

REPORT OF THE  
NATIONAL COMMISSION ON  
AGRICULTURE  
1976

PART IV  
CLIMATE AND AGRICULTURE



GOVERNMENT OF INDIA  
MINISTRY OF AGRICULTURE AND IRRIGATION  
NEW DELHI

**P. Agr. 136. IV**  
**5,000**

---

**PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, FARIDABAD  
AND PUBLISHED BY THE CONTROLLER OF PUBLICATIONS, DELHI, 1976**

## P R E F A C E

The Report of the National Commission on Agriculture comprises 69 chapters in 15 parts. A complete list of chapters and parts is given in pages (iii) to (v). The Terms of Reference of the Commission and its composition are given in Part I—Chapter I—Introduction.

This volume entitled 'Climate and Agriculture', is Part IV of the Report and is divided into the following two chapters :

13. Climate and Agriculture
14. Rainfall and Cropping Patterns

**REPORT OF THE  
NATIONAL COMMISSION ON AGRICULTURE**

**PART I—REVIEW AND PROGRESS**

1. Introduction
2. Historical Review
3. Progress of Agricultural Development
4. Some Economic Aspects

**PART II—POLICY AND STRATEGY**

5. Agriculture in Economic Development
6. Growth with Social Justice
7. Policy and Strategy
8. Centre-State Relations in Agricultural Development
9. Nutrition

**PART III—DEMAND & SUPPLY**

10. Demand Projections
11. Supply Possibilities
12. Export Possibilities and Import Substitution

**PART IV—CLIMATE AND AGRICULTURE**

13. Climate and Agriculture
14. Rainfall and Cropping Patterns

**PART V—RESOURCE DEVELOPMENT**

15. Irrigation
16. Command Area Development
17. Land Reclamation and Development
18. Soil and Moisture Conservation
19. Electricity in Rural Development

**PART VI—CROP PRODUCTION, SERICULTURE  
AND APICULTURE**

20. Reorientation of Cropping Systems
21. Foodgrain Crops
22. Commercial Crops
23. Horticultural Crops
24. Plantation Crops
25. Fodder Crops
26. Sericulture
27. Apiculture

## **PART VII—ANIMAL**

- 28. Cattle and Buffaloes
- 29. Dairy Development
- 30. Sheep and Goats
- 31. Poultry
- 32. Other Livestock
- 33. Mixed Farming
- 34. Livestock Feeding
- 35. Animal Health
- 36. Meat Production and Animal Byproducts

## **PART VIII—FISHERIES**

- 37. Inland Fisheries and Aquaculture
- 38. Marine Fisheries
- 39. Crustacean Fisheries and their Utilisation
- 40. Marketing of Fish and Fishery Products

## **PART IX—FORESTRY**

- 41. Forest Policy
- 42. Production and Social Forestry
- 43. Minor Forest Produce
- 44. Forest Ecology and Wildlife Management
- 45. Forest Protection and Law
- 46. Forest Planning, Research and Education

## **PART X—INPUTS**

- 47. Seeds
- 48. Fertilisers and Manures
- 49. Plant Protection Chemicals
- 50. Farm Power
- 51. Implements and Machinery

## **PART XI—RESEARCH, EDUCATION AND EXTENSION**

- 52. Research
- 53. Education
- 54. Extension

## **PART XII—SUPPORTING SERVICES AND INCENTIVES**

- 55. Credit and Incentives
- 56. Marketing, Transport and Storage
- 57. Processing and Agro-Industries

## **PART XIII—RURAL EMPLOYMENT AND SPECIAL AREA PROGRAMMES**

- 58. Rural Employment
- 59. Special Area Development Programmes

**PART XIV—PLANNING, STATISTICS AND ADMINISTRATION**

- 60. Planning**
- 61. Statistics**
- 62. Administration**
- 63. Farmers' Organisation**
- 64. International Cooperation**

**PART XV—AGRARIAN REFORMS**

- 65. Land Reforms Policy**
- 66. Land Reforms Legislation and Implementation**
- 67. Agrarian Structure and Perspective**
- 68. Consolidation of Holdings**
- 69. Agricultural Labour**

**PART IV**  
**CLIMATE AND AGRICULTURE**  
**CONTENTS**

**CHAPTER 13—CLIMATE AND AGRICULTURE**

**SECTION**

<b>1</b>	INTRODUCTION . . . . .	1
<b>2</b>	CLIMATE . . . . .	2
	General Description . . . . .	3
	Rainfall . . . . .	7
	Rainfall Normals . . . . .	8
	Dates of Onset and Withdrawal of Southwest Monsoon . . . . .	8
	Frequency of Daily Rainfall . . . . .	10
	Nature of Frequency Distribution of Rainfall . . . . .	10
	Depressions/Storms and Heavy Rainfall . . . . .	10
	Snowfall . . . . .	11
	Glaciation . . . . .	12
	Dew . . . . .	12
	Rainfall Variability . . . . .	12
	Rainfall Correlations . . . . .	14
	Breaks in Rainfall in July-August . . . . .	15
	Duration of Breaks . . . . .	15
	Rainfall in Break Periods . . . . .	16
	Spatial Distribution of Rainfall . . . . .	16
	Temperatures . . . . .	17
	Sunshine . . . . .	18
	Winds . . . . .	20
	Weather Phenomena . . . . .	21
	Climatic Change—Trends and Periodicity . . . . .	21
<b>3</b>	AGROMETEOROLOGY . . . . .	
	Meteorology and Crop Production . . . . .	22
	Soil Moisture Observation Network . . . . .	26
	Evapotranspiration Measurements . . . . .	26
	Phenology . . . . .	28
	Pests and Diseases . . . . .	29
	Meteorology in relation to Orchards, Plantations and Forests . . . . .	30
	Forest Meteorology . . . . .	31
	Hill Meteorology . . . . .	32
	Meteorology in Relation to Livestock Production . . . . .	33

SECTION	Page
Weather and Animal Diseases . . . . .	33
Remote Sensing Techniques . . . . .	34
<b>4 DROUGHTS . . . . .</b>	<b>34</b>
Drought Classification . . . . .	35
✓ Drought Studies in India . . . . .	<del>35</del>
Drought Prediction . . . . .	37
<b>5 WEATHER BULLETINS FOR FARMERS . . . . .</b>	<b>39</b>
Present Service . . . . .	39
Crop Weather Calendars . . . . .	39
Limitations and Required Improvement . . . . .	40
Improvement in Dissemination . . . . .	41
Weekly Crop—Weather Bulletins . . . . .	42
<b>6 EXTENDED RANGE FORECASTING . . . . .</b>	<b>42</b>
Seasonal Forecasting—India . . . . .	43
Long Range Forecasts . . . . .	43
Dynamic Climatological Techniques . . . . .	44
World Weather Watch . . . . .	44
Monsoon Experiments . . . . .	44
<b>7. CROP WEATHER RELATIONSHIP . . . . .</b>	<b>45</b>
Weather Parameters and Crops . . . . .	46
Crop Yield Formulation . . . . .	47
Crop Yield and Rainfall Distribution . . . . .	47
Rainfall Indices . . . . .	48
Contribution of Technology to Crop Production . . . . .	49
Physiological Response of Crops to Weather . . . . .	49
<b>8. WEATHER MODIFICATION . . . . .</b>	<b>50</b>
Basic considerations . . . . .	50
Cloud Seeding Experiments . . . . .	51
Australia	
U.S.A.	
Japan	
U.S.S.R.	
Israel	
Artificial Rain Making Experiments . . . . .	52
Hail Suppression	
Development and Seeding Agents	
Economic Aspects	
WMO'S Views . . . . .	54
Future Plans . . . . .	54



SECTION

9 RESEARCH, EDUCATION AND TRAINING AND INTERNATIONAL COOPERATION . . . . .	54
Research . . . . .	54
Mathematical Simulation Modelling . . . . .	55
Production Functions for Crop Yields . . . . .	55
Irrigation Evaluation . . . . .	55
Agro Climatological Maps . . . . .	56
Education and Training . . . . .	56
International Cooperation . . . . .	57
10 ORGANISATION OF METEOROLOGICAL OBSERVATORIES AND RAINGAUGES FOR AGRICULTURE . . . . .	58
Rainfall Registration in India . . . . .	59
11. SUMMARY OF RECOMMENDATIONS . . . . .	63
APPENDIX	
13·1	
Statement—I Average Latitudinal Position of Depressions Crossing Different Longitudes from 92 to 75°E, during July and August—Based on Data of 80 years from 1891 to 1970. . . . .	70
Statement—II Normals of Rainfall (cm) for Meteorological Sub-divisions of the Country . . . . .	71
Statement—III Normals of Rainy Days for Meteorological Sub-divisions of the Country . . . . .	73
Statement—IV Coefficient of Variation(%) of Monthly, Seasonal and Annual Rainfall for 31 Meteorological Sub-divisions of India . . . . .	75
Statement—V Number of Raingauges—Statewise—having published Normals and Number of Reporting Raingauges for which Rainfall Data are received or arranged to be received by IMD at Poona . . . . .	77
Statement—VI Intercorrelation Coefficient (x10 <sup>2</sup> ) . . . . .	78
Statement—VII Intercorrelations between Sub-divisions—June to September . . . . .	79
Statement—VIII Percentage Departure (from normal) of Rainfall in Meteorological Sub-divisions of India during twelve break periods . . . . .	81
Statement—IX Spatial Distribution of Rainfall during Breaks (expressed as percentage) . . . . .	83
Statement—X Format for Weekly Crop Weather Report . . . . .	84
Statement—XI Seasonal Rainfall Forecasts issued by the India Meteorological Department . . . . .	89

## APPENDIX

Statement—XII Critical Periods when Weather Elements Significantly Effect Yields of Rice . . . . .	90
Statement—XIII Percentage Variation in Yield of Rice Accounted for by Technology . . . . .	94
Statement—XIV WMO Statement on Weather Modification . . . . .	95
<b>13.2 MAPS . . . . .</b>	<b>98</b>
I Normal Rainfall, July	
II Normal Rainfall, June—September	
III Normal Rainfall, Annual	
IV Coefficient of Variation of Rainfall, July	
V Coefficient of Variation of Rainfall, June—September	
VI Coefficient of Variation of Rainfall, Annual	
VIa June—September Rainfall as Percentage of Annual	
VII Dates of Onset and Withdrawal of Southwest Monsoon	
VIII Mean Deparature (%) of Rainfall during breaks	
IX Percentage Difference between average number of rainy days dur- ing break periods and during July—August . . . . .	
X Duration of Sunshine (Hours)	
XI Percentage Frequencies of number of days of bright sunshine greater than 9 hours.	
XIa Daily Global Solar Radiation	
XIb Daily Diffuse Solar Radiation	

## CHAPTER 14—RAINFALL AND CROPPING PATTERNS

<b>SECTION</b>	
1. INTRODUCTION . . . . .	125
2. METHODOLOGY . . . . .	127
Rainfall Patterns . . . . .	127
Boundaries of rainfall zones	
Cropping patterns . . . . .	130
Relative Yield Index (RYI) of Crops . . . . .	131
Livestock Patterns . . . . .	132
Soils . . . . .	133
Power . . . . .	133
3. GENERAL INFORMATION . . . . .	134
Area . . . . .	134
Population . . . . .	135
Land Use . . . . .	136
Irrigation . . . . .	138
Soils . . . . .	140
Livestock . . . . .	141

SECTION

4	RAINFALL PATTERNS—ZONES . . . . .	144
	Zonal Areas . . . . .	144
	Gross cropped area	
	All India Rainfall Patterns . . . . .	145
	Rainfall maps	
5	RAINFALL REGIONS . . . . .	149
	Map of rainfall regions	
6	CROPPING PATTERNS . . . . .	154
	Cropping Patterns of Regions . . . . .	156
	Group I : No month with rainfall of 10 cm. or more . . . . .	157
	Region 1 . . . . .	
	Group II : Rainfall of 10 cm. or more for one or two months during June to September . . . . .	159
	Regions 2, 3, 5 and 6	
	Region 2—E4 (C1E3) E4	
	Region 3—E4 (C2E2) E4	
	Region 5—E4 (B1C1E2) E4	
	Region 6—E4 (B2E2) E4	
	Group III : Rainfall for three consecutive months from July or four from June with 10 cm. per month or more . . . . .	164
	Region 4—E4 (C4/C3) E4	
	Region 7—E4 (B2C1E1) E4	
	Region 8—E4 (B2C2) E4	
	Region 9—E4 (B4/B3) E4	
	Region 10—E4 (A1 C3) E4	
	Region 11—E4 (A1B1C1E1) E4	
	Region 12—E4 (A1B1C2) E4	
	Region 13—E4 (A2C1E1)E4	
	Region 14—E4 (A2C2) E4	
	Region 15—E4 (A2B1C1) E4	
	Region 16—E4 (A2B2)E4	
	Region 17—E4 (A3B1)E4	
	Group IV : Rainy season from October for one to three months Regions 18—22	182
	Group V : Rainy season from September for two to four months Regions 23—26	184
	Group VI : Rainy season from August for four or five months Regions 27—29	186
	Group VII : Rainy season for four months from July or five months from June and October 10—20 cm. per month	188
	Region 30—36	
	Group VIII: Rainy season from May for five to seven months Regions 37, 41-42, 44-45, 47—49 and 55.	190

SECTION

Group IX : Six to eight consecutive months of rainy season from April or March . . . . .	191
Regions 56—62	
Group X : Two rainy seasons . . . . .	192
Regions 38—40, 43, 46 and 50—53	
Group XI : Rainy season from January for four months . . . . .	195
Region 54	
All India Cropping Patterns . . . . .	195
Crop Yields . . . . .	197
Rice	
Maize	
Jowar (kharif)	
Jowar (rabi)	
Bajra	
Ragi	
Small millets	
Wheat	
Gram	
Tur	
Total Pulses	
Groundnut	
Cotton	
State Cropping Patterns] . . . . .	216
Orissa	
Kerala	
Assam	
Maharashtra	
Karnataka	
7 SUGGESTIONS FOR FUTURE CROPPING PATTERNS . . . . .	219
Cropping Pattern under Different Rainfall Distribution . . . . .	220
General Observations on Future Cropping Patterns . . . . .	224
8 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS . . . . .	230

APPENDIX

14-1 Code Form for combinations of Rainfall of four months in different intervals . . . . .	237
14-2 Statement—I Frequency of Districts in different area Intervals . . . . .	240
Statement—II Frequency of Districts with Density of Population in different Intervals . . . . .	241
Statement—III Work Force (Human and Animal ) in Agriculture . . . . .	243
Statement—IV Land Utilisation Statistics, 1969-70 . . . . .	244
Statement—V Frequency Distribution of Districts according to Percentages of Net Irrigated Area to Net Sown Area . . . . .	250
Statement—VI Irrigated Area according to Sources . . . . .	251

APPENDIX

14.3	Statement—I	Livestock Categories as per cent of total Livestock Population—Statewise . . . . .	252
	Statement—II	Livestock Patterns in each State . . . . .	256
	Statement—III	Livestock Patterns—All India . . . . .	262
14.4	Statement—I	Rainfall Patterns—Statewise . . . . .	263
	Statement—II	Geographical (Reporting) Area under each of the Rainfall Patterns of June to September . . . . .	275
	Statement—III	Geographical (Reporting) Area under each of the Rainfall Patterns of February to May . . . . .	279
	Statement—IV	Geographical (Reporting) Area under each of the Rainfall Patterns of October to January . . . . .	281
	Statement—V	Gross cropped area under each of the Rainfall Patterns of June—September—1969-70 . . . . .	283
	Statement—VI	All-India Rainfall Patterns . . . . .	287
14.5	Statement—I	Rainfall Regions—Geographical (Reporting) and Gross Cropped Areas . . . . .	292
	Statement—II	Number of Taluks under each of the Rainfall Regions . . . . .	294
14.6	Statement—I	Per cent of Gross Cropped Area under Principal Crops 1969-70 and 1970-71 . . . . .	299
	Statement—II	Relative Yield Index (RYI) Values of Principal Crops . . . . .	304
	Statement—III	Cropping Patterns—Statewise . . . . .	309
	Statement—IV	Number of Cropping Patterns Statewise . . . . .	321
	Statement—V	Basic information for each Rainfall Region . . . . .	324
	Statement—VI	All-India Cropping Patterns . . . . .	418
	Statement—VII	Number of Districts, Geographical and Gross Cropped area—Statewise . . . . .	423
	Statement—VIII	District Rainfall Patterns . . . . .	425
14.7	Statement—I	Rainfall and Cropping Patterns of Orissa State . . . . .	440
	Statement—II	Agro Climatic Zones and recommended Cropping Patterns—Kerala . . . . .	463
	Statement—III	Suggested Cropping Patterns for Assam . . . . .	465
	Statement—IV	Suggested Cropping Patterns for Maharashtra . . . . .	467
	Statement—V	Suggested Cropping Patterns for Karnataka . . . . .	472
14.8	MAPS . . . . .		479

Map I Rainfall Patterns

Map II Month of Maximum Rainfall together with (a) Totals of Rainfall (Rf) and Rainy days (Rd) of two consecutive months—Month of Maximum and of preceding or following whichever is higher and (b) Number of consecutive Months (n) with Month of commencement (m) of Rainfall of 10 cm pm or higher (bmn) with totals of Rainfall (Rf) and Rainy days (Rd) for these months

**APPENDIX**

**Map III Rainfall Regions**

**Map IV Cropping Patterns**

**Map V Livestock Patterns**

**Map VI Population Density (District Map)**

**Map VII Net Irrigated Area as percentage of Net Sown Area (1970-71)**

**14.9 Rainfall and Cropping Patterns—**

**Karnataka . . . . .**