.

18-75 If the use of water supplies is regulated in accordance with the recommendations (a) to (e) above and the administrative changes suggested in (f) above are carried out, the Commission is hopeful that with the available water supplies, with the diversion of surplus Godavari waters into the lower part of the Krishna basin, with the saving in evaporation losses from old tanks as well as new reservoirs, with the regeneration which is likely to result and the salvage in transit losses, it would be possible, in due course, to meet the reasonable requirements of most of the areas proposed to be irrigated by all the projects that have been put forward.

18-76 There should be in every Irrigation Department, a soil survey wing, whose duty should be not only to carry out a scientific soil survey of all areas proposed to be supplied with irrigation waters but also, periodically, to carry out soil survey of the areas already under irrigation in order to study the effect of irrigation supplies on the soil characteristics so that the necessary ameliorative measures can be taken and irrigation ensured as a permanent feature of agriculture (see paragraphs 6-36 to 6-38).

Need for co-operative approach

18-77 It would have been clear from the conclusions reached in various parts of the report and the recommendations made above that optimum development of the water resources of the two river systems would not be possible without a co-operative approach by the States concerned. Close co-ordination in the planning and operation of irrigation and hydro-electric projects, as in other related activities in the two basins, is indispensable. Already, a number of problems have arisen because of the exclusive developments undertaken hitherto which, unless attended to immediately, would become serious as soon as these developments become operative.

The Commission recommends that an inter-State body, a River Board or by whatever name called, should be established without any delay, for bringing about a co-operative approach and establishing the necessary co-ordination in the planning and operation of various developments in the two river basins. The integrated operation of all projects, which is indispensable, would not be possible without such a co-ordinating body.

Irrigation Extension Service

18-78 It has been stated in paragraph 18-73 that the large potential to be created by the projects undertaken since 1951 must be developed not along the lines of earlier developments, undertaken under very different set of conditions, but in full recognition of the changed circumstances. In the Commission's view, the pace of development on works already completed is slow, and in most cases targets have not been achieved, largely due to the fact that the methods being adopted are not adequate to the needs of the situation.

The Commission recommends for serious consideration that, in each State, an Irrigation Extension Service should be introduced as a part of the Irrigation Department.

It is not enough that the Public Works Department should create large irrigation potentials. They must go further and ensure that these potentials are developed, along scientific lines, for maximum national good, keeping in view the requirements of *permanent* irrigated agriculture.

18-79 The main functions of the proposed Irrigation Extension Service should be

- (a) to carry out systematic studies on the economic use of irrigation waters, consistent with maximization of agricultural output ; to determine for each region or district the best crop pattern so as to make maximum use of seasonal rainfall; to co-operate with regional research stations of the Agricultural Department in research on new varieties of crops best suited to the nature of irrigation supplies available in any area ;
- (b) to determine the consumptive use of water by major agricultural and garden crops ;
- (c) to set up a number of demonstration centres and arrange for field demonstrations to show the cultivators how they can use the available irrigation supplies for maximum benefit, proper land treatment required for each field, proper method of irrigating the field, when to apply irrigation water and how much ;
- (d) in conjunction with the soil wing, proposed in paragraph 18-76, advise the cultivators on soil problems.

18-80 In the Commission's view, an organisation of the type described above, as a part of the irrigation department, is indispensable in the Krishna and Godavari basins, where large scale irrigation is being introduced in the uplands for the first time, water is scarce and expensive, but irrigation use to date has been somewhat extravagant. The change-over from un-irrigated to irrigated agriculture in large areas requires expert guidance and supervision.

18-81 The proposed Irrigation Extension Service would supplement the present activities of the Agricultural Department. While the Agricultural Department can concentrate on improvements in un-irrigated areas, research on new varieties of crops, both irrigated and un-irrigated, seed multiplication, *etc.*, the Irrigation Extension Service would show the irrigators how irrigation waters can be used economically to maximum advantage, how land must be prepared for irrigation, the importance of water courses and explain to them the inter-relation between irrigation and soil.

N. D. Gulhati

D. D. Jaini

R. C. Hoon

APPENDIX A

PARTICULARS OF VISITS BY THE COMMISSION TO VARIOUS PARTS OF THE KRISHNA AND GODAVARI BASINS AND ADJOINING AREAS

| | | <i>Distance travelled within the basin and adjoining areas</i> | |
|------------------------------------------|-----------------------------------------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| | | (miles) | |
| May 1961 | 17th Delhi to Hyderabad | .. | Preliminary discussions with the Government of Andhra Pradesh, visit to Inchampalli dam site and areas enroute. |
| | 18th Halt at Hyderabad | .. | |
| | 19th Hyderabad to Mahadevpur | 151 | |
| | 20th Mahadevpur to Warrangal | 128 | |
| | 21st Warangal to Hyderabad | 88 | |
| | „ Hyderabad to Delhi | .. | |
| | 24th Delhi to Bombay | .. | Preliminary discussions with the Government of Maharashtra, visit to upper reaches of Krishna basin. |
| | 25th Bombay to Mahabaleshwar | 149 | |
| | 26th Mahabaleshwar to Bombay | 149 | |
| 27th Bombay to Delhi | .. | | |
| June 1961 | Delhi to Calcutta | .. | |
| | 11th Calcutta to Bhubaneshwar | .. | Preliminary discussions with the Government of Orissa. |
| | 12th Halt at Bhubaneshwar | .. | |
| | 13th Bhubaneshwar to Puri | .. | |
| | „ Puri to Bhubaneshwar | .. | |
| | „ Bhubaneshwar to Calcutta | .. | |
| | 14th Calcutta to Delhi | .. | |
| | 20th Delhi to Bhopal | .. | Preliminary discussions with the Government of Madhya Pradesh. |
| | 21st and 22nd Halt at Bhopal | .. | |
| | 23rd Bhopal to Vijayawada | 660 | Visit to Vijayawada and Dowlaiswaram anicuts. |
| | 25th Vijaywada to Rajahmundry | 77 | |
| | 25th Rajahmundry to Madras | .. | |
| 26th Madras to Bangalore | .. | Preliminary discussions with the Government of Mysore, | |
| 27th to 29th Halt at Bangalore | .. | | |
| 30th Bangalore to Delhi | .. | | |

APPENDIX A (continued)

PARTICULARS OF VISITS BY THE COMMISSION TO VARIOUS PARTS OF THE KRISHNA AND GODAVARI BASINS AND ADJOINING AREAS

| | | <i>Distance travelled within the basin and adjoining areas</i> | |
|----------------------|-------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| | | (miles) | |
| July 1961 | | | |
| 30th | Delhi to Bombay | .. | |
| 31st | Bombay to Poona | .. | Visit model experiments at the Central Water and Power Research Station, Poona on flow on the Vijayawada anicut. |
| .. | Poona to Khadakwasla and back | 16 | |
| .. | Poona to Bombay | .. | |
| .. | Bombay to Delhi | .. | |
| October 1961 | | | |
| 16th | Delhi to Bombay | .. | Discussions with the Deputy Director-General India Meteorological Department. |
| .. | Bombay to Poona | .. | |
| 17th | Halt at Poona | .. | Joint meeting with the representatives of State Governments. |
| 18th | Poona to Bombay | .. | |
| 19th | to 21st Halt in Bombay | .. | |
| 22nd | Bombay to Kopergaon | 210 | |
| 23rd | Kopergaon to Poona | 220 | Joint tour of inspection of various works and sites in the Krishna and Godavari basins and adjoining areas. |
| 24th | Poona to Koyananagar | 140 | |
| 25th | Koyananagar to Belgaum | 190 | |
| 26th | Belgaum to Bijapur | 140 | |
| 27th | Bijapur to Yadgir | 138 | |
| 28th | Yadgir to Raichur | 165 | |
| 29th | Raichur to Munirabad | 190 | |
| 30th | Munirabad to Bellary | 160 | |
| 31st | Bellary to Nandyal | 250 | |
| November 1961 | | | |
| 1st | Nandyal to Srisailam | 245 | |
| 2nd | Srisailam to Nagarjunasagar Dam | 180 | |
| 3rd | Nagarjunasagar Dam to Hyderabad | 100 | |
| 4th | Halt at Hyderabad | .. | |
| 5th | Hyderabad to Pochampad and back | 350 | |
| 6th | Hyderabad to Delhi | .. | |

APPENDIX A (continued)

PARTICULARS OF VISITS BY THE COMMISSION TO VARIOUS PARTS OF THE KRISHNA AND GODAVARI BASINS AND ADJOINING AREAS

| | | <i>Distance travelled within the basin and adjoining areas</i> | |
|---------------|---------------------------------------------------|------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| | | (miles) | |
| December 1961 | | | |
| 12th | Delhi to Bangalore | .. | Inspection of Model experiment at the Indian Institute of Science Bangalore and discussions with the Geological Survey of India. |
| 13th | Halt at Bangalore | .. | |
| 14th | Bangalore to Calcutta | .. | |
| 15th | Halt at Calcutta | .. | |
| 16th | Calcutta to Delhi | .. | |
| February 1962 | | | |
| 14th | Delhi to Bangalore | .. | Discussions with representatives of Mysore. |
| 15th and 16th | Halt at Bangalore | .. | |
| 17th | Bangalore to Hyderabad | .. | Discussions with representatives of Andhra Pradesh. |
| 18th | Hyderabad to Delhi | .. | |
| March 1962 | | | |
| 1st | Delhi to Hyderabad | .. | Discussions with representatives of Andhra Pradesh. |
| | 2nd and 3rd Halt at Hyderabad | .. | |
| 4th | Hyderabad to Delhi | .. | |
| 22nd | Delhi to Hyderabad | .. | Joint tour of inspection of various works and sites in the Krishna and Godavari basins and adjoining areas. |
| 23rd | Hyderabad to Vishakhapatnam | 300 | |
| 24th | Visakhapatnam to Upper Sileru/Guntewada | 128 | |
| 25th | Guntewada to Koraput | 154 | |
| 26th | Koraput to Naurangpur and back | 160 | |
| 27th | Koraput to Jagdalpur | 70 | |
| 28th | Jagdalpur to Raipur via Rudri Headworks | 190 | |
| 29th | Raipur to Durg | 38 | |
| 29th | Do Nagpur | 165 | |
| 29th | Nagpur to Jalgaon | .. | |
| 30th | Jalgaon to Aurangabad | .. | |
| 31st | Aurangabad to Ahmednagar | 145 | |

APPENDIX A (concluded)

PARTICULARS OF VISITS BY THE COMMISSION TO VARIOUS PARTS OF THE KRISHNA AND GODAVARI BASINS AND ADJOINING AREAS

| | <i>Distance travelled within the basin and adjoining areas</i> | |
|----------------------------------------|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | (miles) | |
| April 1962 | | |
| 1st Ahmednagar to Sholapur | 182 | |
| 2nd Sholapur to Poona | 200 | |
| 3rd Poona to Bombay | .. | |
| 4th Bombay to Delhi | .. | |
| 10th Delhi to Madras | .. | Preliminary discussions with Madras, Government study, of Madras City water supply and inspection of lands proposed to be irrigated by Madras Canal Project. |
| 11th Madras to Vidur Dam and back . . | 242 | |
| 12th Madras to Poondi and back . . . | 107 | |
| 13th Madras to Mahabalipuram and back | 65 | |
| 14th Madras to Salem | .. | Visit to Mettur Dam and Lower Bhavani Project. |
| 15th Salem to Mettur Dam to Ootacamund | .. | |
| 16th to 26th Halt at Ootacamund . . . | .. | Joint meeting with representatives of States. |
| 26th Ootacamund to Mysore | .. | |
| 27th Mysore to Bangalore | .. | |
| 28th Bangalore to Delhi | .. | |
| June 1962 | | |
| 3rd Coimbatore to Madras | .. | Discussions with representatives of Madras. |
| 5th Madras to Delhi | .. | |
| 19th Delhi to Calcutta | .. | |
| „ Calcutta to Hirakud | .. | |
| 20th Halt at Hirakud | .. | Visit to Hirakud Project areas |
| 21st Hirakud to Calcutta | .. | |
| 22nd Calcutta to Delhi | .. | |

APPENDIX B

STATISTICS OF SCARCITY AREAS—TALUK-WISE

Note:—This statement and Annexures I and II are to be filled separately for (i) 1931-32 to 1940-41, (ii) 1941-42 to 1950-51 and (iii) 1951-52 to 1960-61.

1. Name of District
2. Name of *Taluk*
3. Area assessed to 'wet' rate :
(including area under wells)acres
4. Area assessed to 'dry' rate :acres
5. Rate of dry assessment per acre : Rs.....to Rs.....
6. Annual amount of dry assessment : Rs.....
7. Average rate of dry assessment (item 6/item 4): Rs.....
8. Accepted settlement yield per acre for principal un-irrigated crops:
 - (a) Cotton
 - (b) *Jawar*
 - (c) Groundnut *etc.*
9. Rules regarding grant of suspension and remission of land revenue:
10. Statement of monthly rainfall for 10 years, as per sample form attached as Annexure I.
11. Statement for 10 years of suspension and remission of land revenue, and expenditure on famine relief as per form attached as Annexure II.
12. Area included in new* projects:

Category†

Name of Project

Proposed Ayacut or C.C.A.

13. Index map of the *Taluk* showing (if possible) Ayacut or C.C.A. under item 3 (in green) and that under item 12 (in red).
-

*excluding area covered by item 3 above.

†A, B, C. 1, C. 2 or C. 3.

ANNEXURE I

STATEMENT OF MONTHLY RAINFALL FOR 10 YEARS

.....TALUK.....DISTRICT.....STATE

| <i>Year</i> | <i>Jan.</i> | <i>Feb.</i> | <i>Mar.</i> | <i>Apr.</i> | <i>May</i> | <i>June</i> | <i>July</i> | <i>Aug.</i> | <i>Sep.</i> | <i>Oct.</i> | <i>Nov.</i> | <i>Dec.</i> | <i>Total annual</i> |
|--------------------|-------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------------|
| 1931 . . | | | | | | | | | | | | | |
| 1932 . . | | | | | | | | | | | | | |
| 1933 . . | | | | | | | | | | | | | |
| 1934 . . | | | | | | | | | | | | | |
| 1935 . . | | | | | | | | | | | | | |
| 1936 . . | | | | | | | | | | | | | |
| 1937 . . | | | | | | | | | | | | | |
| 1938 . . | | | | | | | | | | | | | |
| 1939 . . | | | | | | | | | | | | | |
| 1940 . . | | | | | | | | | | | | | |
| Total . . | | | | | | | | | | | | | |
| Average . . | | | | | | | | | | | | | |

ANNEXURE II

STATEMENT SHOWING RAINFALL, AREA AFFECTED BY SCARCITY AND THE RELIEF MEASURES UNDERTAKEN

.....TALUK.....DISTRICT.....STATE

| Year | Annual Rainfall | Area affected by scarcity conditions | Estimated yield of crop. (anna-wari) | | Amount of land revenue suspended | Amount of land revenue remitted | Expenditure under 54 Famine Relief | Amount of Taccavi* disbursed | Remarks | | |
|------|-----------------|--------------------------------------|--------------------------------------|--------------------------------|----------------------------------|---------------------------------|------------------------------------|------------------------------|---------|----|----|
| | | | In the taluk as a whole | In the scarcity affected areas | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1931 | . | | | | | | | | | | |
| 1932 | . | | | | | | | | | | |
| 1933 | . | | | | | | | | | | |
| 1934 | . | | | | | | | | | | |
| 1935 | . | | | | | | | | | | |
| 1936 | . | | | | | | | | | | |
| 1937 | . | | | | | | | | | | |
| 1938 | . | | | | | | | | | | |
| 1939 | . | | | | | | | | | | |
| 1940 | . | | | | | | | | | | |

*arranged by heads.

Appendix C

ROUGH ESTIMATE OF THE YIELDS FROM SOME OF THE GODAVARI SUB-BASINS

1. It is unfortunate that there is not even a single site, for which reliable discharge data are available, in G.5 Middle Godavari sub-basin, G.7 Penganga sub-basin, G.8 Wardha sub-basin and G.11 Indravati sub-basin.

2. There are four discharge sites in G.9 Pranhita sub-basin; the data for two sites are irregular and that for the other two are available for only two years and are, therefore, not of much help. Even otherwise, these discharge sites are in the upper part of the catchment and represent only a small part of the sub-basin.

3. In G.12 Sabari sub-basin, there are two discharge sites, one at Pulusura on the Kolab and the other at Jalaput on the Machkund. Data for Pulusura are available for the period 1921 to 1928, but the exact method of calculating discharges is not known. Data for Jalaput are available from 1942 for a period of 13 years, but data for the last two years appear to be abnormal. Both Pulusura and Jalaput represent only a small part of the Sabari sub-basin.

4. In G.1 Lower Godavari sub-basin useful data are available for only one site, the Godavari at Dowlaishwaram, for over 60 years. The accuracy and reliability of these data have been examined in paragraphs 9-22 and 9-23. Apart from serving as a general guide, the data at Dowlaishwaram cannot be of much help in determining the yields from the individual sub-basins mentioned above.

5. Sub-basins G.5 and G.7 to G.12 cover more than two-third of the total catchment of the Godavari basin. Under the circumstances explained in paragraphs 1 to 4 above, it is difficult to get any adequate idea of the yields from these catchments which could be utilised for project planning. The only information available, at present, is the appraisal* made by Khosla in 1949. Khosla's formula has been described in paragraph 9-31(f). While taking account of rainfall of each area, it takes only the mean temperature of the area as an all-embracing factor covering evaporation, transpiration, vegetal cover etc.

6. Table I below shows the important discharge sites on the Godavari river system for which somewhat reliable and useful data are available, their catchment areas, the number of years for which data have been made use of, the average annual yield and the average annual run-off in inches. This is the only guide that the Commission has on which to formulate its rough estimates for the whole Godavari basin.

*Khosla, A. N., *Appraisal of Water Resources* ; 1949.

TABLE I

| Name of site | Sub-basin | Catchment area (square miles) | Number of years for working out average annual yield | Average annual yield (T.M.C.) | Average annual run-off (inches) |
|--------------------|-----------|-------------------------------|------------------------------------------------------|-------------------------------|---------------------------------|
| Nandur-Madhmeshwar | G. 1 | 1,650 | 20 | 94.5 | 24.7 |
| Ozer | G. 2 | 592 | 20 | 26.5 | 19.3 |
| Chikalthan | G. 2 | 581 | 13 | 30.7 | 22.7 |
| Siddheswar | G. 3 | 3,000 | 3 | 88.3 | 12.7 |
| Nizamsagar | G. 4 | 8,376 | 26 | 192.8 | 9.9 |
| Maner | G. 6 | 836 | 10 | 22.2 | 11.4 |
| Pulusura | G. 12 | 618 | 8 | 40.8 | 28.4 |
| Jalaput | G. 12 | 755 | 13 | 89.5 | 51.1 |
| Dowlaishwaram | G. 10 | 119,777 | 20 | 4,162.3 | 15.0 |

TABLE II

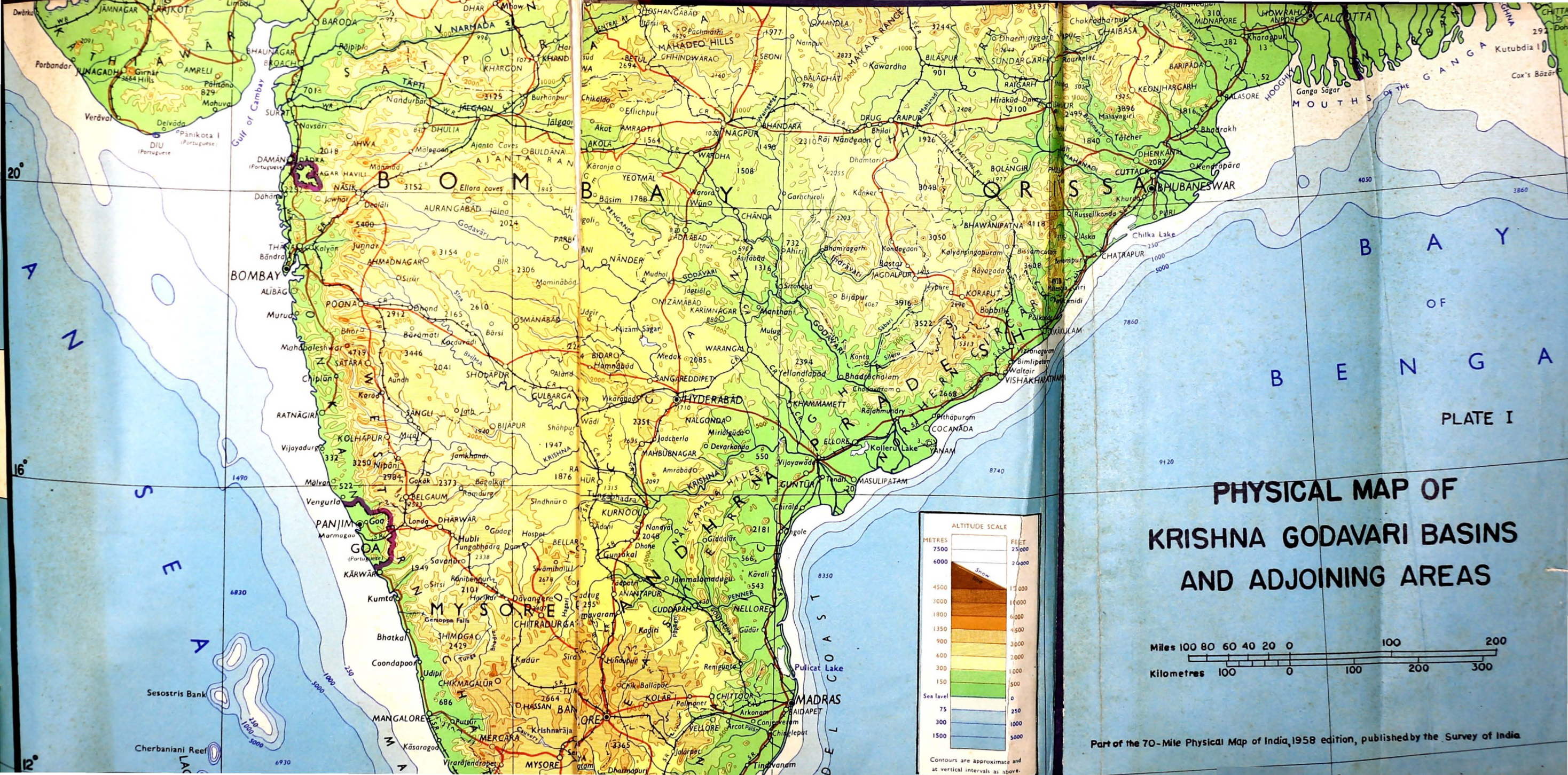
| Name of sub-basin | Direct catchment area (square miles) | Weighted average annual rainfall (inches) | Estimated run-off based on observed data (inches) | Run-off by Khosla's formula (inches) | Commission's estimate of run-off (inches) | Average annual yield assessed by the Commission (T.M.C.) |
|----------------------|--------------------------------------|-------------------------------------------|---------------------------------------------------|--------------------------------------|-------------------------------------------|----------------------------------------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| G. 1 Upper Godavari | 12,935 | 30.3 | 8.0 | 5.34 | .. | 240 |
| G. 2 Parvara | 2,524 | 23.9 | 12.0 | 5.34 | .. | 70 |
| G. 3 Purna | 6,015 | 31.4 | 7.2 | 5.34 | .. | 100 |
| G. 4 Manjra | 11,909 | 33.2 | 9.8 | 8.12 | .. | 270 |
| G. 5 Middle Godavari | 6,643 | 37.6 | .. | 11.23 | 6.5 | 100 |
| G. 6 Maner | 5,060 | 36.7 | 7.7 | 11.23 | .. | 90 |
| G. 7 Penganga | 9,227 | 37.8 | .. | 11.23 | 8.4 | 180 |
| G. 8 Wardha | 9,300 | 39.6 | .. | 11.23 | 11.1 | 240 |
| G. 9 Pranhita | 23,588 | 53.9 | .. | 23.13 | 23.7 | 1,300 |
| G. 10 Lower Godavari | 9,602 | 47.6 | .. | 18.89 | 17.9 | 400 |
| G. 11 Indravati | 16,087 | 61.7 | .. | 29.99 | 31.0 | 1,160 |
| G. 12 Sabari | 7,887 | 56.5 | .. | 18.89 | 26.2 | 480 |
| Entire Basin | 120,777 | 44.6 | .. | 15.77 | .. | .. |

7. In Table II, an attempt has been made to make a rough assessment of the yields of various sub-basins on the Godavari river system. Figures given in column 4 for sub-basins, G.1, G.2, G.3., G.4, and G.6, are based on the detailed calculations given in paragraphs 15-14(e) to 15-17(e) and 15-19(e). The run-off* as given by Khosla's formula has been shown in column 5. The Commission's best estimates of the run-off are shown in column 6. These are based on a study of the run-off as estimated for sub-basins G.1, G.2, G.3, G. 4 and G.6, the weighted average annual rainfall as given in column 3, and a close study of the rainfall isohyets on Maps I to V. The Commission have also taken into consideration other relevant features like vegetal cover. The average annual yield for each sub-basin, as so worked out, is shown in column 7.

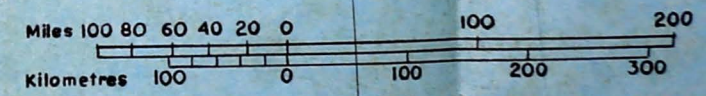
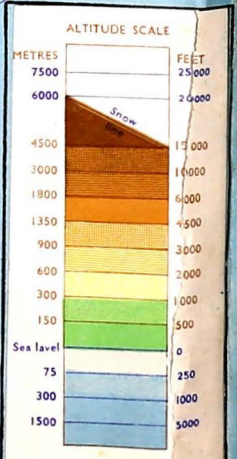
8. It cannot be over-emphasised that the rough estimate, formulated by the Commission in columns 6 and 7 of Table II, is at best an informed guess, taking into consideration the hydrologic characteristics of the area and such other information as is available. While the figures obtained may give an idea of the likely yield from these catchments on an average basis, these figures, in the Commission's view, are not good enough to form the basis of big projects involving large sums of public money.

9. The sum total of the average yields, from individual catchments for the whole Godavari system is 4,630 T.M.C. Out of this, there should be a deduction of at least about 10 per cent for losses in the long length of the Godavari river below Manjra confluence. The figure so obtained is 4,167 T.M.C. which corresponds to 4,162 T.M.C., the recorded average flow at Dowlaishwaram plus the estimated diversion and losses upstream.

*Khosla, A. N; *Appraisal of Water Resources*; 1949.



PHYSICAL MAP OF KRISHNA GODAVARI BASINS AND ADJOINING AREAS



Part of the 70-Mile Physical Map of India, 1958 edition, published by the Survey of India

MAP OF KRISHNA GODAVARI BASINS AND ADJOINING AREAS

SHOWING
DISTRICTS AND PLACES
VISITED BY THE COMMISSION

SCALE
0 20 40 60 80 100 MILES



LEGEND

- RIVER
- HQ. STATE / DISTRICT
- STATE BOUNDARY
- BASIN
- SUB-BASINS KRISHNA
- SUB-BASINS GODAVARI
- DISTRICT BOUNDARY

Base map taken from Survey of India maps with the permission of the Surveyor General of India. Res. No. 7186 HE 67-10,900.

Reproduced from the originals supplied by the Krishna Godavari Commission, Ministry of Irrigation & Power, New Delhi, and the Survey of India is not responsible for the accuracy of details appearing on the map. 1942.

INDEX

PENINSULAR INDIA

HIMALAYA, BURMA & PORTIONS OF ASSAM

- Pleistocene & Recent
- Coastal Tertiary & Pleistocene
- Oligocene & Lower Miocene
- Palaeocene & Eocene
- Deccan Trap (differentiates in Kathiawar- stippled)
- Cretaceous
- Trap (Rajmahal, Abor Hills & Sylhet)
- Upper Gondwana of the Peninsula

Recent & Upper Tertiary Volcanic Rocks at: Koh-i-Sultan, Koh-i-Taftan, Barren Island, Narcondam Island, Padaung & its neighbourhood

- Siwalik, Tipam & Irrawaddy
- Middle Miocene-Oligocene of Burma & Middle-Lower Miocene of Assam
- Palaeocene & Eocene (includes Oligocene in Assam)
- Post-Palaeozoic Intrusions

Granites and Ortho-Gneisses (Ages undifferentiated)

Jurassic

Undifferentiated Mesozoic

Marine Trias

Mesozoic & Palaeozoic in windows

- { Upper Palaeozoic }
{ Lower Gondwana }
- Order Granites of Dalhousie Simla-Garhwal
- Lower Palaeozoic
- Metamorphosed Purana & Lower Palaeozoic
- Purana & Lower Palaeozoic (Undifferentiated)
- Jutogh & Salkhala
- Unclassified Crystallines
- Vindhyan
- Malani Volcanics & Granite
- Cuddapah, Dehli, etc
- Granites
- Dharwarian
- Khondalites
- Charnokites
- Unclassified Crystallines

Purana
(? Cambrian to Pre-Cambrian excluding Archæan)

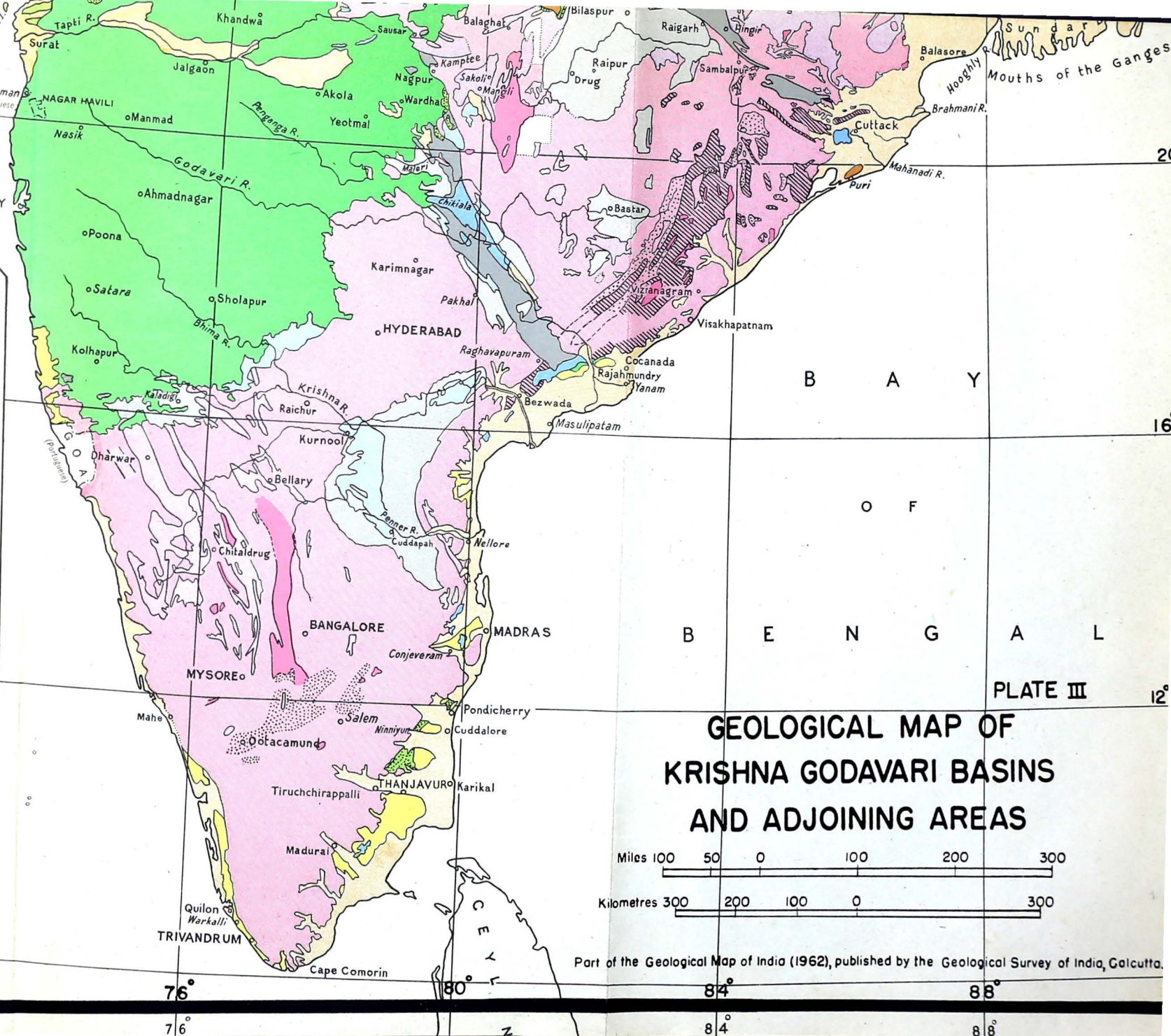
{ Purana & Archæan }

Archæan

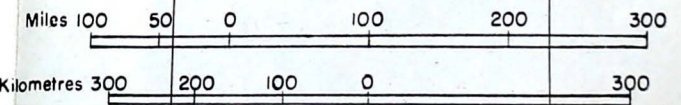
Unclassified Crystallines



LACADIVE, MINICOY AND AMINDIVI ISLANDS (INDIA)



**GEOLOGICAL MAP OF
KRISHNA GODAVARI BASINS
AND ADJOINING AREAS**

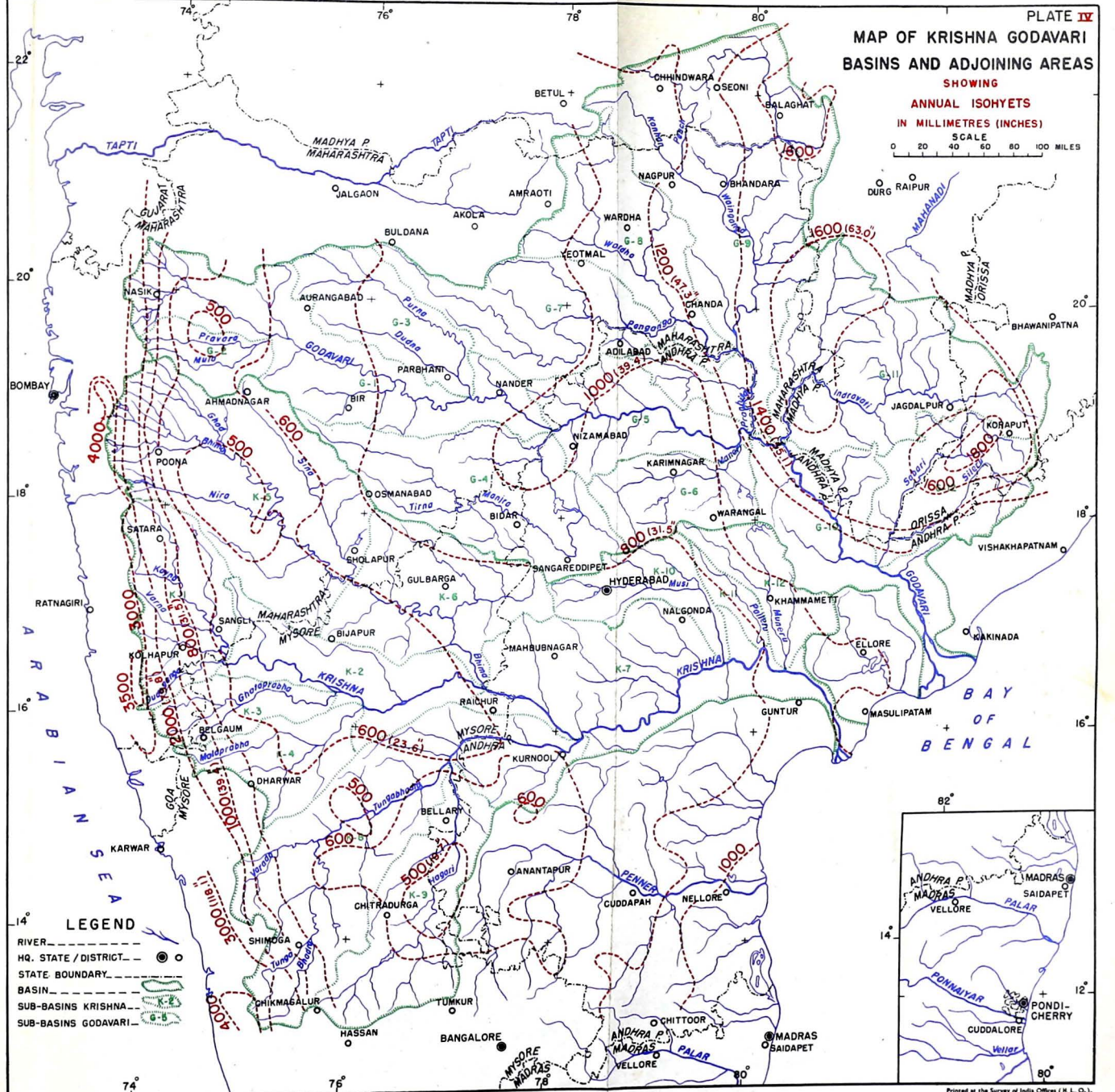


Part of the Geological Map of India (1962), published by the Geological Survey of India, Calcutta.

PLATE III

PLATE IV
**MAP OF KRISHNA GODAVARI
 BASINS AND ADJOINING AREAS**
 SHOWING
ANNUAL ISOHYETS
 IN MILLIMETRES (INCHES)

SCALE
 0 20 40 60 80 100 MILES



LEGEND

- RIVER
- HQ. STATE / DISTRICT
- STATE BOUNDARY
- BASIN
- SUB-BASINS KRISHNA
- SUB-BASINS GODAVARI

Isohyets as drawn by the India Meteorological Department, Poona
 Base map taken from Survey of India maps with the permission of the Survey General of India.
 Res. No. 7184 HE 42-10,500.

Reproduced from the originals supplied by the Krishna Godavari Commission, Ministry of Irrigation & Power, New Delhi,
 and the Survey of India is not responsible for the accuracy of details appearing on the map.
 1942.

MAP OF KRISHNA GODAVARI BASINS AND ADJOINING AREAS

SHOWING
GENERAL DISTRIBUTION OF
HARD & SOFT ROCKS

SCALE
0 20 40 60 80 100 MILES

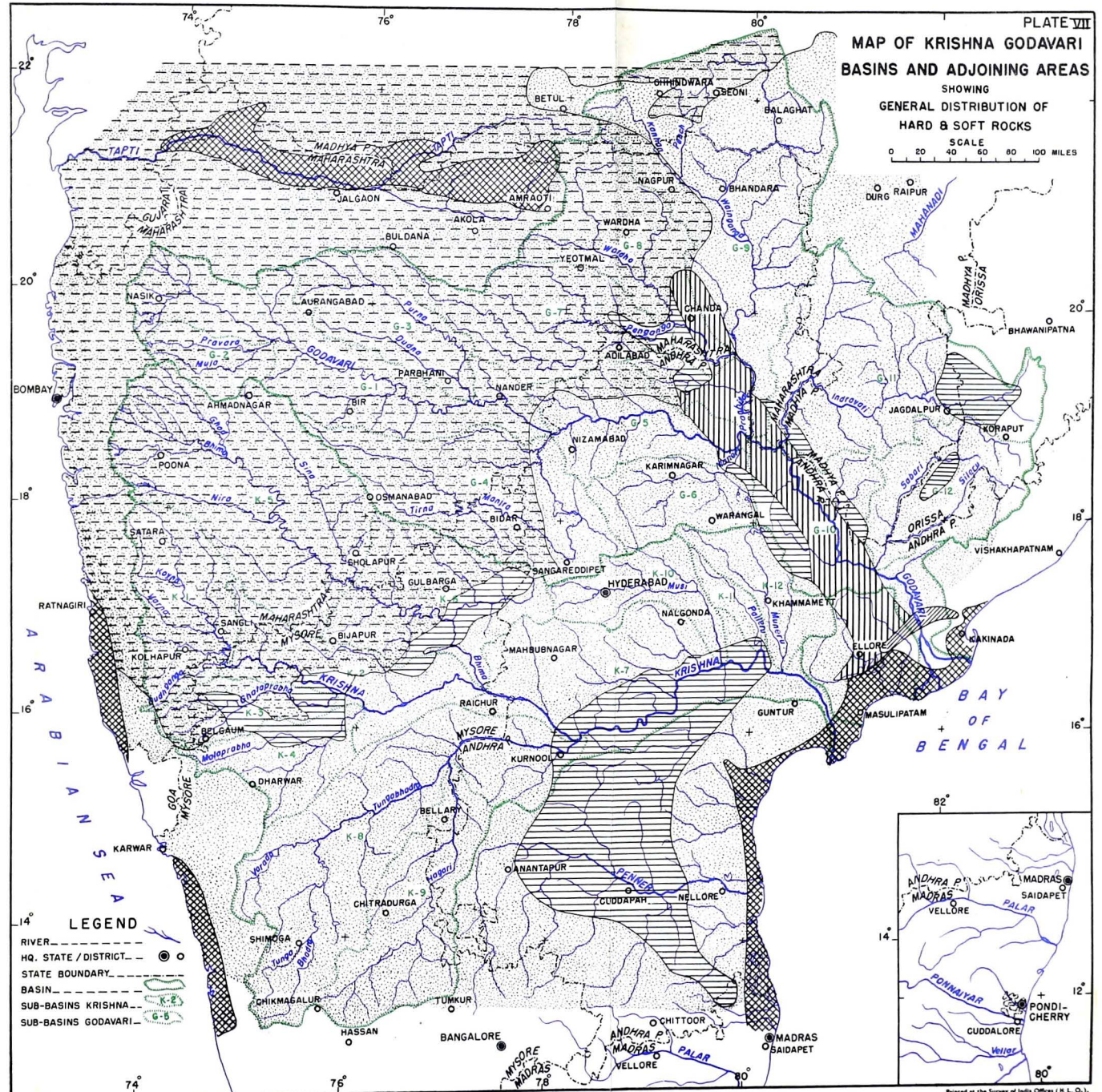
INDEX

DESCRIPTION OF GEOLOGICAL FORMATIONS

- ANCIENT CRYSTALLINES & METAMORPHICS
- DENSE IMPERVIOUS
- GONDWANA CONSOLIDATED SEDIMENTS
- DECCAN TRAP
- TERTIARY CONSOLIDATED TO SEMI-CONSOLIDATED SEDIMENTS
- RECENT AND OLDER ALLUVIUM

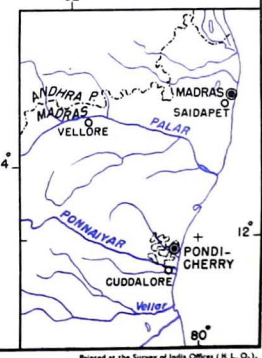
WATERBEARING CHARACTERISTICS

- VERY POOR
- GOOD TO FAIR
- POOR
- FAIR TO GOOD
- GOOD



LEGEND

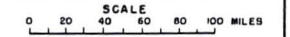
- RIVER
- HQ. STATE / DISTRICT
- STATE BOUNDARY
- BASIN
- SUB-BASINS KRISHNA
- SUB-BASINS GODAVARI



Based on the map supplied by the Superintending Geologist, Engineering Geology Section, G. S. I., Calcutta.
 Reproduced from the originals supplied by the Krishna Godavari Commission, Ministry of Irrigation & Power, New Delhi, and the Survey of India; it is not responsible for the accuracy of details appearing on the map.
 1942.
 GOVERNMENT OF INDIA COPYRIGHT, 1942.

MAP OF KRISHNA GODAVARI BASINS AND ADJOINING AREAS

SHOWING SITES FOR WHICH DISCHARGE DATA HAVE BEEN MADE AVAILABLE



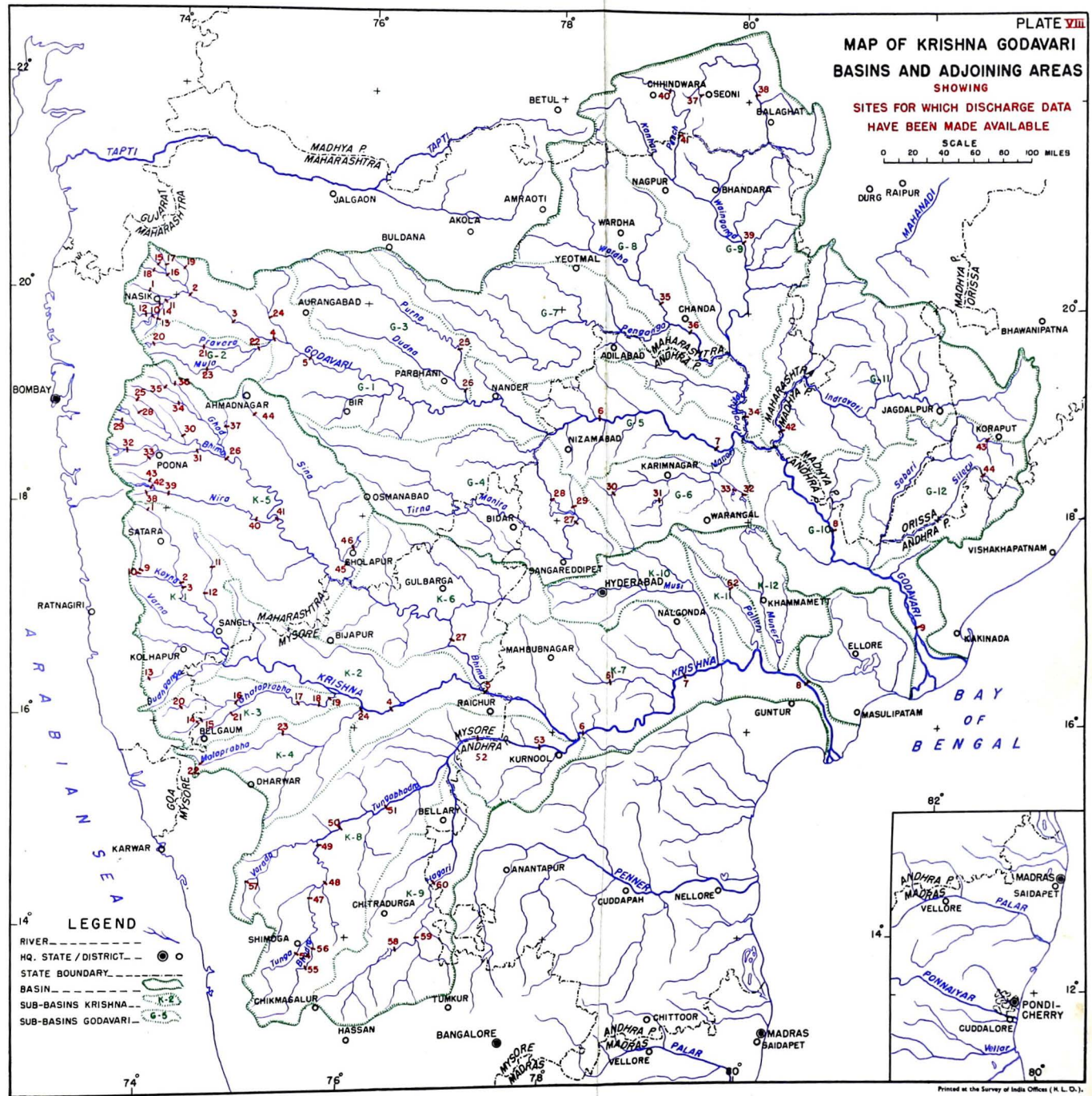
KRISHNA RIVER SYSTEM

1. Dham
2. KHODSHI WEIR
3. Karad
4. Chitapur
5. Deosugur
6. Siddeswaram
7. NAGARJUNASAGAR DAM
8. VIJAYAWADA
9. JALKEWADI
10. Helwak
11. Yeraltwadi
12. RAMAPUR
13. RADHANAGRI
14. Hadalga
15. Daddi
16. DHUPDAL
17. Chinchkandi
18. Anagwadi
19. Murmultisangam
20. Ajra
21. Basapur
22. ASOGA
23. KOLCHI
24. Hiresangam
25. Chaskaman
26. DHOND
27. Yadgir
28. Waki
29. Wadivale
30. SHIKRAPUR
31. Pimpalgaon Rahu
32. MULSHI DAM
33. KHADAKWASLA
34. Nirgudsar
35. WADGAON
36. Edgaon
37. VISAPUR
38. *Natambi*
39. VIR
40. SARATI
41. *Narasingpur*
42. BHATGARH
43. *Mohri*
44. *Hatwalan*
45. *Wadakbal*
46. EKRUK TANK
47. *Hallur*
48. *Harihara*
49. *Havanur*
50. *Hesur*
51. TUNGABHADRA DAM
52. RAJOLIBANDA
53. SUNKESALA
54. TUNGA ANICUT
55. LAKKAVALLI
56. *Bhadra Anicut*
57. *Banavasi*
58. VANI VILAS SAGAR
59. NARANAPUR ANICUT
60. BHAIKAVANITHIPPA
61. GUNDLAPALLI DAM
62. PALERU

GODAVARI RIVER SYSTEM

1. GANGAPUR
2. NANDUR MADHMESHWAR
3. *Puntumba*
4. *Toka*
5. *Mungi*
6. SOAN BRIDGE
7. *Mancherial*
8. DUMMAGUDEM
9. DOWLAISHWARAM
10. DARNA (LAKE BEALE)
11. *Chehadi*
12. PADLI (MUKNE)
13. *Pimpalgaon Dukra*
14. *Nasik Road*
15. LAKHAMAPUR
16. PALKHED (WEIR)
17. OZARKHED
18. WAGHAD
19. *Khadakojhar*
20. BHANDARDHARA
21. OZER
22. *Newasa*
23. CHIKALTHAN
24. KHADAKWAGULGAON
25. SIDHESHWAR
26. PURNA BRIDGE
27. GHANPUR ANICUT
28. NIZAMSAGAR
29. POCHARAM
30. MANAIR
31. SANIGRAM
32. RAMAPPA LAKE
33. GHANPUR CHEROO
34. *Jafferabad*
35. MAJRI
36. BALLARSHAH
37. LAKHANWARA
38. DHUTI
39. WARSA
40. SHINGODI
41. TOTLADOH
42. *Pathagudem*
43. *Pulusara (Upper Kolab H.E. Scheme)*
44. JALAPUT (*Machkund H.E. Scheme*)

NOTE :- Observations have been discontinued at the sites shown in italics.



LEGEND

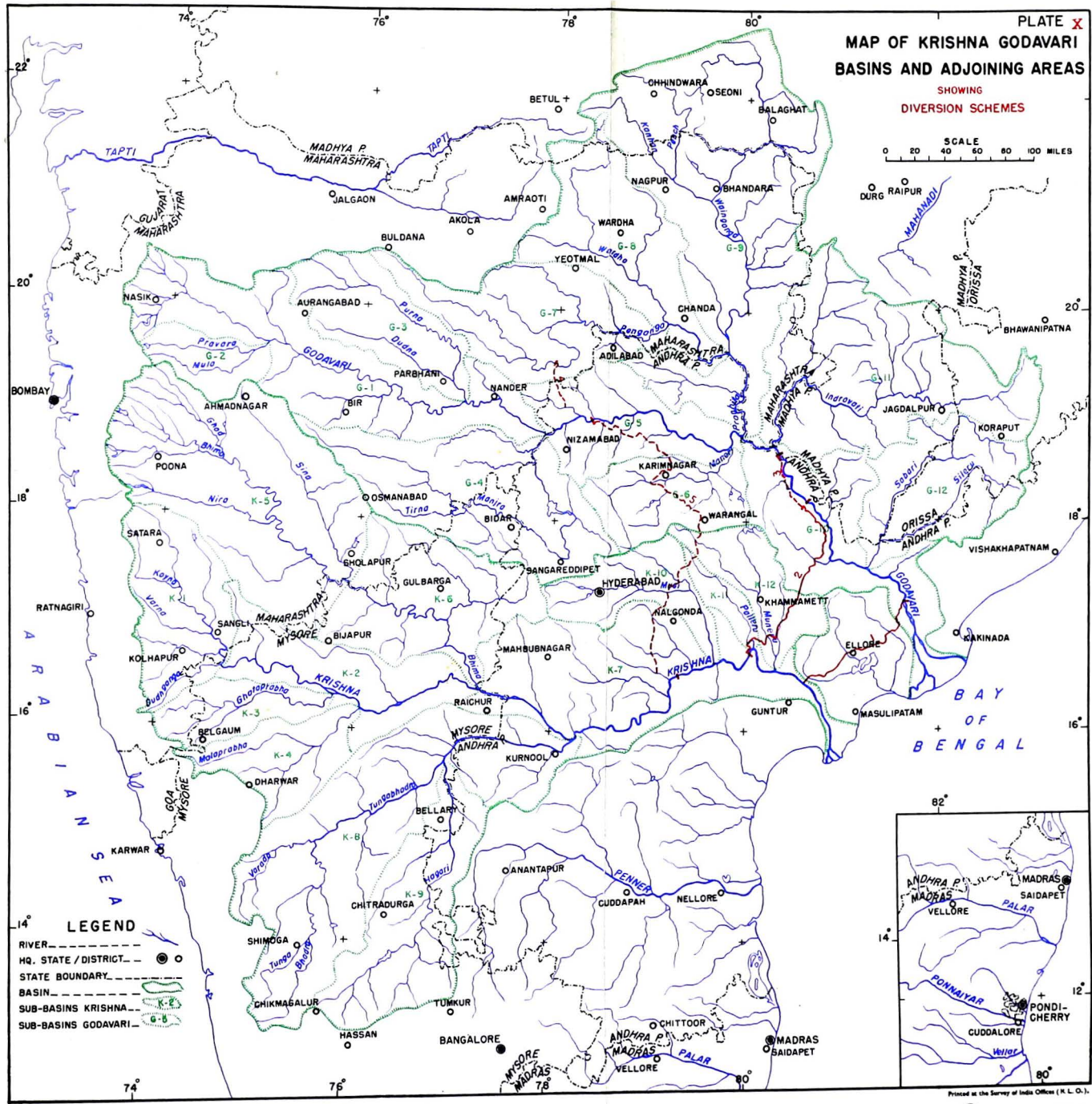
- RIVER ————
- HQ. STATE / DISTRICT — ○
- STATE BOUNDARY ————
- BASIN ————
- SUB-BASINS KRISHNA — K-1, K-2, etc.
- SUB-BASINS GODAVARI — G-1, G-2, etc.

PLATE X
**MAP OF KRISHNA GODAVARI
 BASINS AND ADJOINING AREAS**
 SHOWING
DIVERSION SCHEMES

SCALE
 0 20 40 60 100 MILES

INDEX

1. POLAVARAM VIJAYAWADA LINK
2. GODAVARI PULICHINTALA LINK
3. INCHAMPALLI PULICHINTALA LINK
4. PENGANGA POCHAMPAD LINK
5. POCHAMPAD NAGARJUNASAGAR LINK



Map taken from Survey of India maps with the permission of the Surveyor General of India.
 Nos. 140, 7188 HE 82-10, 800.

Reproduced from the originals supplied by the Krishna Godavari Commission, Ministry of Irrigation & Power, New Delhi, and the Survey of India is not responsible for the accuracy of details appearing on the map.
 1962.

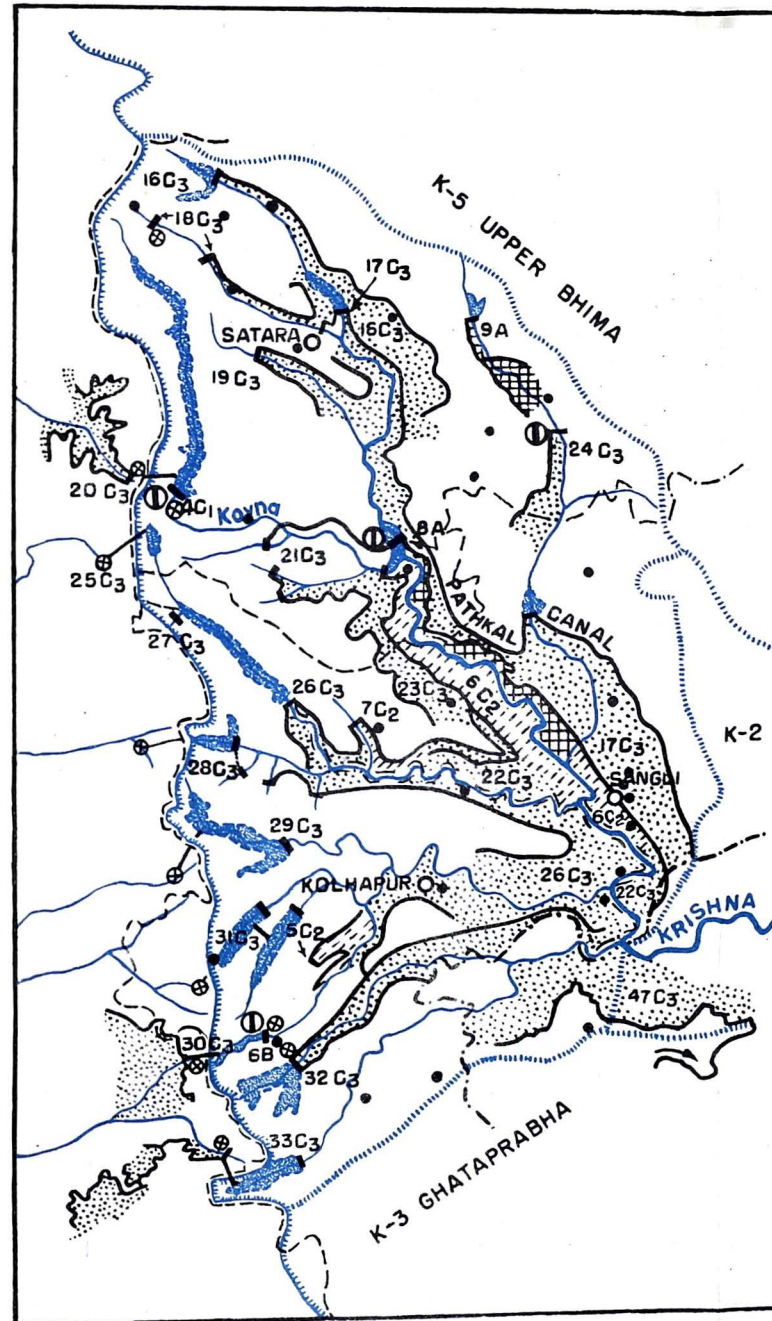
INDEX MAP
OF
K-I UPPER KRISHNA
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LEGEND

- RIVER
- DISTRICT HQ.
- STATE / DISTRICT BOUNDARY
- BASIN / SUB-BASIN
- RAINGAUGE / DISCHARGE SITE
- MAJOR AND MEDIUM SCHEMES
 - A: In operation as in March '51
 - B: Which came into operation after March '51
 - G₁: Under construction
 - G₂: Referred to in III Plan
 - G₃: Not referred to in III Plan
- POWER HOUSE

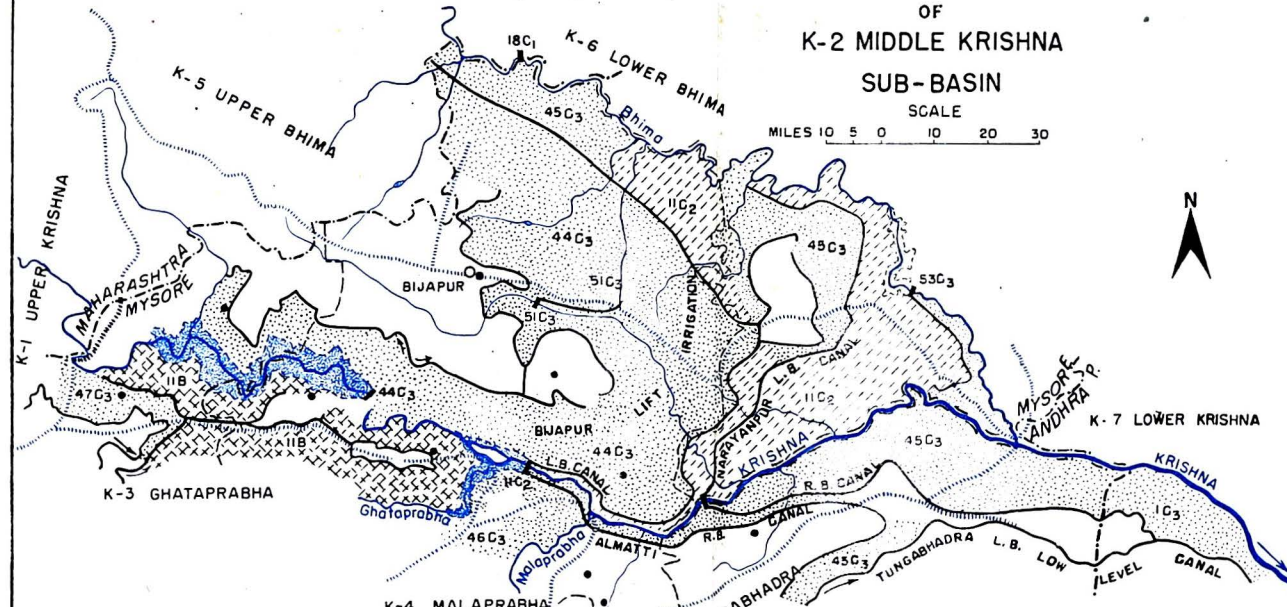


LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|----------------|---------------------------------------------------|
| 8A-K.1-M.1 | ... KRISHNA CANAL |
| 9A-K.1-M.2 | ... NEHR TANK |
| 6B-K.1-M.1 | ... RADHAMAGARI PROJECT |
| 4C.1-K.1-M.1 | ... KOYNA HYDRO-ELECTRIC PROJECT - STAGE I AND II |
| 6C.2-K.1-M.1 | ... KOYNA IRRIGATION SCHEME - STAGE I |
| 7C.2-K.1-M.2 | ... WARNA PROJECT |
| 15C.2-K.1-M.5 | ... TULSHI PROJECT |
| 16C.3-K.1-M.1 | ... DHOM PROJECT |
| 17C.3-K.1-M.2 | ... PATKHAL PROJECT |
| 18C.3-K.1-M.3 | ... VENNA PROJECT |
| 19C.3-K.1-M.4 | ... URMODI PROJECT |
| 20C.3-K.1-M.5 | ... KOYNA HYDRO-ELECTRIC PROJECT - STAGE III |
| 21C.3-K.1-M.6 | ... KOYNA HYDRO-ELECTRIC PROJECT - STAGE IV |
| 22C.3-K.1-M.7 | ... KOYNA IRRIGATION PROJECT - STAGE III |
| 23C.3-K.1-M.8 | ... WNAO PROJECT |
| 24C.3-K.1-M.9 | ... YERALWADI PROJECT |
| 25C.3-K.1-M.10 | ... PATHARPUNJ PROJECT |
| 26C.3-K.1-M.11 | ... KHUJGAON PROJECT |
| 27C.3-K.1-M.12 | ... GOTHANA PROJECT |
| 28C.3-K.1-M.13 | ... KADVI PROJECT |
| 29C.3-K.1-M.14 | ... KASARI PROJECT |
| 30C.3-K.1-M.15 | ... PHONDA PROJECT |
| 31C.3-K.1-M.16 | ... KUMBHI PROJECT |
| 32C.3-K.1-M.17 | ... DUDHGANGA PROJECT |
| 33C.3-K.1-M.18 | ... VEDGANGA PROJECT |

INDEX MAP
OF
K-2 MIDDLE KRISHNA
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|----------------|---------------------------------------------------------|
| 11C.2-K.2-My.2 | ... UPPER KRISHNA PROJECT - STAGE I |
| 1C.3-K.2.A.1 | ... UPPER KRISHNA PROJECT (EXTENSION TO ANDHRA PRADESH) |
| 44C.3-K.2-My.1 | ... BIJAPUR LIFT IRRIGATION SCHEME |
| 45C.3-K.2-My.2 | ... UPPER KRISHNA PROJECT - STAGE II |
| 51C.3-K.2-My.8 | ... DON RIVER PROJECT |

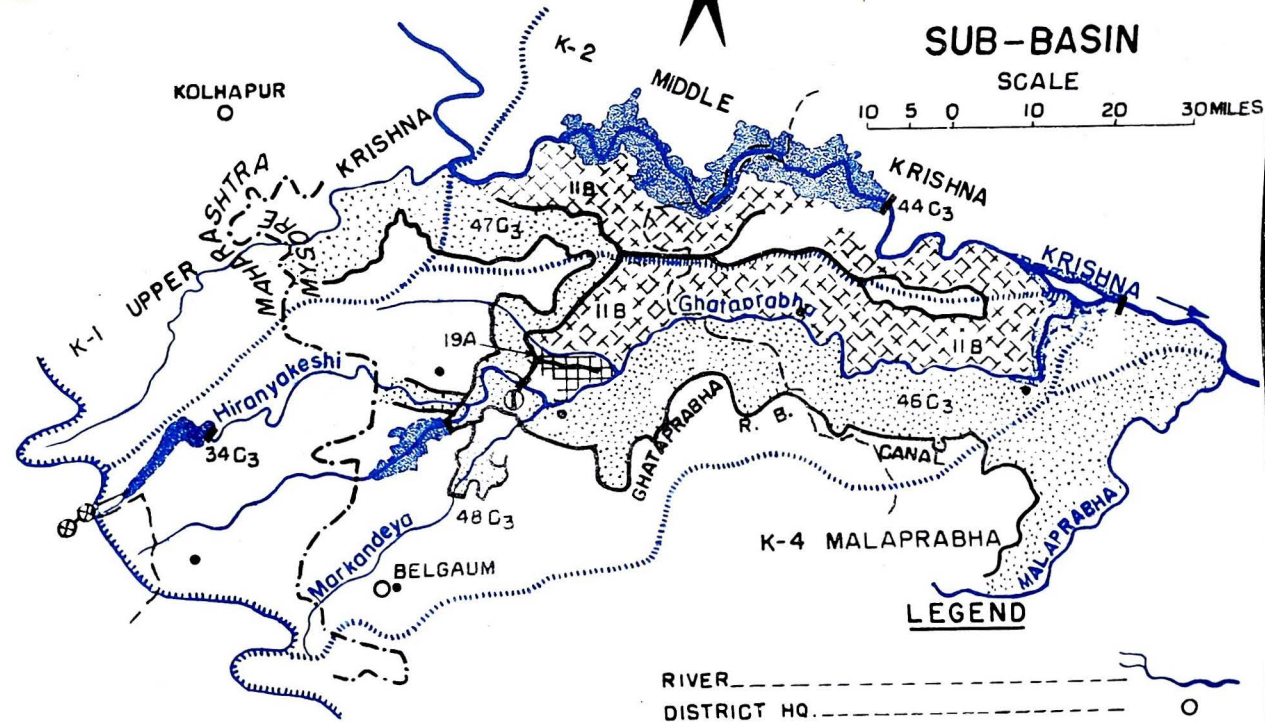
LEGEND

- RIVER
- DISTRICT HQ.
- STATE / DISTRICT BOUNDARY
- SUB-BASIN
- RAINGAUGE STATION
- MAJOR AND MEDIUM SCHEMES
 - B: Which came into operation after March '51
 - C₂: Referred to in III Plan
 - C₃: Not referred to in III Plan

INDEX MAP
OF
K-3 GHATAPRABHA
SUB-BASIN

SCALE

10 5 0 10 20 30 MILES



LIST OF PROJECTS IN THE SUB-BASIN

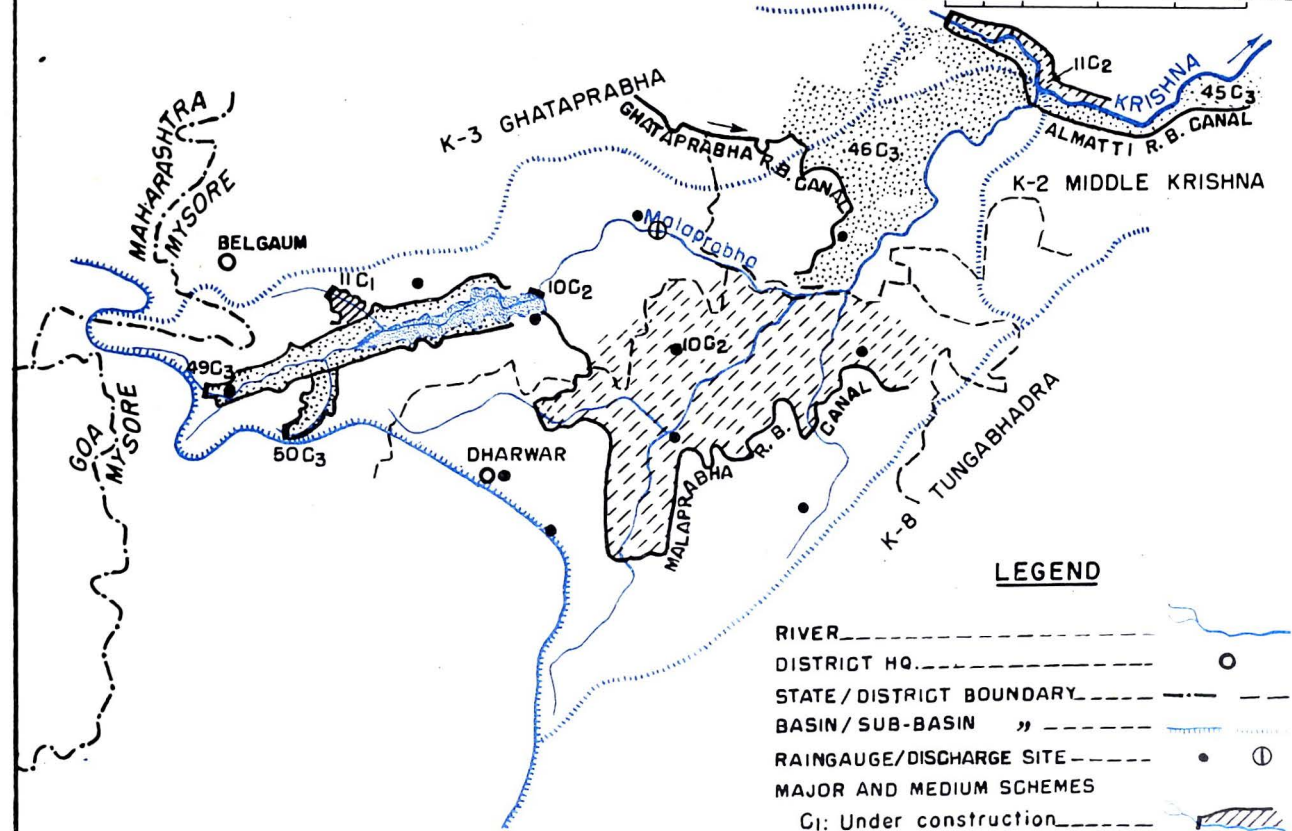
| INDEX NUMBER | PROJECT |
|----------------|-------------------------------------|
| 19A-K.3-My.1 | ... GOKAK CANAL |
| 11B-K.3-My.1 | ... GHATAPRABHA PROJECT |
| 34C.3-K.3-M.19 | ... AJRA PROJECT |
| 46C.3-K.3-My.3 | ... GHATAPRABHA PROJECT - STAGE III |
| 47C.3-K.3-My.4 | ... GHATAPRABHA PROJECT - STAGE IV |
| 48C.3-K.3-My.5 | ... MARKANDEYA PROJECT |

LEGEND

| | |
|----------------------------------------------|--|
| RIVER | |
| DISTRICT HQ. | |
| STATE / DISTRICT BOUNDARY | |
| BASIN / SUB-BASIN | |
| RAINGAUGE / DISCHARGE SITE | |
| MAJOR AND MEDIUM SCHEMES | |
| A: In operation as in March '51 | |
| B: Which came into operation after March '51 | |
| C3: Not referred to in III Plan | |
| POWER HOUSE | |

INDEX MAP
OF
K-4 MALAPRABHA
SUB-BASIN

SCALE 10 5 0 10 20 30 MILES



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|----------------|----------------------------------|
| 11C.1-K.4-My.1 | ... HARINALA PROJECT |
| 10C.2-K.4-My.1 | ... MALAPRABHA IRRIGATION SCHEME |
| 49C.3.K.4-My.6 | ... BHUTEVADI STORAGE SCHEME |
| 50C.3-K.4-My.7 | ... SATTINALA PROJECT |

LEGEND

| | |
|---------------------------------|--|
| RIVER | |
| DISTRICT HQ. | |
| STATE/DISTRICT BOUNDARY | |
| BASIN/SUB-BASIN | |
| RAINGAUGE/DISCHARGE SITE | |
| MAJOR AND MEDIUM SCHEMES | |
| C1: Under construction | |
| C2: Referred to in III Plan | |
| C3: Not referred to in III Plan | |

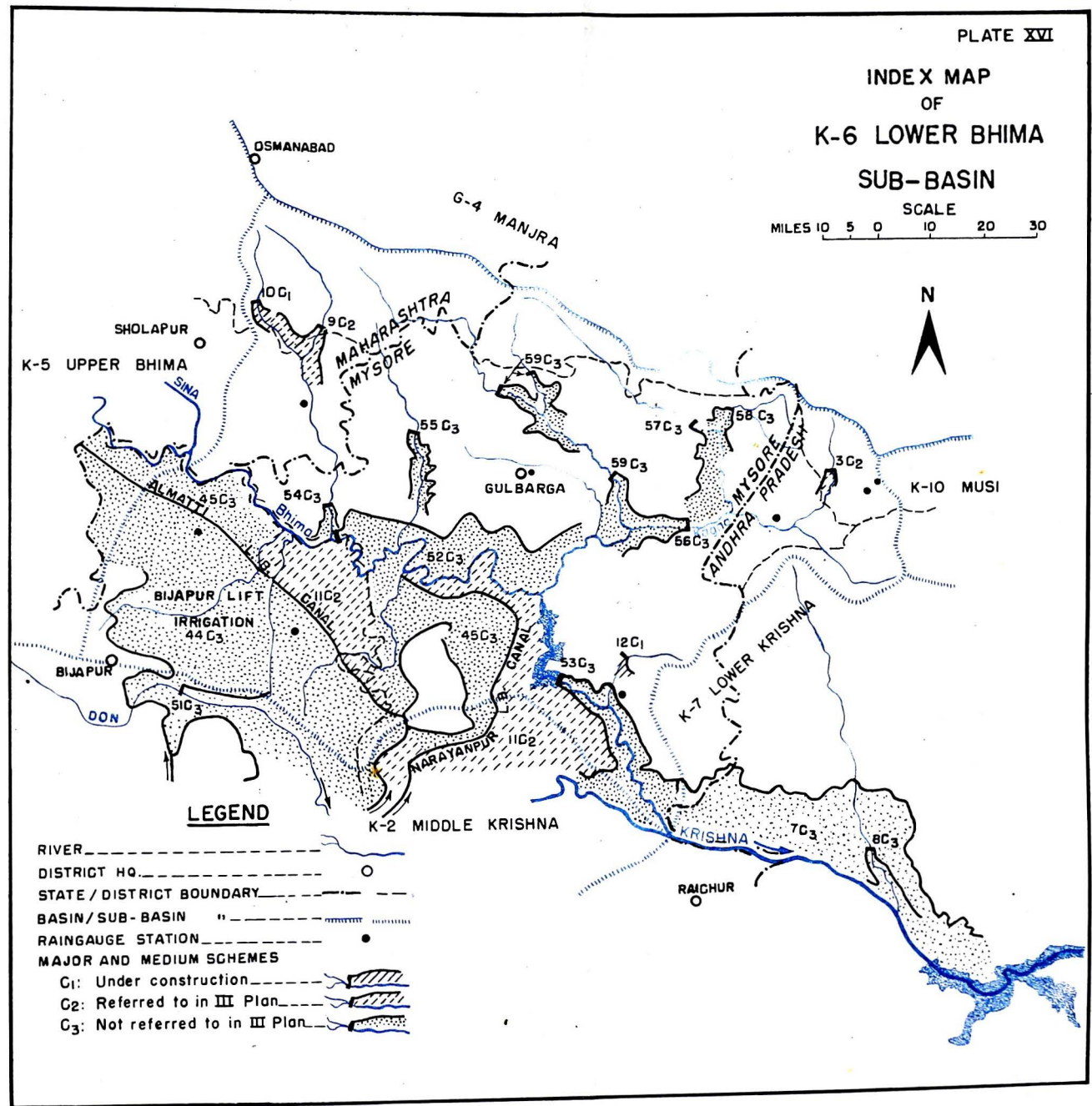
INDEX MAP
OF
K-6 LOWER BHIMA
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|-----------------|----------------------------------|
| 10C.1-K.6-M.7 | ... HARNI PROJECT |
| 12C.1-K.6-My.2 | ... HATHIKOMI PROJECT |
| 3C.2-K.6-A.3 | ... KOTEPALLI PROJECT |
| 9C.2-K.6-M.4 | ... KURNOOR PROJECT |
| 7C.3-K.6-A.7 | ... BHIMA PROJECT |
| 52C.3-K.6-My.9 | ... BHIMA LIFT IRRIGATION SCHEME |
| 53C.3-K.6-My.10 | ... BHIMA IRRIGATION SCHEME |
| 54C.3-K.6-My.11 | ... DIKSANGA SCHEME |
| 55C.3-K.6-My.12 | ... AMARJA PROJECT |
| 56C.3-K.6-My.13 | ... KAGNA PROJECT |
| 57C.3-K.6-My.14 | ... MULLAMARI PROJECT |
| 58C.3-K.6-My.15 | ... CHANDRAMPALLI PROJECT |
| 59C.3-K.6-My.16 | ... BENITHORA PROJECT |

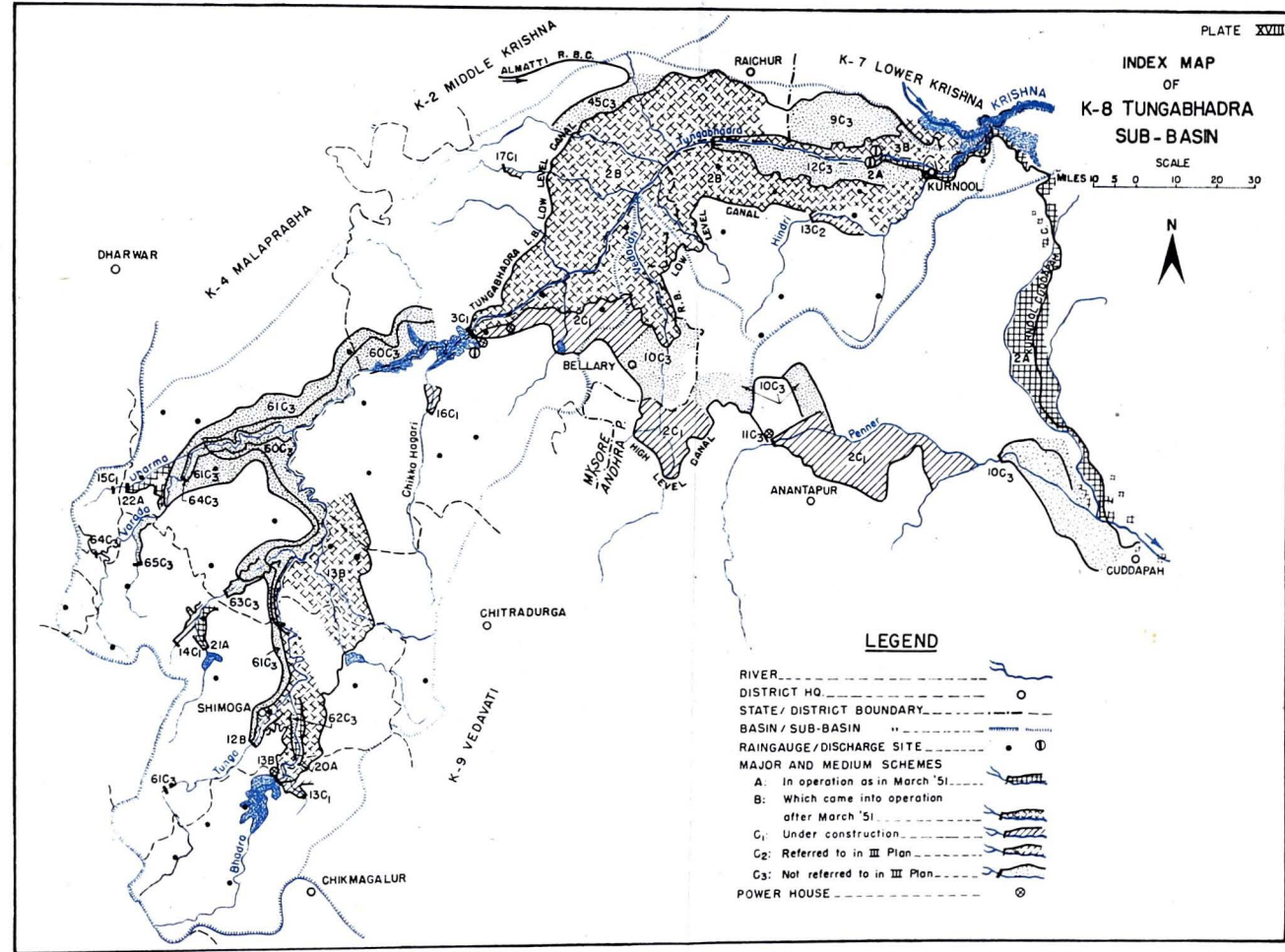


LEGEND

- RIVER _____
- DISTRICT HQ _____
- STATE / DISTRICT BOUNDARY _____
- BASIN / SUB-BASIN " _____
- RAINGAUGE STATION _____
- MAJOR AND MEDIUM SCHEMES
- C₁: Under construction _____
- C₂: Referred to in III Plan _____
- C₃: Not referred to in III Plan _____

LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|---------------------|-------------------------------------------------------------------------------------|
| 2A-K-8-A.2 | ... KURNOOL CUDDAPPAH CANAL SYSTEM |
| 20A-K-8-My.2 | ... BHADRA ANICUT CHANNELS |
| 21A-K-8-My.3 | ... ANJANAPUR RESERVOIR |
| 22A-K-8-My.4 | ... DHARMA CANAL SYSTEM |
| 2B-K-8-A.2/My.2 | ... TUNGABHADRA PROJECT (JOINTLY WITH MYSORE) |
| 3B-K-8-A.3/My.3 | ... RAJOLIBANDA DIVERSION SCHEME - LEFT SIDE (JOINTLY WITH MYSORE) |
| 12B-K-8-My.4 | ... TUNGA ANICUT PROJECT |
| 13B-K-8-My.5 | ... BHADRA RESERVOIR PROJECT |
| 2C.1-K-8-A.2/My.3 | ... TUNGABHADRA PROJECT - HIGH LEVEL CANAL STAGE I (JOINTLY WITH MYSORE) |
| 3C.1-K-8-A.3/My.4 | ... TUNGABHADRA HYDRO-ELECTRIC PROJECT STAGE II (JOINTLY WITH MYSORE) |
| 13C.1-K-8-My.5 | ... JAMBADAHALLA PROJECT |
| 14C.1-K-8-My.6 | ... AMBLIGOLA RESERVOIR PROJECT |
| 15C.1-K-8-My.7 | ... DHARMA RESERVOIR PROJECT |
| 16C.1-K-8-My.8 | ... HAGARI BOMMANAHALLI PROJECT |
| 17C.1-K-8-My.9 | ... KANAKANALA PROJECT |
| 13C.2-K-8-A.7 | ... GAZULADINNI PROJECT |
| 9C.3-K-8-A.9 | ... TUNGABHADRA PROJECT LEFT BANK - LOW LEVEL CANAL EXTENSION (INTO ANDHRA PRADESH) |
| 10C.3-K-8-A.10 | ... TUNGABHADRA PROJECT HIGH LEVEL CANAL STAGE II (JOINTLY WITH MYSORE) |
| 10C.3-K-8-A.10/M 20 | ... TUNGABHADRA HIGH LEVEL CANAL POWER SCHEME |
| 11C.3-K-8-A.11 | ... RAJOLIBANDA RIGHT CANAL SCHEME |
| 12C.3-K-8-A.12 | ... UPPER TUNGABHADRA PROJECT |
| 60C.3-K-8-My.17 | ... TUNGA RESERVOIR PROJECT |
| 61C.3-K-8-My.18 | ... EXTENSION AND REMODELLING OF BHADRA ANICUT CHANNELS |
| 62C.3-K-8-My.19 | ... MADAG MASUR SCHEME |
| 63C.3-K-8-My.21 | ... VARADA SCHEME |
| 64C.3-K-8-My.22 | ... DANDAVATHI RESERVOIR PROJECT |
| 65C.3-K-8-My.23 | ... |



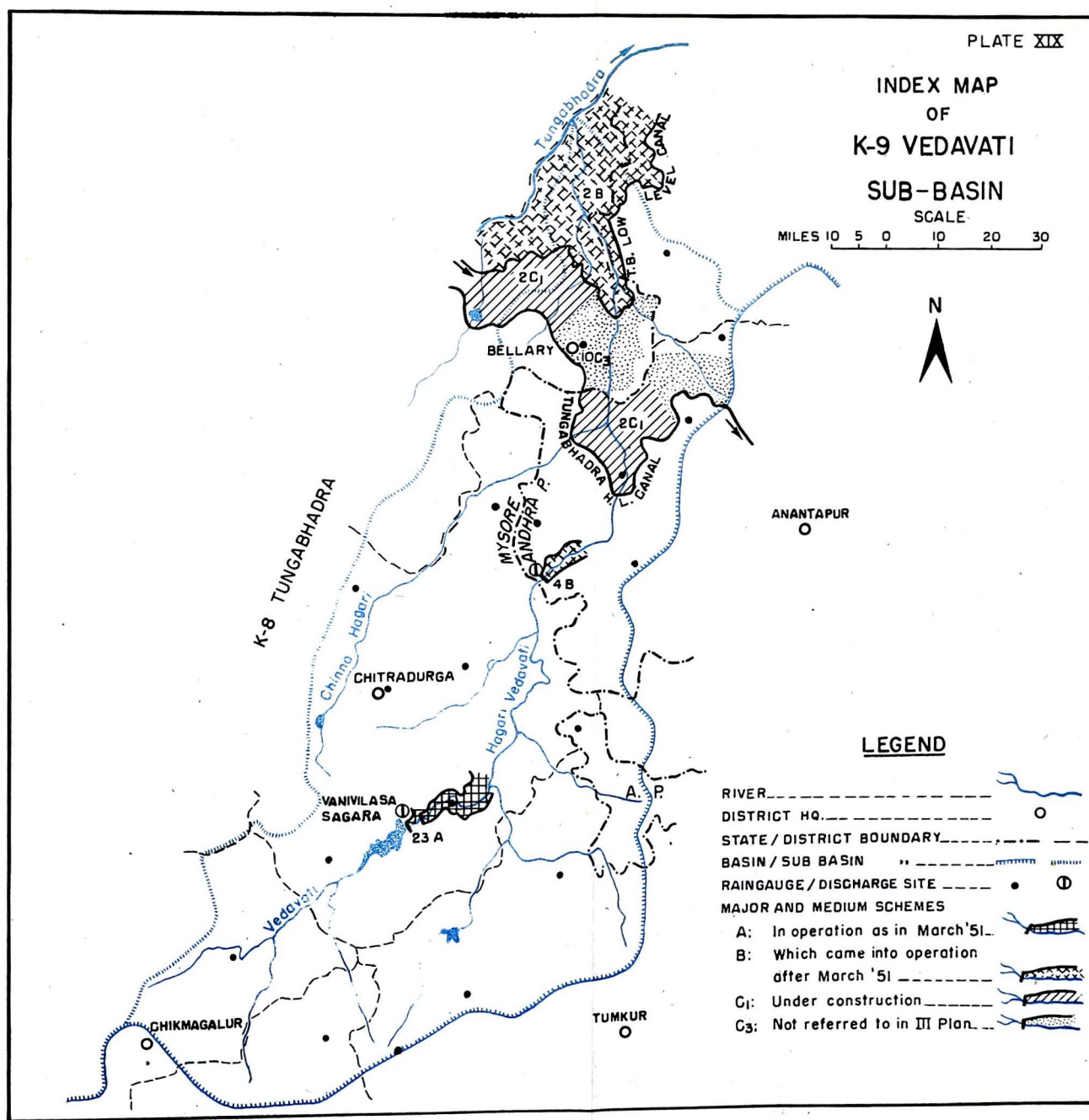
INDEX MAP
OF
K-9 VEDAVATI
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|---------------|-----------------------------|
| 23A-K.9-M.y.5 | ... VANIVILAS SAGAR |
| 4B-K.9-A.4 | ... BHAIKAVANITIPPA PROJECT |



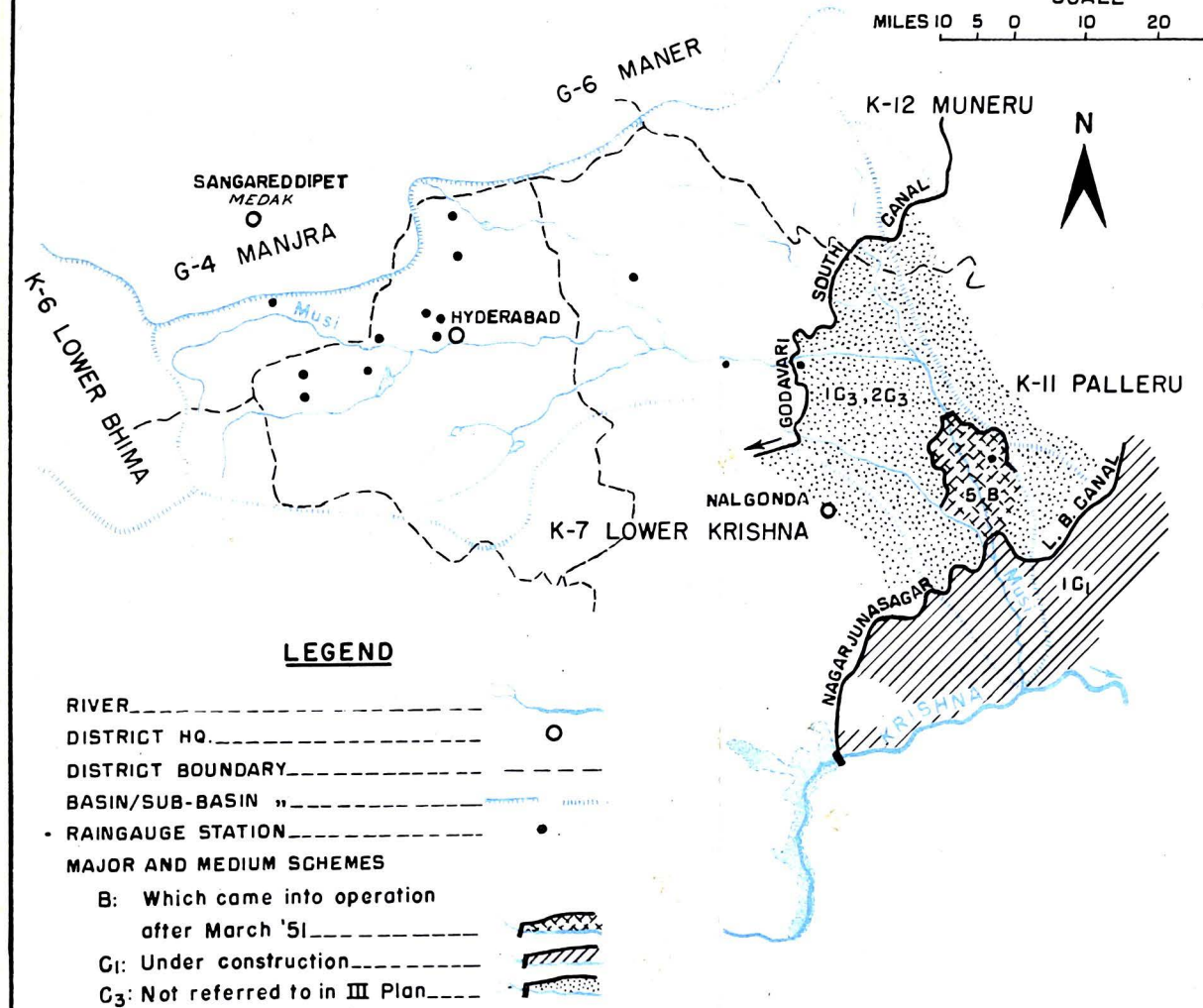
LEGEND

- RIVER -----
- DISTRICT HQ. ----- ○
- STATE / DISTRICT BOUNDARY -----
- BASIN / SUB BASIN ..-----
- RAINGAUGE / DISCHARGE SITE ----- ● ○
- MAJOR AND MEDIUM SCHEMES
- A: In operation as in March '51. -----
- B: Which came into operation after March '51 -----
- C1: Under construction -----
- C3: Not referred to in III Plan. -----

INDEX MAP
OF
K-10 MUSI SUB-BASIN

SCALE

MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

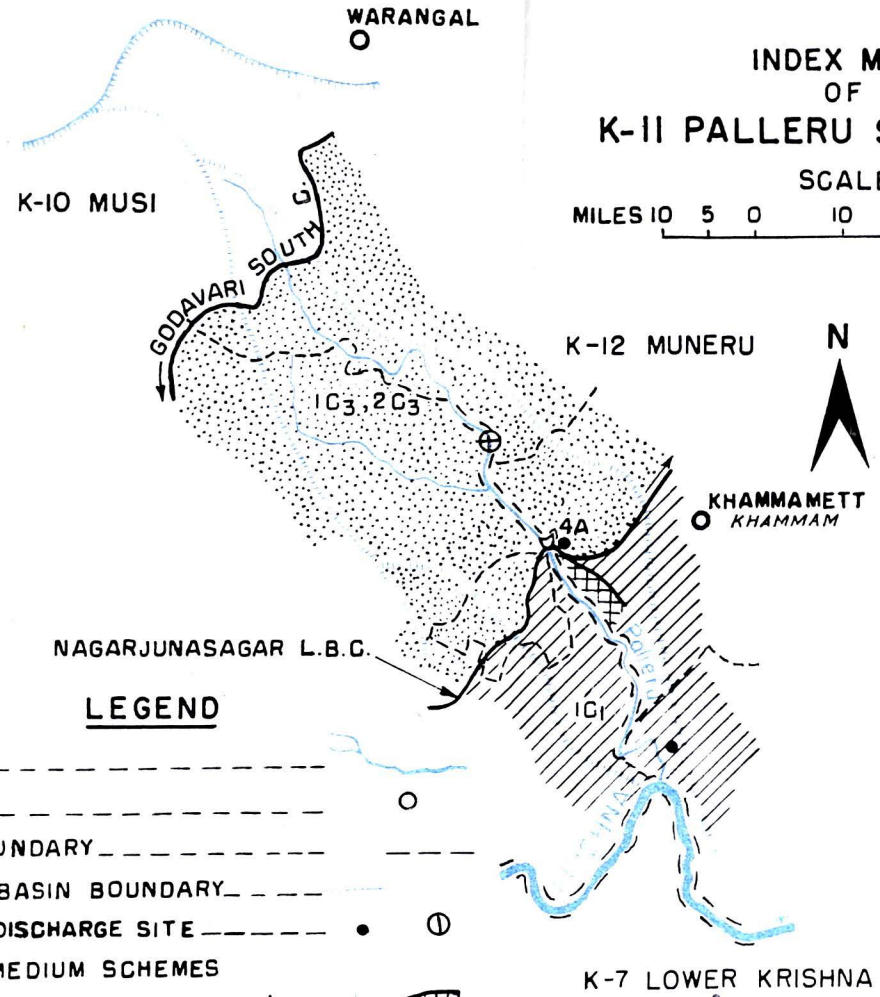
| INDEX NUMBER | PROJECT |
|--------------|--------------|
| 5B-K.10-A.5 | MUSI PROJECT |

LEGEND

- RIVER _____
- DISTRICT HQ. _____ ○
- DISTRICT BOUNDARY _____
- BASIN/SUB-BASIN " _____
- RAINGAUGE STATION _____ ●
- MAJOR AND MEDIUM SCHEMES
 - B: Which came into operation after March '51 _____
 - G1: Under construction _____
 - G3: Not referred to in III Plan _____

INDEX MAP
OF
K-II PALLERU SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LEGEND

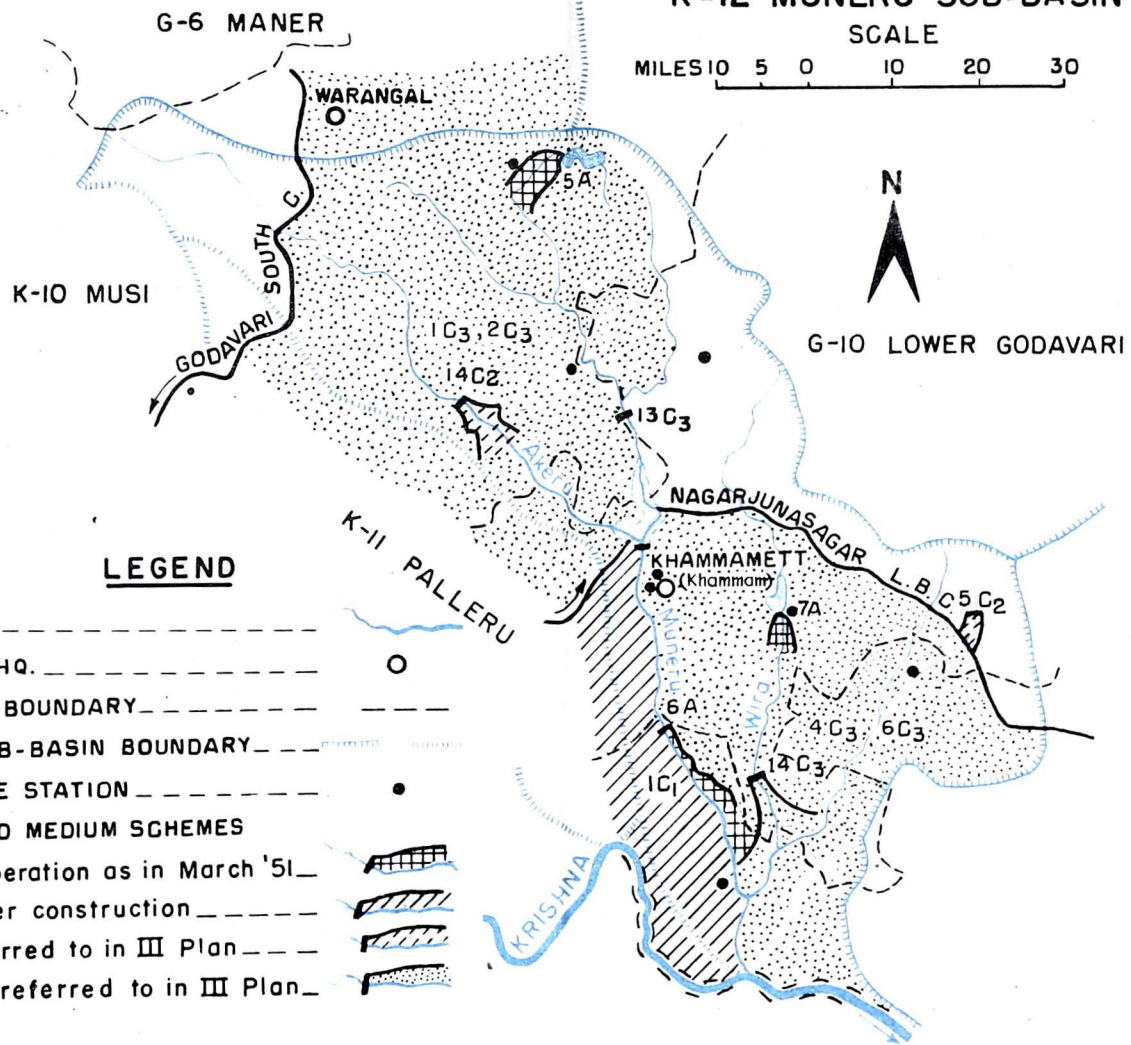
- RIVER _____
- DISTRICT HQ. _____ ○
- DISTRICT BOUNDARY _____
- BASIN/SUB-BASIN BOUNDARY _____
- RAINGAUGE/DISCHARGE SITE _____ ● ○
- MAJOR AND MEDIUM SCHEMES
- A: In operation as in March '51 _____ [diagonal hatching]
- C1: Under construction _____ [cross-hatching]
- C3: Not referred to in III Plan _____ [dotted pattern]

LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|--------------|----------------|
| 4A-K.11-A.4 | PALAIR PROJECT |

INDEX MAP
OF
K-12 MUNERU SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

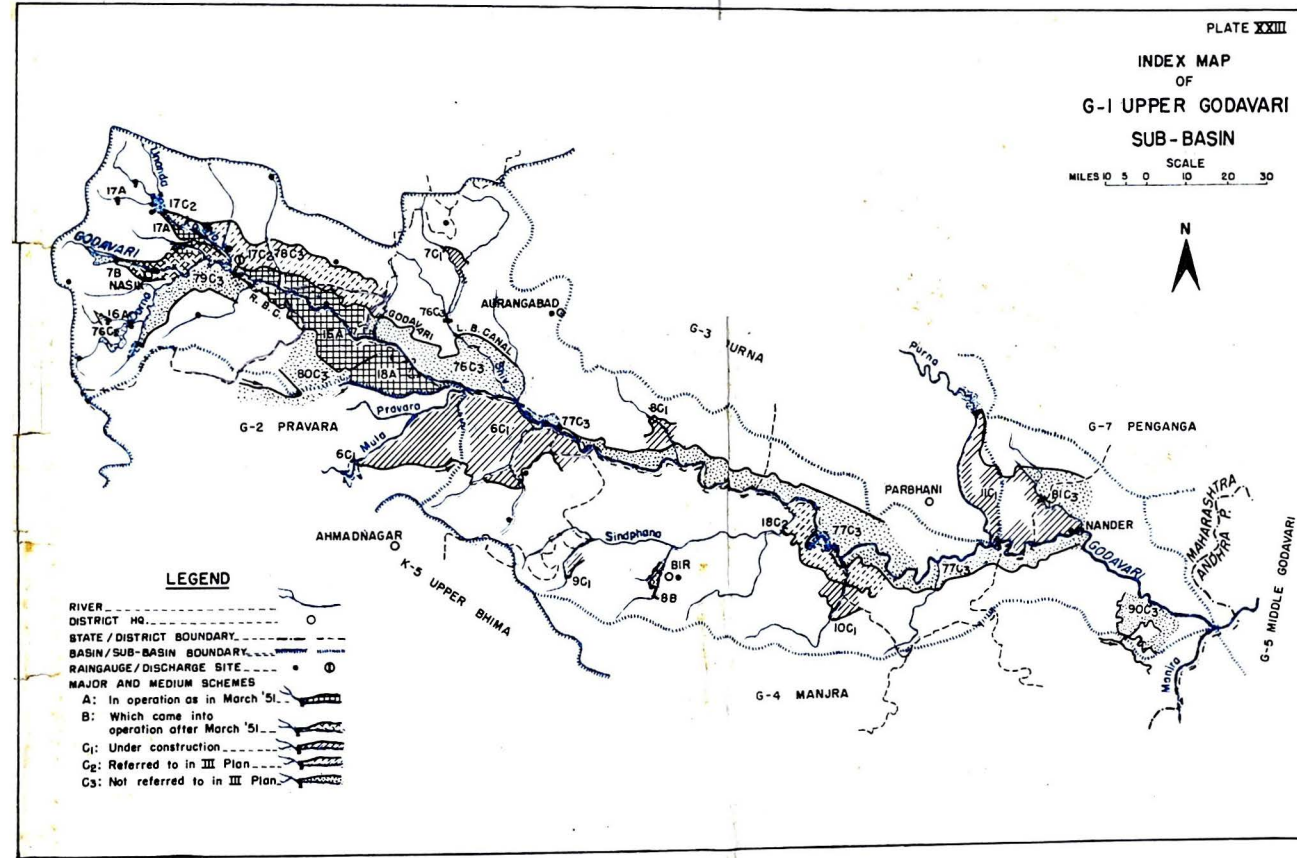
| INDEX NUMBER | PROJECT |
|-----------------|------------------------|
| 5A-K.12-A.5 | ... PAKHAL LAKE |
| 6A-K.12-A.6 | ... MUNIYERU SYSTEM |
| 7A-K.12-A.7 | ... WYRA PROJECT |
| 5C.2-K.12-A.5 | ... LANKASAGAR PROJECT |
| 14C.2-K.12-A.8 | ... AKHERU PROJECT |
| 13C.3-K.12-A.13 | ... MUNERU PROJECT |
| 14C.3-K.12-A.14 | ... KALIKOTA PROJECT |

LEGEND

- RIVER _____
- DISTRICT HQ. _____
- DISTRICT BOUNDARY _____
- BASIN/SUB-BASIN BOUNDARY _____
- RAINGAUGE STATION _____
- MAJOR AND MEDIUM SCHEMES
 - A: In operation as in March '51 _____
 - C₁: Under construction _____
 - C₂: Referred to in III Plan _____
 - C₃: Not referred to in III Plan _____

INDEX MAP
OF
G-1 UPPER GODAVARI
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LEGEND

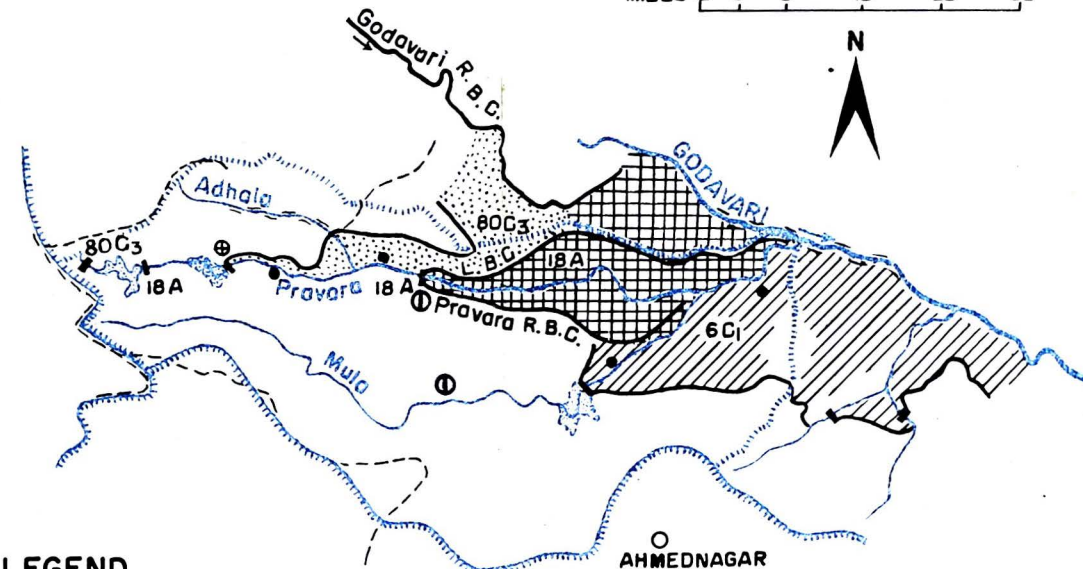
- RIVER ————
- DISTRICT HQ. ———— ○
- STATE / DISTRICT BOUNDARY - - - - -
- BASIN / SUB-BASIN BOUNDARY ————
- RAINGAUGE / DISCHARGE SITE ———— ●
- MAJOR AND MEDIUM SCHEMES
- A: In operation as in March '51. ————
- B: Which came into operation after March '51. ————
- G₁: Under construction. ————
- G₂: Referred to in III Plan. ————
- G₃: Not referred to in III Plan. ————

LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|---------------|---------|
| 16A-G.1-M.1 | ... |
| 17A-G.1-M.2 | ... |
| 78-G.1-M.1 | ... |
| 8B-6.1-M.2 | ... |
| 7C.1-G.1-M.2 | ... |
| 8C.1-G.1-M.3 | ... |
| 9C.1-G.1-M.4 | ... |
| 10C.1-G.1-M.5 | ... |
| 17C.2-G.1-M.7 | ... |
| 18C.2-G.1-M.8 | ... |
| 76C.3-G.1-M.1 | ... |
| 77C.3-G.1-M.2 | ... |
| 78C.3 G.1-M.3 | ... |
| 79C.3-G.1-M.4 | ... |

INDEX MAP
OF
G-2 PRAVARA SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|---------------|---------------------------|
| 18A-6.2-M.3 | PRAVARA CANALS |
| 6C.1-6.2-M.1 | ... MULA PROJECT |
| 80C.3.6.2-M.5 | ... PRAVARA RIVER PROJECT |

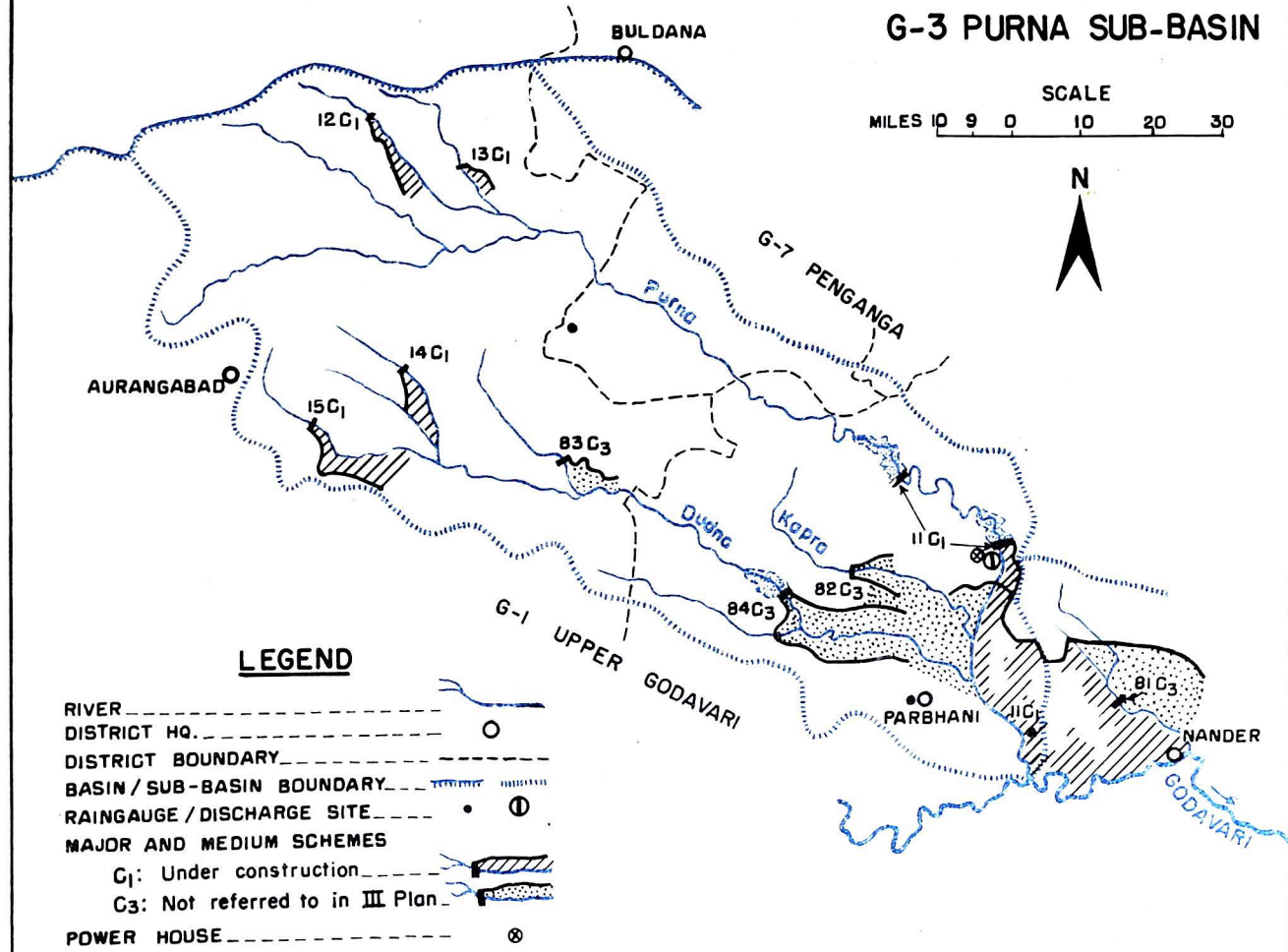
LEGEND

- RIVER -----
- DISTRICT HQ. ----- ○
- DISTRICT BOUNDARY -----
- BASIN / SUB-BASIN -----
- RAINGAUGE / DISCHARGE SITE ----- ● ⊕
- MAJOR AND MEDIUM SCHEMES
 - A: In operation as in March '51. [Cross-hatched pattern]
 - C₁: Under construction. [Diagonal hatched pattern]
 - C₃: Not referred to in III Plan. [Dotted pattern]
- POWER HOUSE ----- ⊕

K-5 UPPER BHIMA

INDEX MAP
OF
G-3 PURNA SUB-BASIN

SCALE
MILES 10 9 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|----------------|-----------------------------------|
| 11C.1-G.3-M.6 | ... PURNA PROJECT |
| 12C.1-G.3-M.7 | ... KHELNA PROJECT |
| 13C.1-G.3-M.8 | ... JUI PROJECT |
| 14C.1-G.3-M.9 | ... UPPER DUDNA PROJECT |
| 15C.1-G.3-M.10 | ... SUKHNA PROJECT |
| 81C.3-G.3-M.6 | ... PURNA CANAL EXTENSION PROJECT |
| 82C.3-G.3-M.7 | ... KAPRA PROJECT |
| 83C.3-G.3-M.8 | ... KALYAN PROJECT |
| 84C.3-G.3-M.9 | ... LOWER DUDNA PROJECT |

LEGEND

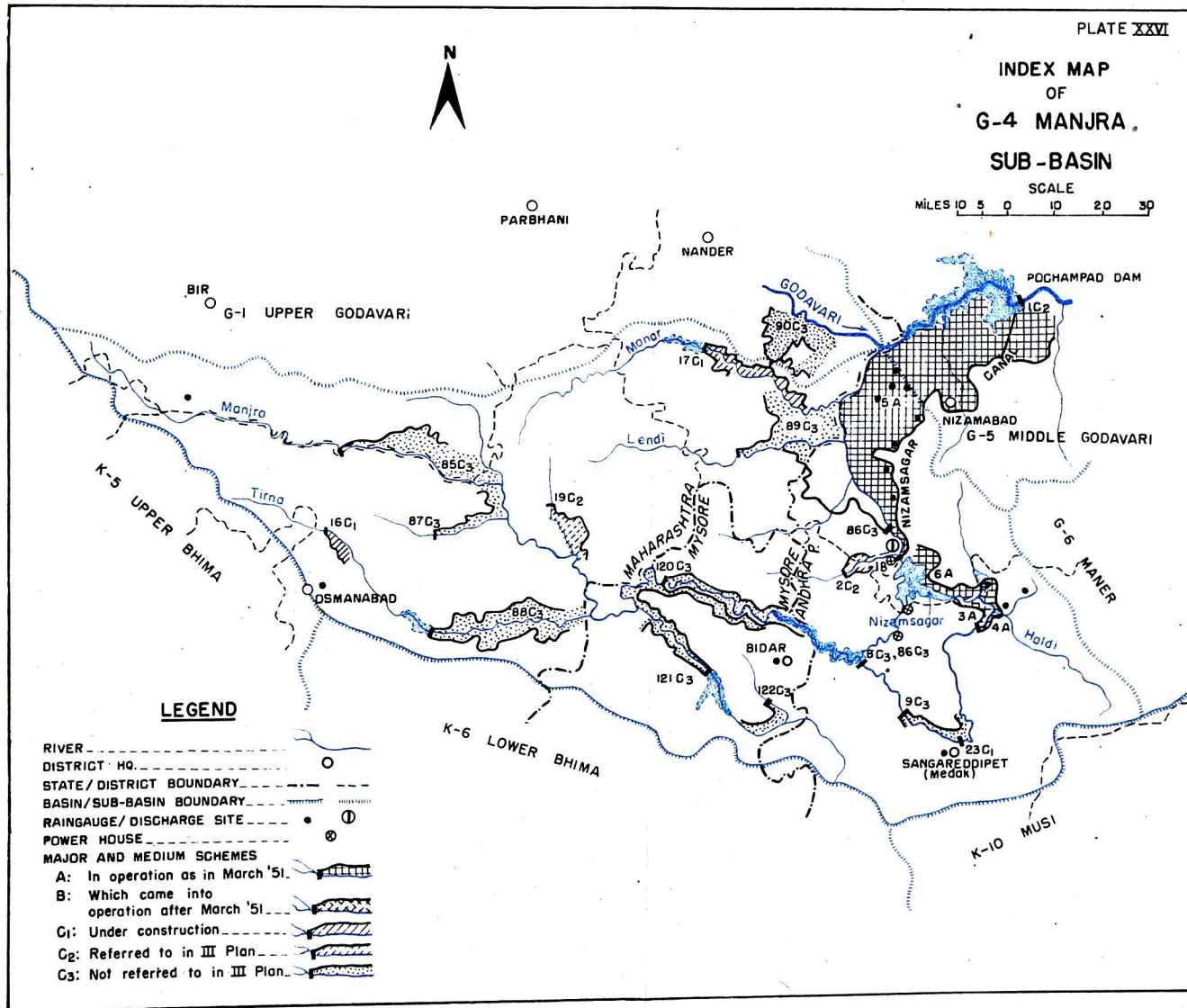
- RIVER
- DISTRICT HQ.
- DISTRICT BOUNDARY
- BASIN/SUB-BASIN BOUNDARY
- RAINGAUGE / DISCHARGE SITE
- MAJOR AND MEDIUM SCHEMES
 - C₁: Under construction
 - C₃: Not referred to in III Plan
- POWER HOUSE

INDEX MAP
OF
G-4 MANJRA,
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30

LIST OF PROJECTS IN THE SUB-BASIN

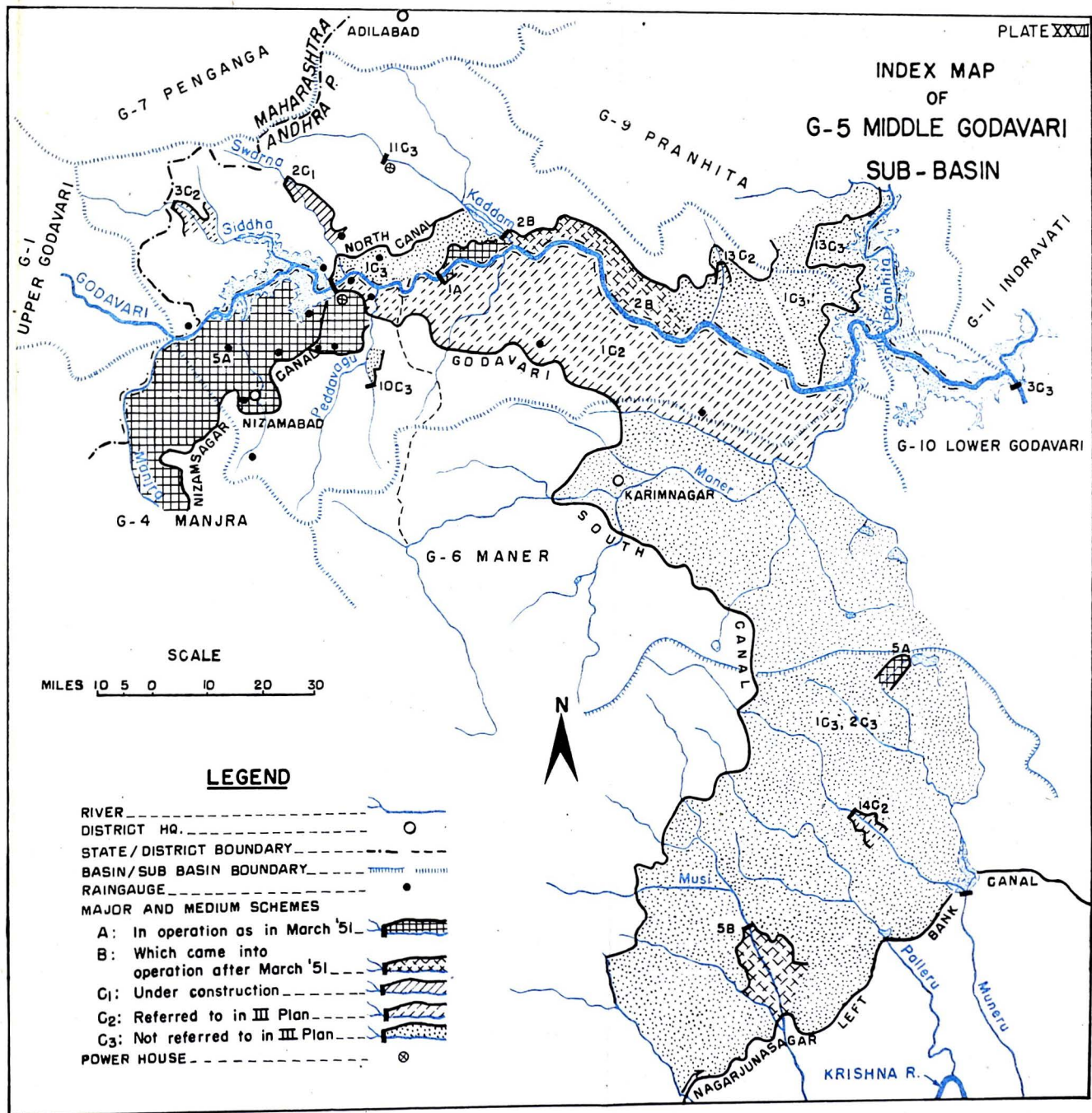
| INDEX NUMBER | PROJECT |
|-----------------|----------------------------------|
| 3A-G.4-A.3 | FATEH NEHAR |
| 4A-G.4-A.4 | MAHBOOB NEHAR |
| 5A-G.4-A.5 | NIZAMSAGAR PROJECT |
| 6A-G.4-A.6 | POCHARAM PROJECT |
| 1B-G.4-A.1 | NIZAMSAGAR HYDRO-ELECTRIC SCHEME |
| 16C.1-G.4-M.11 | TIRNA PROJECT |
| 17C.1-G.4-M.12 | MANAR PROJECT - STAGE I |
| 23C.1-G.4-A.4 | MANJRA WATER SUPPLY SCHEME |
| 2C.2-G.4-A.2 | NALLAVAGU PROJECT |
| 19C.2-G.4-M.9 | GHIRNI PROJECT |
| 8C.3-G.4-A.8 | DEVNOOR HYDRO-ELECTRIC PROJECT |
| 9C.3-G.4-A.9 | MANJRA IRRIGATION SCHEME |
| 85C.3-G.4-M.10 | DHANEGAON PROJECT |
| 86C.3-G.4-M.11 | DEVNOOR PROJECT |
| 87C.3-G.4-M.12 | TAWARJA PROJECT |
| 88C.3-G.4-M.13 | LOWER TIRNA PROJECT |
| 89C.3-G.4-M.14 | LENDI PROJECT |
| 90C.3-G.4-M.15 | MANAR PROJECT - STAGE II |
| 120C.3-G.4-My.1 | MANJRA PROJECT |
| 121C.3-G.4-My.2 | KARANJA PROJECT |
| 122C.3-G.4-My.3 | NAGORA TANK PROJECT |



LEGEND

- RIVER
- DISTRICT HQ.
- STATE / DISTRICT BOUNDARY
- BASIN / SUB-BASIN BOUNDARY
- RAINGAUGE / DISCHARGE SITE
- POWER HOUSE
- MAJOR AND MEDIUM SCHEMES
 - A: In operation as in March '51
 - B: Which came into operation after March '51
 - C1: Under construction
 - C2: Referred to in III Plan
 - C3: Not referred to in III Plan

INDEX MAP
OF
G-5 MIDDLE GODAVARI
SUB-BASIN



LIST OF PROJECTS IN THE SUB-BASIN

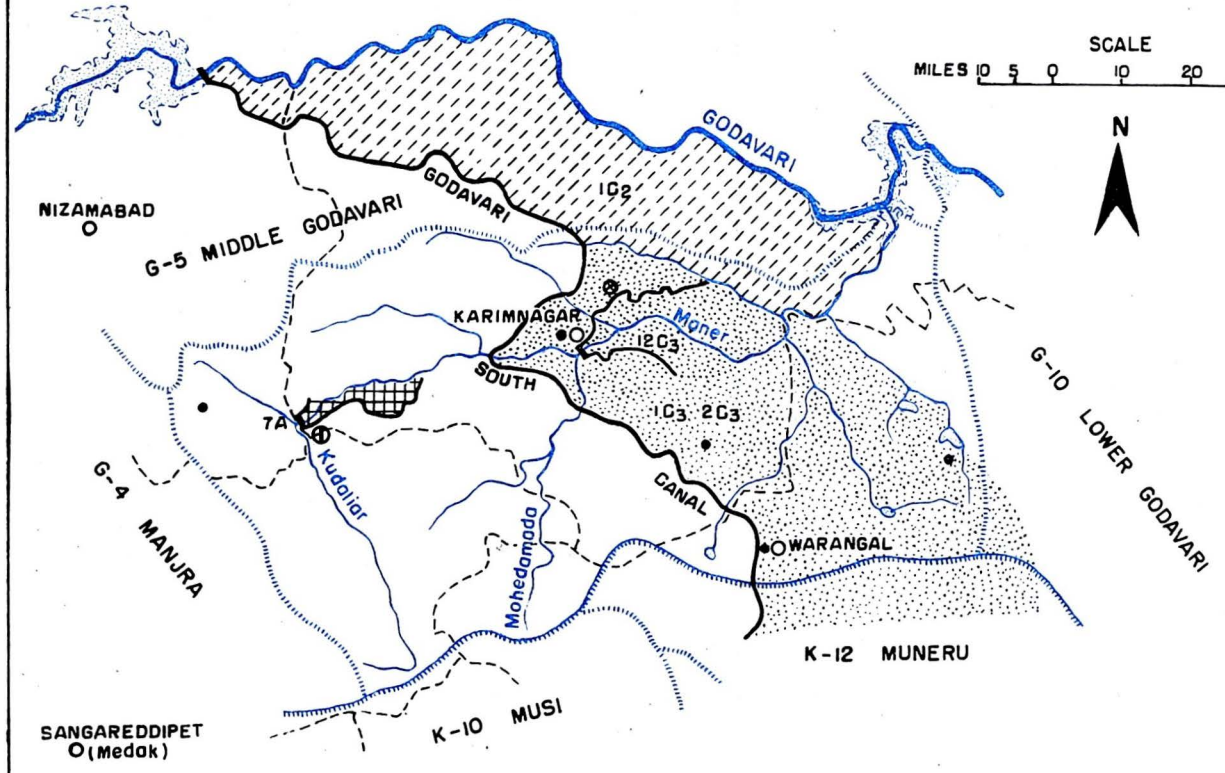
| INDEX NUMBER | PROJECT |
|----------------|----------------------------------------------------|
| 1A-G.5-A.1 | ... KHANAPUR CHANNEL |
| 2B-G.5-A.2 | ... KADDAM PROJECT |
| 2C.1-G.5-A.2 | ... SWARNA PROJECT |
| 1C.2-G.5-A.1 | ... GODAVARI CANALS PROJECT (POCHAMPAD) - STAGE I |
| 3C.2-G.5-A.3 | ... SUDDAVAGU PROJECT |
| 13C.2-G.5-A.5 | ... MANDAMARI PROJECT |
| 1C.3-G.5-A.1 | ... GODAVARI CANALS PROJECT (POCHAMPAD) - STAGE II |
| 2C.3-G.5-A.2 | ... GODAVARI CANAL (POCHAMPAD) - STAGE III |
| 10C.3-G.5-A.10 | ... KAPPALVAGU PROJECT |
| 11C.3-G.5-A.11 | ... KUNTALA HYDRO-ELECTRIC SCHEME |

LEGEND

- RIVER _____
- DISTRICT HQ. ○
- STATE/DISTRICT BOUNDARY - - - - -
- BASIN/SUB BASIN BOUNDARY - - - - -
- RAINGAUGE ●
- MAJOR AND MEDIUM SCHEMES
- A: In operation as in March '51 [diagonal lines]
- B: Which came into operation after March '51 [cross-hatch]
- C₁: Under construction [horizontal lines]
- C₂: Referred to in III Plan [vertical lines]
- C₃: Not referred to in III Plan [dotted]
- POWER HOUSE ⊗

INDEX MAP
OF
G-6 MANER SUB-BASIN

SCALE
MILES 0 5 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|----------------|---------------------|
| 7A-G.6-A.7 | MANER PROJECT |
| 12C.3-G.6-A.12 | LOWER MANER PROJECT |

LEGEND

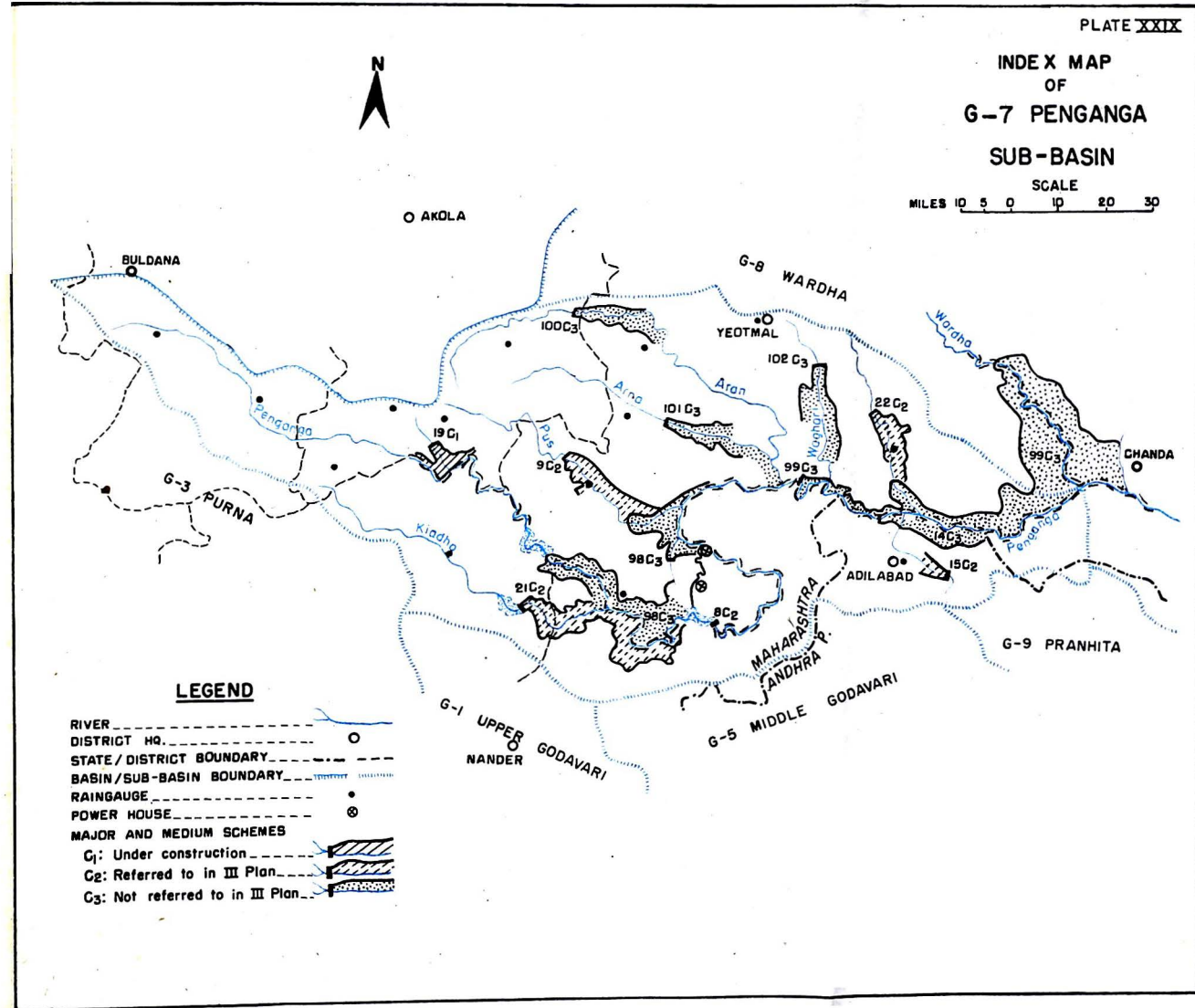
| | |
|---------------------------------|--|
| RIVER | |
| DISTRICT HQ. | |
| DISTRICT BOUNDARY | |
| BASIN/SUB-BASIN BOUNDARY | |
| RAINGAUGE/DISCHARGE SITE | |
| MAJOR AND MEDIUM SCHEMES | |
| A: In operation as in March '51 | |
| C2: Referred to in III Plan | |
| C3: Not referred to in III Plan | |
| POWER HOUSE | |

INDEX MAP
OF
G-7 PENGANGA
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30

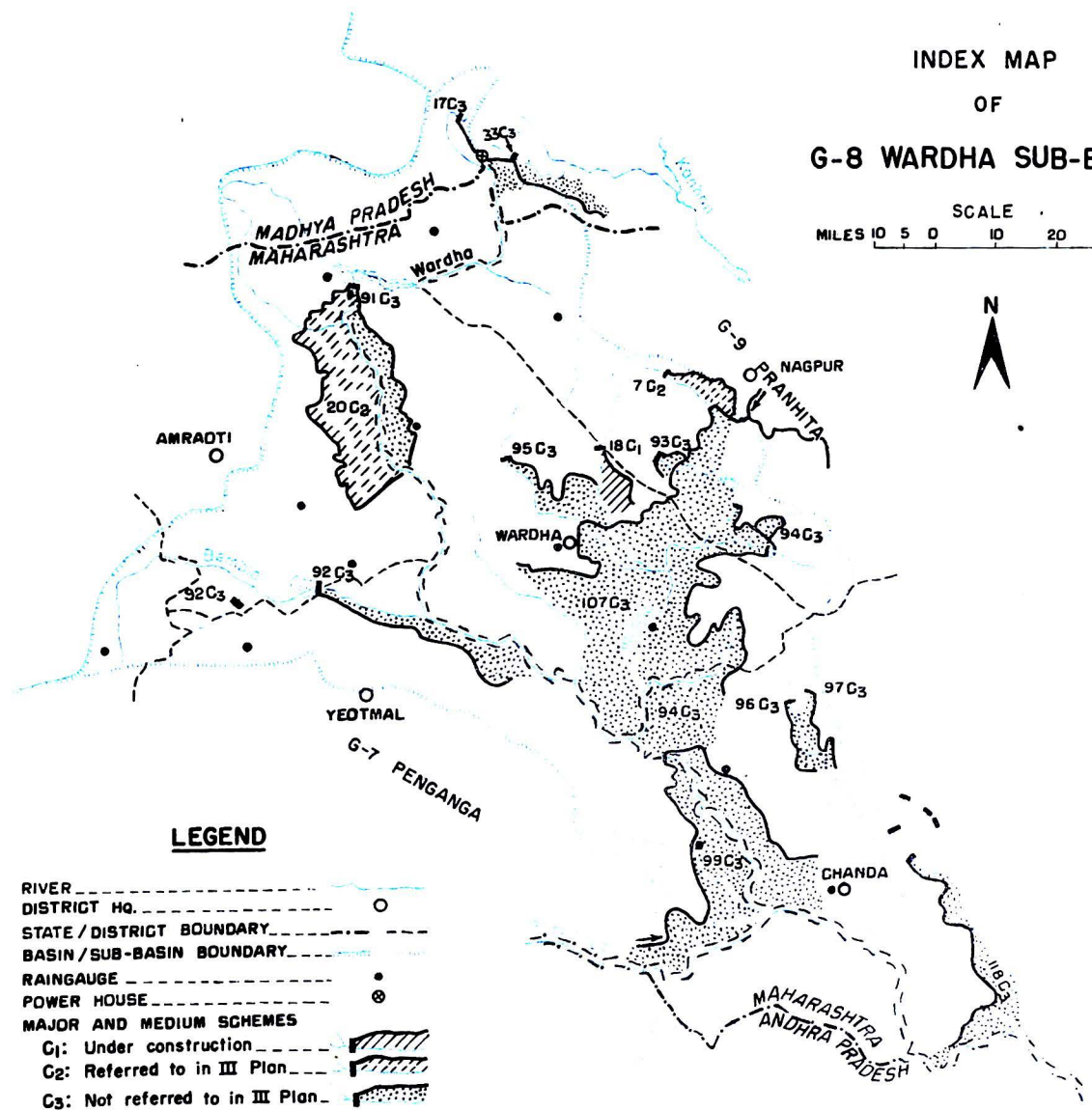
LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|-----------------|---------------------------------|
| 19C.1-6.7-M.14 | ... EKBURJEE PROJECT |
| 8C.2-6.7-M.2 | ... PENGANGA PROJECT |
| 9C.2-6.7-M.3 | ... PUS PROJECT |
| 15C.2-6.7-A.7 | ... SATNALA PROJECT |
| 21C.2-6.7-A.11 | ... KAYADHU PROJECT |
| 22C.2-6.7-M.12 | ... KUNI PROJECT |
| 14C.3-6.7-A.14 | ... PENGANGA PROJECT |
| 98C.3-6.7-M.23 | ... DONGARGAON PROJECT |
| 99C.3-6.7-M.24 | ... PENGANGA IRRIGATION PROJECT |
| 100C.3-6.7-M.25 | ... PIMPRI BARWAT PROJECT |
| 101C.3-6.7-M.26 | ... AR PROJECT |
| 102C.3-6.7-M.27 | ... WAGHARI PROJECT |



INDEX MAP
OF
G-8 WARDHA SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|----------------|-------------------------------------|
| 18C.1-6.8-M.13 | ... BOR PROJECT |
| 7C.2-6.8-M.1 | ... UPPER WUNNA PROJECT |
| 20C.2-6.8-M.10 | ... UPPER WARDHA PROJECT - STAGE I |
| 17C.3-6.8-Ma.1 | ... WARDHA SCHEME |
| 91C.3-6.8-M.16 | ... UPPER WARDHA PROJECT - STAGE II |
| 92C.3-6.8-M.17 | ... BEMBALA PROJECT |
| 93C.3-6.8-M.18 | ... KANHOLI PROJECT |
| 94C.3-6.8-M.19 | ... LOWER WUNNA PROJECT |
| 95C.3-6.8-M.20 | ... DHAM PROJECT |
| 96C.3-6.8-M.21 | ... CHARGAON PROJECT |
| 97C.3-6.8-M.22 | ... CHANDAI PROJECT |

LEGEND

- RIVER
- DISTRICT HQ.
- STATE / DISTRICT BOUNDARY
- BASIN / SUB-BASIN BOUNDARY
- RAINGAUGE
- POWER HOUSE
- MAJOR AND MEDIUM SCHEMES
 - G1: Under construction
 - G2: Referred to in III Plan
 - G3: Not referred to in III Plan

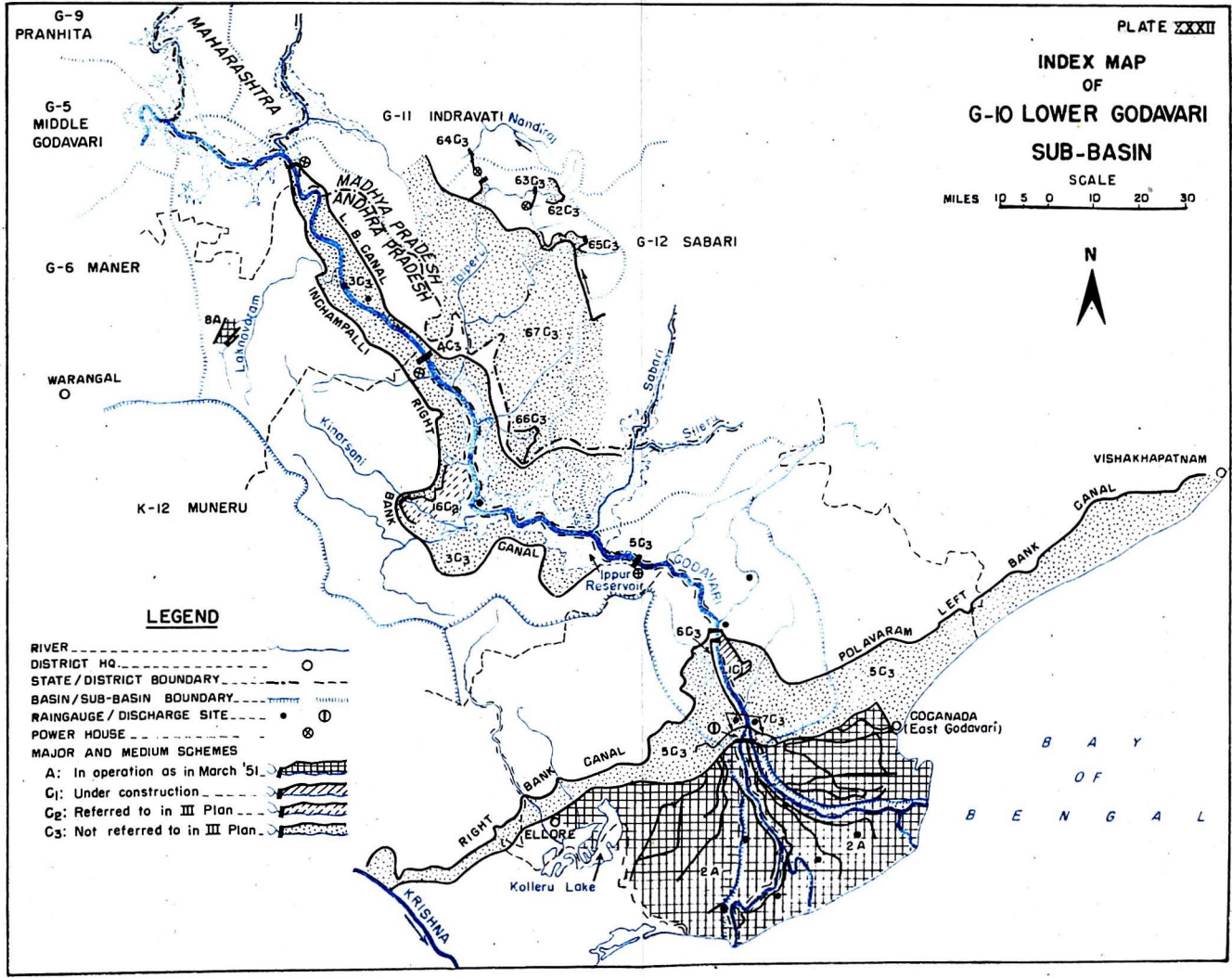
INDEX MAP
OF
G-10 LOWER GODAVARI
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|------------------|------------------------------------------------|
| 2A-G.10-A.2 | ... GODAVARI DELTA SYSTEM |
| 8A-G.10-A.8 | ... LAKNAWARAM LAKE |
| 1C.1-G.10-A.1 | ... TORRIGEDDA PUMPING SCHEME |
| 16C.2-G.10-A.8 | ... KINNERSANI PROJECT |
| 3C.3-G.10-A.3 | ... INCHAMPALLI PROJECT |
| 4C.3-G.10-A.4 | ... SINGAREDDY HYDRO-ELECTRIC SCHEME |
| 5C.3-G.10-A.5 | ... IPPUR RESERVOIR SCHEME |
| 6C.3-G.10-A.6 | ... GUTALA PUMPING SCHEME |
| 7C.3-G.10-A.7 | ... PROVIDING 6' DRUM GATES TO GODAVARI ANICUT |
| 62C.3-G.10-Ma.46 | ... TALPERU PROJECT |
| 63C.3-G.10-Ma.47 | ... MUKPARA PROJECT |
| 64C.3-G.10-Ma.48 | ... KORMANAR SCHEME |
| 65C.3-G.10-Ma.49 | ... JORANVAGU PROJECT |
| 66C.3-G.10-Ma.50 | ... VENKAMADUGU PROJECT |



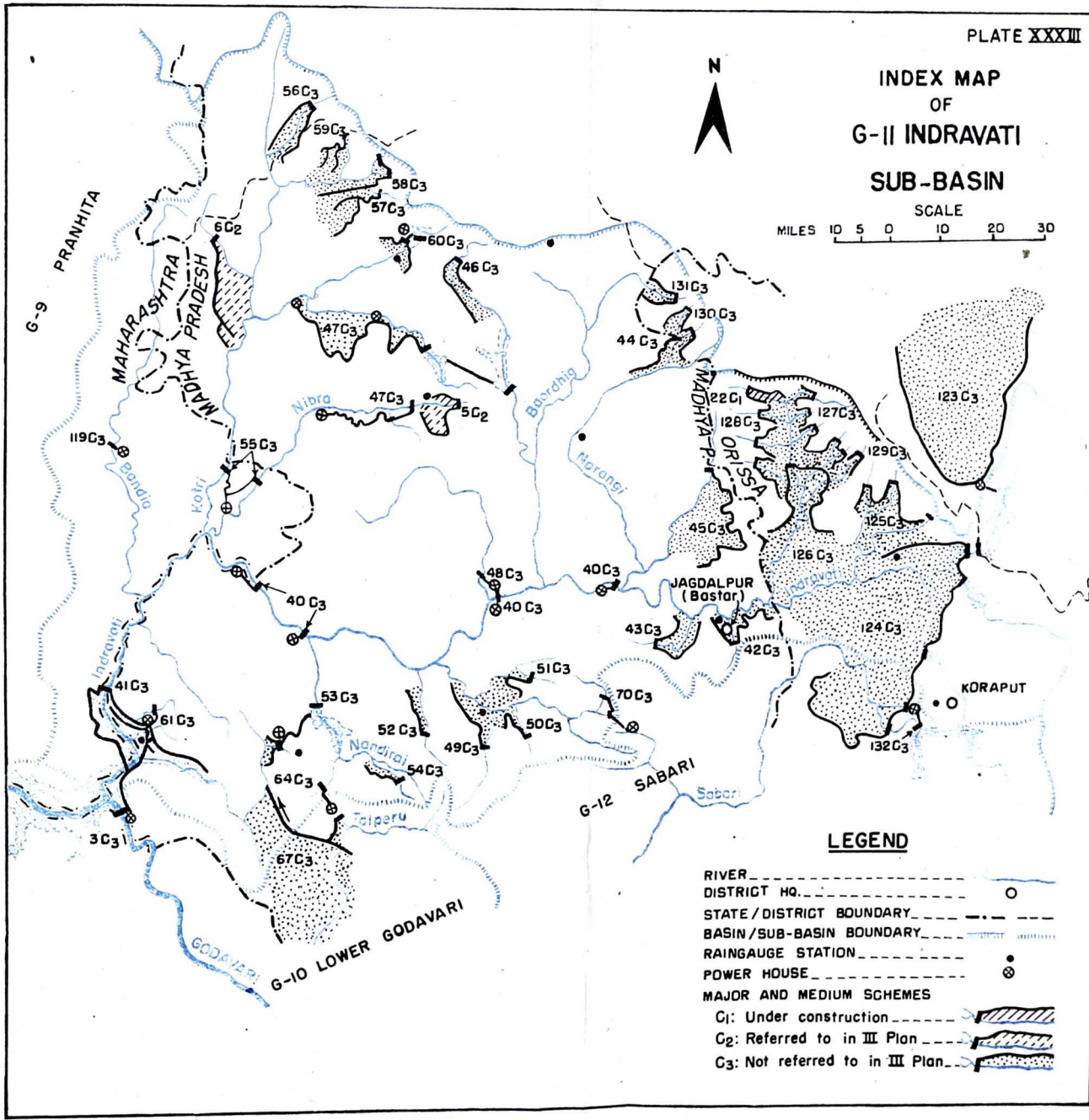
INDEX MAP
OF
G-II INDRAVATI
SUB-BASIN

SCALE
MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|---------------------------|------------------------------------------------------------|
| 22C.1-G.11-0.1 | ... UMERKOT PROJECT |
| 5C.2-G.11-Ma.1 | ... NARAINPUR PROJECT |
| 6C.2-G.11-Ma.2 | ... DEODHA |
| 40C.3-G.11-Ma.24 | ... INDRAVATI HYDEL PROJECT |
| 41C.3-G.11-Ma.25/ M.46 | ... BHOOPALPATNAM PROJECT (JOINTLY WITH MAHARASHTRA) |
| 42C.3-G.11-Ma.26 | ... GORIABAHAR SCHEME |
| 43C.3-G.11-Ma.27 | ... MOTKOT PROJECT |
| 44C.3-G.11-Ma.28 | ... JARANDI NALA PROJECT |
| 45C.3-G.11-Ma.29 | ... MARKANDI PROJECT |
| 46C.3-G.11-Ma.30 | ... TIRKA NALA PROJECT |
| 47C.3-G.11-Ma.31 | ... BARODA-WALER AND UPPER NIBRA SCHEME |
| 48C.3-G.11-Ma.32 | ... GUDRA HYDEL PROJECT |
| 49C.3-G.11-Ma.33 | ... DANTEWARA SCHEME |
| 50C.3-G.11-Ma.34 | ... GODRI NADI PROJECT |
| 51C.3-G.11-Ma.35 | ... BHANPUR PROJECT |
| 52C.3-G.11-Ma.36 | ... MARI NADI PROJECT |
| 53C.3-G.11-Ma.37 | ... BERUDI SCHEME |
| 54C.3-G.11-Ma.38 | ... TONDA NADI SCHEME |
| 55C.3-G.11-Ma.39/ M.45 | ... KOTRI-NIBRA HYDEL SCHEME (JOINTLY WITH MAHARASHTRA) |
| 56C.3-G.11-Ma.40 | ... BORIA TIBHU PROJECT |
| 57C.3-G.11-Ma.41 | ... PARWI TANK PROJECT |
| 58C.3-G.11-Ma.42 | ... BHANUPRATAPPUR PROJECT |
| 59C.3-G.11-Ma.43 | ... HATKONDA SCHEME |
| 60C.3-G.11-Ma.44 | ... KOKRAL SCHEME |
| 61C.3-G.11-Ma.45 | ... JALLAVAGU SCHEME |
| 119C.3-G.21-M.47 | ... BANDIA HYDRO-ELECTRIC PROJECT |
| 123C.3-G.11-0.1 | ... UPPER INDRAVATI PROJECT |
| 124C.3-G.11-0.2 | ... INDRAVATI-KOLAB PROJECT |
| 125C.3-G.11-0.3 | ... TUMARIA PROJECT |
| 126C.3-G.11-0.4 | ... BHASKEL PROJECT |
| 127C.3-G.11-0.5 | ... BELGAM-NILUNDI PROJECT |
| 128C.3-G.11-0.6 | ... NANGI-SINGARI PROJECT |
| 129C.3-G.11-0.7 | ... PATTIA PROJECT |
| 130C.3-G.11-0.8 | ... DASUPUR-MOHAN PROJECT |
| 131C.3-G.11-0.9 | ... JADAPARA PROJECT |



INDEX MAP
OF
G-12 SABARI SUB-BASIN

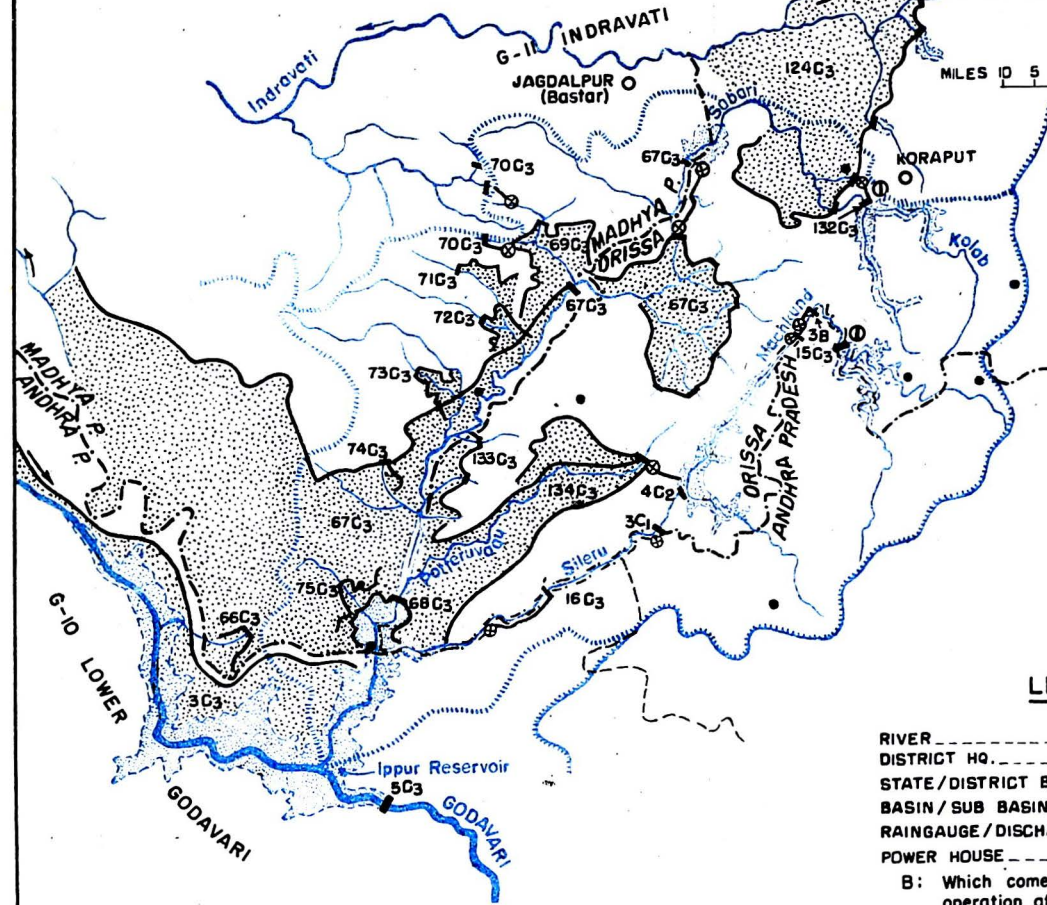
SCALE

MILES 10 5 0 10 20 30



LIST OF PROJECTS IN THE SUB-BASIN

| INDEX NUMBER | PROJECT |
|-----------------------|------------------------------------------------------------------------------------|
| 3B-6.12-A.3/0.1 | ... MACHKUND-HYDRO-ELECTRIC PROJECT (JOINTLY WITH ORISSA) |
| 3C.1-6.12-A.3 | ... UPPER SILERU HYDRO-ELECTRIC PROJECT - STAGE I |
| 4C.2-6.12-A.4/0.1 | ... GUNTEWADA BALIMELA HYDRO-ELECTRIC SCHEME (DAM TO BE BUILT JOINTLY WITH ORISSA) |
| 15C.3-6.12-A.15 | ... LOWER MACHKUND HYDRO-ELECTRIC PROJECT |
| 16C.3-6.12-A.16 | ... LOWER SILERU HYDRO-ELECTRIC PROJECT |
| 68C.3-6.12-Ma.51/0.12 | ... SABARI MULTIPURPOSE PROJECT (JOINTLY WITH ORISSA) |
| 68C.3-6.12-Ma.52/0.13 | ... KONTA PROJECT (JOINTLY WITH ORISSA) |
| 69C.3-6.12-Ma.53 | ... BARU NADI PROJECT |
| 70C.3-6.12-Ma.54 | ... KAKLUR-MUPARI SCHEME |
| 71C.3-6.12-Ma.55 | ... BARSIBARA TANK |
| 72C.3-6.12-Ma.56 | ... GORALI NADI PROJECT |
| 73C.3-6.12-Ma.57 | ... SAILERVAGU PROJECT |
| 74C.3-6.12-Ma.58 | ... ORDELTONG SCHEME |
| 75C.3-6.12-Ma.59 | ... JANAVAGU PROJECT |
| 132C.3-6.12-0.10 | ... UPPER KOLAB HYDRO-ELECTRIC PROJECT |
| 133C.3-6.12-0.11 | ... PERSONPALLI PROJECT |
| 134C.3-6.12-0.14 | ... BALIMELA IRRIGATION PROJECT |

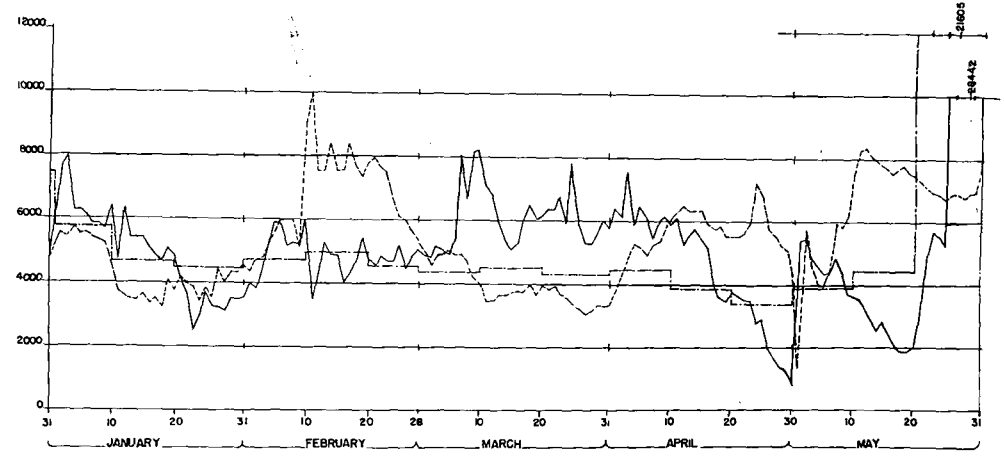
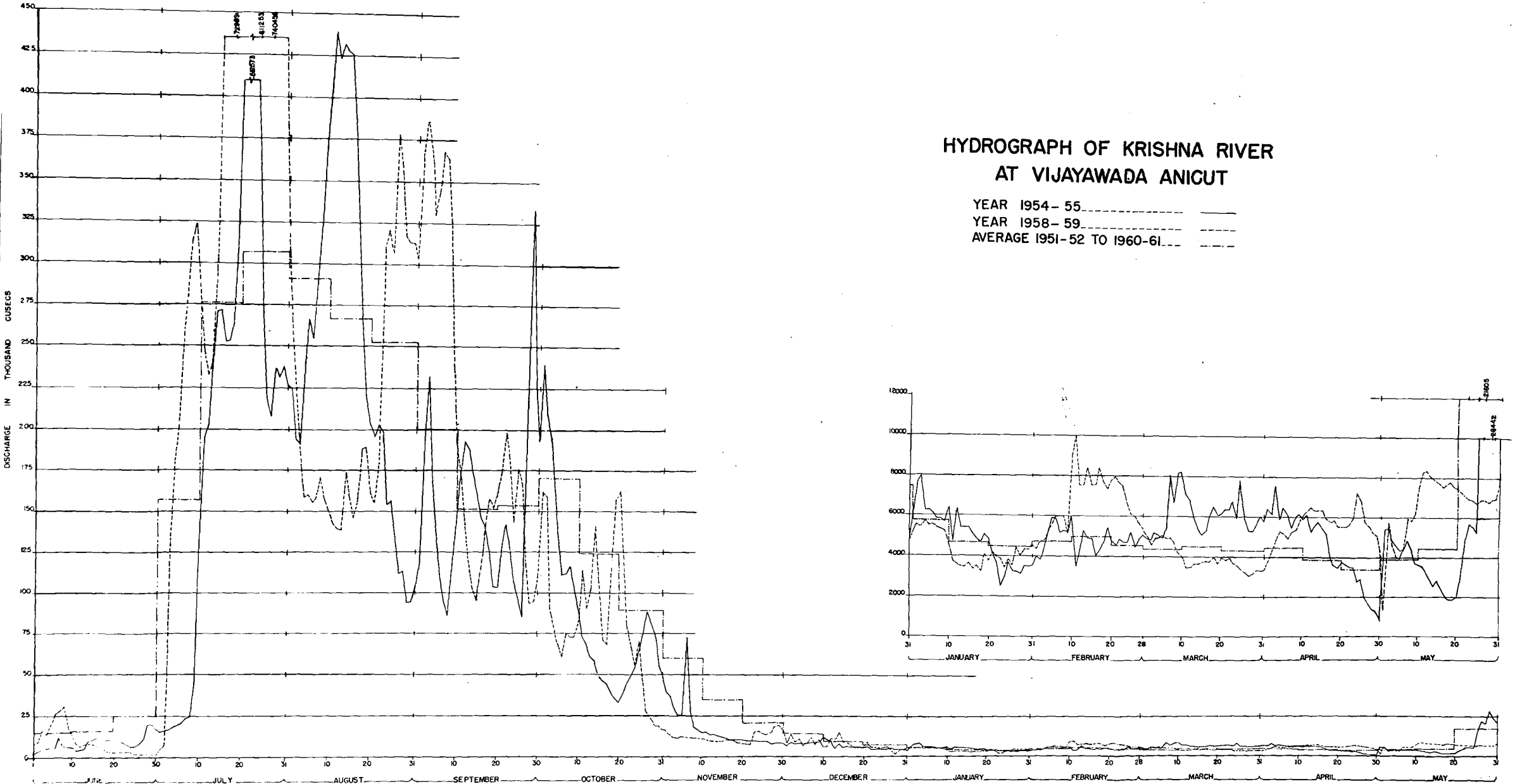


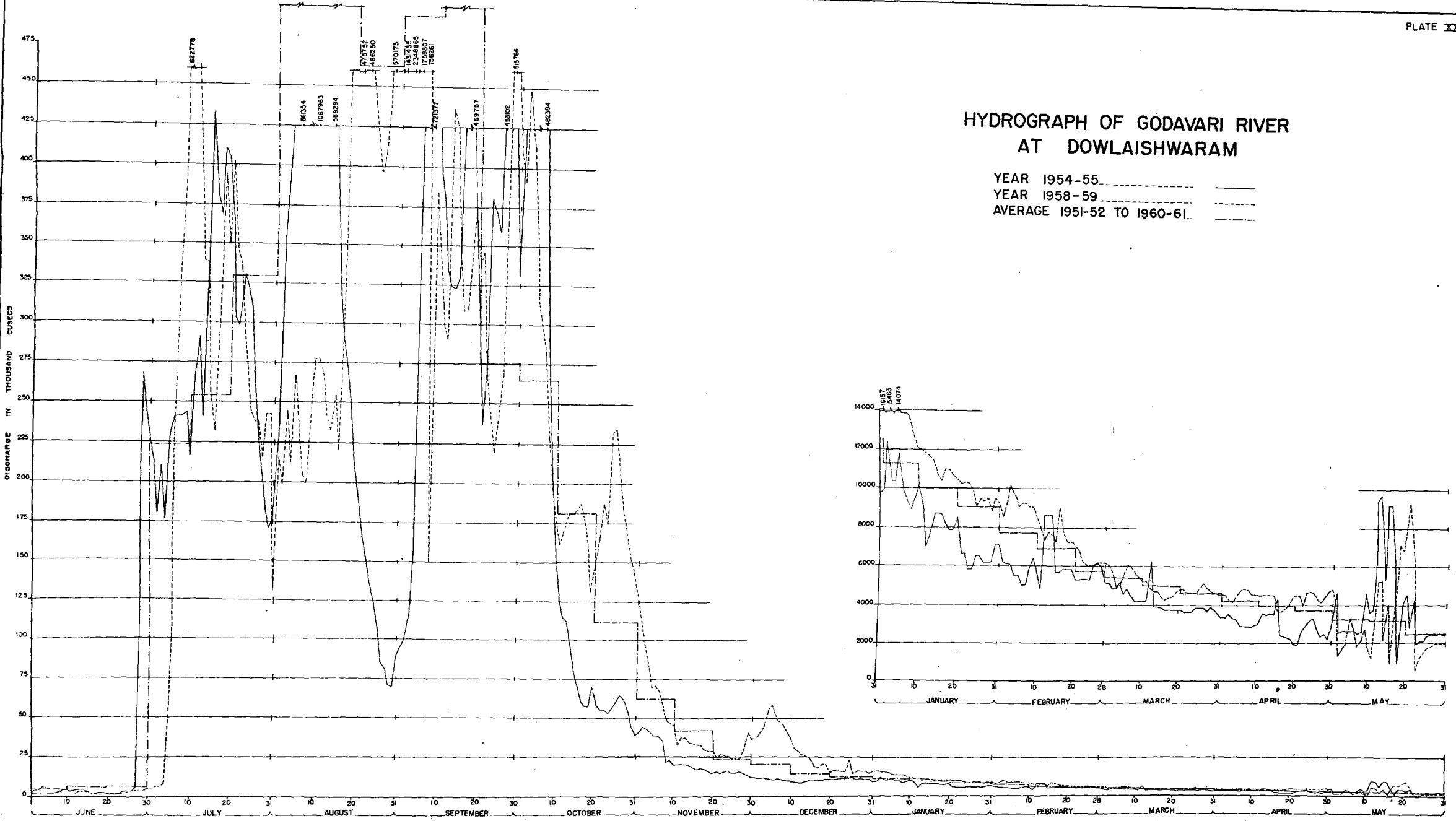
LEGEND

- RIVER
- DISTRICT HQ.
- STATE/DISTRICT BOUNDARY
- BASIN/SUB BASIN BOUNDARY
- RAINGAUGE/DISCHARGE SITE
- POWER HOUSE
- B: Which come into operation after March '51
- C1: Under construction
- C2: Referred to in III Plan
- C3: Not referred to in III Plan

HYDROGRAPH OF KRISHNA RIVER AT VIJAYAWADA ANICUT

YEAR 1954-55 _____
 YEAR 1958-59 _____
 AVERAGE 1951-52 TO 1960-61 _____





HYDROGRAPH OF GODAVARI RIVER AT DOWLAISHWARAM

YEAR 1954-55 _____
YEAR 1958-59 _____
AVERAGE 1951-52 TO 1960-61 _____

LONGITUDINAL SECTION OF GODAVARI - PULICHINTALA LINK

