

ENERGY DEMAND IN INDIAN AGRICULTURE: A POST GREEN-REVOLUTION
EXPERIENCE

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IN

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BY

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APRIL 1999


TO
.....MY PARENTS.....

DECLARATION

I hereby declare that the work embodied in this Dissertation entitled " ENERGY DEMAND IN INDIAN AGRICULTURE: A POST GREEN-REVOLUTION EXPERIENCE" is carried out by me under the Supervision of DR. V. B. N. S. MADDURI, Faculty of Department of Economics, University of Hyderabad, and has not been submitted in part or in full to any other University or Institution.

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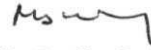
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S. R. K. REDDY

(i)

CONTENTS

S. NO	CHAPTERS	PAGE NO.
1.	INTRODUCTION:	1-17
1.0	Introduction	
1.1	Green Revolution and Changing Scenario of Indian Agriculture	3-7
1.2	Classification of Energy Sources	7-9
1.3	Conversion of Energy Sources into a Uniform Measurement	9-10
1.4	Objectives	10
1.5	Data base	11
1.6	Hypothesis to be tested	12
1.7	Methodology	13-14
1.8	Nature of the Present study	14-16
1.9	Summary	16-17
2.	CROPPING PATTERN AND CROPPING INTENSITY IN INDIAN AGRICULTURE:	18-128
2.0	Introduction	18-31
2.1	Profiles of Selected States and Whole India	31-35
2.2	Factors Affecting Growth Performance in Selected States and all India	35-38
2.3	Area Irrigated by Different Sources in Indian Agriculture	38-42
2.4	All India Cultivated and Irrigated Area-Gross and Net with cropping Intensity	42-46
2.5	Net State Domestic Product(from agriculture) at factor Cost by Industry of Origin(at current prices)	46-49
2.6	Economics of Crops Cultivation in Selected States	50-56
2.7	General Features of the Existing problem	56-59
2.8	potential Yields of HYVs of Seeds: A Comparative Picture	59-61
2.9	Cropping Pattern in Indian Agriculture with respect to Selected States	61-116
2.10	Index Numbers of Area, Production, and Yield of Principal Crops	116-120
2.11	Index Numbers of Net Area Sown, Cropping Intensity, cropping Pattern, and Productivity(yield)	120-121
2.12	Average Annual Rainfall in India and Selected States	122-124
2.13	Percapital Water Availability by Region	124-126
2.14	Summary and Conclusions	126-128
3.	FACTOR SHARES IN AGRICULTURE SECTOR:	129-167
3.0	Introduction	129-130
3.1	Factor Endowments in Indian Agriculture and Selected States	131-132
3.2	Labour Absorption for Major Crops In Selected States	132-140
3.3	Crop-Wise Labour Absorption in Indian Agriculture	141-143
3.4	Value of Inputs in Indian Agriculture (at current prices)	143-147
3.5	Value of Agricultural Output and Inputs in Indian Agriculture (at current and 1980/81 prices)	147-149
3.6	Total Number of Cultivators and Agricultural Labourers in Indian Agriculture	149-152
3.7	Total Draught Power in Indian Agriculture and Selected States	153-156

(ii)

3.8	Consumer Price Index Numbers for Agricultural Labourers	156-158
3.9	Index Numbers of Whole Sale Prices of Different Agricultural Commodities and Inputs	158-164
3.10	Summary and Conclusions	164-166
1.	MECHANIZATION IN INDIAN AGRICULTURE:	167-197
4.0	Introduction	* 167-174
4.1	An Overall View of Trends in Agricultural Inputs	174-182
4.2	General Nature of Farm Mechanization in Indian Agriculture	182-185
4.3	Total Number of Agricultural Machinery and Implements in Whole India and Selected States	185-196
4.4	Summary and Conclusions	196-197
5.	FERTILISER AND PESTICIDES CONSUMPTION IN INDIAN AGRICULTURE:	198-225A
5.0	Introduction	198-204
5.1	Area Under HYVs of Food Grains - All India	204-206
5.2	Area Under HYVs of Rice, Wheat, and Jowar in Selected States and Whole India	206-212
5.3	The Quantity of Plant Nutrients Received from Soil by Different Crops	212-215
5.4	Fertiliser Consumption in Indian Agriculture	215-217
5.5	Fertiliser Consumption In Indian Agriculture with Respect to Selected States	217-219
5.6	Per Hectare Consumption of Fertilisers in Indian Agriculture and Selected States	220-222
5.7	Total Pesticides Consumption in Indian Agriculture and Selected States	222-225
5.8	Summary and Conclusions	225-225A
6.	ENERGY DEMAND AND ENERGY INTENSITIES IN INDIAN AGRICULTURE:	226-268
6.0	Introduction	226-239
6.1	Conversion of Direct and Indirect Sources of Energy	239-241
6.2	Power Utilisation in Indian Agriculture	241-243
6.3	Average Energy Requirements for Principal Crops in Indian Agriculture	243-246
6.4	Estimated Total Energy Consumption Under Principal Crops in All India and Selected States	246-262
6.5	Energy Intensities Under Principal Crops in Whole India and Selected States	262-268
6.6	REGRESSION EQUATIONS FOR SELECTED CROPS AND STATES	269
6.6.1	Output model	269-273
6.6.2	Energy demand (inverse) model	273-275
6.6.3	Analysis of estimated results	275-276
6.6.4	<u>Estimated Output Equations</u>	276-283
6.6.4.1	Rice:	277
6.6.4.2	Wheat:	278-279
6.6.4.3	Jowar:	279-280
6.6.4.4	Groundnut:	280-281
6.6.4.5	Cotton:	282
6.6.4.6	Sugarcane:	283
6.6.5	<u>Estimated Energy Demand Equations</u>	284-291
6.6.5.1	Rice:	284-285
6.6.5.2	Wheat:	286-287
6.6.5.3	Jowar:	287-288
6.6.5.4	Groundnut:	288-289
6.6.5.5	Cotton:	289-290
6.6.5.6	Sugarcane:	290-291
6.7	Summary and Conclusions	292-293

7 . SUMMARY AND CONCLUSIONS:	294-314
7.0 Introduction	294-296
7.1 Cropping Pattern and Cropping Intensity	296-297
7.2 Factors Shares in Indian Agriculture	297-298
7.3 Mechanization in Agriculture	298-301
7.4 Fertilisers and Pesticides Demand in Indian Agriculture	303-304
7.5 Energy Demand and Energy Intensities in Agriculture Sector	305-308
7.6 Policy Recommendations	308-312
7.7 Limitations of the Present Study	312-313
7.8 Directions for the Future Research	313-314
BIBLIOGRAPHY	315-321
SOURCES OF DATA	322

LIST OF TABLES

S. NO	TABLE NO	NAME OF THE TABLE	PAGE NO
1	2.1.1	Profiles of selected states and whole India	32
2	2.2.1	Factors affecting growth performance in selectes states of India	36
3	2.3.1	Area Irrigated by sources	39
4	2.3.2	Compound growth rates of area irrigated by sources	41
5	2.4.1	All Indian cultivated and irrigated area-gross and net — with cropping intensity	43
6	2.5.1	Net state domestic product (from agriculture) at factor cost by industry of origin	47
7	2.5.2	Compound growth rates of net state domestic product (from Agriculture)	48
8	2.6.1	Economic analysis of crops in different states of India	51
9	2.7.1	Cropping pattern according to land use statistics.	57
10	2.7.2	Compound growth rates of cropping pattern according to land use statistics	58
11	2.8.1	potential yields of HYVs of seeds: a comparative picture	60
12	2.9.1.1	Andhra Pradesh: area, production, yield of principal crops(Rice)	63
13	2.9.1.2	Andhra Pradesh: area, production, yield of principal crops (Jowar)	64
14	2.9.1.3	Andhra Pradesh: area, Production, yield of prin — cial crops (Wheat)	64
15	2.9.1.4	Andhra Pradesh: area, production, yield of principal crops (Groundnut)	65
16	2.9.1.5	Andhra Pradesh: area, production, yield of principal crops (Cotton)	65
17	2.9.1.6	Andhra Pradesh: area, production, yield of principal crops (Sugar cane)	66
18	2.9.2.1	Bihar: area, production, and yield of principal crops (Rice)	68
19	2.9.2.2	Bihar: area, production, and yield of principal crops (Jowar)	68
20	2.9.2.3	Bihar: area, production, and yield of principal crops (Wheat)	69
21	2.9.2.4	Bihar: area, production, and yield of principal crops (Sugar cane)	69
22	2.9.3.1	Punjab: area, production, and yield of principal crops (Rice)	71
23	2.9.3.2	Punjab: area, production, and yield of principal crops (Wheat)	72

24	2.9.3.3	Punjab: area, production, and yield of principal crops(CGround nut)	72
25	2.9.3.4	Punjab: area, production, and yield of principal crops(Cot ton)	73
26	2.9.3.5	Punjab: area, production, and yield of principal crops(Sugarcane)	73
27	2.9.4.1	Tamil Nadu: area, production, and yield of principal crops(Rice)	75
28	2.9.4.2	Tamil Nadu: area, production, and yield of principal crops(Jowar)	75
29	2.9.4.3	Tamil Nadu: area, production, and yield of principal crops(Groundnut)	76
30	2.9.4.4	Tamil Nadu: area, production, and yield of principal crops(Cot ton)	76
31	2.9.4.5	Tamil Nadu: area, production, and yield of principal crops(Sugarcane)	77
32	2.9.5.1	Uttar Pradesh: area, production, and yield of principal cropsCRice)	79
33	2.9.5.2	Uttar Pradesh: area, production, and yield of principal cropsC Jowar)	80
34	2.9.5.3	Uttar Pradesh: area, production, and yield of principal cropsC Wheat)	80
35	2.9.5.4	Uttar Pradesh: area, production, and yield of principal cropsC Groundnut)	81
36	2.9.5.5	Uttar Pradesh: area, production, and yield of principal crops C Cotton)	81
37	2.9.5.6	Uttar Pradesh: area, production, and yield of principal crops C Sugar cane)	82
38	2.9.6.1	West Bengal: area, production, and yield of principal cropsCRice)	83
39	2.9.6.2	West Bengal: area, production, and yield of principal cropsC Wheat)	84
40	2.9.6.3	West Bengal: area, production, and yield of principal crops C Sugar cane)	84
41	2.9.7.1	All India: area, production, and yield of principal cropsCRice)	86
42	2.9.7.2	All India: area, production, and yield of principal cropsC Wheat)	87
43	2.9.7.3	All India: area, production, and yield of principal cropsC Jowar)	87
44	2.9.7.4	All India: area, production, and yield of principal cropsC Groundnut)	88
45	2.9.7.5	All India: area, production, and yield of principal crops C Cotton)	88
46	2.9.7.6	All India: area, production, and yield of principal crops C Sugar cane)	89
47	2.9.1.7	Andhra Pradesh: compound growth rates of area production, and yield of principal cropsCrice)	91
48	2.9.1.8	Andhra Pradesh: compound growth rates of area production, and yield of principal crops(Jowar)	91
49	2.9.1.9	Andhra Pradesh: compound growth rates of area production, and yield of principal crops(Wheat)	92
50	2.9.1.10	Andhra Pradesh: compound growth rates of area production, and yield of principal cropsCG.nut)	92
51	2.9.1.11	Andhra Pradesh: compound growth rates of area production, and yield of principal cropsCCotton)	93

52	2.9.1.12	Andhra Pradesh: compound growth rates of area production, and yield of principal crops(S. cane)	93
53	2.9.2.5	Bihar: compound growth rates of area, production and yield of principal crops(Rice)	95
54	2.9.2.6	Bihar: compound growth rates of area, production and yield of principal crops(Jowar)	96
55	2.9.2.7	Bihar: compound growth rates of area, production and yield of principal crops(Wheat)	96
56	2.9.2.8	Bihar: compound growth rates of area, production and yield of principal crops(Sugarcane)	97
57	2.9.3.6	Punjab: compound growth rates of area, production, and yield of principal crops(Rice)	98
58	2.9.3.7	Punjab: compound growth rates of area, production, and yield of principal crops(Wheat)	99
59	2.9.3.8	Punjab: compound growth rates of area, production, and yield of principal crops(C Groundnut)	99
60	2.9.3.9	Punjab: compound growth rates of area, production, and yield of principal crops(C Cotton)	100
61	2.9.3.10	Punjab: compound growth rates of area, production, and yield of principal crops(C Sugarcane)	100
62	2.9.4.6	Tamil Nadu: compound growth rates of area, production, and yield of principal crops(Rice)	101
63	2.9.4.7	Tamil Nadu: compound growth rates of area, production, and yield of principal crops(Jowar)	103
64	2.9.4.8	Tamil Nadu: compound growth rates of area, production, and yield of principal crops(C Groundnut)	103
65	2.9.4.9	Tamil Nadu: compound growth rates of area, production, and yield of principal crops(Cotton)	104
66	2.9.4.10	Tamil Nadu: compound growth rates of area, production, and yield of principal crops(C Sugarcane)	104
67	2.9.5.7	Uttar Pradesh: compound growth rates of area , Production, and yield of principal crops(Rice)	106
68	2.9.5.8	Uttar Pradesh: compound growth rates of area, Production, and yield of principal crops(Jowar)	107
69	2.9.5.9	Uttar Pradesh: compound growth rates of area, Production, and yield of principal crops(Wheat)	107
70	2.9.5.10	Uttar Pradesh: compound growth rates of area, Production, and yield of principal crops(G. nut)	108
71	2.9.5.11	Uttar Pradesh: compound growth rates of area, Production, and yield of principal crops(Cotton)	108
72	2.9.5.12	Uttar Pradesh: compound growth rates of area , Production, and yield of principal crops(S. cane)	109
73	2.9.6.4	West Bengal: compound growth rates of area, production, and yield of principal crops(Rice)	110
74	2.9.6.5	West Bengal: compound growth rates of area, production, and yield of principal crops(Wheat)	110
75	2.9.6.6	West Bengal: compound growth rates of area, production, and yield of principal crops(C Sugarcane)	111
76	2.9.7.7	All India: compound growth rates of area, production, and yield of principal crops(Rice)	113
77	2.9.7.8	All India: compound growth rates of area, production, and yield of principal crops(Wheat)	113
78	2.9.7.9	All India: compound growth rates of area, production, and yield of principal crops(Jowar)	114

79	2.9.7.10	All India: compound growth rates of area, production, and yield of principal crops(CG.nut)	114
80	2.9.7.11	All India: compound growth rates of area, production, and yield of principal crops(Cotton)	115
81	2.9.7.12	All India: compound growth rates of area, production, and yield of principal crops(Sugarcane)	115
82	2.10.1	All India index numbers of area, production, and yield of principal crops <u>Compound growth rates* of all India index numbers</u> of area, production, and yield of principal crops	117
84	2.11.1	All India index numbers of net area sown, cropping intensity, cropping pattern and productivity per hectare of the net area sown	119
85	2.12.1	Average annual rainfall in India and selected states	123
86	2.13.1	Per capita water availability by region, selected countries	125
87	3.2.1	Labour absorption for major crops in selected states	140
88	3.3.1	Crop-Wise labour absorption in Indian Agriculture	142
89	3.4.1	Value if inputs in Indian Agriculture sector	144
90	3.4.2	Compound growth rates of value of inputs in Indian agriculture sector	146
91	3.5.1	Value of agriculture output and inputs in Indian agriculture	148
92	3.6.1	Total number of cultivators and agricultural labourers	150
93	3.6.2	Compound growth rates of total number of cultivators and agricultural labourers	152
94	3.7.1	Total number of cattle and buffaloes(d. Power) used for work only	154
95	3.7.2	Compound growth rates of total number of cattle and buffaloes(Cd. power) used for work only	155
96	3.8.1	Consumer price index numbers for agricultural labourers-general index	157
97	3.9.1	Index numbers of whole sale prices of different agriculture related commodities	160-161
98	4.1.1	An overall view of trends in agricultural inputs	175-176
99	4.1.2	Compound growth rates of agricultural inputs	175-176
100	4.2.1	Farm mechanization in Indian agriculture	180-181
101	4.3.1	Total number of agricultural machinery and implements in India and selected states, 1966/67	183
102	4.3.2	Total number of agricultural machinery and implements in India and selected states, 1971/72	186
103	4.3.3	Total number of agricultural machinery and implements in India and selected states, 1976/77	187
104	4.3.4	Total number of agricultural machinery and implements in India and selected states, 1981/82	188
105	4.3.5	Total number of agricultural machinery and implements in India and selected states, 1986/87	189
106	4.3.6	Total number of agricultural machinery and implements in India and selected states, 1991/92	190
			191

107	5.1.1	Area under HYVs of food grains - all India	205
108	5.1.2	Compound growth rates of area under HYVs of food grains	206
109	5.2.1	Area under high yielding varieties of rice	207
111	5.2.2	Compound growth rates of area under HYVs of rice	208
112	5.2.3	Area under HYVs of Wheat	209
113	5.2.4	Compound growth rates of area under HYVs of Wheat	210
114	5.2.5	Area under HYVs of Jowar	211
115	5.2.6	Compound growth rates of area under HYVs of jowar	212
116	5.3.1	Quantity of plant nutrients received from soil by K removals relative to N and P/Mt of yield production for different crops under field conditions in India	213
117	5.3.2		214
118	5.4.1	Fertilizer consumption in Indian agriculture	216
119		Fertiliser consumption in selected states and all India	218
	5.5.1		
120		Compound growth rates of fertilizer consumption in selected states and all India	219
	5.5.2		
121		Per hectare consumption of fertilizers in Indian agriculture	220
	5.6.1		
122		Total pesticides consumption in Indian agriculture	223
	5.7.1		
123		Compound growth rates of total pesticides consumption in Indian agriculture	224
	5.7.2		
124		Energy inputs per hectare of rice, Sacramento Valley, California	236
	6.0.1		
125		Equivalents of direct and indirect sources of energy	240
	6.1.1		
126	6.2.1	Power utilization in Indian agriculture	242
127	6.3.1.1	Average energy requirements under principal crops in Indian agriculture	244
128	6.4.1	Estimated total energy consumption under principal crops in Andhra Pradesh	247
129	6.4.2	Estimated total energy consumption under principal crops in Bihar	248
130	6.4.3	Estimated total energy consumption under principal crops in Punjab	249
131	6.4.4	Estimated total energy consumption under principal crops in Tamil Nadu	251
132	6.4.5	Estimated total energy consumption under principal crops in Uttar Pradesh	252
133	6.4.6	Estimated total energy consumption under principal crops in West Bengal	253
134	6.4.7	Estimated total energy consumption under principal crops in All India	254
135	6.4.8	Compound growth rates of estimated total energy consumption under principal crops in A.P	255
136	6.4.9	Compound growth rates of estimated total energy consumption under principal crops in Bihar	256
137	6.4.10	Compound growth rates of estimated total energy consumption under principal crops in Punjab	257
138	6.4.11	Compound growth rates of estimated total energy consumption under principal crops in T.Nadu	258
139	6.4.12	Compound growth rates of estimated total energy consumption under principal crops in U. P	259
140	6.4.13	Compound growth rates of estimated total energy consumption under principal crops in W.Bengal	260

141	6.4.14	Compound growth rates of estimated total energy consumption under principal crops in All India	261
142	6.5.1	Energy intensities under principal crops in A. P	263
143	6.5.2	Energy intensities under principal crops in Bihar	264
144	6.5.3	Energy intensities under principal crops in Punjab	265
145	6.5.4	Energy intensities under principal crops in Tamil Nadu	266
146	6.5.5	Energy intensities under principal crops in Uttar Pradesh	267
147	6.5.6	Energy intensities under principal crops in West Bengal	267
148	6.5.7	Energy intensities under principal crops in All India	268

LIST OF ABBREVIATIONS

1. FYM	• Farm Yard Manure
2. GIA	■ Gross Irrigated Area
3. GCA	• Gross Cropped Area
4. G. J	• Giga Jouls
5. ha, he, hec	■ hectare
6. Kg	• Kilogram
7. Kw	- Kilo watt
8. Kwh	■ Kilo watt hour
9. MJ	■ Mega Jouls
10. A. P	■ Andhra Pradesh
11. U. P	■ Uttar Pradesh
12. Rs	■ Rupees
13. T. t	■ Thousand Tonns
14. LMJ	■ Lakh Mega -Jouls
15. T. he	■ Thousand Hectares
16. NIA	• Net Irrigated Area
17. NSA	■ Net Sown Area

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION:

Energy is a basic requirement of human life, agriculture, industry, transportation, communication and all other economic activities of the present civilization. As far as India is concerned, agriculture constitutes the foundation of socio-economic structure, where seventy percent of the population is engaged in activities related to crop-animal-aqua production, processing and marketing.

Man derives his energy from the food he eats. An average Indian lives on a diet of 2000 food calories (unit of food calorie = 1000 units of calorie or 1 food calorie = 1kcal), and produces 60 watts of power when he works for 8 hours a day. Thus he generates energy roughly equal to 0.5 kwh. At a rate of Rs. 5/day/man, this amounts to a cost of Rs. 10 per kwh for heaved energy. A human being is an expensive source of energy. It is better to use him to organize, manage, steer, direct and govern rather than as a energy source.

Energy is both the fuel and the feed stock for agriculture. Primary energy is the fuel, solar energy is the feed stock material. Both are essential and indispensable for the efficient and optimal utilisation of energy in industrialised and commercialised agriculture which is evidenced from the Inclusion

of it. In many non-agricultural sources **Widely differing** proposals have been made for **changes** in agricultural policy in response to the **energy-related** concerns. Controversy **exists over** the correctness and **feasibility** of many of these proposals. It is of extreme importance, therefore, that the energetic relationships of agricultural systems have been known and understood. We must be able to correctly identify and measure the flow of energy **in** the system comparing crop and livestock **production**, food processing, distribution and preparation. We **call** such activities as **agricultural energetics**.

In recent years, the introduction and spread of modern technology have brought about a substantial **increase** in agricultural productivity in India. But the gains of such increased productivity are said to have been shared unevenly by various factors of production and **administrative** regions. There was evidence from different studies that there is some degree of growing inequality in factor shares in agricultural production. However, since most of these studies did not have any systematic data base over time and **space**, the **results** reported remained largely **inconclusive**. Besides, there were noticeable changes in factor use **in** farm production in the **late** seventies. But the nature, extent and impact of such changes at the macro level have not thus far been explored.

The share of capital **in** the total cost should increase and that of labour and **land** should decline with the advance in the level of agricultural technology. The impact of technology, which is generally **land-substituting**, on the share of land may be partly

nullified due to relatively faster **increase in the value of land** as compared to other category of factors mainly because of its scarcity, investment of capital in it and increase in its **productivity**. The share of labour would **decline** because both wage rate and the use of labour has been increasing at a much slower rate vis-a-vis other factors of production. Within a region a technologically advanced crop would have a lower share of land and labour and a higher share of **capital** as compared to other crops. Under homogeneous agro-climate conditions, the share of factors for a crop are not expected to **differ much among the regions**. Based on these observations the following main objectives have been identified for this study. The study emphasizes the importance of energy in the agricultural activities for the period identified generally with Post Green Revolution. As identified in the literature, the **classification of Green Revolution period** showed variation depends on the individual researcher is concerned. It is also noticed that, there are three classifications for Green Revolution, those reflects, **pree-Green Revolution, Green Revolution, and Post-Green Revolution**. But the present study has considered the time period from 1966/67 to 1991/92, so that **title of the thesis may looks slight different** from other studies.

1.1 GREEN-REVOLUTION AND CHANGING SCENARIO OF INDIAN AGRICULTURE!

Since the early day's of '**green revolution**' signs of cropping pattern imbalances were visible. **Technological** changes of mid-sixties caused significant area shifts in favour of crops like wheat and rice at the cost of area under coarse cereals, pulses and oil seeds. This shift was the combined effect of **differential**

rates of **technological** change among crops, irrigation bias of new technology causing shift of area out of dry crops **into irrigated ones**, and the encouragement policy of price support as well as market intervention for some crops but not for other **around, by the Government**. This brought distortions in cropping pattern in the form of relatively abundant supply of some crops (**like wheat of which the Government had surplus stocks**) and acute shortage of others **like pulses and edible oils which had to be imported at huge cost in terms of foreign exchange**). These changes in cropping pattern were **determined** by factors **like, agro-climatic conditions, technology, infrastructure, institutional environment, and profitability**.

The single most important **element** in crop production strategy in the post-green revolution period is the **improvement** in agricultural technology consisting of high yielding **plant varieties**, intensive cultivation, greater use of fertilizers, increased irrigation and better **techniques** for ploughing, harvesting and plant protection. It has been noticed that even though High Yielding Varieties have been developed for a number of crops but their impact on production, productivity and costs varies across crops and regions.

The level of cropping intensity is determined by several factors. The **most** important factor is the **availability** of water from natural (**rainfall**) and or **man-made** resources (**irrigation**). However, the scope for year round cropping activities in most states of India is severely constrained by the seasonal distribution of rainfall. To the extent this natural constraints

is relaxed by developing irrigation facilities, the level of multiple cropping improves. The flexibility in selecting appropriate cropping pattern is also enhanced when irrigation facilities such as make water made available in a controllable form to the farmers throughout the year. It would, therefore, be reasonable to hypothesize that a greater part of inter-state, or inter regional disparity in the level of cropping intensity could be due to the disparity in the pattern of development of irrigation facilities, both in qualitative and in quantitative terms. In general the level of cropping intensity is higher in the regions with higher percentage of net sown area irrigated and with higher intensity of land use with irrigation (CGIA/NIA). However, it is futile to expect a one-to-one correspondent between irrigation and cropping intensity.

The other crucial variable that determine the level of cropping intensity is the availability of labour. The characteristics of the Indian agriculture based on land size holding India suggest that labour availability is an important determinant. The various farm management studies carried out in India showed that as the average size of holding increases, the average family size increases but not in the same proportion. As a result, percapita land goes up and population density declines with an increase in the holding size. In other words, an inverse relationship is established between cropping intensity and holding size. With modernization of agriculture, this relationship is undergoing changes. Tractorization and other labour-saving mechanical devices have altered the picture.

There are several other factors but generally **speaking**, **there** are basically three factors that determine the level of cropping **intensity**. Those are: CO Supply of energy in the form of human labour, animal labour and mechanical devices, **(ii)** supply of water in the form of rainfall or irrigation and **its** distribution over the crop year, and **(iii)** the physical limits imposed by the adopted cropping **pattern**, on the duration of cropping activities, during the crop year. The above discussion is indicative of **the** changes in cropping pattern, and cropping intensity which will put more pressure on energy demand in the form of human, **bullock**, mechanical and fertilizers and pesticides.

The area under paddy and wheat has continuously increased in many states at the cost of coarse cereals, millets, pulses, and cotton. As stated earlier, the **reason** for **this** growth is technological support, price support, **infrastructure** support including markets and irrigation, subsistence **requirements**, lesser price and yield risk are well known. The adverse **effects** of this development are: serious influence on the cropping pattern, widened regional **disparities**, increased instability in production and unplanned imports of **commodities**.

To remedy the situation, the elements of the green revolution strategy have to be reexamined and set right. This study will discuss the process as **discussed** in **this** study **should include**: breeding high yielding varieties of seeds, disease, pest, drought and flood resistance varieties of **all** crops, particularly coarse cereals, millets, pulses and **oil** seeds, exploiting the **untapped**

potential (mostly dry land areas) and raising the economic potential of fertilizer use development and management of irrigation facilities, market experience and product diversification, land development and farming comprehensive price policy integrating products by products, input and markets (including international).

The higher the cropping pattern index, the higher will be the agricultural productivity. This result is important in deciding how far high-yielding food grain technology, along with fertilizer and irrigation, needs to be pushed in comparison with growing more of high value crops in order to increase agricultural productivity in different regions. It appears that marginal manipulations in the cropping pattern in region can increase agricultural productivity significantly even if fertilizer and irrigation use remain unchanged. The extension of machinery can play a big role in tapping the comparative advantage of different regions.

1.2 CLASSIFICATION OF ENERGY SOURCES:

According to the *Indian Council of Agriculture Research*, energy sources in agriculture sector can be classified as follows. On the basis of source, the energy sources can be classified as direct and indirect energy.

Direct sources of energy: The direct sources of energy are those which release the energy directly like human labour, bullock, stationery and mobile mechanical or electric power units, such as diesel engines, electric motors, power tillers and tractors. The

direct energy may be further classified as renewable and non-renewable sources of energy depending upon their nature of replenishment.

Renewable Direct Sources of Energy: In this category, the energy sources which are direct in nature but can be substantially replaced, are grouped. The energetics that may fall in this group are human energy, animal, solar and wind energy, fuel wood, biomass, and agricultural wastes.

Non-Renewable Direct Sources of Energy: In this category, the direct energy sources which are not renewable (at least in near future say next 100 years) are classified. Coal and petroleum products (hydrocarbon deposits!) will come under non-renewable direct sources of energy.

Indirect Sources of Energy: The indirect sources of energy are those which do not release energy directly but release it by conversion process. Some energy is invested in producing indirect sources of energy. Seeds, manures (FYM), chemical fertilizers, and machinery can be classified under indirect sources of energy. Again, on the basis of their replenishment, these can be further classified into renewable and non-renewable indirect sources of energy.

Renewable Indirect Sources of Energy: Seed and manures can be termed as renewable indirect sources of energy as those can be replenished in due course of time.

Non-Renewable Indirect Sources of Energy: The energy sources which are not **replenishable** comes under **non-renewable indirect** sources of energy. For **example, Chemicals,** fertilizers and **manufacturing** machinery are the non-renewable indirect sources of energy.

1.3 CONVERSION OF ENERGY SOURCES INTO A UNIFORM MEASUREMENT:

To account for the total consumption of energy in agricultural sector by different **sources** one can look through different conversion process. All the energy sources can be **converted** in to a single measure to estimate energy demand under selected crops. According to *ICAR (1988)*, the conversion of energy sources were analyzed as stated in the **following** manner.

Human energy can be measured in the form of man-hour, which was equal to 1.96 Giga Joules. Woman **power is measured** in woman hour i.e 1.57 Giga Joules. Where as bullock power measured in pair-hour, was equal to 10.10 Giga Joules. However **diesel** and petrol energy was accounted in liter i.e 56.31 and 48.33 Giga Joules(**per liter**). **Electricity** measured in Kw-hour, was around 11.93 Giga Joules. **Prime** movers other than electric motors were measured in kgs i.e equal to 64.80 Giga Joules. Farm machinery energy measured in Kgs, which equals to 62.70 Giga Joules.

Nitrogen fertilizers energy can be accounted in Kgs i.e equal to 60.60 Giga Joules. Where as **phosphate** and **potassium** energy is measured in Kgs i.e 11.10 and 6.70 Giga Joules. Energy **component** in paddy measured as Kgs i.e 14.77 Giga Joules. **Next** comes to the **straw**, which accounted in Kgs, was equals to 12.50 Giga Joules of

energy equivalent. On the basis of this conversion rate, energy consumption per hectare under different crops were estimated and analyzed in the preceding sections. Among all the sources prime movers was accounted higher energy equivalent. next to farm machinery, nitrogen, diesel, petrol, and electricity respectively.

1.4 OBJECTIVES:

- CO. To examine the inter state variations in cropping pattern and cropping intensity.
- (2). To find the trends in factor shares and substitution possibilities over a period of time in Indian agriculture.
- (3). To identify the nature- and intensity of mechanization in Indian agriculture.
- (4). To examine the extent of fertilizer and pesticide demand in Indian agriculture.
- (5). To estimate the spatial energy demand variations and energy intensities for selected crops across the states.
- (6) To establish a relation that quantifies the impact of various factor inputs, including energy, on the agricultural output across states and by selected crops. Also to estimate the demand for energy in agriculture depending upon agricultural output and other factors.

1.5 DATA BASE:

For the purpose of the present study the period 1966-67 to 1991-92 is chosen, Keeping in view the availability of published data. The data is based on the survey undertaken with every five year intervals, namely 1966-67, 1971-72, 1976-77, 1981-82, 1986-87 and 1991-92 respectively. For some of the other important indicators like, crop wise energy demand, such as human, bullock, farm yard manure, seed, diesel, electricity, mechanical, fertilizers, and pesticides data is collected from different published, unpublished, and project works.

The study also collected secondary data from publications like Statistical Abstract of selected states, Statistical Abstract of India, Fertilizer statistics, pesticide statistics, ICAR publications, Indian agriculture in Brief, Indian Labour Statistics, Statistical compendium, Indian live stock census and CMIE reports etc. The published data is supplemented by primary data, available from other different studies, where ever necessary. Much amount of data used in this study has taken mainly from DESAg Govt. of Indian and CMIE reports. Because DESAg is collecting data for every five years, that why some important inputs are not available for every year, so that the data from CMIE is also used in this study. On this reason the present study has concentrated on cross section data. Even though the study is considered the time period from 1966/67 to 1991/92, in some chapters data analysis was also under taken for other time periods, to get clarity in the subject matter is concerned.

1.6 HYPOTHESIS TO BE TESTED:

In order to identify the causal relation between Energy demand and Agricultural Production in the presence of other inputs, the following hypothesis has been **established**. The **hypothesis** can talk about the cause and effect **relation** between dependent and independent variable, such as Energy and **Agricultural** production. The present hypothesis has formed on the **basis** of available **literature** in the **subject matter** is concerned. As highlighted in several **studies** that, "*there is direct relationship between energy demand and agricultural production*", Which reflects when more and more energy used there should be greater agricultural production. It shows there is a positive relation between energy and agricultural production. This can be tested in the **process** of **present** study, with respect to selected crops and states.

1.7 METHODOLOGY:

The **units** of measurement used in **this** study are: Area under **crop** in thousand hectares, output in thousand **tonns**, **yield** rate in kgs for each crop, labour **input** measured in physical **units(lakhs)**, drought power in thousands, iron and wooden ploughs, sugarcane crushers, pump **sets**, and tractors measured in physical units, fertilizers and **pesticides** in lakh and **thousands tonns**, energy consumption in **Mega Joules**, anti **rainfall** in millimeters. **Cobb-Douglas** production funn.t.ion has been applied for **estimating** the inter input **substitution possibilities** in the production of total output for selected crops in India as well as **six** major

agriculture producing states. The derived demand function (inverse) for energy was also estimated to identify the role of energy in agriculture production.

This study examined 6 principal crops namely rice, wheat, Jowar, groundnut, cotton and sugarcane, that are produced in selected states in India. The states are Andhra Pradesh, Bihar, Punjab, Tamil Nadu, Uttar Pradesh, and West Bengal. The selection of states for the present study has been under taken on the basis of the available resource endowments and institutional setup which may reflects the nature of agriculture, and also expecting the wide variations on those states. For example, West Bengal and Bihar states resembles traditional nature of agriculture, where as Punjab and Uttar pradesh in the sense of modern agriculture, and Andhra Pradesh and Tamil Nadu reflects mixed features. At the same time even though the study considered six principal crops for crop wise comparison, in some states one or two crops are almost neglected in production.

The main inputs considered here are area under crop(land), labour, draught power, agricultural machinery and implements (capital) such as iron and wooden ploughs, sugarcane crushers (run by bullocks as well as power), pumpsets(diesel as well as electric),and tractors, fertilizers, pesticides, energy and rain fall. Total production under crops in India along with 6 major states has been taken directly from published source. Labour input was measured in number of workers engaged in agriculture sector for each state over the period under consideration. The data on this variable refers to 1961, 1971, 1981 and 1991 census

with respect to India and **different** states. Draught power was accounted by considering the total number of cattle and buffaloes used for work **in** agriculture in India and selected states.

Agricultural machinery and implements such as wooden and iron ploughs, sugarcane crushers, **oil** and electric **pumpsets**, and tractors were measured in number of equipment engaged **in** agriculture **sector** in whole India and **selected** states.

In case of **fertilizers**, the total consumption of fertilizers in **India**, as **well** as different states has been **considered for** the purpose of analysis. Regarding pesticides, total consumption with respect to **different** states and whole India was **considered**.

With Regard to energy, the **source wise** energy consumption for selected crops was considered. Here human, bullock, FYM, and seeds were treated as renewable forms of **energy**, where **as diesel**, **electricity**, mechanical and **fertilizers** as non-renewable forms of energy sources. Total energy consumption under each crop **was** used to estimate the total energy consumption **with** respect to different states and whole India.

Rainfall data, was **measured** by the **average** rainfall in different states over the period under consideration.

1.8 NATURE OF THE PRESENT STUDY:

The present study has been divided **into** 7 chapters. The first chapter can talk about the general introduction of the existing

problem, and other methodological aspects. In chapter 3 the emphasis is on the cropping pattern and cropping intensity, along with the data analysis undertaken for some important issues such as profiles of selected states, factors affecting growth performance, area irrigated by different source, net state domestic product (from agriculture), economics of crop cultivation, potential yields of HYVs, Index numbers of area, production, and yield, Index numbers of net area sown, cropping intensity, cropping pattern, and productivity, average annual rainfall, and percapita water availability etc.

The third chapter concentrates on explaining the factors shares in Indian agriculture, labour absorption under different crops, value of agricultural inputs and outputs, total cultivators and labourers, draught power, index numbers of agricultural labourers, and Index numbers of whole sale prices of different agricultural commodities and inputs.

The nature of mechanization in Indian agriculture with respect to selected states was examined in the chapter 4. This chapter provides an overall view of trends in agricultural inputs, general nature of farm mechanization in Indian agriculture etc.

Chapter five focuses upon fertilizer and pesticides consumption in Indian agriculture with respect to the selected states. This chapter also analyses the area under HYVs of rice, wheat, and jowar, the quantity of plant nutrients received from the soil, and per hectare consumption of fertilizers etc.

The chapter 6 has been discusses the core problem of energy demand and energy intensities, with other aspects like, conversion of various energy sources. power utilisation in agriculture, average energy consumption, and regression equations for selected crops and selected states (Output and energy demand equations). In the final chapter 7, summary of entire study is presented along with policy recommendations. The limitations of the study were also highlighted at the end of the chapter.

1.9 SUMMARY:

On the basis of above highlighted reasons, the energy is a important input in modern agriculture in order to produce more amount of output. One should be aware of the role of energy in Indian agriculture with respect to adoption of modern technology, which reflect the capitalistic feature of Indian agriculture since Post Green Revolution.

It is recapitulated from the earlier discussion, that the use of energy intensive inputs has increased, in Indian agriculture with the spread of Green Revolution technology. Further, future has cautioned that the capacity to produce enough food for the existing population in 2000 years, will depend on its efforts to provide energy-intensive inputs such as fertilizers, pesticides, and irrigation facilities.

Finally, another most important priority area of research is to under take studies on alternative farming systems in their entirety by incorporating the analysis of energy intensities, resource endowments, and management skills in farming which

reflect the **development** of agriculture sector. It has **been generally** identified that, there is a direct **relationship** between energy input and energy **output(food)** in agriculture production. To maintain **this**, unless some thing is done at macro level, soon the agriculture sector **will** be in the grip of a severe energy **demand** crisis. In the preceding **chapters**, the **chapter 8** deals with the nature of cropping pattern and cropping **intensity** in Indian **agriculture and selected** states. Along **with** this some other relevant **issues** are also analyzed.

CHAPTER 2

CROPPING PATTERN AND CROPPING INTENSITY IN INDIAN AGRICULTURE

2.0 INTRODUCTION:

Since the early day's of 'Green Revolution' there are signs of imbalance in cropping pattern. Technological changes of mid-sixties caused significant shifts, in land utilisation, in favour of crops like wheat and rice at the cost of area under coarse cereals, pulses and oil seeds. This shift was the combined effect of differential rates of technological change among crops, irrigation bias of new technology causing shift, of land away from dry crops in favour of irrigated crops and the associated policy of price support system as well as market intervention by the Government for certain crops. Distortions in cropping pattern were reflected in relatively abundant supply of the same crops (like wheat of which the Government had surplus stocks) and acute shortage of others (like pulses and edible oils which had to be imported at huge cost in terms of foreign exchange). Changes in cropping pattern is determined by factors like agro-climatic conditions, technological, infrastructural and institutional environment and profitability signals.

The single most important element in crop production strategy in the post-green revolution period is improved agricultural technology. This technology is in the form of high yielding plant varieties, intensive cultivation, greater use of fertilizers,

increased irrigation and better techniques for ploughing, harvesting and plant protection. High yielding varieties have been developed for a number of crops but their impact on production, productivity and costs varies across crops and regions.

The level of cropping intensity is determined by several factors. The most important factor is the availability of water from natural (rainfall) and or man-made resources (irrigation). However, the scope for year round cropping activities in most states of India are severely constrained by the seasonal distribution of rainfall. So long as this natural constraints is relaxed, by developing irrigation facilities, the level of multiple cropping improves. The flexibility in selecting appropriate crop pattern is also enhanced when irrigation facilities make water available in a controllable manner farm to the farmers throughout the year. It would, therefore, be reasonable to hypothesise that a greater part of inter-state, or inter regional disparity in the level of cropping intensity could be due to the disparity in the pattern of development of irrigation facilities, both in qualitatively and quantitatively. In general the level of cropping intensity is higher in the regions with higher percentage of net sown area irrigated and with higher intensity of land use by irrigation (GFA/NIA). However, it is futile to expect a one-to-one correspondence between irrigation and cropping intensity.

The other crucial variable that determines the level of cropping intensity is the availability of labour. The

characteristics of the farms according to holding size in India suggest that labour availability is an important determinant. The various farm management studies carried out in India showed that as the average size of holding increases, the average family size increases but not in the same proportion. As a result, land percapita will goes up and population density declines with an increase in the holding size. In other words, an inverse relationship is established between cropping intensity and holding size. With modernization of agriculture. Currently this relationship is undergoing changes. Tractorization and other labour-saving mechanical devices have altered this picture. Several other factors can also be listed, but generally speaking, there are basically three factors that determine the level of cropping intensity.

Firstly, Supply of energy in the form of human labour, animal labour and mechanical devices, secondly, supply of water in the form of rainfall or irrigation and its distribution over the crop year, and thirdly the physical limits imposed by the adopted cropping pattern on the duration of cropping activities during a particular crop year. The above discussion is indicative of the changes in cropping pattern. Cropping intensity will put more pressure on energy demand in the form of human, bullock, mechanical and fertilizers and pesticides. In this regard one can concentrate the existing literature available with respect to cropping pattern and cropping intensity.

One of the interesting study in this regard is by **Mruthyunjaya and Praduman Kumar(1989)**, who **extensively** worked on cropping pattern changes in Indian agriculture, to examine the changes in **input** use, **productivity**, cost of production, **profitability** and employment in crops. He identified and explained the cropping pattern changes, by suggesting ways and means for controlling the imbalance in the cropping **pattern** and thereby widening the base for crop production in **India**.

The changes in cropping pattern in various states in India has been examined by collecting data on area, **production**, and yield of **principal** crops. The **Directorate** of **Economics** and Statistics, Government of India carried over a survey in **regular** intervals of **five** years, related to crop **input**, output, cost of cultivation of principal **crops** in India.

The main findings from this study can be summarised as follows: **area** under paddy and wheat has **continuously** increased in many states at the cost of coarse cereals, millets, pulses, and in **some**, areas, **cotton**. The reason for this **growth**, viz. , technological support, price support, **infrastructural** support including markets and irrigation, subsistence **requirements**, lesser price and yield risk, are **well** known. The **important** cost to the society as a part of this development is the serious influence on cropping pattern, increased regional disparities, **increased** **instability** in production, and resulted in unplanned imports of **commodities**.

To remedy the situation, the elements of the green revolution strategy have to be reexamined. The process, as discussed in this study, should include breeding the disease, pest, drought and flood resistance high yielding varieties of all crops particularly attention to coarse cereals, millets, pulses and oil seeds. There is a need for exploiting the untapped potential (mostly dry land areas) and raising the economic potential (create awareness) of fertilizer use. It is also important to improve management of irrigation facilities, market experience and product diversification, land development and farming comprehensive price policy integrating products by products, input and markets (including international).

. B. D. (1989), did analytical work on sources of irrigation and cropping pattern. He considered the improvement of crop output through the process of a more shift in irrigation resource from more heavily irrigated to light-irrigated crops. Interest in this subject of investigation is heightened by the harsh fact that irrigation endowment is much more limited than the endowment of arable land.

The investigation was based on data in respect of eleven major irrigation projects for which information on crop yields and irrigation requirements is available. This data base is some what nearer to the actual farm position prevailing in the first half of the eighties, in the canal commands of the major irrigation works.

The main observation in this study are that, in Northern India the combination of sugar cane verses paddy or wheat showed that, with ground water as the source of irrigation, the productivity differential in favor of sugar cane signified an advantage in energy use also. Given the scarcity of energy resources like diesel oil and electric power that are now extensively used in lifting ground water in north India, the energy conservation angle of sugar cane vis-a-vis paddy or wheat combination merits in overall development planning.

Where as in deccan plateau, the results showed that, in this water-short region, coarse grain, pulses and oil seeds are mainly grown under dry conditions. In the absence of irrigation, the yields of this crops are low and highly variable over time. While irrigation raises their yields, the yield and income gains are modest compared to irrigation yields of crops like sugar cane etc.

In case of western India the results indicated that, among the kharif crops, 'guar' and ground nut revealed substantially higher water productivity than for bajra, paddy and cotton. Among the rabi crops, wheat has perceptibly high productivity of water than gram.

The results relating to Eastern India showed that, the land productivity of paddy is much higher than that of wheat, but water productivity of wheat is greater. From the view point of productivity per unit of land as well as per unit of irrigation potato is an attractive proposition for the rabi season.

Another interesting study in this context is by *Venkataramanan.L.S and Prahladachar(1980)* He analysed the growth rates in area, yield and output of major crops in six states, viz., Punjab(Including Haryana), Rajasthan, Uttar Pradesh. Bihar. Maharashtra and Andhra Pradesh for the period 1950-51 to 1974-75 and **examined** the impact of growth rates of crops on cropping pattern in these states. This study also attempted, through 'decomposition method', to study the area, yield and cropping pattern effects on crop output growth in these states in the **period under the reference.**

At First the rates of growth in individual crops is related to the changes in cropping pattern, then the attempts to offer a plausible explanation for the? macro state level changes in the cropping pattern witnessed in the six states during the reference period. Secondly, it suggested a method of measuring the 'aggregate' change in the cropping pattern of a state in terms of 'substitution' and 'expansion' effects by comparing the area growth rates of individual crops with the corresponding growth rate in gross cropped area.

The main findings of this study are the following: **The** relative acreage under food grains and non-food grains in the **Punjab remained** stationary over the period 1950-75, but the relative shares of wheat and rice among food grains and that of cotton among non-food grains improved. **The** favorable factors for their growth, either singly or Jointly, were the use of HYVs,

fertilizers and irrigation. Unlike in Punjab, in Rajasthan the share of food grain crops in the gross cropped area, bajra in particular, increased considerably. This development in Rajasthan unmistakably reflects the increase of subsistence agriculture and the growing disparity in farming conditions and farm incomes between states like Punjab and Rajasthan. The main changes in the cropping pattern that occurred in Andhra Pradesh during the period 1950-75 were the improvements in the relative shares of paddy, maize and sugar cane (the latter two crops however occupied small shares in the gross cropped area). Yield increase and/or the spread of irrigation were the main contributing factors for area growth, and consequently for the growth of output.

Ranade, C. G. (1980), analysed effect of cropping pattern along with fertilizer and irrigation upon agricultural production. This study examined the effect of these factors upon agricultural output per hectare across 54 agroclimatic regions covering 16 major states for the pre-green revolution period from 1962 to 1965 and then for the post-green revolution period from 1970 to 1973.

The results of this study showed that, comparison between Northern Punjab and Coastal Northern Tamil Nadu, for 1970-73, shows that even though the percent irrigated land was higher in the former region (73.62 %) than in the latter region (61.66 %), the agricultural production per hectare (productivity) was higher in the latter region (Rs. 20303) than in the former (Rs. 1067). At the same time, the cropping pattern index was higher in Coastal Northern Tamilnadu (126.4) than in Northern Punjab (119.5). The

fertilizer use was less in Coastal Northern Tamil Nadu than that in Northern Punjab. In Orissa, although the cropping pattern index is higher than that in Punjab, the agricultural productivity is much low and so are the fertilizer use and irrigation too.

In this study the regression results show that higher the cropping pattern index, the higher will be the agricultural productivity. This result is important in deciding how far high-yielding food grain technology, along with fertilizer and irrigation, needs to be pushed in comparison with growing more of high value crops in order to increase agricultural productivity in different regions. It appears that marginal manipulations in the cropping pattern in region can increase agricultural productivity significantly even if the use of fertilizer and irrigation remain unchanged. The extension machinery can play a big role in tapping the comparative advantage of different regions.

One of the pioneering study by Gulati. A and Sharma. P. critically examines various studies on cropping pattern changes, direct and indirect employment intensity of different crops as well as their environmental effects etc. A cropping pattern which is oriented towards these objectives is defined as desirable cropping pattern.

The analysis suggests that studying cropping pattern changes purely from demand/supply point of view could lead to adoption of a crop mix which has high economic cost. Pursuit of self-sufficiency in all commodities regardless of economic cost

need to be reexamined. On the employment front, the study admits that direct impact of movement of cropping pattern towards more labour using crops may be rather limited (especially in relation to area and yield effects). It indicates that domestic incentive structure is more favorable to wheat, rice, oil seeds and sugar cane.

Mann. S. P. (1989), who examined the impact of Green Revolution programme in Indian agriculture by using two models, namely the logit model for the adoption of HYV wheat seeds and the second model is the linear regression model to estimate the percentage of land under HYV wheat for its users.

The data used in this study was based on the NCAER's, Additional Rural Income survey conducted for a period of three years during 1968-71. According to this study, the proportion of land, the availability of land irrigated, and the availability of tractors on hire in the village are highly significant variables in all the cases except for the IAAP districts for the adoption of HYV seeds of wheat. The proportion of land irrigated is also highly significant, explaining the proportion of land under HYV wheat, in all estimates of the linear regression model. Land owned was significant, with a negative sign, in two of the three estimates of the linear regression model, indicating that small farmers devoted higher percentage of their lands to HYV wheat. It is observed from the empirical results that irrigation is one of the most significant factors affecting the adoption of HYV seeds.

Chadha. G.K and Sharma. R. K(1982), as examined whether the Green Revolution has any relationship with farm size cropping intensity in Indian agriculture. The study examines the relationship separately for each of the 318 districts of India, spread over almost all states. The 1970/71 agricultural census reports for various states has been used extensively for this analysis.

As per the results it is interesting to note that an almost conclusive evidence emerges in favor of the inverse relationship in a green revolution areas such as the Punjab and Haryana. The small farmers in these districts have lost their traditional edge of higher cropping intensity. This study also examined the cropping intensity on irrigated as well as on unirrigated area. Among the irrigated areas, a majority of districts suggested an inverse relationship, but there is a large percentage of districts showing a positive or neutral relationship. In some districts, an improved irrigation structure seems to have promoted higher cropping intensity on irrigated areas of large farms, while for many others, the inverse relationship persists in spite of a positive correlation between farm size and improved irrigation base. It means that in spite of a technological disadvantage in the matter of improved irrigation facilities, the marginal and small farmers continue to cultivate their lands more intensively over a large part of Indian agriculture. In summary it appears that an assured and flexible year round supply of their family labour continues to play a critical role in increasing cropping intensity. Perhaps, their family labour will continue to play this

role in future as well.

Mahendra Dev. S(1989), has analysed the variations in cropping intensity in Indian Agriculture. The main objectives of this study were to examine the factors influencing (a) the regional variations in cropping intensity at different time points since the early sixties and (b) the temporal variations in cropping intensity for selected districts in Andhra Pradesh, Maharashtra and Tamil Nadu. The data used for this study is taken from National Sample Surveys.

The results showed that, based on the pooled cross-section regression with the explanatory variables like cropping intensity on normal rainfall, percentage irrigation and tractorization. The results reveal that the first two variables seem to be important in explaining the inter-state and inter-regional variations in cropping intensity. With the introduction of intensity of land use with irrigation (GIA/NIAD) variable in place of tractorization, irrigation variables became dominated in explaining inter-regional variations in cropping intensity. The estimates based on time-series data for selected districts also reveals the importance of irrigation. In particular the intensity of land use with irrigation on cropping intensity differs from district to district. This study suggests the policy side aspect also where in the emphasis on the agricultural development strategy in India was more on raising the yield of any particular crop per unit of land rather than increasing the total output per unit of land from all crops grown in a year.

Another interesting study is by *Sharma, J.L(1990)*, who examined the inter-state disparities in agricultural growth in India. The main objectives of this study are: to examine the inter-state disparities in agricultural growth, and to identify the factors responsible for these disparities. The data for the study was obtained from Statistical Abstract of India, covering the period 1966-67 to 1987-88.

The main conclusions of this study are that, size of holding is the basic factor affecting the structure of agriculture and there exists vast disparities across states in India. The states with higher agricultural growth rates were having relatively higher average size of holding except Uttar Pradesh. Punjab and Haryana states, which are the center of agricultural growth in India, have the highest proportion of cultivated area under irrigation. In Orissa, Madhya Pradesh, Bihar and Kerala the use of fertilizers were less than the national average. These were the states which have recorded low growth rates in food grains production. Further, the irrigation facilities were also lower in these states compared to all-India level.

Regarding tractorization the analysis showed that, Punjab, Haryana and Uttar Pradesh have the highest intensity of tractorization compared to other states. The growth rates in food grains production along with the cropping intensity in each state indicate that the states with higher agriculture growth rates were also having higher intensity of cropping. A look at the percentage

area irrigated and percent area under high yielding varieties of cereals indicates that these two variables are closely linked.

2.1 PROFILES OF SELECTED STATES AND WHOLE OF INDIA:

This section will talk about the general profiles (indicators) of selected states and overall India. The performance of agricultural development has been taking place in each state depending upon the availability of resources. However, the relative index of development across the states is not uniform due to various institutional and resource constraints. It has observed from the table E.1.1, the relative index of development is very high in case of Punjab, which has 199, compared to other states and whole of India. Next comes Tamil Nadu, Andhra Pradesh, West Bengal, Uttar Pradesh, and Bihar consisting of 135, 99, 97, 72 and 43 respectively.

It is a clear indication that, the states which have tremendous development in agriculture scene were showing relatively higher development index, while compared with agriculturally less development states. In case of population growth, while the population is increasing at 2.14 % per annum in all India level, with respect to states, U.P showing 2.29 %, Tamil Nadu and Punjab noticing 1.40 % and 1.86 % respectively. This is also a clear indication that, the states which have higher development index were showing lesser population growth. However, from the theories it is known that lesser population with more agricultural growth does lead to economic progress.

Table 2.1.1

PROFILES OF SELECTED STATES AND WHOLE INDI AC 1993)

States	A. P	Bihar	Punjab	T.Nadu	U. P	W. Bengal	ALL India	
Indicators	Unit							
Relative Index of development		99	43	199	135	72	97	100
Population growth	X	2.17	P. 13	1.86	1.40	2.29	2.22	2.14
Population Density	No's	241.81	496	402	429	472	767	274
Workers as X of Total Pop.	X	47.05	32.16	30.87	43.81	32.20	32.19	37.46
Workers in Ag. & Allied	X	70.38	81.10	56.07	61.51	72.92	55.71	66.92
Net Sown Area as of reporting Area	X	38.00	44.43	83.39	43.65	57.78	fi0.37	46.30
Gross Irrigated Area, X of Gross Cropped Area	X	35.85	36.31	91.01	47.51	50.68	23.93	30.72
Average size of holding	her	1.72	0.87	3.77	1.01	0.93	0.92	1.69
Fertilizer Consumption	Kgs	131	58	177	124	90	95	72
Value of Output Major crops								
Per hectare	Rs	4392	3017	6856	6622	4502	5139	3576
Percapital	Rs	799	368	2420	809	813	603	758
Percapital Food grain Production	Kgs	150	118	827	124	220	152	173
Percapital Bank Credit to Agriculture	Rs	338	110	599	365	159	SO	222
Per hectare Bank Credit to Agriculture	Rs	1858	903	1696	2985	877	765	1046

Source: CMIE: Profiles of Districts, November, 1993.

Regarding the density of population, West Bengal having highest density of population i.e 767 per square kilometer, and Bihar, U.P, Tamil Nadu, and Punjab comes next with 476, 472, 429, and 402 respectively. Labour force is increasing at the rate of 37.46 % in all India level, with respect to states, Andhra Pradesh noticed highest i.e 47.65 X. Punjab experiencing less growth 30.87 % per annum. The participation of workers in agriculture and allied activities consists 66.92 % in all India level as compared with 81.10 V. highest in Bihar, next U.P, A.P, Tamil Nadu, Punjab, and West Bengal having 72.92 %, 70.31%, 56.07 % and 53.71 X respectively.

However, the net sown area as of total reporting area, is 46.30 % in all India level as against to 83.39 V. in Punjab, 63.37 %, 57.78 %, 44.43 %, 43.65 % and 38.00 % in West Bengal. U.P, Bihar, Tamil Nadu, and Andhra Pradesh respectively. Punjab is showing highest(83.39 %) in case of net sown area, where as A.P recorded lowest i.e 38.00 %. In case of gross irrigated area to percentage of gross cropped area it is 30.72 % in all India level as against 91.01 % in Punjab. 50.68 %, 47.51 %, 36.31 %, 35.85 %, and 23.93 % in case of U.P, Tamil Nadu. Bihar, A.P. and West Bengal respectively. Punjab recorded highest percentage of gross irrigated area as against lowest percent reported in West Bengal.

Meanwhile, it is important to notice that the size of the holding is differing from one state to another state due to institutional set up existed in these states. Contrary to this, the average size of holding in all India level is around 1.69, and

highest in case of Punjab 3.77 following by 1.72, 1.01, 0.93, 0.92, and 0.87 in A.P., Tamil Nadu, U.P., West Bengal, and Bihar respectively.

Fertilizer consumption also differs from state to state, which is a cause for yield difference as well as regional imbalances in agricultural production and development. The per hectare consumption of fertilizers at all India level is around 72 kg/he, as against highest consumption of 177 kg/he noticed in Punjab, next followed by 131, 124, 95, 90, and 58 in A.P., Tamil Nadu, West Bengal, U.P., and Bihar respectively.

Value of output per hectare under major crops were showing significant difference from state to state. At all India level it is Rs. 3576, whereas it is Rs. 6856 in Punjab, Rs. 5139 in Tamil Nadu, and Rs. 4502, Rs. 4392, Rs. 3017 in West Bengal, U.P., A.P., and Bihar. The Per capita value of output under major crops also differs from state to state. In case of all India, which accounts for Rs. 758, the highest Rs. 2420 is in Punjab, Rs. 813, Rs. 809, Rs. 799, Rs. 603, and Rs. 368 in U.P., Tamil Nadu, A.P., West Bengal and Bihar respectively.

Per capita food grain production is around 173 Kgs in all India level as against 827 Kgs in Punjab, and 220, 152, 150, 124, and 118 Kgs in U.P., West Bengal, A.P., Tamil Nadu and Bihar. Among all the states Bihar is showing lowest production (per capita), while comparing with highest in Punjab.

Regarding financial flows in India's agricultural sector there is variation over the respective states. The per capita bank credit is Rs.222 in all India level, highest i.e Rs.599 in Punjab, Rs.365, Rs.338, Rs.189, Rs.110, and Rs.90 in Tamil Nadu, A.P, U. P. Bihar, and West Bengal. Contrary to this the per hectare bank credit to agriculture is Rs.1046 in all India, where as it is highest in Tamil Nadu i.e Rs.2985, followed by Rs.1858, Rs.1696, Rs.903, Rs.877, and Rs.765 in A. P. Punjab, Bihar, U. P. and West Bengal respectively. Here Tamil Nadu noticed highest per hectare bank credit in agricultural production as against to lowest in West Bengal.

2.2 FACTORS AFFECTING GROWTH PERFORMANCE IN SELECTED STATES AND ALL INDIA:

There are several factors that influence growth performance in Indian agriculture across the states. This can be traced especially from Green Revolution in Indian Agriculture. Because Green Revolution itself will demand larger amount of inputs in production process. But all the states which concerned are not in a position to provide the necessary factors at larger extent. Due to this reason the disparities are over velling in different states.

Sharma. J. L(1990), who did analytical work on factors affecting agricultural growth, observed that, difference in average size of holding, intensity of cropping, percentage area under HYVs, percentage area irrigated to total cultivated area, fertilizer use

per **hectare**, and credit **availability** are the some important factors which explain regional **disparities**.

As shown in table 2.2.1, the **average** size of holding **1.82** hectare in all India level which compares with Punjab having the highest of **3.79**, and **0.94** being lowest in West Bengal. The intensity of cropping differing **122 %** in all India level as comparing with states, **165 %** in Punjab, **143 %**, **120 %**, **116 %**, **116**

Table 2.2.1

FACTORS AFFECTING GROWTH PERFORMANCE IN SELECTED STATES OF INDIA (1983/84).

Item	A. P	Bihar	Punjab	T.Nadu	U. P	W.Bengal	All India
Average size of holding(ha)1981.	1.87	0.99	3.79	1.07	1.01	0.94	1.82
Intensity of cropping(%)	116	116	165	115	143	126	122
Percentage area under HYVs of cereals	55.8	57.1	93.5	74.0	56.7	40.3	51.3
Percentage area irrigated to total cultivated area	22.9	28.1	84.5	42.9	57.4	33.0	28.2
Fertilizer use in Kg. per cropped area(ha)	75.0	35.9	151.2	100.0	65.1	54.8	46.3
Intensity of Tractors (No. per 1000 ha)	3.82	5.54	57.76	5.24	12.98	1.28	7.33
pesticides use in kg/ha	0.7	0.3	0.6	0.2	0.3	0.2	0.3
Credit availability	147	50	307	245	99	54	113

Source: Sharma, J.L. (1990)

%, and **115 %** in U. P. West Bengal, A. P. Bihar, and Tamil Nadu respectively. Intensity of cropping is always dependent up on the availability of irrigation facilities. Percentage area under HYVs seeds also one of the important factor which influenced growth performance in different states.

Percentage area under HYVs is 51.3 % at all India level, Among the states it is 93.5 % in case of Punjab, 74 %, 37.1 %, 56.7 %, 55.8 %, and 40.3 % in case of Tamil Nadu, Bihar, U. P, A. P, and West Bengal respectively. Contrary to this the percentage area under irrigation is around 28.2 % in all India level which compares highest 84.5 % in Punjab, followed by 57.4 %, 42.9 %, 33.6 %, 28.1 %, and 22.9 % in U. P, Tamil Nadu, West Bengal, Bihar, and Andhra Pradesh respectively. The highest irrigated area is noticed in Punjab and lowest Andhra Pradesh.

Regarding, fertilizer consumption, all India level recorded 46.3 Kgs per hectare where as in states, 151.7. Kg/hect in Punjab, next 100.0, 75.0, 65.1, 54.8, and 35.9 kg/hect in Tamil Nadu, A. P. U. P, West Bengal and Bihar respectively. Intensity of tractors were also another important factor which largely influenced the growth performance and regional disparities in different states. The intensity of tractors per 1000 hectares is 7.33 in all India level. 57.76 in Punjab, Where as it is 12.98, 5.54, 5.24, 3.82, 1.28 in U. P. Bihar, Tamil Nadu, A. P, and West Bengal respectively. Pesticide consumption was also noticed variation such as 0.3 Kg/hect in all India level, where as 0.7 in A. P. 0.6, 0.3, 0.3, 0.2, and 0.2 in Punjab, U. P, Bihar, Tamil Nadu, West Bengal respectively.

Credit availability is another important factor in present agriculture production, where the farmer is facing substantial input burden in production process. Credit availability is much more needed in recent years to come across the inputs burden. Capital(credit) availability differs across state, as Rs.307 highest in Punjab, 245, 147, 99, 54. and 50 in Tamil Nadu, A.P, U. P. West Bengal, and Bihar respectively. The highest credit availability(per capita) has been noticed in Punjab, where as lowest in case of Bihar.

By considering the above said factors, one must be aware of the factors which influencing growth performance in Indian Agriculture. Along with the above said factors, Energy is also one of the prime factor which influenced growth performance in agriculture, in recent years. However, one should also be aware of the unfavorable rainfall conditions in Indian agriculture, due to failure of monsoons in almost every alternative years.

2.3 AREA IRRIGATED BY DIFFERENT SOURCES IN INDIAN AGRICULTURE:

Irrigation is one of the important device in modern agriculture, where the HYVs seeds are well implemented, will demand large amount of water resources. In recent years, the irrigation is affected a lot due to unfavorable rainfall conditions. The area under irrigation is changing continuously.time. This sub section will examine the sources available for irrigation and analyse how the irrigated area changing from one source to another.

The table 2.3.1 illustrate the area irrigated by different sources in Indian agriculture. The irrigated area under Government Canals was around 9170 thousand hectares in 1960/61, which increased to 15853 Thousand hectares in 1985/86, later declined to 14990 thousand hectares in 1987/88. In percentage terms 34.2 % in 1960/61, which increased to 36.3 % in 1985/86, latter declined to 34.8 % in 1987/88 respectively. The area under private canals noticed 1200 thousand hectares in 1960/61, which has been continuously rip) ined to 484 thousand hectares in 1987/88, which is equal to 4.9 % in 1960/61 and 1.1 % in 1987/88.

Table 2.3.1
AREA IRRIGATED BY SOURCES (1960/61 TO 1987/88)
(Thousand Hectares)

Year	1960/61	1970/71	1980/81	1985/86	1986/87	
Source						
Government canals	9170 (34.2)	11972 (38.53)	14450 (37.3)	15853 <36.6)	15548 (36.6)	14990 C34.83
Private canals	1200 (4.93)	866 (2.83)	842 (2.2)	464 (1.2)	479 C1.13	484 (1.1)
Tanks	4561 (18.53)	4112 (13.2)	3182 (8.23)	3049 (7.2)	2965 (7.03)	2806 (6.53)
Tube Wells	135 (0.6)	4461 (14.33)	9531 (24.6)	11866 C28.23	12275 (28.93)	13156 (30.63)
Other Wells	7155 C29.0)	7426 (23.93)	8164 (21.1)	8676 (20.6)	8552 (20.1)	8661 (20.1)
Other sources	2440 (9.83)	2266 (7.3)	2551 (6.63)	2809 (6.2)	2667 (6.33)	2951 (6.9)
Total CNet irrigated area.	24661 (100)	31103 (100)	38720 (100)	42079 (100)	42486 (100)	43040 (100)

Source: Indian Agriculture in Brief, 24th edition, DESAg. Govt. of India.

The area under Tanks, was around 4561 thousand hectares in 1960/61, which declined to 2806 thousand hectares in 1987/88, which equals to 18.5 % in 1960/61, that has further declined to 6.5 % in 1987/88. On the other hand the area irrigated under tube wells has increased tremendously from 138 thousand hectares in 1960/61 to 13156 thousand hectares in 1987/88, which is equivalent to 0.6 % in 1960/61 to 30.6 % in 1987/88. Contrary to this the area under other wells also increased notably from 7155 thousand hectares in 1960/61 to 8661 thousand hectares in 1987/88, which is equal to in percentage terms 29.0 % in 1960/61, and later declined to 20.1 % in 1987/88. The area irrigated by other sources was around 2440 thousand hectares in 1960/61 and 2951 thousand in 1987/88, in percentage terms it was 9.8 % in 1960/61 and fall to 6.9 % in 1987/88. On the whole the total net irrigated area was accounted nearly 24661 thousand hectares in 1960/61, has increased to 43040 thousand hectares in 1987/88 respectively.

The compound growth rates of area irrigated by different sources, is shown in table 2.3.2. In case of Government canals the area increased at the rate of 2.70 % per annum in 1970/71, which further experienced negative growth rates of - 3.59 % by 1987/88. Where as the area under private canals experienced negative growth rates i.e -3.21 % in 1970/71, which showed further improvement in 1985/86 with 11.24 %, and later declined to 1.05 % in 1987/88. Interestingly the area under tanks noticed negative growth rate i.e -1.03 % in 1970/71 to -5.36 % in 1987/88.

The area under tube wells increased at the rate of 41.88 % in 1970/71 to a decline trend of 7.18 % by 1987/88. The area under other wells increased at the rate of 0.37 % in 1970/71 to 1.28 % in 1987/88. The area under other sources was noticed negative growth rates i.e -0.74 % in 1970/71 to -10.65 % in 1987/88. The overall growth rates of net irrigated area was around 2.35 % in 1970/71. It later declined at the rate of 1.31 % per annum in 1987/88.

Table 2.3.2

COMPOUND GROWTH RATES OF AREA IRRIGATED BY SOURCES (1960/61 TO 1987/88)

(Thousand Hectares)

Year	1960/61	1970/71	1980/81	1985/86	1986/87	1987/88
Source						
Government canals		2.70	1.90	1.87	-1.92	-3.59
Private canals		-3.21	-0.28	11.24	3.23	1.05
Tanks		-1.03	-2.53	-0.85	-2.76	-5.36
Tube Wells		41.88	7.89	4.48	3.45	7.18
Other Wells		0.37	0.95	1.22	-1.43	1.28
Other sources		-0.74	1.19	0.45	2.22	10.65
Total (Net irrigated area)		2.35	2.21	1.68	0.96	1.31

Source: Indian Agriculture in Brief, 24th edition, DESAg Govt. of India.

The above analysis indicates that, the area under canals has been slightly declining, where as the area under tube wells and other wells was increasing drastically. This is a clear indication that, the pressure on Energy sources such as Diesel and Electricity is increasing at faster rate. This is one of the important highlighting feature of Indian irrigation system and Indian agriculture environment. Due to this, the demand for energy is increasing continuously, especially from 1966 on wards, when the Green Revolution Programme was implemented in Indian agriculture. At the same time the area under rain fed was fluctuating, due to unfavorable rainfall conditions.

2.4 ALL INDIA CULTIVATED AND IRRIGATED AREA- GROSS AND NET WITH CROPPING INTENSITY:

Land utilisation for agricultural purpose is one of the important controversial issue since Independence, due to its availability and contribution to the agricultural growth. As identified by different Researchers, the area under agriculture was continuously varying from time to time due to various reasons. One of the important factor is Rainfall fluctuations and second adoption of modern agricultural technology which has been influencing the cropped area under cultivation. In consideration to this, this, the present section will look at the nature of cultivated and irrigated area-gross and net with cropping intensity.

Table 2.4.1 illustrate the all India cultivated and irrigated area with cropping intensity from 1966/67 to 1991/92. The gross area sown was around 1573S5 thousand hectares in 1966/67, which has been increased to 177042 thousand hectares in 1981/82, later declined slightly in 1986/87, further increased to 181236 thousand

Table 2.4.1

ALL INDIA CULTIVATED AND IRRIGATED AREA - GROSS AND NET- WITH CROPPING INTENSITY.

Year / Item	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Area Sown						
Gross	1573S5	165194	167340	177042	176656	181236
	(--)	CO. 98)	(0.26)	(1.13)	(-0.04)	CO. 51)
Net ('000 ha)	137232	140040	139460	142003	140020	146235
	(--)	CO. 41)	CO.00)	(0.36)	(-0.28)	CO. 87)
More than once	20123	25154	27880	35039	36636	35001
	(--)	(4.57)	(2.08)	C 4.68)	CO. 90)	(-0.91)
Area irrigated						
Gross	32683	38431	43552	51554	55690	62171
	(--)	(3.29)	(2.53)	(3.43)	(1.56)	(2.22)
Net ('000 ha)	26907	31546	35147	39924	42486	45326
	(--)	(3.23)	C2.19)	(2.58)	(1.25)	(1.30)
More than once	5776	6885	8405	11630	13204	16485
	(--)	(3.57)	C 4.07)	(6.71)	(2.57)	C 4.54)
Gross area under HYVs	1886	18173	33560	46493	56174	62385
	(--)	(57.32)	(13.05)	(6.74)	(3.85)	(2.12)
Share of GIA to GSA	20.8	23.3	26.0	29.1	31.5	34.3
	(--)	(2.30)	(2.22)	(2.28)	(1.60)	(1.84)
Increase(+)/Decrease						
GSA	1.3	-0.4	- 2.3	2.6	-1.2	2.8
GIA (CX)	5.8	0.6	0.4	3.3	1.9	2.0
Cropping Intensity	114.7	118.0	120.0	124.7	126.2	123.9
	(--)	(0.57)	(0.34)	(0.77)	CO. 24)	(-0.37)

Source: Fertilizer Statistics, **FAI**, 1991, 1992 and 1993.

(). Figures in the brackets indicates compound growth rates.

hectares in 1991/92 respectively. Contrary to this the net sown area was 132232 thousand hectares in 1966/67, which raised to 142003 thousand hectares in 1981/82, and slightly declined to 140020 thousand hectares in 1986/87, further increased to 146235 thousand hectares in 1991/92. The area sown more than once was 20123 thousand hectares in 1966/67, this has gone up to 36636 thousand hectares in 1986/87, later it has declined to 35001 thousand hectares in 1991/92 respectively.

However . the gross area irrigated was noticed to be 32683 thousand hectares 1966/67, which has increased to 62171 thousand hectares in 1991/92. Net area irrigated was around 26907 thousand hectares in 1966/67, which has later increased to 45326 thousand hectares in 1991/92. On the other hand, the area irrigated more than once was 5776 thousand hectares in 1966/67, which further increased to 16485 thousand hectares in 1991/92. The gross area under HYVs was around 1886 thousand hectares in 1966/67, later it increased to 62385 thousand hectares in 1991/92. This drastic increase in area under HYVs clearly indicates the pressure on agricultural inputs such as Land, labour, fertilizers, pesticides, water, and machinery etc. This will leads to more demand on energy resources in agriculture sector.

Interestingly the share of gross irrigated area to gross sown area has been increased drastically i.e 20.8 % in 1966/67, which raised to 34.3 % in 1991/92. This is showing a positive land contribution in agricultural production. As stated in the table that, the percentage increase or decrease of gross sown area and

gross irrigated area was nearly 1.3 and 5.8 in 1986/87, which declined to 2.8 and 2.0 in 1991/92 respectively.

Mean while the cropping intensity was around 114.7 in 1966/67, has increased to 126.2 in 1986/87, but declined to 123.9 in 1991/92. Here the major indication is that fluctuations in water availability is influencing the cropping intensity.

Contrary to this, the compound growth rates were showing interesting features i.e gross sown area was increased at the rate of 0.98 % per annum in 1971/72, later increased at the rate of 1.13 % in 1981/82. The negative growth rate was showed in 1986/87 i.e -0.04 percent per annum. Net area sown has Increased at the rate of 0.41 % in 1971/72, but noticed negative growth rates i.e -0.28 in 1986/87. The area sown more than once was increased at the rate of 4.57 % in 1971/72, later declined to 2.08 % in 1976/77, and increased to 4.68 % per annum in 1981/82. Negative growth rate was experienced i.e -0.91 % in 1991/92.

Gross and net irrigated area raised at the rate of 3.29 % and 3.53 % per annum in 1971/72. Later it has declined i.e 2.22 and 1.30 % in 1991/92. The area irrigated more than once noticed at the rate of 3.57 % per annum in 1971/72, was gone up to 6.75 % in 1986/87, later declined to 4.54 % in 1991/92 respectively. Area under HYVs seeds recorded at the rate of 57.32 % in 1971/72, has further increased at a decreasing rate at 2.12 % per annum in 1991/92. On the other hand the share of gross irrigated area to gross sown area witnessed 2.30 % growth per annum in 1971/72. It

was drastically declined to 1.84 % per annum in 1991/92.

Cropping intensity has raised at the rate of 0.57 % in 1971/72, later declined to 0.34 % per annum in 1976/77. Further it has been increased at 0.72 % per annum in 1981/82, where as negative growth of -0.37 % was experienced in 1991/92 respectively.

2.5 NET STATE DOMESTIC PRODUCT (FROM AGRICULTURE) AT FACTOR COST BY INDUSTRY OF ORIGINAL CURRENT PRICES:

The net contribution of agriculture sector to the national economy is very much essential for countries like India, where 70 % of the rural population depending on agriculture sector, by contributing nearly 40 % of the national income. Countries economic growth naturally depends up on the performance of agriculture sector. In this section, an analytical work has been done to trace out the role of agriculture sector to increase in the growth performance in India.

The table 2.5.1 illustrates the Net State Domestic Production from agriculture in all India and selected states from 1966/67 to 1991/92. Net state domestic product from agriculture in Andhra Pradesh was recorded 103481 lakhs in 1966/67, which is increased to 331527 lakhs in 1991/92, as equivalent to 9.06 % in 1966/67 to 6.97 % in 1991/92. Where as in case of Bihar it was around 71500 lakhs in 1966/67, later increased to 701358 lakhs in 1991/92, which is equal to 6.23 % in 1966/67 and 9.19 % in 1991/92 respectively.

Table 2.5.1
NET STATE DOMESTIC PRODUCT (FROM AGRICULTURE) AT FACTOR COST BY
INDUSTRY OF ORIGIN (AT CURRENT PRICES)
CRs. lakhs)

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh	103481 C 9.065	150022 (8.875)	185363 (7.03)	395427 (9.335)	491737 (8.10)	531527 (6.975)
Bihar	71500 (6.23)	131109 (7.75)	213692 C 8.115	300518 (7.09)	643368 (10.60)	701358 C 9.19
Punjab	568// C 4.985	87710 (5.19)	158663 (6.02)	227572 C 5.375	384912 (6.245)	431251 (5.655)
Tamil Nadu	75242 C 6.585	105879 (6.26)	138993 (5.275)	186830 (4.41)	228686 (3.375)	301207 (3.955)
Uttar Pradesh	220142 (19.275)	252758 (14.95)	432212 C 1 ft. 40	629722 C 14.85	983198 (16.19)	1011213 (13.255)
West Bengal	91900 (8.045)	145324 (8.59)	223539 C 8.485	302120 (7.135)	617015 (10.165)	812275 (10.145)
All India (Rs. crores)	11421 (100.05)	16913 (100.05)	26357 (100.05)	42394 C 100.0	60721 (100.0)	76313 (100.0)

Source: H. L. Chandhok and Policy Group: Indian Data Base, The Economy, Volume 1, 1990.
CSO, National Accounts Statistics (New Series 5, 1992).

Interestingly in case of Punjab, it was 56877 lakhs in 1966/67, later gone up to 431251 lakhs in 1991/92, which is equal to 4.78 % in 1966/67 to 8.65 % in 1991/92. Tamil Nadu experienced declining trend in agriculture contribution i.e. 75242 lakhs in 1966/67, which has later increased to 301207 lakhs in 1991x92, it is equivalent to a declining share of 6.58 % in 1966/67 to 3.95 % in 1991/92 resp

Uttar Pradesh accounted 220142 lakhs in 1966X67, which has increased to 1011213 lakhs in 1991/92, an equivalent of 19.27 % in 1966/67, later declined to 13.25 % in 1991X92. West Bengal

experienced notable change i.e Rs. 91900 lakhs in 1966/67, has further increased to Rs. 812275 lakhs in 1991/92, which is almost equivalent to 8.04 % in 1966/67 to 10.14 V. in 1991/92. Overall contribution in all India level i.e Rs. 11421 crores in 1966/67, was further raised up to Rs. 76313 crores in 1991/92 respectively.

However, compound growth rates show that, net domestic product (from agriculture) accounted in Andhra Pradesh at the rate of 7.71 V. per annum in 1971/72, which has increased at a declining

Table 2.S.2

COMPOUND GROWTH RATES OF NET STATE DOMESTIC PRODUCT (FROM AGRICULTURE) AT FACTOR COST BY INDUSTRY OF ORIGIN AT CURRENT PRICES)

(CRs. lakhs)

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh		7.71	4.32	14.51	6.14	1.57
Bihar		12.89	10.26	7.06	16.44	1.74
Punjab		9.08	12.59	7.48	11.08	2.30
Tamil Nadu		7.07	5.59	6.09	4.12	5.66
Uttar Pradesh		2.80	11.33	7.82	9.32	0.56
West Bengal		9.60	8.89	6.21	15.34	5.65
All India (Rs. crores)		0.65	9.28	9.97	7.45	4.6ft

Source: H.L. Chandhok and Policy Group: Indian Data Base, The Economy, Volume 1, 1990. CSO, National Accounts Statistics (New Series), 1992.

rate i.e 1.57 % in 1991/92. Where as in case of Bihar, it was around 12.89 % per annum in 1971/72, slowly the growth rate has come down to 1.74 % in 1991/92. On the other hand the growth rates are also showing fluctuations in Punjab, which witnessed 9.05 % in 1971/72, was later declined to 2.70 % in 1991/92 respectively.

Tamil Nadu showed, 7.07 % in 1971/72, was leveled at 5.66 % in 1991/92. Contrary to this U. P showing volatile growth performance i.e 2.80 % in 1971/72, which has later increased at decreasing rate of 0.56 % in 1991/92. West Bengal has noticed increased growth rates of 9.60 % in 1971/72, which increased at 5.65 % growth per annum in 1991/92. On the other hand the all India picture is quite clear where the overall growth was 0.65 % per annum in 1971/72, has increased to 9.97 % in 1981/82, and later come down to 4.68 % in 1991/92 respectively.

On the whole it was observed that, the net state domestic production from agriculture is showing fluctuations over a time due to several causes. It may be due to declining area under irrigation, unfavorable monsoons and changes in cropping pattern, and cropping intensity etc. It was observed that, the year 1991/92 showed declining growth rates not only in whole India but also in almost all the states. This can be further examined in view of agricultural growth and development.

2.6 ECONOMICS OF CROPS CULTIVATION IN SELECTED STATES:

In modern agriculture, especially the late 70's scenario showed that, cost incurred in agriculture is very much high as compared to before. The cost of production is increasing at a faster rate, due to application of HYVs seeds in Indian agriculture, which demands greater level of agricultural inputs. An impressive study is by *Mruthyunjaya and Praduman Kumar(1989)*, who observed the cost of cultivation from crop to crop and with respect to different states over a period of time. They have taken the time period from 1972 to 1983. Based on this study, the table 2.6.1 illustrates the economics of crops cultivation under selected crops across the states.

Firstly, in Andhra Pradesh, paddy cultivation is showing interesting picture, i.e fertilizers demand per hectare noticed around 96.00 Kg/hect, and yield accounts 37.06 quintal per hectare, where as the real cost of production, rate of profit, average net income, labour absorption, and irrigation accounts 46.71 Rs/Quintal, 17.80 %, 474 Rs/hectare, 1051 man days/hectare, and Rs. 54 per/hectare respectively. On the other hand Jowar consuming negligible amount of fertilizers i.e 4.00 Kgs per hectare, yield was 3.11 quintal/hectare, where as real cost of production, rate of profit, average net income, labour absorption and irrigation accounts 86.54 Rs/Q, 12.00 %, 67 Rs/he, 349 man days/he and 2 Rs/hect respectively.

Table 2.6.1
ECONOMIC ANALYSIS OF CROPS IN DIFFERENT STATES OF INDIA 1972/83.

State	Crop	Fertilizer (N+P+O) Kg/ha	Yield (Q/ha)	Real cost of Production (Rs/Q)	Rate of profit X	Average net income Rs/ha	Labour Empt. (Han day/' ha)	Irriga tion
A. P	Rice	96.00	37.06	46.71	17.80	474	1051	54
	Jowar	4.00	3.17	86.54	12.00	67	349	2
	S. cane	299.00	777.00	708.00	35.30	3204	3278	617
	Cotton	110.00	12.72	171.89	15.10	535	1049	44
Bihar	Rice	22.00	21.47	58.49	4.00	85	786	13
	Wheat	55.00	20.70	79.18	19.20	528	660	93
	S. cane	32.00	409.00	6.75	51.20	2595	865	63
Pun- Jab	Rice	144.00	47.67	33.64	69.20	2272	808	340
	Wheat	113.00	25.50	51.19	16.20	422	441	119
	Cotton	49.00	10.40	131.64	43.80	856	852	60
Tamil Nadu	Rice	106.00	40.01	39.74	33.20	975	1202	88
	Jowar	4.00	8.42	54.29	- 0.15	- 218	522	67
	S. cane	237.00	683.00	4.37	22.50	2075	2739	623
	6. nut S.	OO	10.30	98.28	10.40	172	761	51
U. P	Cotton	72.00	8.69	180.82	22.10	706	1282	203
	Rice	36.00	21.20	51.19	11.60	251	818	66
	Wheat	65.00	24.51	51.82	11.40	692	610	171
West Bengal	S. cane	48.00	402.00	4.17	87.50	3479	1097	250
	Rice	21.00	26.30	34.12	32.00	628	591	10

Source: **Mruthyunjaya** and Praduman **Kumar(1989)**.

In case of Sugar cane, the fertilizer consumption was 299.00 Kg/he and yield rate recorded 777.00 Q/he, and real cost of production, rate of profit, average net income, labour absorption and irrigation comes to 708.00, 35.30, 3204, 3278, and 617 Rs/he. Cotton crop consuming 110.00 Kgs/he fertilizer and yield 32.72 Q/he, where as real cost of production , rate of profit, average net income, labour absorption, and irrigation consists, 171.89, 15.10, 535, 1049, and 44 respectively.

Here the interesting feature is that. Sugar cane demanding higher rate of fertilizers, as comparing with other crops, next comes to yield per hectare, real cost of production, rate of profit, average net income, labour absorption, and irrigation are also high in sugar cane. On the other hand Jowar consumed, low amounts of fertilizers, yield, real cost of production, rate of profit, average net income, labour employment, and irrigation. It was observed that labour employment can be improved by cultivating more of sugar cane. And the state scenario is showing that, for farmers point of view sugar cane cultivation is more profitable , next comes to cotton, rice, and Jowar respectively.

With respect to Bihar, in case of rice, fertilizer consumption noticed. 22.00 kg/he, and yield potential recorded 21.47 Q/he, and real cost of production, rate of profit, average net income, labour absorption, and irrigation accounts, 58.49, 4.00, 85, 786, and 13 Rs/he. Wheat is consuming 55.0 kg/he of fertilizers, and 20.70 Q/he yield, next comes to real cost of production, rate of

profit, average net income, labour absorption, and irrigation equal to 79.18, 19.20, 528, 860, and 93 Rs/he. However, still sugar cane is demanding much of fertilizers i.e 32.00 Kg/he, and yield 409.00 Q/he, also with real cost of production, rate of profit, **average net income, labour absorption, and irrigation** consists, 6.75, 51.20, 2595, 80S, and 63 Rs/he. It was noticed that, sugar cane still demanding much of labour, next comes rice. On the whole sugar cane noticed highest average net income, which also shows high rate of profit.

Punjab witnessed, 144.00 Kg/he of fertilizers in rice production, and 47.67 Q/he of yield, in addition this real cost of production, rate of profit, average net income, labour employment, and irrigation noticed 33.64, 69.20, 2272, 808, and 340 Rs/he respectively. Wheat is consuming 113.00 Kg/he of fertilizers and productivity recorded 25.50 Q/he area, next comes real cost of production, rate of profit, average net income, labour absorption, and irrigation counts to 51.19, 16.20, 422, 441, and 119 respectively. Regarding, cotton, which demands 49.00 Kg/he fertilizers and productivity accounted 10.40 Q/he area, contrary to this real cost of production, rate of profit, average net income, labour absorption, and irrigation consists, 131.64, 43.80, 856, 852, and 60 Rs/hectare. Punjab scenario showed that, rice is demanding large amount of fertilizers, and high level of average net income. Next comes to cotton, which demanding less fertilizers and noticing reasonable level of net income, by demanding more labour force.

Tamil Nadu's picture is quite clear. Rice demands 106.00 Kg/he of fertilizers and yielding 40.01 Q/he, next real cost of production, rate of profit, average net income, labour employment, and irrigation recorded, 39.74, 33.20, 975, 1202, and 88 Rs/he . Jowar demands less amount of fertilizers i.e 4.00 Kg/he, and yield 8.42 Q/he next real cost of production accounts 54.29 Rs/Q. The rate of profit and average net income noticed negative, i.e -0.15 and -218, due to several factors. Where as labour absorption accounts 522 Man days/he and irrigation accounts 67 Rs/he respectively. Sugar cane is the important crop in the state, which consuming 237.00 Kg/he of fertilizers and noticed 683.00 Q/he of yield. And real cost of production, rate of profit, average net income, labour employment, and irrigation recorded 4.37, 22.50, 2075, 2739, and 623 Rs/he respectively. Where as ground nut is demanding less fertilizers i.e 5.00 Kg/he and yield 10.30 Q/he, and next comes to real cost of production, rate of profit, average net income, labour employment, and irrigation noticed 98.28, 10.40, 172.761, and 51 Rs/he. Cotton demands 72.00 Kg/he of fertilizers and yielding 8.69 Q/he, with real cost of production, rate of profit, average net income, labour absorption, and irrigation consisting of 180.82, 22.10, 706, 1282, and 203 Rs/he respectively. This analysis shows that, sugar cane is demanding higher level of fertilizers, accounting high yield, with high average net income, and high labour absorption and irrigation, that is followed by crops like rice, cotton, and ground nut respectively.

With respect to U. P. the rice is consuming 36.00 Kg/he of fertilizers and yield rate is 21.50 Q/he, comes to the real cost of production, rate of profit, average net income, labour employment, and irrigation accounts 51.19, 11.60, 252, 818, and 65 Rs/he. In case of wheat fertilizer consumption is around 65.00 Kg/he, which accounted yield rate is 24.51. contrary to this real cost of production, rate of profit, average net income, labour employment, and irrigation recorded 51.82, 11.40, 692, 610, and 171 Rs/he. Regarding sugar cane, the fertilizer consumption accounts 48.00 Kg/he and yield rate noticed 402.00 Q/he. And real cost of production, rate of profit, average net income, labour employment, and irrigation witnessed 4.17, 87.50, 3479, 1097, and 250 respectively. In U. P overall picture is showing that, wheat demanding more fertilizers, where as sugar cane noticed high yield, average net income, labour employment, and irrigation, later comes to rice, which showed similar trend as sugar cane.

West Bengal picture is quite clear that where in rice demanding 21.00 Kg/he of fertilizers having 26.30 Q/he yield, next comes to real cost of production, rate of profit, average net income, labour employment, and irrigation consists of 34.12, 32.00, 628, 591, and 10 Rs/he respectively.

In all most all the states, sugar cane is showing higher cost of cultivation while comparing with other crops, due to high application of inputs with more operational activities. However, the employment irrigation, and average net income is also very high in case of sugar cane. But at this stage even though sugar

cane is much profitable than that of other crops, one should be aware of the availability of water **resources**, and other **input** equipment. For that alternative crops should be recommended in order to remove the shortage **problems** in inputs and **avoiding** over water use. which is scarce resource in recent years in Indian agriculture.

Due to changes in **institutional** set up in Indian **agriculture** like traditional agriculture to modern agriculture, the cropping pattern is changing **over** a period of time. Incidentally in early years, the farmer concentrated on **subsistence** crops, and later he diverted **towards** commercial crops, where **commercial** crops are more profitable than food crops. Because of this problem India still facing food **scarcity**, even though she is treated as **agriculturally** self sufficient.

Changes in cropping pattern laid a foundation stone to the several **controversial** problems such as resource crunch and **input** scarcity in Indian agriculture. At this Juncture, this section talks about the nature of cropping pattern in whole India, and selected states. And **also** emphasis cropping intensity, **which** is another chronic problem in Indian **agri culture**.

ft. 7 GENERAL FEATURES OF THE EXISTING PROBLEM:

In general the table 2.7.1 illustrate the nature of cropping pattern in Indian **agriculture**, and later sections will talks about particular changes occurred in selected crops. The area under

rice. accounts **34056** thousand hectares in **1960/61**, which was increased to **41169** thousand hectares in **1986/87**, later declined to **38944** thousand hectares in **1987/88**, as equivalent to **22.3 V.** in **1960/61** to **23.3 V.** in **1986/87**, later the share has declined to **22.5 y.** by **1987/88** respectively.

Where as wheat noticed, **12931** thousand hectares in **1960/61**, which was increased to **23372** The in **1987/88**, which is equivalent to percentage increase from **8.5 %** in **1960/61** to **13.5 %** in **1987/88**. Jowar accounted **18426** The in **1960/61**, which declined to **16523** The in **1987/88**, which is almost equal to **12.0 %** in

Table 2.7.1

CROPPING PATTERN ACCORDING TO LAND USE STATISTICS, FROM **1960/61** TO **1987/88**.

		('000' hectares) ³					
Year		1960/61	1970/71	1980/81	1985/86	1986/87	1987/88
Crop							
Rice		34056	37381	40237	41099	41 169	38944
		(22.3)	(22.6)	(23.35)	(23.05)	(23.35)	(22.55)
Wheat		12931	18293	22225	23094	23315	23372
		(8.5)	(11.05)	(12.85)	(12.95)	(13.25)	(13.55)
Jowar		18426	16871	16412	16097	16193	16523
		(12.0)	(10.2)	(9.55)	(9.05)	(9.25)	(9.65)
Groundnut		6467	7552	6789	7094	7009	7556
		(4.2)	(4.65)	(3.95)	(4.05)	(4.05)	(4.45)
Cotton		7610	7830	7752	7530	7031	7190
		(5.0)	(4.75)	(4.5)	(4.2)	(4.05)	(4.2)
Sugarcane		2417	2889	2897	3009	3202	3391
		(1.6)	(1.6)	(1.7)	(1.7)	(1.85)	(1.9)

Source: Indian Agriculture in Brief, 24th edition, DCSAg. Govt. of India.

1960/61 to **9.6 %** in **1987/88**. Regarding ground nut the level has increased from **6467** The in **1960/61** to **7552** The in **1970/71**, later

declined to 7009 T/he in 1986/87, later gone up to 7586 T/he in 1987/88 respectively. It is almost equal to 4.2 % in 1960/61, and 4.6, 4.0, and 4.4 % in 1970/71, 1986/87, and 1987/88 respectively.

Cotton crop has showed, fluctuations over a period of time. This accounts. 7610 T/he in 1960/61. raised to 7830 T/he in 1970/71. declined to 7190 T/he in 1987/88. which is nearly equal to 5.0 % in 1960/61, 4.7 % and 4.2 % in 1970/71 and 1987/88 respectively. In case of sugar cane it was 2417 T/he in 1960/61 later increased to 3391 T/he in 1987/88, an equivalent of 1.6 % in 1960/61 to 1.9 % in 1987/88 respectively.

Considering compound growth rates, as stated in table 2.7.2 area under rice accounted 0.94 % per annum in 1970/71, was later experienced negative growth rate of - 5.40 % in 1987/88. Wheat

Table 2.7.2

COMPOUND GROWTH RATES OK CROPPING PATTERN ACCORDING TO LAND USE STATISTICS, FROM 1960/61 TO 1987/88.

(000' hectares)

Year Crop	1960/61	1970/71	1980/81	1985/86	1986/87	1987/88
Rice		0.94	0.74	0.42	0.17	- 5.40
Wheat	-	3.53	1.97	0.77	0.96	0.24
Jowar		-0.88	-0.28	-0.39	0.59	2.04
Groundnut		1.56	-1.06	0.88	-1.19	7.80
Cotton		0.29	-0.10	-0.58	-6.63	2.26
Sugarcane		0.69	1.13	0.76	6.41	5.91

Source: Indian Agriculture in Brief, 24th edition, DESAg. Govt. of India.

recorded 3.53 % per annum in 1970/71, has later declined at 0.24 % per annum in 1987/88. Jowar experienced negative growth of -0.88 in 1970/71, and a positive 2.04 % in 1987/88. Next is ground nut, which noticed 1.56 % growth per annum in 1970/71, and increased at 7.80 % in 1987/88. Cotton and sugar cane have witnessed, 0.29 and 0.69 in 1970/71, which further noticed at 2.26 and 5.91 % per annum in 1987/88 respectively.

The whole scenario is showing that, the area under rice and Jowar slowly declining, where as the area under wheat and sugar cane increasing at faster rate. However, cotton and ground nut showed fluctuations over a period of time, with changing shares in overall agricultural production.

2.8 POTENTIAL YIELDS OF HYVS OF SEEDS: A COMPARATIVE PICTURE:

Yield component is one of the important concept in modern agriculture scenario, where almost all the countries in the world adopted HYVS of seeds with differential yield structure. Yield ratio has been differing from country to country with respect to different crops. So that, this section observe the yield component in selected crops not only in India but also with respect to other agriculture producing countries. The table 2.8.1 explains the comparative picture of potential yields of HYVs of seeds in Indian and some selected countries. In case of rice, the potential yields of HYVs Indian variety comes under 4000-5810 Kg/he, where as the actual India's yield is at 2807 Kg/he. Contrary to this the world's actual yield is around 5807 Kg/he. China is the largest

producer of **rice**, and Australia accounting abnormal yield **8813** respectively.

Table 2.8.1

POTENTIAL YIELDS OF HYVs OF SEEDS: A COMPARATIVE PICTURE.

Crop	Potential of high yielding Indian variety	India, s yield	Actual World's yield	yield(Kg/hect) in 1992/93 Largest producer Country	World's highest yield Country
Rice	4000 - 8810	2607	5807	China	8813 Australia
Wheat	6000 - 6800	3295	3295	China	7556 Ireland
Jowar	3000 - 4200	897	3704	USA	5949 Italy
G. nut	2000 - 3000	953	953	India	6833 Israel

Source: CMIE: Basic Statistics Relating to the Indian Economy, 1994.

With respect to **Wheat**, potential of HYVs Indian variety is around **6000-6800 Kg/he**, but the actual India yield is noticed to **be3295 Kg/he**. Meanwhile the world's actual yield was around **3295 Kg/he**. **China** is the largest producer of wheat, and Ireland noticed world's higher **abnormal** yield producing country i.e **7556 Kg/he**.

Potential of Hyv. Indian variety of Jowar, falls under **3000-4200 Kg/he**, but Indian yield noticed at **897 Kg/he** where as actual world yield accounts **3704 Kg/he**. **USA** is the largest producer of wheat in the world. Interestingly, **Italy** is the **highest** yield producing country in the **world agriculture** production. With respect to Ground nut, potential of high yielding

Indian variety falls under 2000-3000 Kg/he, where as India's actual yield recorded at 953 Kg/he. Actual world yield witnessed at 953 Kg/he, and India is the largest producer of ground nut, Where as Israel accounted highest yield i.e 6833 Kg/he. This analysis indicating that, there is a clear difference between potential yield and actual yield with respect to different crops. There are several factors which influence yield mechanism in Indian agriculture. Generally the yield component was influenced by several factors such as availability of water, fertilizers, and other inputs, especially application of inputs at efficient level, which are related to the farm management skills in production.

2.9 CROPPING PATTERN IN INDIAN AGRICULTURE WITH RESPECT TO SELECTED STATES:

Andhra pradesh noticed spectacular growth in agriculture production in recent years, with wide variation of crops in the last two decades. Cropping pattern is slowly shifting over a period of time. This section will analyse the nature of cropping pattern in selected states and all over India from 1966/67 to 1991/92 with five year intervals. Along with cropping pattern, production, and productivity(yield) will also be analysed.

2.9.1 ANDHRA PRADESH:

The nature of cropping pattern in A.P is shown in tables 2.9.1.1 to 2.9.1.6. Rice area in Andhra Pradesh was 3089 Thousand hectares in 1966/67, which increased to 3921 T/he in 1991/91, an

equivalent of 8.76 % in 1966/67 to 9.27 % in 1991/92. Along with area, production and yield was noticed, 4010 Thousand tonns and 1302 Kg/he in 1966/67, which later increased to 9465 T.t and 2414 Kg/he in 1991/92 respectively. The production is equivalent to 13.17 % in 1966/67 to 12.85 % in 1991/92 respectively. Where as Jowar noticed. 2289 T/he in 1966/67, was declined to 1075 T/he in 1991/92. which is equal to 12.68 % in 1966/67 to 8.54 % in 1991/92. On the other hand production and productivity, recorded 1080 T.t and 460 Kg/he in 1966/67 respectively. Out of which production declined to 673 T.t in 1991/92, where as productivity increased to 626 Kg/he in 1991/92. The share of production recorded at 11.71 % in 1966/67, was later declined to 8.05 % in 1991/92 respectively.

Wheat production is almost negligible in the state, i.e area was 13 T/he in 1966/67, has declined to 8 T.he in 1991/92, which is equivalent to 0.10 % in 1966/67 to 0.05 % in 1991/92. Production was at 2 T.t in 1966/67, later increased to 7 T.t in 1991/92 respectively. This is equal to 0.02 % in 1966/67 to 0.01 % in 1991/92. Considering yield rate was at, 188 Kg/he in 1966/67, later increased to 827 Kg/he in 1991/92. Next, ground nut was recorded at 1022 T/he in 1966/67, which increased to 2496 T/he in 1991/92, this is equal to 14.00 % in 1966/67 to 28.78 % in 1991/92. This has almost doubled the area of cultivation. However production noticed a level of 1013 T.t in 1966/67, which was increased to 2235 T.he in 1991/92, which is almost equal to 22.97 % in 1966/67 to 31.63 % in 1991/92. Ground nut production also noticed double the amount as comparing with previous years. With

respect to yield recorded at 721 Kg/he in 1966/67, which raised to 896 Kg/he in 1991/92 respectively.

Cotton is another important commercial crop in the state, which was at T/he in 1966/67, has later increased to 708 T/he in 1991/92, as equal to 4.03 % in 1966/67 to 9.20 % in 1991/92. Production noticed. 144 T. t in 1966/67 to 1314 T. t in 1991/92, was almost equal to 2.73 % in 1966/67 to 13.36 % in 1991/92. A four times increase in yields took place during this period namely 76 Kg/he in 1966/67 to 316 Kg/he in 1991/92. Regarding sugar cane, which recorded 155 T/he in 1966/67, increased to 203 T.he in 1991/92, or 5.00 % in 1966/67 to 5.36 in

Table 2.9.1.1

ANDHRA PRADESH : ARFA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000 tons)	Yield(Kg/ha)
1966/67	3089 C 8.763	4010 (13.173)	1302
1971/72	3041 (8.05)	4717 (10.95)	1551
1976/77	3565 (9.26)	4930 (11.76)	1383
1981/82	3824 (9.39)	7868 (14.783)	2058
1986/87	3459 (8.40)	6592 (10.89)	1906
1991/92	3921 C 9.27)	9465 (12.853)	2414

Source: CMTE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.2

ANDHRA PRADESH : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Jowar), 1966/67 to 1991/92.

Year	Area(*000 hec)	Production(*000tons)	Yield(Kg/ha)
1966/67	2289	1080	461
	f 12.685	(11.71)	
1971/72	2S32	1140	450
	(15.09)	(14.76)	
1976/77	2043	1065	521
	C 12.955	(10.125	
1981/82	2214	1334	603
	(13.34)	(10.885	
1986/87	1656	994	600
	(10.38)	(10.82)	
1991/92	1075	673	626
	C 8.54)	(8.05)	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.3

ANDHRA PRADESH : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area(*000 hec)	ProductionC *000tons)	Yield(Kg/ha)
1966/67	13	2	188
	CO. 10)	CO. 02)	
1971/72	21	11	512
	(0.115	CO. 04)	
1976/77	23	14	594
	CO.115	(0.05)	
1981/82	17	11	669
	C 0.08)	CO. 03)	
1986/87	12	5	403
	CO. 05)	CO. 01)	
1991/92	8	7	827
	CO. 05)	C 0.015	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.4
 ANDHRA PRADESH : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
 (Ground nut), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	1022 (14.00)	1013 (22.97)	721
1971/72	1533 (20.41)	1164 (18.83)	759
1976/77	1051 (14.92)	583 (11.08)	555
1981/82	1451 (19.53)	1437 (19.89)	991
1986/87	1571 (22.50)	1308 (22.263)	833
1991/92	2496 (28.78)	2235 (31.63)	896

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.5
 ANDHRA PRADESH I AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
 (Cotton), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	316 (4.03)	144 (2.73)	76
1971/72	335 (4.293)	175 (2.52)	89
1976/77	288 (4.18)	261 (4.47)	154
1981/82	473 (5.873)	663 (8.413)	238
1986/87	411 (5.92)	609 (8.82)	252
1991/92	708 (9.203)	1314 (13.363)	316

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.6
ANDHRA PRADESH : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Sugarcane), 1966/67 to 1991/92.

Year	Area(*000 hec)	Production(*000tons)	Yield(Kg/ha)
1966/67	115	8789	76588
	(5.003	C9.473	
1971/72	119	10571	88761
	C4.98)	C9.313	
1976/77	146	10281	70366
	(5.09)	(6.72)	
1981/82	180	14962	83258
	C5.64)	C8.033	
1986/87	138	10286	74645
	(4.483	(5.53)	
1991/92	203	14833	73211
	(5.363	C5.953	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

1991/92. Where as in case of production it was 8789 T.t in 1966/67, and increased to 14833 T.t in 1991/92, or from 9.47 % in 1966/67 to 5.95 % in 1991/92. In case of yield the increase is from 76588 Kg/ha in 1966/67 to 88761 Kg/ha in 1971/72, which declined to 73211 Kg/ha in 1991/92 respectively. Sugar cane yields were showing variations over a period of time. This may be due to several factors such as scarcity of water, fertilizers, and other inputs.

2.9.2 BIHAR:

In case of Bihar as illustrated in tables 2.9.2.1 to 2.9.2.1, rice area under cultivation at 5126 T/ha in 1966/67, later it declined to 4792 T/ha in 1991/92, or in percentage terms 14.54 % in

1966/67 to 11.33 % in 1991/92. Considering production, it was 4212 T.t in 1966/67 increased to 4461 T.t in 1991/92. This is equivalent to 13.84 % in 1966/67 to 5.08 % in 1991/92. With respect to yield, which was 878 Kg/he in 1966/67, later increased to 1126 Kg/he in 1980/81, slowly declined to 931 Kg/he in 1991/92 respectively. Area under jowar, almost negligible in the state which accounts. 10 T/he in 1966/67 is down to 5 T.he in 1991/92, as equal to 0.06 % in 1966/67 to 0.04 % in 1991/92. Production recorded at 6 T.t in 1966/67 to 3 T.t in 1991/92, which was almost equal to 0.07 % in 1966/67 to 0.04 % in 1991/92. In case of yield it was 497 Kg/he in 1966/67, and latter raised up to 885 Kg/he in 1986/87, but declined to 453 Kg/he in 1991/92 respectively.

However, wheat production was some what impressive in the state, the area under crop noticed 995 T/he in 1966/67, latter increased to 1963 T/he in 1991/92, which is equal to 7.75 % in 1966/67 to 8.54 % in 1991/92 respectively. The production accounted 900 T.t in 1966/67 declined to 3566 T.t in 1991/92, in percentage terms the decline is from 7.90 % in 1966/67 to 6.47 % in 1991/92. Yield rate was increased from 800 Kg/he in 1966/67 to 1816 Kg/he in 1991/92. In case of sugar cane the increase is from 108 T/he in 1966/67 to 145 T/he in 1991/92, or 4.67 % in 1966/67 to 3.83 % in 1991/92. Double fold increase in production has taken place from 3995 T.t in 1966/67 to 7076 T.t in 1991/92, which nearly equal to 4.30 % in 1966/67 to 2.84 % in 1991/92 respectively. Yield has been increased from 33475 Kg/he in 1966/67 to 48836 Kg/he in 1991/92. The improvement in the yield laid a foundation stone to the double fold production in the state.

Table 2.9.2.1

Bihar : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice),
1966/67 to 1991/92.

Year	Area(* 000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67	5126 (14.543)	4212 (13.843)	876
1971/72	5411 (14.33)	5273 (12.24)	975
1976/77	5310 (13.793)	4752 (11.34)	895
1981/82	5368 (13.19)	4257 (7.993)	793
1986X87	5368 (13.04)	6045 (9.98)	1126
1991/92	4792 (11.33)	4461 (6.06)	931

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992,
1993 and 1994.

Table 2.9.2.2

Bihar : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Jowar), 1966/67 to 1991/92.

Year	AreaC * 000 hec)	ProductionC * 000tons)	Yield(Kg/ha)
1966X67	10 CO. 06)	6 CO. 073	497
1971/72	5 C 0. 03)	2 C 0. 03)	365
1976X77	11 C 0. 07)	6 CO. 06)	509
1981/82	11 (0. 07)	7 (0. 06)	636
1986X87	6 CO. 04)	5 CO. 05)	885
1991/92	5 CO. 043	3 CO. 04)	453

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992,
1993 and 1994.

Table 2.9.2.3

Bihar : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat),
1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	995 (7.755)	900 (7.905)	800
1971/72	1397 C 7.305	2494 (9.44)	1785
1976/77	1945 (9.305)	2470 (8.515)	1270
1981/82	1640 (7.41)	2202 (5.885)	1343
1986/87	1840 (7.955)	2861 (6.455)	1555
1991/92	1963 C 8.54)	3566 C 6.475)	1816

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992,
1993 and 1994.

Table 2.9.2.4

Bihar : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
CSugarcane5, 1966/67 to 1991X92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	108 C 4.695	3995 C 4.305	33475
1971/72	142 (5.945)	4465 (3.93)	31468
1976/77	128 (4.47)	4176 C 2.735	32675
1981/82	124 (3.885)	4180 (2.235)	33822
1986/87	112 C 3.645	3729 (2.00)	33295
1991/92	145 (3.83)	7076 (2.845)	48836

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992,
1993 and 1994.

2. 9.3 PUNJAB:

The tables 2. 9. 3. 1 to P. 9. 3. 5 explains the cropping pattern in Punjab from 1966/67 to 1991/92. Rice area in Punjab noticed, an increase from 303 T/he in 1966/67 to 2074 T.he in 1991/92, or 0.86 % in 1966/67 to 4.90 % in 1991/92. Nearly seventeen times increase in production took place i.e from 414 T. t in 1966/67 to 6755 T. t in 1991/92, in percentage terms 1.3 % in 1966/67 to 9.12 % in 1991/92. A three fold increase in yield was accounted where it was 1276 Kg/he in 1966/67 gone upto 3238 Kg/he in 1991/92 respectively. A notable change was witnessed in cropped wheat area, i.e 1692 T/he in 1966/67 to 3233 T/he in 1991/92, as equal to 13.18 % in 1966/67 to 14.07 % in 1991/92. A four times increase in production took place i.e 3173 T. t in 1966/67 to 12295 T. t in 1991/92, which was equal to 27.85 % in 1966/67 to 22.32 % in 1991/92. The yield was witnessed a three time increase from 1621 Kg/he in 1966/67 raised up to 3803 Kg/he in 1991/92 respectively.

Area under ground nut has declined drastically in the state. It was 200 T/he in 1966/67 and has declined to 12 T/he in 1991/92, which is equal to 2.74 % in 1966/67 to 0.14 % in 1991/92. On the other hand production has declined from 211 T. t in 1966/67 to 12 T. t in 1991/92, which in percentage terms is 4.78 % in 1966/67 to 0.17 % in 1991/92. Yield was accounted 990 Kg/he in 1966/67 and marginally raised to 1000 Kg/he in 1991/92. The overall picture in the state indicates that, the ground nut production was drastically declining, where cereals like wheat and rice production increased at faster rate.

With respect to cotton, which accounts 390 T/he in 1966/67, was later gone up to 680 T. he in 1991/92, or 5.05 % in 1966/67 to 8.58 V. In 1991/92, A three time increase in production taken place i.e 746 T. t in 1966/67 to 2357 T. t in 1991/92. On the other hand it doubled its yield from 320 Kg/he in 1966/67 to 607 kg/he in 1991/92 respectively. The area under Sugar cane was 120 T/he in 1966/67, but declined to 109 T/he in 1991/92. Contrary to this, production increased from 4326 T. t in 1966/67 to 6920 T. t in 1991/92. A two fold increase was noticed in case of productivity i.e 32786 Kg/he in 1966/67 to 63486 Kg/he in 1991/92 respectively.

Table 2.9.3.1
Punjab s AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice),
1966/67 to 1991/92.

Year	Area(*000 hec)	Production(*000tons)	Yield(Kg/ha)
1966/67	303	404	1276
1971/72	CO. 86)	C1.333	
	450	920	2044
	(1.19)	(2.14)	
1976/77	674	1741	2583
	(1.75)	C4.15)	
1981/82	1270	3755	2957
	C3.12)	(7.05)	
1986/87	1809	6022	3329
	C4.39)	(9.943	
1991/92	2074	6755	3257
	C4.903	C9.17)	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.3.2

Punjab : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	1692	3173	1621
	(13.18)	(27.85)	
1971/72	2335	5618	2406
	(12.20)	(21.273)	
1976/77	2579	6272	2432
	(12.33)	(21.623)	
1981/82	2917	8553	2932
	(13.17)	(22.84)	
1986/87	3189	9458	2966
	(13.79)	(21.343)	
1991/92	3233	12295	3803
	(14.073)	(22.32)	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.3.3

Punjab : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Groundnut), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	200	211	990
	(2.743)	(4.78)	
1971/72	174	183	1052
	(2.32)	(2.963)	
1976/77	164	150	915
	(2.33)	(2.85)	
1981/82	92	90	978
	(1.24)	(1.25)	
1986/87	43	42	977
	(0.623)	(0.71)	
1991/92	12	12	1000
	(0.143)	(0.173)	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.3.4

Punjab : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Cotton), 1966/67 to 1991/92.

Year	Area(* 000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67	396	746	320
	(5.053)	(14.17)	
1971/72	475	1029	368
	(6.09)	(14.81)	
1976/77	557	1138	347
	C 8.09}	(19.49)	
1981/82	683	1270	316
	(8.485)	(16.11)	
1986/87	567	1691	507
	(8.16)	C 24.493	
1991/92	660	2357	607
	(8.58)	(23.96)	

Source : **CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.**

Table 2.9.3.5

Punjab : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugarcane), 1966/67 to 1991/92.

Year	Area(* 000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67	120	4326	32786
	(5.22)	C 4.663	
1971/72	103	4030	39126
	C 4.373	(3.55)	
1976/77	113	6070	53717
	(3.943)	(3.973)	
1981/82	106	6120	57736
	C 3.32)	(3.283)	
1986/87	97	6110	62590
	(3.15)	C 3.283	
1991/92	109	6920	63486
	(2.88)	(2.78)	

Source: **CMIEs Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.**

2.9.4 TAMIL NADU:

Tamil Nadu scenario is quite different in comparison with other states, as stated in tables 2.9.4.1 to 2.9.4.5, the area under rice was 2345 T/he in 1966/67, has later declined marginally to 2293 T/he in 1991/92, or from 6.66 % in 1966/67 to 5.42 % in 1991/92. Whereas production which was at 4002 T. t in 1966/67 has increased to 5928 T. t in 1991/92, equal to 13.15 % in 1966/67 to 18.05 % in 1991/92. On the other hand yield recorded 1498 Kg/he in 1966/67, has gone up to 2586 Kg/he in 1991/92 respectively. Jowar noticed 731 T. he in 1966/67, later declined to 578 T. he in 1991/92, equal to 4.05 % in 1966/67 to 4.59 % in 1991/92. Production accounted, 521 T. t in 1966/67, has further raised to 703 T. t in 1991/92. Productivity per hectare increased from 726 Kg/he in 1966/67 to 1216 Kg/he in 1991/92 respectively. Ground nut area noticed an increase from 846 T. he in 1966/67 to 1031 T. he in 1991/92. However the production has increased at 821 T. t in 1966/67 to 1320 T. t in 1991/92. On the other hand productivity per hectare has witnessed 945 Kg/he in 1966/67, which raised up to 1280 Kg/he in 1991/92.

Regarding cotton the cultivated area was around 325 T. he in 1966/67, which happened to decline to 264 T. he in 1991/92, in percentage terms it was 4.15 % in 1966/67 to 3.43 % in 1991/92. Production recorded at 361 T. t in 1966/67 and increased to 437 T. t in 1991/92, an equivalent of 6.86 % in 1966/67 to 4.4 % in 1991/92. Productivity per hectare has witnessed improvement

Table 2.9.4.1

Tamil Nadu : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Rice), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	2346	4002	1498
	(6.66)	(13.15)	
1971/72	2691	5302	1970
	(7.13)	(12.31)	
1976/77	2284	4215	1845
	(5.933)	(10.063)	
1981/82	2467	5607	2273
	(6.06)	(10.52)	
1986/87	1955	5333	2728
	C 4.753	C 8.81)	
1991/92	2293	5928	2586
	(5.42)	(8.05)	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.4.2

Tamil Nadu : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Jowar), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	731	521	726
	C 4.05)	(5.653	
1971/72	717	515	718
	(4.27)	(6.673	
1976/77	842	793	942
	(5.34)	(7.54)	
1981/82	669	534	798
	C 4.03)	(4.353	
1986x87	730	659	903
	C 4.583	(7.17)	
1991/92	578	703	1216
	C 4.593	C8.413	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.4.3
Tamil Nadu : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Ground nut), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons3	Yield(Kg/ha)
1966/67	846 (11.59)	821 (18.61)	945
1971/72	1117 (14.87)	1273 (20.60)	1140
1976/77	890 (12.64)	785 (14.91)	882
1981/82	1013 (13.64)	1238 (17.14)	1222
1986X87	897 (12.853)	1093 (18.60)	1219
1991/92	1031 (11.893)	1320 (18.68)	1280

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.4.4
Tamil Nadu : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Cotton), 1966X67 to 1991/92.

Year	Area('000 hec)	Production('000tons3	Yield(Kg/ha)
1966/67	325 C 4.15)	361 (6.863)	167
1971/72	313 C 4.01)	411 C 5.91)	223
1976X77	240 (3.493)	348 (5.963)	247
1981/82	240 C 2.983)	278 (3.533)	197
1986/87	238 (3.43)	278 C 4.033)	199
1991/92	264 (3.43)	437 (4.443)	281

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2. 9.4. S

Tamil Nadu : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugarcane), 1966/67 to 1991/92.

Year	AreaC*OOO hec3	Production(*OOOtons3	Yield(Kg/ha)
1966/67	107	8023	77295
	C 4. 65)	(8. 64)	
1971/72	117	9626	82274
	C 4. 90)	(8. 48)	
1976/77	155	14246	91910
	C 5. 41)	C 9. 31)	
1981/82	201	20208	100537
	CO. 303	(10. 843	
1986/87	196	21605	110230
	(6. 373	(11. 61)	
1991/92	232	23417	101022
	(6. 133	C 9. 393	

Source: **CMIE**: Basic Statistics Relating to Indian **Economy**, 1992, 1993 and 1994.

from 167 Kg/he in 1966/67 to 261 Kg/he in 1991/92. With respect to Sugar cane, area was 107 T/he in 1966/67, later gone up to 232 T/he in 1991/92. Contrary to this a three time increase in production it recorded 8023 T.t in 1966/67 and moved upto 23417 T.t in 1991/92, an equivalent of 8.64 % in 1966/67 to 9.39 % in 1991/92. Where as productivity per hectare increased from 77295 Kg/he in 1966/67 to 101102 Kg/he in 1991/92 respectively.

2.9.5 UTTAR PRADESH:

On the other hand the nature of cropping pattern in U.P agriculture is shown in tables 2.9.5.1 to 2.9.5.6. The area under rice in Uttar Pradesh accounted, 4224 T/he in 1966/67, and later

increased to 5298 T/he in 1991/92, on percentage basis it was 11.98 % in 1966/67 to 12.52 % in 1991/92. A triple fold increase in production was accounted namely from 3012 T.t in 1966/67 to 9104 T.t in 1991/92, in percentage terms 9.90 % in 1966/67 to 12.36 % in 1991/92. However the yield potential doubled from 720 Kg/he in 1966/67 to 1718 Kg/he in 1991/92.

Jowar area showed a declining trend i.e from 886 T/he in 1966/67 to 516 T/he in 1991/92, which is equal to 4.91 % in 1966/67 to 4.10 % in 1991/92. Production also has declined from 431 T.t in 1966/67 to 384 T.t in 1991/92, which is equal to 4.61 % in 1966/67 to 4.59 % in 1991/92. Contrary to this, yield per hectare showed variation over a period of time. It was 510 Kg/he in 1966/67, has increased to 882 Kg/he in 1981/82, later declined to 745 Kg/he by 1991/92 respectively.

A spectacular increase in the cultivated area of wheat was noticed in U. P. It was 4671 T/he in 1966/67, which has gone up to 8626 T/he in 1991/92, that is from 36.38 % in 1966/67 to 36.34 % in 1991/92. Nearly a four time increase in production accounted in this period. It was 5332 T.t in 1966/67 increased to 20156 T.t in 1991/92, in percentage terms from 46.80 % in 1966/67 to 36.59 % in 1991/92. At the same time a two fold increase in yield took place from 1169 Kg/he in 1966/67 to 2337 Kg/he in 1991/92 respectively.

The ground nut area has declined drastically from 391 T.he in 1966/67 to 159 T. ho in 1991/92, equal to 5.36 % in 1966/67 to 1.63

% in 1991/92. Production has also declined from 283 T.t in 1966/67 to 113 T.t in 1991/92, which accounted for 6.42 % share in 1966/67 to 1.63 % in 1991/92. On the other hand the yield structure also has declined from 711 Kg/he in 1966/67 to 558 Kg/he in 1971/72, which later increased to 973 Kg/he in 1981/82, again declined to 826 Kg/he in 1991/92 respectively. Cotton crop was totally neglected in Uttar Pradesh over this period of observation i.e 62 T/he in 1966/67, later declined to 14 T/he in 1991/92, or from 0.79 % in 1966/67 to 0.18 % in 1991/92. Production also has declined from 31 T.t in 1966/67 to 16 T.t in 1991/92, an equivalent of 0.59 % in 1966/67 to 0.16 % in 1991/92. Where as the yield rate showed improvement i.e 82 Kg/he in 1966/67 to 186 Kg/he in 1991/92 respectively.

Table 2.9.5.1

Uttar Pradesh : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	4224 (11.98)	3012 C 9.903	720
1971/72	4722 (12.51)	3777 (8.77)	800
1976/77	4653 (12.08)	4291 (10.243)	922
1981/82	5389 (13.24)	5898 (11.083)	1095
1986/87	5542 (13.46)	7509 (12.40)	1355
1991/92	5298 (12.523)	9104 (12.36)	1718

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.2

Uttar Pradesh : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Jowar), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	886 C 4.91)	431 C 4.67)	510
1971/72	621 C 3.70)	228 (2.25)	367
1976/77	703 (4.46)	484 C 4.60)	689
1981/82	686 C 4.13)	608 (4.93)	882
1986/87	579 C 3.633	468 (5.10)	808
1991/92	516 C 4.10)	384 C 4.593	745

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.3

Uttar Pradesh : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	4671 C 36.38)	5332 C 46.80)	1169
1971/72	6046 (31.593	7550 C 28.59)	1249
1976/77	6624 C 31.663	8940 (30.82)	1350
1981/82	7772 C 35.10)	12740 (34.04)	1640
1986/87	8405 C 36.34)	16236 C 36.633	1932
1991/92	8626	20156 C 36.593	2337

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.4

Uttar Pradesh : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
 (Ground nut3, 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	391	283	711
	(5.36)	(6.42)	
1971X72	328	183	558
	C 4.37)	(2.963	
1976/77	389	233	599
	C S. 52)	(4.43)	
1981/82	261	254	973
	(3.51)	(3.52)	
1986/87	123	111	902
	(1.76)	(1.89)	
1991/92	159	115	826
	(1.833	(1.63)	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.5

Uttar Pradesh : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
 C Cotton3, 1966X67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	62	31	82
	CO. 793	CO. 593	
1971/72	56	27	82
	CO. 72)	CO. 393	
1976X77	23	14	104
	(0.333	CO. 24)	
1981/82	30	22	125
	C 0.373	C 0.283	
1986/87	22	18	139
	C 0.32)	C 0.26)	
1991/92	14	16	186
	CO. 183	CO. 163	

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.6

Uttar Pradesh : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugarcane), 1966/67 to 1991/92.

Year	Area(C*000 hec)	Production(*000tons)	Yield(Kg/ha)
1966/67	944	34787	35632
1971/72	C41.03)	(37.48)	
	1274	49354	38739
	(53.31)	(43.46)	
1976/77	1456	65216	44791
	C50.81)	C42.62)	
1981/82	1652	76440	46271
	(51.74)	C41.02)	
1986/87	1678	84736	50498
	(54.50)	f45.53)	
1991/92	1883	108433	57588
	(49.74)	C43.50)	

Source: CMIE Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Notable increase in Sugar cane area was noticed from 944 T/he in 1966/67 to 1883 T/he in 1991/92. This is nearly equal to 41.03 % in 1966/67 to 49.74 % in 1991/92. A three fold increase took place in production i.e 34787 T.t in 1966/67 to 108433 T.t in 1991/92, which is equal to 37.48 % in 1966/67 to 43.50 % in 1991/92. Almost a double time increase in yield was noticed from 35632 Kg/he in 1966/67 to 57588 Kg/he in 1991/92 respectively.

2.9.6 WEST BENGAL:

In case of West Bengal, as illustrated in tables 2.9.6.1 to 2.9.6.3 . the area under rice crop accounted for 4233 T/he in 1966/67, and increased to 5681 T.he in 1991/92, or equal to 12.00

% in 1966/67 to 14.21 % in 1991/92. Contrary to this a two fold increase in production took place from 5011 T. t in 1966/67 to 11756 T. t in 1991/92. This is equal to 16.46 % in 1966/67 to 15.96 % in 1991/92. In the same manner yield rate increased from 1076 Kg/he in 1966/67 to 2069 Kg/he in 1991/92 respectively.

Area sown for Wheat noticed a marginal change from 267 T/he in 1966/67, which was slightly raised to 269 T/he in 1991/92, as equal to 0.52 % in 1966/67 to 1.17 % in 1991/92. In case of production it was 269 T. t in 1966/67, later raised to 530 T. t in 1991/92. This is equal to 0.61 % in 1966/67 to 0.96 % in 1991/92. With respect to yield, i.e 1022 Kg/he in 1966/67, which has

Table 2.9.6.1

West Bengal : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000 tons)	Yield(Kg/ha)
1966/67	4233 (12.003)	5011 (16.46)	1076
1971/72	4991 (13.22)	6508 (15.11)	1304
1976/77	5205 (13.52)	5949 (14.19)	1143
1981/82	5210 (12.80)	5833 (10.95)	1120
1986/87	5376 (13.06)	8463 (13.98)	1574
1991/92	5681 (14.21)	11756 (15.963)	2069

Source: CMTE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.6.2

West Bengal » AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	67 C 0.52)	69 C 0.61)	1022
1971/72	422 (2.20)	921 (3.493)	2183
1976/77	515 (2.46)	1051 (3.62)	2041
1981/82	214 CO. 97)	389 (1.04)	1818
1986/87	398 (1.72)	683 (1.54)	1716
1991/92	269 (1.17)	530 (0.963)	1970

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.6.3

West Bengal : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugar cane), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	23 (1.00)	1071 C 1.15)	41081
1971/72	34 (1.42)	1657 (1.463)	48735
1976/77	30 C 1.05)	1812 (1.18)	60400
1981/82	23 CO. 723	1411 CO. 763	61348
1986/87	13 CO. 42)	757 CO. 41)	58231
1991/92	12 CO. 323	859 CO. 343	70434

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

increased to 1870 Kg/he in 1991/92 respectively. The area under sugar cane was completely neglected in West Bengal. It was 23 T/he in 1966/67, that was later declined to 12 T.he in 1991/92. This is almost equal to 1.00 % in 1966/67 to 0.32 V. in 1991/92. The production has also declined from 1071 T. t in 1966/67 to 859 T. t in 1991/92, or from 1.15 % in 1966/67 to 0.34 % in 1991/92. On the other hand yield rate maintained the growth from 41081 Kg.he in 1966/67 to 70434 Kg/he in 1991/92 respectively.

2.9.7 ALL INDIA:

The tables 2.9.7.1 to 2.9.7.6 illustrates the nature of cropping pattern in all India from 1966/67 to 1991/92. The all India level scenario showed that. the area under rice accounted 35251 T/he in 1966/67, which was later increased to 42308 T/he in 1991/92. On the other hand production increased from 30438 T. t in 1966/67 to 73664 T. t in 1991/92. Where as the yield rate recorded 863 Kg/he in 1966/67, has increased to 1741 Kg/he in 1991/92 respectively. However, wheat area which noticed 12838 T.he in 1966/67, has increased to 22980 T.he in 1991/92. A five fold increase in production took place from 11393 T. t in 1966/67 to 58087 T. t in 1991/92. Where as a three time increase in yield was witnessed from 887 Kg/he in 1966/67 to 2397 Kg/he in 1991/92 respectively.

A decline in area under **jowar** was noticed from, 18054 T/he in 1966/67 to 12592 T/he in 1991/92. Contrary to this production noticed **fluctuations**, i.e 9224 T.t in 1966/67. then raised to 12062 T. t in 1981/82, but later declined to 8357 T. t in 1991/92. On the other hand, yield level also noticed variations i.e 511 Kg/he in 1966/67, which raised up to 727 Kg/he in 1981/82, and then declined to 576 Kg/he in 1986/87, but increased again to 664 Kg/he in 1991/92 respectively. In case of cotton, th@ area was 7836 T/he in 1966/67, and declined to 769S T/he in 1991/92. Interestingly, the production which was 5266 T. t in 1966/67, has increased to 9836 T. t in 1991/92. This increase in production took place due to stable yield rate. Yield was recorded at 114 Kg/he in 1966/67, later gone up to 217 Kg/he in 1991/92 respectively.

Table 2.9.7.1

All. INDIA s AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	35251	30438	863
1971/72	37758	43068	1141
1976/77	38511	41917	1088
1981/82	40708	53248	1308
1986/87	41167	60S57	1471
1991/92	42308	73664	1741

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.2

ALL INDIA t AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area(' 000 hec)	Production(' 000tons)	Yield(Kg/ha)
1966/67	12838	11393	887
1971X72	19139	26410	1380
1976X77	20922	29010	1387
1981X82	22144	37452	1691
1986/87	23131	44323	1916
1991/92	22980	55087	2397

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.3

ALL INDIA : ARFA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Jowar), 1966X67 to 1991/92.

Year	Area(' 000 hec)	ProductionC ' 000tons)	Yield(Kg/ha)
1966/67	18054	9224	511
1971/72	16777	7722	460
1976X77	15772	10524	667
1981/82	16599	12062	727
1986/87	15948	9185	576
1991/92	12592	8357	664

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.4

ALL INDIA : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Ground nut), 1966X67 to 1991X92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	7299	4411	604
1971/72	7510	6181	823
1976/77	7043	5264	747
1981/82	7429	7223	972
1986/87	6982	5875	841
1991/92	8672	7066	815

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.5

ALL INDIA : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Cotton), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966X67	7836	5268	114
1971/72	7800	6950	151
1976/77	6885	5839	144
1981/82	8057	7884	166
1986/87	6948	8005	167
1991/92	7695	9836	217

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.6

ALL INDIA : AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS
(Sugarcane), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67	2301	92826	40342
1971/72	2390	113570	47519
1976/77	2866	153007	53387
1981/82	3193	186358	58365
1986/87	3079	186090	60438
1991/92	3786	249256	65836

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Sugar cane. experienced noticeable growth i.e 2301 T/he in 1966/67 to 3786 T/he in 1991/92. A three fold increase in production has recorded from 92826 T.t in 1966/67 to 249256 T.t in 1991/92. The yield structure also noticed positive trend namely from 40342 Kg/he in 1966/67 to 65836 kg/he in 1991/92 respectively.

The compound growth rates of different crops grown in the states showed interesting picture. Compound growth rates of changing cropping pattern in A.P is shown in tables 2.9.1.7 to 2.9.1.12. In case of Andhra Pradesh, rice area showed a negative growth rate i.e -0.35 % in 1971/72, and later increased at the rate of 2.54 % in 1991/92. On the other hand production of rice increased from 3.30 % in 1971/72 to 7.50 % in 1991/92. Where as

yield level has increased from 3.58 % in 1971/72, next in the period a negative growth rates were experienced. in 1976/77, 1981/82, and 1986/87 respectively. The growth rate of jowar area was 2.03 % in 1971/72, has decreased by later negative -4.06 % in 1991/92. Production showed significant fluctuations. The yield structure accounted negative growth rate i.e -0.48 % in the beginning but overall ended up with an increase of 6.58 % in 1991/92. Regarding wheat area shown has increased at rate of 10.07 % in 1971/72, later noticed negative growth rates of -5.03 and -8.34 % in 1981/82 and 1986/87. Production increased at the rate 41.60 % in 1971/72, and later increased at a decreasing rate of 14.87 % per annum in 1991/92. Mean while yield rate noticed a 22.14 % per annum in 1971/72, with some fluctuations it finally increased at 14.84 % per annum in 1991/92.

Ground nut area increased at a rate of 8.45 % per annum in 1971/72 and 9.49 % in 1991/92. Production raised at the rate of 2.82 % per annum in 1971/72, later at the rate of 2.86 % in 1991/92. Yield rate which noticed 1.03 % per annum in 1971/71, has increased to 6.19 % per annum in 1991/92 respectively. Cotton area accounted at the rate of 1.24 % per annum in 1971/72, but later it increased at rate of 10.27 % in 1991/92. The production experienced 3.98 % per annum in 1971/72. and later increased at increasing rate of 10.65 % per annum in 1991/92. Contrary to this, rate of growth of yield was 3.21 % per annum in 1971/72, later increased at a rate of 3.89 % per annum in 1991/92. However, sugar cane area witnessed 0.69 % per annum in 1971/72, has a substantial

Table 2.9.1.7
 ANDHRA PRADESH : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND
 YIELD OF PRINCIPAL CROPS (**Rice**), 1966/67 to 1991/92.

Year	Area('000 hec)	Production(' 000tons)	Yield(Kg/ha)
1966/67			
1971/72	- 0.35	3.30	3.58
1976/77	3.23	0.88	- 2.28
1981/82	1.41	9.80	- 7.65
1986/87	- 1.98	- 3.48	- 1.52
1991/92	4.33	9.47	8.88

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.8
 ANDHRA PRADESH : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND
 YIELD OF PRINCIPAL CROPS (**Jowar**), 1966/67 to 1991/92.

Year	Area('000 hec)	Production(' 000tons)	Yield(Kg/ha)
1966/67			
1971/72	2.03	1.09	- 0.48
1976/77	- 4.19	- 1.34	2.97
1981/82	1.82	4.61	2.93
1986/87	- 5.64	- 5.71	- 0.07
1991/92	- 4.06	0.32	6.58

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.9

ANDHRA PRADESH : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	10.07	41.80	22.14
1976/77	0.93	4.19	3.02
1981/82	- 5.03	- 3.28	2.41
1986X87	- 8.34	-14.59	- 9.61
1991/92	0.00	14.87	14.84

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.10

ANDHRA PRADESH : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Ground nut), 1966X67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	8.45	2.82	1.03
1976/77	- 7.27	-12.22	- 6.07
1981/82	6.66	19.77	12.27
1986/87	1.60	10.94	- 3.40
1991/92	9.49	2.86	6.19

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.11

ANDHRA PRADESH I COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (**Cotton**), 1966/67 to 1991X92.

Year	Area('000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67			
1971/72	1.24	3.98	3.21
1976/77	- 2.98	8.32	11.59
1981/82	10.43	20.50	9.11
1986/87	- 2.77	- 1.69	1.15
1991/92	10.27	10.65	3.89

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.1.12

ANDHRA PRADESH : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (**Sugarcane**), 1966/67 to 1991X92.

Year	Area('000 hec)	Production(*000tons)	Yield(Kg/ha)
1966/67			
1971/72	0.69	3.76	2.99
1976/77	4.17	- 0.55	- 4.54
1981/82	4.28	7.79	3.42
1986/87	- 5.18	- 7.22	- 2.46
1991/92	6.15	5.73	- 0.61

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

rate of increase of 6.15 % per annum in 1991/92. Production noticed 3.76 % per annum in 1971/72, and the final year growth rate was 5.73 % per annum in 1991/92. But the yield increased at 2.99 % in 1971/72, but ended up with a negative growth rate of -0.61 % in 1991/92 respectively. The overall scenario show that the yield structure, was not maintained at a steady rate over the time period. The area irrigated under specific crops, due to this production rate is also fluctuating over this time.

Area under Rice in Bihar, as stated in the tables 2.9.2.5 to 2.9.2.8; it was noticed a 1.09 % per annum in 1971/72, and later increased at a rate of 5.41 % per annum in 1991/92. On the other hand production was 4.60 % per annum in 1971/72, and it further increased at a rate? decreasing rate of 3.00 % per annum in 1991/92. The yield rate also experienced 2.16 % per annum in 1971/72, and later increased at a rate of 4.76 % per annum in 1991/92. Regarding jowar, negative growth rates were experienced i.e -12.96 % in 1971/72, later growth rate was continued to be negative -3.58 % per annum in 1991/92. Production and yield was also recorded negative growth rates namely -19.73 and -5.99 in 1971/72 to -9.71 and -9.05 in 1991/92 respectively.

Wheat area has increased at a rate of 7.02 % per annum in 1971/72, later it increased at a rate of 2.92 % in 1991/92. Production has increased at a rate of 22.61 % in 1971/72, which further increased at a rate of 10.06 % in 1991/92, even though

there are some negative growth rates in between. However, yield rate was increased at 17.41 % per annum in 1971/72, later raised at a rate of 6.20 % per annum in 1991/92. respectively. Area under sugar cane increased at 5.53 V. per annum in 1971/72, and it further raised at a rate of 7.12 % in 1991/92. Production has increased at 2.25 % per annum in 1971/72, later in the period it increased at a rate of 18.20 % per annum in 1991/92. Contrary to this, yield rate showed a negative rate of growth at -1.23 in 1971/71, but later it become positive rate at 13.67 V, per annum in 1991/92 respectively.

Table 2.9.2.5

Bihar : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000 tons)	Yield(Kg/ha)
1966/67			
1971/72	1.09	4.60	2.16
1976/77	- 0.38	- 2.06	- 1.70
1981/82	0.22	- 2.18	- 2.39
1986/87	0.00	7.27	7.26
1991/92	5.41	3.00	4.76

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.2.6

Bihar : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (**Jowar**), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	-12.95	-19.73	- 5.99
1976/77	17.08	24.58	6.88
1981/82	0.00	3.13	4.52
1986/87	-11.42	- 6.51	6.87
1991/92	- 3.58	-9.71	- 9.08

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.2.7

Bihar : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (**Wheat**), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	7.02	22.61	17.41
1976/77	6.84	- 0.97	- 6.58
1981/82	- 3.35	- 2.28	1.12
1986/87	2.33	5.38	2.97
1991/92	2.92	10.06	6.20

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.2.8

Bihar : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugarcane), 1966/67 to 1991/92.

Year	Area(*000 hec)	Production(*000tons)	Yield(Kg/ha)
1966/67			
1971/72	5.63	1.25	- 1.23
1976/77	- 2.05	- 1.33	-33.23
1981/82	- 0.63	0.02	0.02
1986/87	- 2.01	- 2.26	51.44
1991/92	7.12	18.20	13.67

Source: CMTE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

The tables 2.9.3.6 to 2.9.3.10 illustrate the compound growth rates of cropping pattern in Punjab agriculture, noticed positive rate of growth in rice area i.e, 8.23 % per annum in 1971/72, and 6.04 % per annum in 1991/92. Where as production increased at 17.89 % per annum in 1971/72, and further it increased at a rate of 4.83 % per annum in 1991/92. On the other hand yield rate increased at 9.88 % per annum in the beginning, and ended up with a growth rate of 3.79 % in 1991/92. Area under wheat accounted 6.68 % per annum in 1971/72, which further increased at a rate of 4.69 % per annum in 1991/92. Mean while production increased at 27.12 % in 1971/72, and later it increased at a rate of 6.84 % per annum in 1991/92. Contrary to this, yield has noticed positive growth

rate of **8.22** V. per annum in **1971/72** and **9.71** % in **1991/92** respectively.

The ground nut recorded negative growth rates, **-2.75** and **-17.94** % per annum in **1971/72** and **1991/92** respectively. Production has also experienced negative growth rates of **-2.81** and **-17.55** in **1971/72** and **1991/92** respectively. Where as yield, showed a positive growth rate of **1.24** % per annum in **1971/72**, but later it experienced negative growth rates like **-0.04** % per annum in **1991/92**. Regarding cotton, area sown increased at a rate of **3.76** % per annum in **1971/72**, which was further increased at a rate of **5.07** % per annum in **1991/92**. Production noticed **5.64** % growth per

Table 2.9.3.6

Punjab : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), **1966/67** to **1991/92**.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	8.23	17.89	9.88
1976/77	17.34	13.61	4.79
1981/82	13.51	16.62	2.74
1986/87	7.33	9.91	2.40
1991/92	6.04	4.83	3.79

Source: CMIE: Basic Statistics Relating to Indian Economy, **1992**, 1993 and 1994.

Table 2. 9.3.7

Punjab : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area(* 000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67			
1971/72	6.65	27.12	8.22
1976/77	2.01	-14.42	0.22
1981/82	2.49	27.09	3.81
1986/87	1.80	2.03	0.23
1991/92	4.69	6.84	9.71

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.3.8

Punjab : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Ground nut), 1966/67 to 1991/92.

Year	Area(* 000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67			
1971/72	- 2.75	- 2.81	1.22
1976/77	- 1.18	- 3.90	- 2.75
1981/82	-10.92	- 9.71	1.34
1986/87	-14.11	-14.14	- 0.02
1991/92	-17.94	-17.55	- 0.04

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.3.9

Punjab : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (**Cotton**), 1966/67 to **1991/92**.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	3-70	6.64	2.84
1976/77	3.24	2.03	- 1.17
1981/82	4.16	2.22	- 1.85
1986/87	- 3.65	5.89	9.92
1991/92	5.07	7.35	2.90

Source: **CMIE**: Basic Statistics **Relating** to Indian Economy, 1992, 1993 and **1994**.

Table 2.9.3.10

Punjab : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (**Sugarcane**), **1966/67** to **1991/92**.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	- 3.01	- 1.41	3.60
1976/77	1.87	8.54	6.55
1981/82	- 1.27	0.16	1.45
1986/87	- 1.76	- 0.03	1.76
1991/92	S.54	0.05	0.55

Source: **CMIE**: Basic Statistics **Relating** to Indian Economy, 1992, 1993 and **1994**.

annum in **1971/72**, and later increased at a rate of 7.35 % per annum in **1991/92**. On the other hand, yield rate was 2.84 % per

annum in 1971/72, and raised to 2.90 % rate per annum in 1991/92 . Sugar cane area showed a negative growth of - 3.01 % in 1971/72, and later increased at a rate of 5.54 % per annum in 1991/92. Production showed a negative growth of -1.41 54 in 1971/72, later it has a positive rate of growth at 0.05 % per annum in 1991/92. Yield also has a rate of growth of 3.60 % in 1971/72, and later it increased at a rate of 0.55 % per annum in 1991/92 respectively.

As shown in tables 2.9.4.6 to 2.9.4.10, Tamil Nadu experienced positive growth in rice production, namely 2.78 % per annum in 1971/72, but later a negative growth rate was noticed, -1.45 % in 1991/92. Here production increased at 5.79 % in 1971/72, and later it increased at a rate of around 4.94 % per

Table 2.9.4.6

Tamil Nadu : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	2.78	5.79	5.63
1976/77	- 3.23	- 4.48	- 1.30
1981/82	1.55	5.87	4.26
1986/87	- 4.55	- 1.00	3.72
1991/92	- 1.45	4.94	5.63

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

annum in 1991/92. The rate of growth for yield was 5.63 % per annum in 1971/72, and later it maintained a similar growth rate of 5.63 % in 1991/92 respectively. However, Jowar accounted negative growths of -0.39 % in 1971/72, and again a negative growth rate of -23.29 % in 1991/92. Mean while production showed negative growth -0.23 % in 1971/72, and was later it become positive at 0.36 % in 1991/92. Yield rate also noticed negative growth rate of -0.22 % in 1971/72, later it witnessed a positive growth rate of 6.08 % per annum.

Area under ground nut increased at the rate of 6.72 % per annum in 1971/72, and later it increased at a rate of 4.18% per annum in 1991/92. Production also noticed a growth rate of 9.17 % in 1971/72, and it increased at a rate of 3.06 % per annum in 1991/92. Yield rate was reasonable at 3.82 % per annum in 1971/72, and later it increased at a rate of 1.99 % per annum. Cotton crop experienced negative growth rate of -0.75 % in 1971/72, later became positive at 3.81 % per annum in 1991/92. Where as production increased at a rate of 2.63 % in 1971/72 anti 8.24 % per annum in 1991/92. Yield rate was positive at 5.95 % in 1971/72, and it was 13.27 % per annum in 1991/92. Area under sugar cane, increased at a rate of 1.80 % per annum in 1971/72, and later it, increased at a rate of 4.13 % per annum in 1991/92. Production noticed a growth rate of 3.71 % per annum in 1971/72, and 1.82 % per annum in 1991/92 respectively. The rate of growth of yield was 1.25 % per annum in 1971/72, which has experienced a negative growth rate of -1.73 % per annum in 1991/92.

Table 2.9.4.7

Tamil Nadu : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Jowar), 1966/67 to 1991/92.

year	Area ('000 hec)	Production ('000 tons)	Yield (Kg/ha)
1966/67			
1971/72	- 0.39	- 0.23	- 0.22
1976/77	3.27	9.02	5.58
1981/82	- 4.50	- 7.60	- 3.26
1986/87	1.76	4.30	2.50
1991/92	-23.29	0.36	6.08

Source: CMTE: **Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.**

Table 2.9.4.8

Tamil Nadu : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Groundnut), 1966/67 to 1991/92.

Year	Area ('000 hec)	Production ('000 tons)	Yield (Kg/ha)
1966/67			
1971/72	5.72	9.17	3.82
1976/77	- 4.44	- 9.22	- 5.00
1981/82	2.62	9.54	6.74
1986/87	- 2.40	- 2.46	- 0.00
1991/92	4.18	3.06	1.99

Source: CMTE: **Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.**

Table P. 9.4.9

Tamil Nadu : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Cotton), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	- 0.75	2.63	5.95
1976/77	- 5.17	- 3.27	2.07
1981/82	0.00	- 4.39	- 4.42
1986/87	- 0.17	0.00	0.20
1991/92	3.81	8.24	13.27

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.4.10

Tamil Nadu : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugarcane), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	1.80	3.71	1.26
1976/77	5.79	8.16	2.24
1981/82	5.34	7.24	1.81
1986/87	- 0.50	1.35	1.86
1991/92	4.73	38.21	35.40

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Area under rice in Uttar Pradesh, as illustrated in tables 2.9.S.7 to 2.9.S.12, accounted a growth rate of 0.23 % per annum in 1971/72, and the growth rate in 1991/92 was 4.28 % per annum. Contrary to this production recorded of 4.63 % per annum in 1971/72, the rate of increase in 1991/92 was 8.06 % per annum. It is important to that the yield showed 2.13 % rate of growth in 1971/72 and 8.22 % per annum in 1991/92. Jowar area witnessed negative growth rate of -6.86 in 1971/72, and ended up with negative growth rate of -1.31 % in 1991/92. Production noticed negative growth rate of -11.96 in 1971/72, which has become positive at a rate of 2.17 % per annum in 1991/92. Yield rate also witnessed negative growth rate in the beginning -6.39 % in 1971/72, but increased at a rate of 5.12 % per annum in 1991/92 respectively.

Compound growth rates of area, production, and yield of wheat crop in the state noticed post II VP growth rates of 5.30, 7.20, and 1.33 % per annum in 1971/72 respectively, and later the area and production increased at a rate of 1.40 % and 4.50 % per annum, where as yield increased at a rate of 8.27 % per annum in 1991/92. Ground nut noticed fluctuations in growth rate namely negative at in the beginning of at -3.45 % in 1971/72, and later increased at a rate of 5.27 % per annum in 1991/92. Production experienced negative growth rates of -8.33 % in 1971/72, and later a modest growth rate of 0.71 % in 1991/92. The yield rate was negative through out the observation period of 4.70 % in 1971/72, and -1.74 in 1991/92 respectively.

The cotton crop witnessed negative growth rate of -2.01 % per annum in 1971/72, and -2.89 % per annum in 1991/92. Production recorded negative growth rate of -2.72 % in 1971/72, but later there was no change in 1991/92. Yield rate experienced negative rate of -0.07 in 1971/72, but later it increased at a rate of 6.56 % per annum in 1991/92 respectively. Sugar cane noticed almost positive growth in case of area, production, and yield. The area growth was 1.18 % per annum in 1971/72, which increased to 2.80 % in 1991/92, production witnessed 7.25 % per annum in 1971/72, which raised at increasing rate i.e. 21 % per annum in 1991/92. A five time increase in yield took place i.e.

Table 2.9.5.7

Uttar Pradesh : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	0.23	4.63	2.13
1976/77	- 0.29	2.58	2.88
1981/82	2.98	6.57	3.50
1986/87	0.56	4.95	4.35
1991/92	2.28	8.06	8.22

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2. 0.5.8

Uttar Pradesh : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Jowar), 1966/67 to 1991/92.

Year	Area ('000 hec)	Production ('000 tons)	Yield (Kg/ha)
1966/67			
1971/72	- 6.86	-11.96	- 6.37
1976/77	2.51	16.25	13.39
1981/82	- 0.49	4.56	5.09
1986/87	- 3.34	- 5.00	- 1.74
1991/92	- 1.31	2.17	5.12

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.9

Uttar Pradesh : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area ('000 hec)	Production ('000 tons)	Yield (Kg/ha)
1966/67			
1971/72	5.30	7.20	1.33
1976/77	1.84	3.44	1.57
1981/82	3.25	7.36	3.97
1986/87	1.58	4.95	3.33
1991/92	1.40	4.50	8.27

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.10

Uttar Pradesh : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Groundnut), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	- 3.45	- 8.35	- 4.70
1976/77	3.47	4.95	7.35
1981/82	- 7.67	1.74	10.19
1986/87	-13.97	-15.26	- 1.50
1991/92	5.27	0.71	- 1.74

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.11

Uttar Pradesh : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Cotton), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	- 2.01	- 2.72	- 0.07
1976/77	-16.30	-12.31	4.87
1981/82	5.46	9.46	3.75
1986/87	- 6.02	- 3.93	2.15
1991/92	- 2.89	0.00	6.56

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.5.12

Uttar Pradesh : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugarcane), 1966/67 to 1991/92.

Year	Production('000tons)	Yield(Kg/ha)
1966/67		
1971/72	6.18	7.25
1976/77	2.71	5.73
1981/82	2.56	3.23
1986/87	0.31	2.08
1991/92	2.80	8.21

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

from a annual growth rate of 1.69 % per annum in 1971/72 to 6.09 % per annum in 1991/92 respectively. It was observed that, yield rate has not shown an even growth rate over the period of time. At the same time production also noticing fluctuations in the time period.

Compound growth rates of cropping pattern in West Bengal is shown in tables 2.9.6.4 to 2.9.6.6. The area under rice crop in West Bengal increased at a rate of 3.35 % per annum in 1971/72, later it raised at a rate of 2.26 % in 1991/92. Production noticed a growth rate of 5.37 % per annum in 1971/72, and increased at a rate of 5.82 % per annum in 1991/92. The Yield rate also noticed 3.92 % per annum in 1971/72, which raised at 5.15 % in

Table 2.9.6.4

West Bengal : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (**Rice**), 1966/67 to 1991/92.

Year	AreaC * 000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67			
1971/72	3.35	5.37	3.92
1976/77	0.84	- 1.78	- 2.60
1981/82	0.02	- 0.39	- 0.41
1986/87	0.00	7.73	7.04
1991/92	2.26	5.82	5.15

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.6.5

West Bengal : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (**Wheat**), 1966/67 to 1991/92.

Year	AreaC * 000 her")	Production(* 000tons)	Yield d(Kg/ha)
1966X67			
1971/72	44.91	67.91	16.39
1976/77	4.06	2.68	- 1.34
1981/82	-16.11	-18.02	- 2.29
1986/87	13.21	11.92	- 1.15
1991/92	- 6.6	-4.38	5.35

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.6.6

West Bengal : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugarcane), 1966/67 to 1991/92.

Year	Area(*000 hec)	Production(*000t.ons)	Yield(Kg/ha)
1966/67			
1971/72	8.13	9.12	3.48
1976/77	- P..47	1.80	4.38
1981/82	-5.18	- 4.88	0.31
1986/87	-10.78	-11.71	- 1.04
1991/92	4.24	6.46	5.82

Source:CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

negative growth rate of -6.61 % per annum in 1991/92. Production was at a rate of 27.91 % in 1971/72, was later witnessed negative growth rate of -4.38 % in 1991/92. Yield per hectare increased at a rate of 16.39 % per annum in 1971/72, and later it increased at a rate of 5.35 % per annum in 1991/92 respectively. The area for sugar cane noticed a growth rate of 8.13 % per annum in 1971/72, which raised at a rate of 4.24 % per annum in 1991/92. Production growth rate was 9.12 % per annum in 1971/72, and it was 6.46 % per per annum in 1991/92. Yield growth rate was 3.48 % per annum in 1971/72, and 5.82 % per annum in 1991/92 respectively.

On all India level, as stated in the tables 2.9.7.7 to 2.9.7.12, rice area increased at 1.39 % in 1971/72, later it increased at a rate of 1.00% per annum in 1991/92. Production growth rate was at 7.18 V. per annum in 1971/72, later increased at a rate of 4.57 %per annum in 1991/92. Yield growth rate was at 8.74 % in 1971/72, later it increased at a rate of 4.83 V. per annum in 1991/92. Area under wheat increased at a rate of 8.31 % in 1971/72, and later a negative growth was recorded at -0.13 % per annum in 1991/92. Production noticed a 18.31 % growth rate in 1971/72, was later it increased at a rate of 4.44 V. in 1991/92 respectively. Yield growth rate raised was 9.24 % in 1971/72, which increased at a rate of 4.58 % in 1991/92 respectively.

Jowar area, production, and yield showed almost negative growth rates of -1.46, -3.49, and -2.08 % in 1971/72 respectively. They later continued the negative growth rate of -4.62, -1.87, and a positive growth of 1.88 % for yield in 1991/92. Ground nut crop area increased at a rate of 0.51 % per annum in 1971/72, was later the growth rate was 4.43 % per annum in 1991/92. Production accounted for 6.98 % growth rate per annum in 1971/72, later increased at a rate of 3.76 % per annum in 1991/92. The Yield component noticed a growth rate of 6.38 % per annum in 1971/72, and later a negative of -0.63 % in 1991/92 respectively. Considering area under cotton a negative growth of -0.09 % per annum was noticed in 1970/71, and an increased growth rate of 2.06 % in 1991/92. The rate of growth in production was at 5.70 % in 1971/72, and later it was at 7.33 % per annum in

Table 2.9.7.7

ALL INDIA t COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Rice), 1966/67 to 1991/92.

Year	Area(* 000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67			
1971/72	1.39	7.18	5.74
1976/77	0.39	- 0.54	- 0.94
1981/82	1.11	4.90	3.75
1986/87	0.22	2.60	2.37
1991/92	1.00	4.57	4.83

Sources CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.8

ALL INDIA : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Wheat), 1966/67 to 1991/92.

Year	Area(* 000 hec)	Production(* 000tons)	Yield(Kg/ha)
1966/67			
1971/72	8.31	18.31	9.24
1976/77	1.80	1.90	0.10
1981/82	2.96	5.24	4.04
1986/87	0.88	3.43	2.53
1991/92	1.56	5.05	4.56

Source: CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.9

ALL INDIA : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Jowar), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)>
1966/67			
1971/72	- 1.40	- 3.49	- 2.08
1976/77	- 1.23	6.39	7.71
1981/82	1.03	2.77	1.74
1986/87	- 0.80	- 5.30	- 4.55
1991/92	- 0.34	6.92	9.75

Source:CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.10

ALL INDIA : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Groundnut), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	0.57	6.98	6.38
1976/77	- 1.27	- 3.16	- 1.92
1981/82	1.07	6.53	5.41
1986/87	- 1.23	- 4.05	- 2.85
1991/92	5.70	5.95	3.73

Source:CMIE: Basic Statistics Relating to Indian Economy, 1992, 1993 and 1994.

Table 2.9.7.11

ALL INDIA : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Cotton), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	- 0.09	5.70	S.78
1976/77	- 2.46	- 3.42	- 0.94
1981/82	3.19	6.19	2.88
1986/87	- 2.92	- 2.62	0.35
1991/92	4.10	7.90	12.01

Source: CMIE: **Basic Statistics Relating to Indian Economy**, 1992, 1993 and 1994.

Table 2.9.7.12

ALL INDIA : COMPOUND GROWTH RATES OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS (Sugarcane), 1966/67 to 1991/92.

Year	Area('000 hec)	Production('000tons)	Yield(Kg/ha)
1966/67			
1971/72	0.76	4.12	3.33
1976/77	3.70	6.14	2.36
1981/82	2.19	4.02	1.80
1986/87	- 0.73	- 0.03	0.70
1991/92	6.01	7.83	2.46

Source: CMIE: **Basic Statistics Relating to Indian Economy**, 1992, 1993 and 1994.

1991/92. The Yield growth rate was at 5.78 % per annum in 1971/72, and later it increased at a rate of 5.38 % per annum in 1991/92. The Area under sugar cane raised at a rate of 0.78 % per annum in 1971/72, later it recorded a growth rate of 4.22 % per annum in 1991/92. Production raised at 4.12 % per annum in 1971/72, and later increased at a rate of 6.02 % per annum in 1991/92. The Yield showed a growth rate of 3.33 % per annum in 1971/72, and the growth rate was 1.72 % per annum in 1991/92 respectively.

2.10 INDEX NUMBERS OF AREA, PRODUCTION, AND YIELD OF PRINCIPAL CROPS:

Considering indexes of area, production, and yield of selected principal crops are very much essential to identify the performance of crops in Indian agriculture. This section will deal with the indices of selected crops from 1966/67 to 1991/92. With regards to rice crop, the area index (A) was 95.2 in 1966/67, and later it increased to 118.1 by 1991/92. whereas the production index (P) raised from 77.8 in 1966/67 to 157.3 in 1991/92. However, yield index (Y), raised from 81.7 in 1966/67, to 142.8 in 1991/92 respectively.

With respect to wheat, area index increased from 80.9 in 1966/67, to 156.7 in 1991/92, similarly the production index raised from 63.2 in 1966/67 to 291.3 in 1991/92. The yield index rate was at 78.1 in 1966/67, and later increased to 177.4 in

Table 10.1

ALL INDIA INDEX NUMBERS OF AREA, PRODUCTION AND YIELD OF PRINCIPAL CROPS, FROM 1966/67 TO 1991/92.

C Base Year: 1969-70 = 100

Year		1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Crop	Wt./y						
Rice	A	95.2	102.0	104.1	110.1	111.4	118.7
	P 33.98	77.8	110.2	107.2	136.2	155.3	167.3
	Y	81.7	108.0	103.0	123.7	139.4	142.8
Wheat	A	80.9	120.6	131.7	139.4	145.0	156.7
	P 12.16	63.2	146.4	160.8	207.4	245.5	291.3
	Y	78.1	121.4	122.1	148.8	168.6	177.4
Jowar	A	97.2	90.2	84.8	89.2	85.7	91.3
	P 4.86	93.5	78.3	106.6	122.2	93.1	101.4
	Y	96.2	86.8	125.7	137.0	108.6	120.6
G. Nut	A	100.6	103.5	97.0	102.3	96.2	104.7
	P 4.82	85.4	119.7	102.0	140.0	113.9	121.7
	Y	84.9	115.7	105.2	139.9	118.4	125.6
S. Cane	A	94.2	97.9	119.0	132.4	127.6	138.7
	P 7.01	78.3	95.4	130.0	156.3	156.0	168.4
	Y	83.1	97.4	109.2	118.1	122.3	132.4
Cotton	A	100.8	100.4	88.5	103.5	89.2	93.4
	P 3.01	94.1	124.2	104.2	140.7	123.2	131.4
	Y	93.4	123.7	117.7	135.9	138.2	145.7

Source: H. L. Chandhok and The Policy Group: Indian Data Base: The Economy, Vol.1, 1990.

1991/92 respectively. On the other hand Jowar area index raised from 97.2 in 1966/67, but later declined to 91.3 in 1991/92. The production index for cotton was 93.5 in 1966/67, later improved to 101.4 in 1991/92. Interestingly the yield index showed fluctuations over the time period, from 1966/67 to 1991/92, i.e 96.2 in 1966/67, 125.7 in 1976/77, 108.6 in 1986/87, was later increased to 120.6 in 1991/92 respectively.

Area Index of ground nut raised from 100.6 in 1966/67 to 104.7 in 1991/92. Production index was also showed positive growth from 85.4 in 1966/67 to 121.7 in 1991/92. However, the yield index recorded 84.9 in 1966/67, and later raised to 125.6 in 1991/92 respectively. Meanwhile, the sugar cane area index raised from 94.2 in 1966/67, to 138.7 in 1991/92. Production index almost doubled from 78.3 in 1966/67 to 168.4 in 1991/92. Contrary to this, yield index improved from 83.1 in 1966/67, to 132.4 in 1991/92 respectively. However, cotton arpa index recorded 100.8 in 1966/67, it later declined to 93.4 in 1991/92. Interestingly production index showed a positive trend i.e the index increased from 94.1 in 1966/67 to 131.4 in 1991/92. On the other hand yield index witnessed improvement from 93.4 in 1966/67 to 145.7 in 1991/92 respectively.

Compound growth rates of rice crop index w.r.t, area, production, and yield showed interesting picture. The area index of rice increased at a rate of 1.39 % in 1971/72, the later growth rate was 1.28 % per annum in 1991/92. Production index raised at a rate of 7.11 % in 1971/72, and the growth rate was 1.50 % per annum in 1991/92. However, yield index accounted 5.74 % growth rate per annum in the beginning of 1971/72, which raised later at a rate of 0.48 % per annum in 1991/92. Wheat area index increased at the rate of 8.31 % per annum in 1971/72 and 1.56 % per annum in 1991/92. Notably production index recorded a high growth rate of 18.29 % in 1971/72, but the rate of growth was only 3.48 % in 1991/92 respectively. The yield index also raised at a rate of

Table 2.10.2

COMPOUND GROWTH RATES OF ALL INDIA INDEX NUMBERS OF AREA, PRODUCTION AND YIELD OF PRINCIPAL CROPS, FROM 1966/67 TO 1991/92.

C Base Year: 1969-70 = 100

Year		Wt/y 1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Rice	A	--	1.39	0.41	1.13	0.23	1.28
	P	33.98	--	7.21	-0.55	4.90	2.66
	Y	--	5.74	-0.94	3.73	2.42	0.48
Wheat	A	--	8.31	1.78	1.14	0.79	1.56
	P	12.16	--	18.29	1.90	5.22	3.43
	Y	--	9.22	0.11	4.04	2.53	1.02
Jowar	A	--	-1.48	-1.23	1.02	-0.80	1.27
	P	4.86	--	-3.49	6.37	2.77	-5.29
	Y	--	-2.04	7.69	1.74	-4.54	2.12
G. Nut	A	--	0.57	-1.29	1.07	-1.22	1.71
	P	4.82	--	6.99	-3.15	6.54	-4.04
	Y	--	6.39	-1.88	5.87	-3.28	1.19
S. Cane	A	--	0.77	3.98	2.16	-0.74	1.68
	P	7.01	--	4.03	6.38	3.75	-0.04
	Y	--	3.23	2.31	1.58	0.70	1.60
Cotton	A	--	-0.08	-2.49	3.18	-2.93	0.92
	P	3.01	--	5.71	-3.45	6.19	-2.62
	Y	--	5.78	-0.99	2.92	0.34	1.06

Source: H. L. Chandhok and The Policy Group: Indian Data Base: The Economy, Vol.1, 1990.

9.22 % per annum in 1971/72, but this rate of growth decreased to 1.02 % per annum in 1991/92 respectively. Jowar Area Index expressed negative growth rate of -1.41 % per annum in 1971/72, but latter improved at a rate of growth of 1.27 % per annum in 1991/92. Production and yield indices also experienced negative growth rate of -3.49 and -2.04 per annum in 1971/72, but later the growth rates were positive at 1.72 % and 2.12 % per annum in 1991/92 respectively.

Area index for ground nut, was 0.77 54 growth rate per annum in 1971/72, it was increased to a growth rate of 1.71 54 per annum in 1991/92. Production index noticed a rate of growth of 6.99 54 in 1971/72, and gone up to a rate of growth of 1.42 54 per annum in 1991/92. The yield index also increased at a rate of 6.39 % per annum in 1971/72, later the rate of increase was only 1.19 % per annum in 1991/92. Regarding sugar cane, area index showed a growth rate of 0.77 54 per annum in 1971/72, and the growth rate was 1.68 % in 1991/92. The production raised at a rate of 4.03 % per annum in 1971/72, even though this rate has come down to 1.54* per annum in 1991/92. The yield index raised at 3.23 % per annum in 1971/72 and at 1.60 % rate per annum in 1991/92 respectively. The area index under cotton experienced negative growth rate of -0.08 % per annum in 1971/72, this has slightly improved to a growth rate of 0.92 % per annum in 1991/92. The production index showed positive mobility at rate of 5.71 % per annum in 1971/72, and its decreased to 1.30 54 per annum in 1991/92. However, yield index increased at 6.78 % per annum in 1971/72, but it increased at decreasing rate of 1.06 54 per annum in 1991/92 respectively.

2.11 INDEX NUMBERS OF NET AREA SOWN, CROPPING INTENSITY, CROPPING PATTERN, AND PRODUCTIVITY(YIELD):

Index's of net area sown in all India showed an index of 99.0 in 1966/67, which has raised to 112.4 in 1991/92. The cropping intensity index was 97.0 in 1966/67, and it later raised to 115.7 in 1991/92. Cropping pattern index increased from 98.5 in 1966/67

to 116.81 in 1991/92. On the other hand productivity index indicated a rise from 81.5 in 1966/67, to 171.7 in 1991/92 respectively.

Table 2.11.1

ALL INDIA INDEX NUMBERS OF NET AREA SOWN, CROPPING INTENSITY, CROPPING PATTERN AND PRODUCTIVITY PER HECTARE OF THE NET AREA SOWN.

C Base Year: 1969-70 = 100

Year Item	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Net Area Sown	99.0 (--)	101.1 (0.42)	101.2 (0.02)	102.3 (0.22)	104.5 (0.43)	112.4 (1.47)
Cropping Intensity	97.0 (--)	100.8 (0.77)	102.0 (0.24)	105.7 (0.71)	106.2 (0.09)	115.7 (1.73)
Cropping Pattern	98.5 (--)	101.5 (0.60)	103.4 (0.37)	105.2 (0.35)	108.3 (0.58)	116.8 (1.52)
Productivity Per hectare of Net Area Sown	81.5 (--)	110.0 (6.18)	114.9 (0.88)	139.8 (4.00)	158.9 (2.60)	171.7 (1.56)

Source: H. L. Chandhok and The Policy Group: Indian Data Base: The Economy, Vol.1, 1990

Considering the compound growth rates, the net area sown index increased at a growth rate of 0.42 % per annum in 1971/72 to 1.47 % growth per annum in 1991/92. Cropping intensity index raised up from a growth rate of 0.71 % per annum in 1971/72 to 1.73 % per annum in 1991/92. Cropping pattern index had a growth rate of 0.60 % per annum in 1971/72 and it is gone up to 1.52 % per annum in 1991/92 respectively. Mean while productivity index (yield) raised at a rate of growth of 6.18 % in 1971/72, and later the rate of growth was 1.56 % per annum in 1991/92 respectively.

2.12 AVERAGE ANNUAL RAIN FALL IN INDIA AND SELECTED STATES:

Rain fall is one of the foremost important deterministic factor in agriculture production, which decides the growth performance of agriculture over a period of time. There were several draught years noticed in Indian agriculture, due to lack of sufficient rain fall. Often Indian agriculture experience declining in cropping intensity and yield levels. Nevertheless rainfall does have a control on agriculture production in recent years. The water level has been declining in several states, due to unfavorable monsoon conditions, and over exploitation of water for wet crops such as rice, sugar cane etc. Thus, the present section deals with the nature of rainfall situation in all India and selected states from 1966/67 to 1991/92 respectively.

Considering Andhra Pradesh, the average rainfall accounted 882 mm in 1966/67, which has declined to 839 mm in 1991/92. Whereas Bihar experienced a raise in rainfall from 805 mm in 1966/67 to 1017 mm in 1991/92. Contrary to this Punjab scenario is quite interesting. Here the rainfall fall from 518 mm in 1966/67 to 418 mm in 1991/92. Tamil Nadu experienced drastic decline in average rainfall namely from 1155 mm in 1966/67 to 362 mm in 1991/92. On the other hand U. P situation was far better in the sense that, the average rainfall increased from 799 mm in 1966/67 to 1158 mm in 1986/87, but later declined to 979 mm in 1991/92. West Bengal accounted 1667 mm in 1966/67, then raised to 2533 mm in 1971/72, but later declined to 1273 mm in 1976/77, and again raised to 2335 mm in 1981/82, then declined to 1508 mm in 1991/92 respectively.

Table 2.12.1

Average Annual Rainfall in India, from 1966/67 to 1991/92.
(Millimeters).

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh	882 (--)	741 (-1.87)	945 (4.98)	959 (0.29)	843 (-2.55)	839 (-0.10)
Bihar	805 (--)	1796 (17.41)	1271 (-6.68)	1324 (0.82)	1294 (-0.42)	1017 (-4.70)
Punjab	518 (--)	647 (4.55)	764 (3.38)	533 (-6.95)	660 (4.37)	418 (-8.73)
Tamil Nadu	1155 (--)	1034 (-2.19)	881 (-3.15)	1087 (4.29)	840 (-5.03)	362 (-15.50)
Uttar Pradesh	799 (--)	1274 (9.78)	850 (-7.78)	1054 (4.40)	1158 (1.90)	979 (-3.30)
West Bengal	1667 (--)	2533 (8.73)	1273 (-12.86)	2335 (12.90)	2091 (-2.18)	1508 (-8.33)
All India	971 (--)	1337 (6.61)	977 (-6.08)	1215 (4.46)	1147 (-1.15)	853 (-5.75)

Source: Statistical Abstract of India, Various issues 1966 to 1991. Agricultural Statistics at Glance, 1992 and 1994.

(). Figures in the brackets indicates compound growth rates.

All India picture showed wide fluctuations in rainfall. At all India level the average rainfall was 971 mm in 1966/67, it raised to 1337 mm in 1971/72, later declined to 971 mm in 1976/77, then increased again to 1215 mm in 1981/82, and again declined to 853 mm in 1991/92. The overall picture indicates that, the rainfall situation is completely volatile not only in overall India but also with respect to individual states. This is the prime cause for declining output over a period of time in Indian agriculture. Which implied that favorable rainfall is very much essential to meet the necessary water requirement in agriculture sector producing more food and non-food grains.

On the other hand the compound growth rates of **average rainfall**, showed that there is negative growth rate of -1.87 % in 1971/72 in Andhra Pradesh, and also in the final year of study-0.10 % in 1991/92. Bihar experienced an increasing in rainfall growth rate of 17.41 % per annum in 1971/72, but later it was negative -4.70 % per annum in 1991/92.

In Punjab, the rainfall growth rate was 4.55 % per annum in 1971/72, but it has declined to negative growth of -8.73 in 1991/92. Contrary to this Tamil Nadu showed almost negative growth rate throughout the study period of -a.19 in 1971/72 and -15.50 % in 1991/92 respectively. U.P has some what better rainfall experience of 9.78 % per annum in 1971/72, to 4.40 % per annum in 1981/82, later experienced negative growth rate of -3.31 % per annum in 1991/92. West bengal experienced positive growth in the beginning period of 8.73 % per annum in 1971/72, but later it was negative growth of -6.33 in 1991/92. All India scenario show that the average rainfall experienced a growth rate of 6.61 % per annum in 1971/72, and negative growth of -5.75 % per annum in 1991/92 respectively.

2.13 PER CAPITA WATER AVAILABILITY BY REGION:

Per capita water availability by different regions, varied significantly over the period under study. Per capita water availability differs from one region to another region due to unfavorable monsoon and rainfall rate. This section deals with a.

brief scenario of water availability per capita in the world with respect to different regions.

In Africa, the per capita water availability was 20.6 T.M³ in 1950, which has declined to 5.4 T.M³ in 1980, which is expected to decline further to 5.1 T.M³ by 2000 AD. Whereas Asia which had 9.6 T.M³ in 1950, has declined to 5.1 T.M³ in 1980, later will be expected to decline further to 3.3 T.M³ by 2000 Years. In case of Latin America, it was 105.0 T.M³ in 1950, it declined to 48.8 T.M³ in 1980 and is expected to decline further to 28.3 T.M³ by 2000

Table 2. 13.1

PERCAPITA WATER AVAILABILITY BY REGION, SELECTED COUNTRIES 1950 TO 2000 (1000 m³)

Region	1950	1960	1970	(Projection)	
				1980	2000
Africa	20.6 (--)	16.5 (-2.19)	12.7 (-2.58)	9.4 (-2.96)	5.1 (-3.01)
Asia	9.6 (--)	7.9 (-1.93)	6.1 (-2.55)	5.1 (-1.783)	3.3 (-2.15)
Latin America	105.0 C-3	80.2 (-2.66)	61.7 (-2.59)	48.8 (-2.32)	28.3 (-2.693)
Europe	5.9 C-3	5.4 (-0.88)	4.9 (-0.97)	4.4 (-1.073)	4.1 (-0.35)
North America	37.2 (--)	30.2 (-2.06)	25.2 (-1.79)	21.3 (-1.67)	17.5 (-0.98)

Source: N. B. Aylbefe lu 1992.

years. However, in Europe the per capita water availability was 5.9 T.M³ in 1950, but it is later expected to decline to 4.1 T.M³ by 2000 A.D. Finally, North American experience was that, it was 37.2 T.M³ in 1950, declined to 21.3 T.M³ in 1980, and further expected to decline to 17.5 T.M³ by 2000 A.D.

A measure of compound growth rates indicate, a negative growth rate all over the world. In case of Africa, almost negative growth experienced i.e -2.19 % in 1980 to -3.01 % to 2000 A. D. Asia also accounted negative growth of -1.93 % in 1980 and -2.15 to 2000 years, Latin America and Europe noticed negative growth rates of -2.66 % and -0.88 % in 1980 to -2.69 % and -0.35 % by 2000 Years. Finally North America also noticed negative growth of -2.06 in 1980 and -0.98 by 2000 Years respectively.

2.14 SUMMARY AND CONCLUSIONS:

In this chapter the data relating to the cropping pattern and cropping intensity in Indian agriculture and selected states was analysed. Along with this some other issues like profiles of selected states, factors affecting growth performance, area irrigated by different sources, net state domestic product from agriculture, economics of crops cultivation, potential yields of HYVs, index numbers of area, production, and yield of principal crops, index numbers of net area sown, cropping intensity, cropping pattern, and productivity, average annual rainfall, and percapita water availability were also analysed. The main findings are listed as follows.

It is clear indication that, the states which have tremendous development in agriculture scene were showing relatively higher development index, while compared with agriculturally less development states. Regarding factors affecting growth

performance, observed that, difference in average size of holding, intensity of cropping, percentage area under HYVs, percentage area irrigated to total cultivated area, fertilizer use per hectare, and credit availability are the some important factors which explain regional disparities. The analysis relating to source wise irrigation indicates that, the area under canals has been slightly declining, where as the area under tube wells and other wells was increasing drastically. This is a clear indication that, the pressure on energy sources such as diesel and electricity is increasing faster rate.

In case of net state domestic production from agriculture, the analysis was showed that fluctuations over time due to several causes. It may be due to declining area under irrigation, unfavourable monsoons and changes in cropping pattern, and cropping intensity etc. It was observed that, the year 1991/92 showed declining growth rates not only in whole India but also in almost all the states. The analysis with respect to economics of crops cultivation observed that, in all most all the states, sugarcane is showing higher cost of cultivation while comparing with other crops, due to high application of inputs with more operational activities. However, the employment, irrigation, and average net income is also high in case of sugarcane.

The observations with respect to cropping pattern and cropping intensity were identified that, the area under rice and jowar slowly declining, where as the area under wheat and

sugarcane increasing at faster rate. However, cotton and ground nut showed fluctuations over a period of time, with changing shares in overall agricultural production. Cropping intensity was also showed fluctuations over a period of time, due to unfavourable rainfall and drastic decline in irrigated area. The data analysis relating to potential yields of H&V seeds indicate that, there is a clear difference between potential yield and actual yield with respect to different crops. There are several factors which influence yield mechanism in Indian agriculture. Generally the yield component was influenced by several factors such as availability of water, fertilizers, and other inputs, especially application of inputs at efficient level, which are related to the farm management skills in production.

In case of rainfall the analysis observed that, the rainfall situation completely volatile not only in overall Indian but also with respect to individual states. This is the prime cause for declining output over a period of time in Indian agriculture. Which implied that favourable rainfall is very much essential to meet the necessary water requirements in agriculture sector producing more food and non-food grains. Based on these findings the next chapter will demonstrate the nature of factor shares in Indian agriculture with respect to selected states.

CHAPTER 3

FACTOR SHARES IN AGRICULTURE SECTOR

3.0 INTRODUCTION:

In recent years, the introduction and spread of modern technology have brought about a substantial increase in agricultural productivity in India. But the gains of such increased productivity are said to have been shared unevenly by various factors of production and administrative regions. There was evitenci? from different studies that there is some degree of growing inequality in factor shares in agricultural production. However, since most of these studies did not have any systematic data base over time and space, the results reported remained largely inconclusive. Besides, there were noticeable changes in factor use in farm production in the late seventies and the nature, extent and impact of such changes at the macro level have not thus far been explored.

The share of capital in the total cost should increase and that of labour and land should decline with the advance, in the level, of agricultural technology. The impact of technology, which is generally land-substituting, on the share of land may be partly nullified due to relatively faster increase in the value of land as compared to other category of factors mainly because of its scarcity, investment of capital in it and increase in its productivity. The share of labour would decline because both wage rate and the use of labour has been increasing at a much slower

rate vis-a-vis other factors of production. Within a region a technologically advanced crop would have a lower share of land and labour and a higher share of capital as compared to other crops. Under homogeneous agro-climatic conditions, the share of factors for a crop should not differ much among the regions.

3.1 FACTOR ENDOWMENTS IN INDIAN AGRICULTURE AND SELECTED STATES:

While comparing the statewise variations in agricultural production and factors combinations, it is relevant to discuss the available resources which endowed by states over a period of time. Factor endowments will always talks about the specialisation or dominance of particular factor which is abundant in the respective region. Depending on this factor availability the variations in agricultural production will take place in between states. In the present study the factors considered are, land under crop, labour, draught power, capital (agricultural machinery and implements), fertilizers, pesticides, and energy in particular.

However, it is interesting to look at this juncture, if a particular factor is abundant, in selected state, that state can be produced more output by considering those factors. Suppose, Bihar and West Bengal has still having much amount of human and draught power, so that these states can depend for some time on this sources, which can be supplemented in place of commercial energy sources. On the other hand these states are showing less number of tractors and pump sets as comparing with other states, much number of wooden and iron ploughs has noticed in these states.

Similarly, Punjab and U.P has recorded high number of tractors and pump sets with relatively less number of labour and draught power. In this context, these states were mechanized their farms at faster rate in order to reach the requirements of the state. So, the above analysis indicates that, factor endowments are very much essential to overcome the statewise variations. It can be further suggested that by considering above mentioned observations one can meet the energy requirements, as well as alternative energy resources which are very much essential for producing self sufficient food grains in Indian agriculture.

Factor combinations and factor shares in agriculture depend on a number of factors such as the resource endowments of the region, the type of crops grown, level of technology used, factor prices and Government policy. Distribution of factor shares and their change over time, and space is important in the context of economic growth and social Justice. Estimates of factors shares in agriculture can be viewed in two ways. One approach is to estimate the contribution of various factors in the total agricultural output through the method of production function analysis. Another method is to estimate the factor proportions in the total cost of production and their shares in the total value of output, and to determine how these shares vary among different crops, over time, as well as among different regions and to indicate the reasons thereof.

One should be aware of changes in factor participation from traditional type to modern type that have created enough pressure on energy demand in recent modern agriculture. It should be

noticed that the efficiency of modern inputs are always higher while comparing with traditional inputs. Keeping this into consideration the preceding section will discuss about the existing literature available in factor shares or substitution in Indian agriculture.

Waghmare, R. E and Dhongade (1983) analysed, input-output data of important crops studied under cost of cultivation schemes operated in the state of Maharashtra. They examined the changes in factor shares due to use of high-yielding variety (HYV) seeds, irrigation, and improved method of cultivation over the use of local varieties, unirrigated cultivable and traditional method of cultivation respectively. The study covered the crops of paddy (1973-74), bajra (1973-74), jowar (1971-72, 1973-74, 1977-78), cotton (1976-77), wheat (1975-76) and sugarcane (1973-74 and 1977-78).

A comparison of the factor shares in respect of local and HYV paddy, unirrigated and irrigated wheat indicated that their relative share of capital has increased as against a decline in the share of labour, indicating thereby a substitution between labour and capital that has taken place in HYV paddy and irrigated wheat.

The study of hired labour shares due to improved technology in jowar, cotton, paddy and wheat showed a marginal decline over the traditional technology. However, over a period of time, the share of hired labour in the cultivation of jowar and sugarcane crop showed an increase. Comparing the changes in the factor

shares for sugarcane and Jowar over a period of time , it was observed that there was a decline in the share of profit in sugarcane cultivation while there was neither an increase nor a decrease in the share of profit in Jowar cultivation.

Another interesting study was by *Bhatia, M. S et.al(1982)*, who did analytical work based on state wise data of factor cost and returns in the cultivation of wheat and rice for the year 1971-72 to 1980-81 that was generated under the " comprehensive scheme for studying the cost of cultivation/production of principal crops of the Directorate of Economics and Statistics, Ministry of Agriculture. Government of India.

The main conclusions drawn in this study were: The rising capital-labour ratio without affecting the absolute share of labour in gross output would help not only increasing farm output but also in maintaining an egalitarian order in the economy. The states, like Assam, Bihar, Orissa, West Bengal and MadhyaPradesh were showing low capital-labour ratio and low productivity, exist simultaneously. In addition, the results indicate that more increase in the use of capital would not raise factor productivity in states like West Bengal and MadhyaPradesh, unless supported by other measures such as technological and institutional changes.

With an abrupt increase in the prices of oil products since 1973-74 the cost structure and input-mix in farming have been experiencing a rapid change. This has affected the allocation, utilisation and payment of various factors of production.

According to *Bal, H. K et.al(1983)*, who did extensive work, to examine the efficiencies, factor share and the productivity of various factors in crop cultivation in the central districts of Punjab at two points of time, namely (i) pre price hick period(1972-73) and (ii) post-price hick period(1980-81). The data of 50 holdings from the "comprehensive schemes to study the cost of cultivation of principal crops" for the above two time periods were taken and Cobb douglas model was employed for this analysis. However labour, draught power, irrigation, fertilizer s value including weedicides, and rental value of land were taken as the independent variables and value of the farm output(crops only) as the dependent variable.

It was noted that the elasticities of production(in value) of human labour, draught power and rental value of land have declined in 1980-81 over 1972-73, but that of irrigation has increased over this period. Per hectare use of human labour has decreased from 536.11 man-hour in 1972-73 to 508.11 man-hour in 1980-81. The average level of use of other factors has increased over the period. This indicates substitution of human labour with other factors, mainly with irrigation, fertilizers and weedicides. Marginal value of productivity in both the time periods were higher than the factor cost with human labour and fertilizers having sufficiently higher marginal value productivity. This indicates that productivity (in value terms) can be increased further at the same level of cost gain.

Pandey, U. K. et.al(1983), analysed the factor shares and value shares of output in Haryana agriculture under different periods and the impact of technological change on factor proportions and their shares in output based on total factor productivity approach. The study involves the measurement of growth rates of output and input indices for each of the seven districts in Haryana during period I (pre-green revolution period, 1956-57 to 1965-66) and period II (green revolution period, 1966-67 to 1973-74) and eleven districts during period III (post green revolution period, 1974-75 to 1981-82) with the help of secondary data.

The study reveals that the traditional input accounted for the bulk of total factor inputs during the pre-green revolution period while in the subsequent periods (green revolution and post green revolution periods) the share of modern inputs has considerably increased. Due to green revolution the output growth has considerably increased amongst districts and state. Undoubtedly, considerable growth has occurred in modern inputs during the post-green revolution period but productivity has also fallen steeply amongst the districts and in the state. The districts which has better resource endowments has realised the benefit of technological change in the state.

One of the important study by *Singh, J. P. (1983)*, looks at the factor shares in Indian agriculture. The main objective was to examine the extent of variation in factor shares in agriculture among the regions and also over a period of time and to find the reasons for these variations.

The share of factors has been worked out in the total cost of production. This approach is based on the assumption that the returns to scale are constant and prices of various factors of production are proportional to their marginal value products. The data used for deriving factor shares comes from the "studies in the economics of Farm Management" and the "comprehensive scheme for the study of cost of cultivation of principal crops". The farm management studies data have been used for three out of five districts for which the studies were repeated.

The main findings of this study are, the share of land has declined and that of capital has increased in regions with better agricultural performance. The share of labour declined in all the regions. The factor shares for wheat are found to be quite close among the major wheat growing states. This is because the agro-climatic conditions and the extent of adoption of new technology are fairly similar in the major wheat growing states, but differ widely among the major rice growing states. Capital is found to be the most important factor in Punjab where as labour is found to be the most important in Orissa.

According to Guha. S(1990), who did analytical study on changes in labour intensity in Indian agriculture by taking farm level data from four periods commencing with the 1880s in order to study the variation in labour use for different crops. The main observation for this study is that agriculturally progressive areas showed decline in labour intensity by the 1950s, while increases are observable else where. It is largely showing that

modernization in agriculture is replacing the labour force, which means substitution of inputs are taking place to improve the efficiency of agriculture with notable productivity.

Ramaswamy. C and Suresh kumar. DC(1993), who did extensive work on inter-regional variations in agrarian labour productivity in North-Western zone of Tamil Nadu. The main objectives of this study are, estimating the labour productivity and marginal productivity of labour in across regions, to examining the various factors influencing variations in the constituent components of labour productivity across regions and prescribing policy measures to increase the labour productivity and to reduce its regional variations . For this study two different regions were selected on the basis of irrigation intensity. One representing high irrigation intensity and another low irrigation intensity. Thirty farm households were selected randomly to represent each region.

The main evident from the analysis that, the man-land ratio, fertilizer, cropping pattern index are the major factors influencing variations in yield. Man-land ratio is the most prominent factor. Cropping intensity is the single dominant factor explaining variations in the man-land ratio across all regions. Tractor power shows significant negative influence on the man-land ratio. Development of major and minor irrigation, net sown area and net irrigated area will substantially increase the labour productivity. Increased use of yield augmenting inputs like HYV seeds, fertilizers also augment labour productivity.

In a recent study conducted by *SatyaPaul and Rajesh Mehta(1991)*, they explored the factor demand and substitution in Indian agriculture. Translog cost function has been used to provide measures of factor demand, elasticities of substitution, biases of technical change and to test hypothesis about the structure of productivity technology in Indian agriculture. The study covers the period 1950-61 to 1982-83.

The results based on this approach reveal that the agricultural technology has been biased towards the use of labour and capital, and towards the saving of fertilizers and other inputs. Since the prices of all the inputs have increased, the labour and capital using biases of technology seem to be the outcome of biased innovation possibilities. There exist strong substitution possibilities between labour and capital and between capital and fertilizers. This is of great importance for India and other less developed countries. Instead of massive use of capital (such as tractor, etc.), these countries can make extensive use of chemical fertilizers and human labour in order to increase agriculture production. The low value of price elasticity of demand for fertilizer and other inputs is also of closer importance. It suggests that a marginal change in its price level (through fertilizer subsidy or other policy measures) is not likely to affect its consumption substantially in Indian agriculture.

According to *Ramesh. C(1986)*, who did analytical study on effects of input and output prices on input demand in Punjab agriculture, CO to estimate the systems of input demand equations for major crops of Punjab. (ii) to compare the inter and inter

crop effects in input-output prices and some other exogenous variables in input use, (111) to study the effects of price changes on growth of input demand. This study has used profit function rather than production function for estimating effects of price and non-price variables on input demand. The data used for this study available under 'comprehensive scheme for studying the cost of cultivation' collected under the aspirin of Directorate of Economics and Statistics, Ministry of agriculture, Government of India.

The results showed that, all fixed inputs appear to be important in influencing inputs use, and their effect on different inputs and in different crops is not uniform. Expenses for the investment in irrigation increased their demand for all the input and in almost all the crops. Its effect was more pronounced in paddy compared with other crops. Capital expenditure which consisted mainly of investment in fixed assets/farm machinery was observed to be a perfect substitute- of bullock labour. An increase in capital expenditure at the rate of 10 percent would displace the bullock labour at the rate of about 9 percent in wheat, 5 percent in paddy and cotton respectively, and about 4 percent in gram.

A sum of elasticities of input use with respect to capital expenditure, irrigation and land provides the scale elasticity which gives the simultaneous effect of all the fixed inputs on input use. With the increase in the scale of production human labour use increased at diminishing rate in wheat and paddy but it increased in cotton and gram. The scale elasticity of bullock

labour was negative in wheat and nearly zero in paddy. Scale elasticity of fertilizer demand were quite uniform as in wheat, paddy and cotton and they ranged between 1.01 to 1.05 respectively.

3.2 LABOUR ABSORPTION FOR MAJOR CROPS IN SELECTED STATES:

Ashok Gulati, Pradeep.K. Sharma(1990), analysed the absorption of labour force for major crops in selected states, by considering man days per hectare of cropped area under different crops. The table 3.2.1 illustrate labour absorption for major crops in selected states According to them in Andhra Pradesh the rice crop demands around 150.58 man days/he, as against Jowar 50.09 man days/he, where as ground nut and sugar cane absorbing 86.26 and 344.88 man days/he respectively. It was observed that sugar cane is demanding much labour next to rice.

Table 3.2.1

LABOUR ABSORPTION (Man days/ha) FOR MAJOR CROPS IN SELECTED STATES

States Crop	A.P	Bihar	Punjab	T.Nadu	U.P	W. Bengal	Weighted average.
Rice	150.58	107.37	104.77	159.36	108.80	129.19	101.84
Wheat		92.03	51.54		77.34		66.03
Jowar	50.09						61.63
Groundnut	86.26			106.88			80.16
Cotton			101.27				99.76
Sugarcane	344.88	122.41		332.54	137.45		191.76

Source: Ashok Gulati, Pradeep K. Sharma, 1990.

However in Bihar, rice absorbing 107.37 man days/he, wheat noticed 92.03 man days/he and sugar cane 122.41 man days/he. In case of Punjab rice noticed 104.77 man days/he, next comes wheat around 51.54 man days/he and cotton 101.27 man days/he respectively. Rice demanding much labour compared with other crops. Tamil Nadu noticed 159.36 man days/he in rice production, next was 105.88 and 332.54 man days/he in ground nut and sugar cane respectively. Sugar cane demanding much labour force, compared with other crops.

Uttar Pradesh noticed, 108.80 man days/he in rice cultivation, 77.34 man days/he and 137.45 man days/he in case of wheat and sugar cane respectively. West Bengal accounted 129.19 man days/he in rice cultivation. On the whole, based on the weighted average, it is noticed that, rice, wheat, jowar, ground nut, cotton, and sugar cane are absorbing 101.84, 66.03, 61.63, 80.16, 99.76, and 191.76 man days/he cropped area. Overall observation witnessed that sugar cane demanding more labour force, next is rice, cotton, ground nut, wheat, and Jowar respectively. Because sugar cane cultivation involves several operations, next to rice cultivation, consisting of operations such as land preparation, plantation, interculture, winnowing, threshing, and transplantation etc.

3.3 CROP-WISE LABOUR ABSORPTION IN INDIAN AGRICULTURE:

According to Tyagi (1981), who estimated the crop-wise labour absorption by taking two periods i.e 1970/71 and 1979/80,

as stated in table 3.3.1. the crop wise labour absorption in Indian agriculture, noticed interesting observations. It was observed that rice crop is absorbing 109.94 man days/he in 1970/71. later it increased to 110.04 man days/he in 1979/80. where as wheat demanding 80.46 man days/he in 1970/71, which has been raised to 82.11 man days/he in 1979/80. In case of Jowar, it is absorbing 55.75 man days/he in 1970/71, later it witnessed 58.09 man days/he in 1979/80. Labour absorption rate was slightly declined in case of ground nut, which was 73.31 man days/he in 1970/71, later declined to 73.01 man days/he in 1979/80. Cotton and sugar cane accounted 81.98 and 217.75 man days/he in 1970/71, which was further increased to 83.98 and 219.92 man days/he in 1979/80 respectively.

Table 3.3.1
CROP-WISE LABOUR ABSORPTION IN INDIAN AGRICULTURE.

(Man day's per hectare)

Crop	Tyagi Estimates,	Triennium ending	Ashok Gulati Study
	1970/71	1979/80	average of 1980/81 to 1986/87.
Rice	109.94	110.04	101.84
Wheat	80.46	82.11	66.03
Jowar	55.75	58.09	61.63
Groundnut	73.31	73.01	80.16
Cotton	81.98	83.98	99.76
Sugar cane	217.75	219.92	191.76

Source: Tyagi, D. S., 1981.

Ashok Gulati, Pradeep K. Sharma, 1990.

Ashok Gulati(1990), has also estimated the labour absorption rate in different crops in Indian agriculture by taking the period average of 1980/81 to 1986/86. He noticed that, rice is demanding 101.84 man days/he, where as wheat, jowar, ground nut, cotton, and sugar cane on the average from 1980/81 to 1986/87 where demanding around 66.03, 61.63, 80.16, 99.76, and 191.76 respectively.

In both the estimations it was observed that sugar cane absorbing much amount of labour force, next is rice, cotton, ground nut, wheat, and jowar respectively. This indicates that the labour absorption is still much high in different crops, even though modern technology was introduced in Indian agriculture. It implies that labour force is still existing along with modern technology. This conclusion gave raise to a reasonable support to the positive economists, where the arguments enlightened that modern technology improved the employment conditions in Indian agriculture.

3.4 VALUE OF INPUTS IN INDIAN AGRICULTURE(AT CURRENT PRICES):

Value of inputs is one of the over emphasising issue in modern agriculture, where the input costs are increasing at a faster rate. In order to identify the nature of inputs contribution in agriculture, its contribution towards output production can be examined in this section. The value of inputs in Indian agriculture is shown in table 3.4.1. Firstly, the cost of seeds used in Indian agriculture noticed, Rs. 708 crores in 1966/67, increased to 4287 crores in 1991/92, an equivalent of 21.9 % in 1966/67 to 11.5 V. in 1991/92.

On the other hand contribution of Organic manure increased at, Rs.182 crores in 1966/67, which has raised up to Rs. 2156 crores in 1991/92, in percentage terms it is almost equivalent to 7.5 % in 1966/67 and 5.6 % in 1991/92. Chemical fertilizers

Table 3.4.1

VALUE OF INPUTS IN INDIAN AGRICULTURE SECTOR: 1966/67 TO 1991/92.

(At Current Prices, Rs. Crores.)

Inputs	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Seeds	708 (21.9)	743 (16.4)	1119 (13.1)	1844 C10.95	2493 (9.9)	4287 (11.1)
Organic Manures	182 (7.53)	294 CO.5)	584 (6.93)	753 (4.53)	1260 (5.0)	2156 (5.6)
Chemical Fertilizers	185 (5.43)	470 (10.4)	1390 (16.3)	3010 (17.8)	5051 (20.0)	6398 (16.53)
Maintenance of assets	127 (4.63)	124 (2.73)	227 (2.75)	871 (5.2)	1638 (6.5)	3019 (7.8)
Freed of live stock C	1604 54.5)	3600 (52.2)	3600 (42.45)	8333 C49.3)	11000 (46.2)	17914 C46.2)
Irrigation Charges	37 (1.5)	48 (1.15)	133 (1.63)	147 (0.95)	195 (0.85)	267 (0.7)
Market Charges	68 (2.33)	102 (2.35)	161 (1.9)	660 (3.95)	946 (3.75)	1670 (4.35)
Electricity	23 (0.7)	71 (1.65)	197 (2.3)	314 (1.9)	530 f 2.15	643 (1.73)
Pesticides & Insecticides	30 (0.53)	44 (1.0)	171 (2.05)	310 (1.8)	431 (1.7)	488 (1.3)
Diesel Oil	68 (1.2)	270 (6.03)	927 (10.93)	658 (3.93)	1070 (4.2)	1881 (4.9)
Total Inputs	3031 (100.0)	4524 f 100.05	8518 (100.0)	16892 (100.0)	25283 r 100.0)	38713 (100.0)

Source: CMIE: Basic Statistics Relating to the Indian Economy (1994)

(Figures in the brackets will indicate percentage share of Inputs).

increased at faster rate i.e Rs. 185 crores in 1966/67 to Rs. 6398 crores in 1991/92, in percentage terms it equals 5.4 % in 1966/67 to 1991/92 respectively. Maintenance of assets raised from Rs. 127 crores in 1966/67 to Rs. 3019 crores in 1991/92, percentage wise 4.6 % in 1966/67 and 7.8 % in 1991/92. Animal feed noticed Rs. 1604 crores in 1966/67, later it has gone up to Rs. 17914 crores in 1991/92, or from 54.5 % in 1966/67 to 48.2 % in 1991/92 respectively.

Irrigation charges raised from Rs. 37 crores in 1966/67, to Rs. 1287 crores in 1991/92, or from 1.5 % in 1966/67 to 0.7 % in 1991/92. Market charges also gone up from Rs. 68 crores in 1966/67, to Rs. 1570 crores in 1991/92, or from 0.2 % in 1966/67 to 2.3 % in 1991/92. Electricity is one of the important energy source in agriculture, which noticed a jump from Rs. 53 crores in 1966/67, to Rs. 648 crores in 1991/92, in percentage terms it is 0.7 % in 1966/67 to 1.7 % in 1991/92 respectively.

Regarding pesticides and Insecticides, which increased from Rs. 30 crores in 1966/67 to Rs. 488 crores in 1991/92, or 0.5 % in 1966/67 to 1.3 % in 1991/92. Diesel oil is another important energy component in agricultural production process, which witnessed an increase from Rs. 68 crores in 1966/67, to Rs. 1881 crores in 1991/92, or 1.2 % in 1966/67 and 4.9 % in 1991/92 respectively. Total value of inputs experienced a twelve times increase in value i.e Rs. 3031 crores in 1966/67 to Rs. 38713 crores in 1991/92. This is a clear indication that, the input burden is raising at a faster rate in agriculture sector in modern agriculture. Due to this reason farmers shifted their production

from food crops to commercial crops, where commercial crops are more profitable < while comparing with food crops.

On the other hand, as stated in the table 3.4.2, compound growth rates show some interesting scenario: Seed increased at 0.97 V. per annum in 1971/72, later it was raised at increasing rate 11.45 % per annum in 1991/92. Organic manures noticed a growth rate of 10.07 % per

Table 3.4.2

COMPOUND GROWTH RATES OF VALUE OF INPUTS IN INDIAN AGRICULTURE SECTOR: 1966/67 TO 1991/92.

Inputs	CAt Current Prices), Rs. Crores.					
	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Sends		0.97	8.53	10.51	3.23	11.45
Organic Manures		10.07	14.71	5.22	10.84	11.34
Chemical Fertilizers		HO. SO	24.22	16.71	10.91	4.84
Maintenance of assets		-0.48	12.86	30.86	13.46	13.01
Feed of livestock		8.03	8.87	18.22	6.96	8.95
Irrigation Charges		5.34	22.61	2.02	5.81	6.49
Market Charges		8.45	9.56	32.60	7.47	12.04
Electricity			P.P. 64	ft. 77	11.04	3.98
Pesticides & Insecticides		7.96	31.19	12.63	6.81	2.52
Diesel Oil		31.49	27.98	-6.63	10.21	11.95
Total Inputs		8.34	13.49	14.68	8.40	8.89

Source: CMIE: Basic Statistics Relating to the Indian Economy(1994)

annum in 1971/72, and 11.34 % in 1991/92. where as chemical fertilizers increased at the rate of 20.50 % per annum in 1971/72, but later witnessed a decreasing rate of 4.84 % in 1991/92. Maintenance of assets experienced negative growth 0.48 % in 1971/72, was later managed to have a positive growth rate of 13.01 % in 1991/92.

However feed of live stock increased at 8.05 % per annum in 1971/72, later raised to 8.95 % in 1991/92. Irrigation charges note a growth rate of 5.34 % per annum in 1971/72, but later showed an increasing rate of 6.49 % per annum in 1991/92. Market charges were accounted at 8.45 % per annum in 1971/72, which increased at an increasing rate of 12.04 % per annum in 1991/92. Meanwhile electricity was noticed at a rate of 25.29 % per annum in 1971/72, has raised to a rate of 3.98 % per annum in 1991/92. On the other hand pesticides and insecticides witnessed at the rate of 7.96 % in 1971/72, further increased at a rate of 2.52 % per annum in 1991/92. Contrary to this, Diesel oil accounted a growth rate of 31.49 % per annum in 1971/72, and further gone up at a rate of 11.95 % per annum in 1991/92. On the whole it was observed that, total inputs increased at 8.34 % per annum in 1971/72, which raised up to 14.68 % per annum in 1981/82, later slightly declined to 8.40 % per annum in 1986/87, which then increased at a rate of 8.89 % per annum in 1991/92 respectively.

3.5 VALUE OF AGRICULTURAL OUTPUT AND INPUTS IN INDIAN AGRICULTURE (AT CURRENT AND 1980/81 PRICES)

A comparative analysis has been done in this section, to

Identify the inter dependence between value of output and value of inputs by taking current and 1980/81 prices. The comparative picture of value of inputs and output in Indian agriculture is shown in table 3.5.1. It was observed that at current prices, the value of output noticed, Rs. 12223 crores in 1966/67, which raised to Rs. 129015 crores in 1991/92. As against this, value of inputs increased at Rs. 3038 crores in 1966/67 to Rs. 38713 crores in 1991/92 respectively. Interestingly, a twelve fold increase in value of output took place between 1966/67 to 1991/92. Contrary to this 13 fold increase in total value of inputs was observed. This indicates that value of inputs was very much high while compared with value of output. This leads to worse position towards farmers, where they are facing more input burden (prices) and less output prices over a period of time.

Table 3.5.1

VALUE OF AGRICULTURE OUTPUT AND INPUTS IN INDIAN AGRICULTURE
(Rs. crores)

Year	(At current prices)		(At 1980/81 prices)	
	Value of output	Value of Input	Value of Output	Value of Input
1966/67	12223 (--)	3038 (--)	35395 (--)	8837 (--)
1971/72	17843 (7.86)	4524 (8.29)	46803 (5.75)	11078 (4.62)
1976/77	27876 (9.23)	8518 (13.49)	49721 (1.22)	12601 (2.61)
1981/82	50880 (12.79)	16892 (14.68)	60163 (3.89)	15885 (4.74)
1986/87	72990 (7.44)	25283 (8.40)	66041 (1.88)	18036 (2.57)
1991/92	129015 (12.07)	38713 (8.89)	80887 (4.14)	20666 (2.76)

Source: CMIE: Basic Statistics Relating to the Indian Economy, 1994.

(). Figures in the brackets indicates compound growth rates.

However, at 1980/81 prices, the value of output accounted Rs. 35395 crores in 1966/67, was later raised to Rs. 80887 crores in 1991/92. On the other hand value of inputs raised from Rs. 8837 crores in 1966/67 to Rs. 20666 crores in 1991/92 respectively. It was showed that the value of output and inputs increased at Z times more from 1966/67 to 1991/92 levels respectively.

The value of output and input at current prices indicates that, the growth rate was 7.86 % per annum in 1971/72, was later increased at a rate i.e 12.07 % in 1991/92. Where as inputs value noticed a growth rate of 8.29 % per annum in 1971/72 and 8.89 % per annum in 1991/92 respectively. On the other hand value of output and inputs at 1980/81 prices, observed that, value of output raised at 5.75 % in 1971/72, which further increased at a rate of 4.14 % per annum in 1991/92. Value of inputs recorded a growth rate of 4.62 % in 1971/72, and the growth rate was 2.76 % per annum in 1991/92 respectively.

3.6 TOTAL NUMBER OF CULTIVATORS AND AGRICULTURAL LABOURERS IN INDIA AND SELECTED STATES:

Labour participation in agriculture sector in India, witnessed several controversial observations since green revolution. Some studies, due to adoption of modern techniques in agriculture sector. There are two important schools of thought: one suggests that, Green revolution had replaced the labour force in agriculture, on the other hand it was mentioned that, Green revolution improved the labour absorption in Indian agriculture due to many operations (involved in HYVs production). Under these suggestions, the present section will concentrate the labour

force participation in selected states and whole India from 1966/67 to 1991/92 respectively.

As stated in the table 3.6.1, the total number of cultivators and agricultural labourers in Andhra Pradesh noticed. 121.95 lakhs in 1966/67, which was increased to 389.08 lakhs in 1991/92, in percentage terms it is 9.79 % in 1966/67 to 10.50 % in 1991/92 respectively. Bihar witnessed 140.5 lakhs in 1966/67, that raised to 413.60 lakhs in 1991/92, which in percentage terms, it is 11.28 % in 1966/67 to 11.16 % in 1991/92. However Punjab experienced loss labour force participation compared with other states i.e 21.38 lakhs in 1966/67 to 67.78 lakhs in 1991/92, or 1.72 % in 1966/67 to 1.83 % in 1991/92 respectively.

Table 3.6.1

TOTAL NUMBER OF CULTIVATORS AND AGRICULTURAL LABOURERS, 1966/67 TO 1991/92.

(in Lakhs).

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh	121.95 (9.79)	126.23 (9.97)	139.37 (9.97)	157.33 (10.63)	242.07 (10.63)	389.08 (10.50)
Bihar	140.56 (11.28)	143.86 (11.36)	151.20 (10.81)	164.09 (11.09)	252.47 (11.10)	413.60 (11.16)
Punjab	21.38 (1.72)	24.52 (1.94)	27.07 (1.94)	28.60 (1.93)	44.00 (1.93)	67.78 (1.83)
Tamil Nadu	88.31 (7.09)	90.98 (7.18)	110.44 (7.90)	115.97 (7.83)	170.39 (7.49)	271.50 (7.33)
Uttar Pradesh	206.27 (16.55)	211.52 (16.70)	222.31 (15.90)	241.35 (16.31)	371.35 (16.32)	595.98 (16.09)
West Bengal	65.48 (5.25)	72.27 (5.71)	79.79 (5.71)	84.82 (5.73)	130.51 (5.74)	217.44 (5.87)
All India	1246.25 (100.0)	1266.61 (100.0)	1398.44 (100.0)	1480.23 (100.0)	2275.52 (100.0)	3704.76 (100.0)

Source: All India Census Reports 1961, 1971, 1981, and 1991 respectively.
Statistical Abstract of India various issues from 1966 to 1991.

On the other hand, Tamil Nadu accounted 88.31 lakhs in 1966/67, that has gone up to 271.50 lakhs in 1991/92, which translates to a 7.09 % in 1966/67 and 7.33 % in 1991/92. Uttar Pradesh is the only state where highest labour participation was witnessed i.e 206.27 lakhs in 1966/67, to 595.98 lakhs in 1991/92, or 16.85 % share in 1966/67 to 16.09 % in 1991/92 respectively. Next is the West Bengal, accounting for five 48 lakhs in 1966/67, and 217.44 lakhs in 1991/92, or 5.25 % in 1966/67 and 5.87 % in 1991/92 respectively.

All India picture was quite impressive where the labour force raised from 1246.25 lakhs in 1966/67 to 3704.76 lakhs in 1991/92. It is almost three times increase in labour participation in agriculture sector. But still several studies were noticed raise of unemployed labour force in agriculture sector. The main reason for this is that, the existing agricultural sector not in a position to absorb the entire labour force, due to unfavorable monsoons, and seasonal draw-backs in Indian agriculture scenario.

Considering compound growth rates in the table 3.6.2, the total number of cultivators and agricultural labourers increased at the rate of 0.69 % per annum in 1971/72, which increased at a rate of 8.96 % per annum in 1991/92.

As against this Bihar showed 0.49 % per annum in 1971/72, which has raised at 10.38 % per annum in 1991/92. On the other hand Punjab experienced a growth rate of 11.72 % per annum in 1971/72, and 9.03 % per annum in 1991/92 respectively.

Table 3.6.2

COMPOUND GROWTH RATES OF TOTAL NUMBER OF CULTIVATORS AND AGRICULTURAL LABOURERS, 1966/67 TO 1991/92.

(in Lakhs).

States.	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh		0.69	2.00	2.45	9.00	9.96
Bihar		0.49	1.00	1.65	9.00	10.38
Punjab		2.78	2.00	1.11	6.00	9.03
Tamil Nadu	—	0.60	3.95	0.98	8.00	9.77
Uttar Pradesh		0.50	1.00	1.66	9.00	9.92
West Bengal		1.99	2.00	1.23	6.00	10.75
All India		0.32	1.99	1.15	8.98	10.24

Source: All India Census Reports 1961, 1971, 1981, and 1991 respectively.

Statistical Abstract of India various issues from 1966 to 1991.

Tamil Nadu accounted, 0.60 % per annum in 1971/72, and later it increased at a rate of 9.77 % per annum in 1991/92. Interestingly a twenty times increase in growth rate was observed in U. P from 0.50 % per annum in 1971/72, to 9.92 % in 1991/92. However, West Bengal showed only 1.99 % growth per annum in 1971/72, which later raised to 10.75 % per annum in 1991/92 respectively. All India scenario witnessed 0.32 % growth per annum in 1971/72, which increased at a rate of 10.24 % per annum in 1991/92 respectively.

3.7 TOTAL DRAUGHT POWER IN INDIAN AGRICULTURE AND SELECTED STATES:

Draught power still is a main source of energy in Indian agriculture, due to its reasonable and most convenient source to small and marginal farmers. But most of the studies observed that, the maintenance of draught power is very much expensive than other sources. That's why the depletion of animal power took place especially in recent years, from Green revolution onwards. Here the interesting feature is that, animal feed (food energy) is much expensive as comparing with output energy produced by animal. On this grounds the present section will evaluate the available draught power in Indian agriculture from 1966/67 to 1991/92 respectively.

The table 3.7.1 illustrate the total draught power available in all India and selected states, from 1966/67 to 1991/92. Total number of cattle and buffaloes used for work in Andhra Pradesh, was 6390 thousands in 1966/67, which increased to 8057 thousands in 1991/92, or from 8.14 % in 1966/67 to 6.71 % in 1991/92. Bihar accounted 7641 thousands in 1966/67, that increased to 10034 thousands in 1991/92, or a 9.73 % in 1966/67 to 8.34% in 1991/92. However Punjab recorded lesser draught power, which was around 2703 thousands in 1966/67, that later diminished to 1598 thousands in 1991/92. This is equal to 3.44 % in 1966/67 to 1.32 % in 1991/92 respectively.

Table 3.7.1

TOTAL NUMBER OF CATTLE AND BUFFALOES (DROUGHT POWER) USED FOR WORK ONLY, 1966/67 TO 1991/92.

(Thousands in Number)

States.	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh	6390 (8.14)	6417 (8.05)	6271 (7.75)	6893 (7.90)	7013 (7.77)	8067 (6.71)
Bihar	7641 (9.73)	8038 (10.04)	8082 (9.98)	8362 (10.73)	9938 (11.01)	10034 (8.34)
Punjab	2703 (3.44)	1733 (2.17)	1521 (1.88)	1628 (1.87)	1356 (1.50)	1598 (1.32)
Tamil Nadu	5060 (6.44)	4931 (6.16)	4900 (6.05)	5975 (6.85)	6021 (6.67)	7323 (6.09)
Uttar Pradesh	14403 (18.34)	14926 (18.65)	15227 (18.81)	16728 (19.17)	16969 (18.80)	17335 (14.41)
West Bengal	5103 (6.50)	5003 (6.25)	4922 (6.08)	5235 (6.00)	4978 (5.52)	5236 (4.35)
All India	78517 (100.0)	80026 (100.0)	80949 (100.0)	87239 (100.0)	90246 (100.0)	120297 (100.0)

Source: Statistical Abstract of India, Various Issues from 1966 to 1991.

Indian Livestock Census various issues.

Livestock Census of selected states from 1966 to 1991.

On the other hand Tamil Nadu witnessed 5060 thousands in 1966/67, which further raised to 7323 thousands in 1991/92, or 6.44 % in 1966/67 to 6.09 % in 1991/92. Uttar Pradesh recorded highest draught power compared to other states. Here there were 14403 thousands in 1966/67, later increased to 17335 thousands in 1991/92, or from 18.34 % in 1966/67 to 14.41 % in 1991/92. Whereas West Bengal showed 5103 thousands in 1966/67, that raised to 5236 thousands in 1991/92. This is an improvement from 6.50 % in 1966/67 to 4.35 % in 1991/92 respectively. All India situation showed that there were around 78517 thousands in 1966/67, later it recorded 120297 thousands in 1991/92 respectively.

As reported in table 3.7.2, compound growth rates observed that. Andhra Pradesh experienced negative growth rates i.e -1.87 % in 1971/72 to -0.10 % in 1991/92. As against this. Bihar noticed 17.41 % per annum in 1971/72, later witnessed negative growth at -4.70 % in 1991/92. Where as Punjab showed 4.55 % growth per annum in 1971/72, later experienced negative growth rate of -8.73 % in 1991/92. Contrary to this Tamil Nadu also showed negative growth

Table 3.7.2

COMPOUND GROWTH RATES OF TOTAL NUMBER OF CATTLE AND BUFFALOES (DROUGHT POWER) USED FOR WORK ONLY, 1966/67 TO 1991/92.
(Thousands in Number).

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh		-1.87	4.98	0.29	-2.55	-0.10
Bihar		17.41	-6.68	0.82	-0.42	-4.70
Punjab		4.55	3.38	-6.95	4.37	-8.73
Tamil Nadu		-2.19	-3.15	4.29	-5.03	-15.50
Uttar Pradesh	---	9.78	-7.78	4.40	1.90	-3.30
West Bengal		8.73	-12.86	12.90	-2.18	-6.33
All India		6.61	-6.08	4.46	-1.15	-5.75

Source: Statistical Abstract of India, Various Issues from 1966 to 1991.

Indian Livestock Census various issues.

Livestock Census of selected states from 1966 to 1991.

i.e -2.19 % in 1971/72 to -15.50 % in 1991/92. On the other hand U.P accounted 9.78 % per annum in 1971/72, which has further witnessed negative growth of 3.30 % per annum in 1991/92 respectively.

In case of West Bengal, 8.73 % growth per annum noticed in 1971/72, was later it observed a negative growth rate of -6.33 % per annum in 1991/92. Mean while All India picture showed that. 6.61 % per annum in 1971/72, but it has a negative growth of -5.75 % per annum in 1991/92. Overall picture gave a impressran that the year 1991/92. showed negative growth in almost all the states and whole India, due to substitution of modern technology in place of traditional tools such as wooden and iron ploughs. Tractors population was increased drastically in recent years, especially agriculturally advanced states like. Punjab, U.P, A.P. and Tamil Nadu respectively.

3.8 CONSUMER PRICE INDEX NUMBERS FOR AGRICULTURAL LABOURERS:

In case of consumer price index numbers for agricultural labourers in all Indian and selected states from 1966/67 to 1991/92 is shown in table 3.8.1. Index numbers of agricultural labourers at 1960/61 prices in Andhra Pradesh noticed 155 in 1966/67, which has later raised to 510 in 1991/92. In case of Bihar, it was around 210 in 1966/67, later it has gone up to 695 in 1991/92. However. Punjab recorded 161 in 1966/67, later raised to 713 in 1991/92 respectively. On the other hand. Tamil Nadu showed an index of 167 in 1966/67, which later raised to 675 in 1991/92. U.P witnessed 191 in 1966/67, which has increased to 676 in 1991/92. Similarly, West Bengal had an index of 190 in 1966/67, and later it raised to 712 in 1991/92. As against this all India level index showed that it was 181 in 1966/67, has increased almost five times to an index of 675 in 1991/92 respectively.

Table 3.8.1

CONSUMER PRICE INDEX NUMBERS FOR AGRICULTURAL LABOURERS- GENERAL INDEX, FROM 1966/67 TO 1991/92.

C 1960/61 Base Year)

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh	188 (--)	180 (3.043)	273 C 8.693	405 C 8.21)	480 (3.463)	510 (1.22)
Bihar	210 (--)	204 (-0.58)	285 (6.923)	460 (10.05)	589 (5.07)	695 C 3.373
Punjab	161 (--)	200 (4.433)	298 (8.30)	461 (9.12)	602 (5.483)	713 (3.443)
Tamil Nadu	167 (--)	184 (1.96)	290 (9.53)	436 (8.50)	567 (5.40)	675 (3.55)
Uttar Pradesh	191 (--)	185 (-0.64)	267 (7.61)	452 (11.10)	590 (5.473)	676 (2.763)
West Bengal	190 (--)	208 C 1.833	315 C 8.66)	433 (6.573)	600 (6.74)	712 (3.483)
All India	181 (--)	196 (1.60)	293 (8.3/3)	444 (8.67)	572 (5.203)	675 (3.373)

Source: H. L. Chandhok and Policy Group: Indian Data Base, The Economy, Volume 1, 1990.

(). Figures in the brackets indicates compound growth rates.

Mean while, compound growth rates of index numbers of agricultural labourers in Andhra Pradesh showed that, 3.04 % growth per annum in 1971/72, and 1.22 % in 1991/92. Bihar noticed negative growth of -0.58 % in 1971/72, but later showed a positive growth of 3.37 % per annum in 1991/92. Interestingly Punjab noticed 4.43 % growth per annum in 1971/72, was further gone up to a growth rate of 3.44 % per annum in 1991/92 respectively.

Next is Tamil Nadu showing 1.96 % per annum in 1971/72, which increased to a rate of 3.55 % per annum in 1991/92. Contrary to this U. p accounted negative growth of -0.64 % in 1971/72, but later

witnessed a positive rate of 2.76 % per annum in 1991/92. West Bengal recorded 1.83 % growth per annum in 1971/72, and raised to a rate of 3.48 % per annum in 1991/92. Whole India index raised at 1.60 % per annum in 1971/72, and later it raised at a rate of 3.37 % per annum in 1991/92 respectively.

3.9 INDEX NUMBERS OF WHOLE SALE PRICES OF DIFFERENT AGRICULTURAL COMMODITIES AND INPUTS:

Indian agricultural production has experienced higher costs during the last three decades. The reason for this is that almost all the prices of agricultural inputs and allied equipment have increased drastically due to several reasons. Petroleum based inputs such as diesel, petrol, fertilizers, pesticides, and other lubricants prices gone up especially from 1973 onwards, where there were great oil price hikes in world. On the other hand agricultural machinery and implement prices also raised at faster rate while comparing with agricultural production.

The general observation is that prices of inputs increased at faster rate than prices of agricultural products. On the other side it was highlighted that energy inputs prices raised at faster rate than energy output prices (food price). Due to this reason major changes took place in Indian agriculture especially since Green revolution. By keeping this in to consideration the present section discusses the Index numbers of whole sale prices of agricultural commodities and inputs from 1966/67 to 1991/92 respectively.

As stated in the table 3.9.1, the index numbers of whole sale prices of rice, has noticed, a index of 83.8 in 1966/67, later increased to 363.7 in 1991/92. As against this wheat index raised from 85.2 in 1966/67 to 292.0 in 1991/92 respectively. Jowar index which recorded around 109.9 in 1966/67, has later witnessed 311.9 in 1991/92. Where as cotton Index was 60.9 in 1966/67, has increased to 306.3 in 1991/92. Interestingly ground nut index raised at faster rate from 88.4 in 1966/67, to 427.8 in 1991/92. Sugar cane index raised from 70.9 in 1966/67, to 282.2 in 1991/92 respectively. It was also observed that out of six crops ground nut index increased faster rate than other five crops, next comes rice, jowar, cotton, wheat, and sugar cane. It is further observed that, in case of sugar cane, which have high cost of production its own price has less increase in price index. This was the reason why farmers often raised the issue of support price to the sugar cane crop.

With respect to the agriculture inputs, petrol index had an index of 74.9 in 1966/67, has later drastically increased in 1976/77 to 285.0, which was due to great oil hick in world scenario, and later it has further increased to 734.0 in 1991/92. Diesel oil index also witnessed similar trend from 98.5 in 1966/67, it increased to 690.0 in 1991/92. Light speed diesel oil noticed an increase from 106.4 in 1971/72, to 929.3 in 1991/92. Finally the high speed diesel oil raised from 103.3 in 1971/72 to 450.7 in 1991/92 respectively.

Table 3.9.1

INDEX NUMBERS OF WHOLE SALE PRICES OF DIFFERENT AGRICULTURE REFATED COMMODITIES, FROM 1966/67 TO 1991/92.

(Base Year : 1970-71 • 100)

Item	Weight	1966X67	1971/72	1976/77	1981/82	1986/87	1991 X92
Rice	5.13	83.8 (--)	103.0 (4.21)	156.9 (8.783)	226.1 (7.58)	302.1 (5.973)	363.7 (3.78)
Wheat	3.42	85.2 (--)	99.5 (3.783)	152.0 (8.843)	191.6 (4.74)	238.6 (4.493)	292.0 (4.12)
Jowar	0.84	89.9 (--)	109.9 (4.10)	163.6 (8.283)	241.5 (8.10)	260.7 (1.54)	311.4 (3.62)
Cotton	2.25	60.9 (--)	107.8 (12.10)	197.5 (12.873)	227.3 (2.85)	184.7 (-4.073)	306.3 (10.65)
Groundnut	1.82	88.4 (--)	87.7 (-0.16)	142.2 (10.153)	270.5 (13.733)	372.4 (6.60)	427.8 (2.81)
Sugar cane	1.64	70.9 (-3)	100.6 (7.25)	125.8 (4.57)	189.9 (8.58)	251.4 (5.773)	282.2 (2.343)
Petrol	0.86	74.9 (--)	116.5 (10.44)	285.0 (19.593)	505.5 (12.14)	642.6 (4.92)	734.0 (2.70)
Diesel Oil	1.7a	98.5 (--)	104.9 (1.27)	213.9 (15.32)	552.9 (20.923)	090.8 (-3.72)	690.0 (-0.02)
Light Diesel Oil	0.34	(--)	106.4 (--)	267.7 (20.27)	732.5 (22.30)	929.3 (4.873)	929.3 (0.003)
High Speed Diesel Oil	1.37	(--)	103.3 (--)	160.1 (9.163)	373.3 (18.45)	452.2 (3.91)	450.7 (-0.07)
Electricity	2.40	91.3 (--)	102.5 (2.343)	171.6 (10.863)	279.6 (10.26)	564.6 (15.09)	656.6 (3.073)
Animal Feed	0.04	(--)	99.2 (--)	149.0 (8.48)	210.4 (7.15)	231.3 (1.91)	297.4 (5.16)
Fertilizers	1.2b	70.1 (--)	100.0 (5.74)	186.5 (13.14)	273.6 (7.97)	288.8 (1.09)	288.4 (-0.03)
Nitrogen	0.84	(--)	99.8 (--)	186.2 (13.283)	281.0 (8.58)	303.3 (1.543)	303.3 (0.00)
Phosphatic	0.35	(--)	102.8 (--)	190.6 (13.14)	262.8 (6.63)	262.0 (-0.06)	260.4 (-9.12)
Potassic	0.06	(--)	98.6 (--)	167.4 (11.17)	235.8 (6.24)	246.6 (1.71)	246.6 (0.00)

contd...

Table 3.9.1 (contd)

INDEX NUMBERS OF WHOLE SALE PRICES OF DIFFERENT AGRICULTURE RELATED COMMODITIES, FROM 1966/67 TO 1991/92.

(Base Year : 1970-71 = 100)

Item	Weight	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Pesticides	0.12	86.9 (--)	101.4 (3.13)	232.4 (18.043)	351.8 (8.65)	469.3 (5.93)	525.4 (2.29)
Tractors	0.26	(--)	112.3 (--)	203.0 (12.57)	331.0 (10.27)	428.7 (5.31)	492.6 (2.823)
Ag. Spreyers	0.01	C--3	100.7 (--)	154.6 (8.95)	187.8 (3.97)	289.8 (9.063)	311.3 (1.443)
Diesel Engins	0.21	C-3	100.0 (- i)	138.0 (6.65)	184.0 (5.92)	216.2 (3.28)	277.7 (5.13)
Power Driven Pumps	0.27	C ->	101.0 (--)	165.4 (10.37)	271.0 (10.38)	348.5 (5.16)	414.3 (3.52)
Electric Motors	0.27	(--)	100.0 (--)	141.7 (7.22)	248.7 (11.91)	351.6 (7.17)	458.1 (5.43)
Ag. Commod	40.42	82.0 (--)	104.4 (4.95)	158.5 (8.71)	236.5 (8.333)	329.9 (6.88)	400.7 (3.963)
Non-Ag. Commodities	59.58	83.3 (--)	109.1 (5.55)	188.9 (11.60)	311.7 (10.53)	408.6 (5.56)	458.8 (2.353)
Total Food Group	43.12	84.1 C--3	106.4 C4.823	165.7 C9.26)	254.8 C8.993	392.0 C9.00)	411.5 (0.973)
Total Non- Food Group	56.88	81.8 (--)	105.0 (5.12)	184.0 (11.97)	301.4 (10.28)	395.6 (5.593)	453.4 (2.77)

Source: H. L. Chandhok and Policy Group: Indian Data Base, The Economy, Volume I, 1990.

(). Figures in the brackets indicates compound growth rates.

Electricity index was 91.3 in 1966/67, that raised to 856.6 in 1991/92. However, animal feed accounted for a index number of 99.2 in 1971/72, has gone up to 297.4, in 1991/92. Fertilizer index raised from 76.1 in 1966/67, to 288.4 in 1991/92 respectively. However, nitrogen, phosphate, and potassium indexes were at 99.8, 102.8, and 98.6 in 1971/72, have later increased to 303.3, 260.4, 248.6 in 1991/92 respectively.

A drastic increase in pesticides index, namely 88.9 in 1966/67, to 524.4 in 1991/92. Tractors whole sale price index increased from 112.3 in 1971/72, to 492.6 in 1991/92. On the other hand agricultural sprayers increased from an index of 100.7 in 1971/72, to 311.3 in 1991/92. Irrigation equipment such as, diesel engines-, power driven pumps, and electric motors indexes were also noticed an increase from 100.0, 101.0, and 100.0 in 1971/72, to 277.7, 414.3, and 458.1 in 1991/92 respectively.

It was observed that, agriculture commodities index increased from 82.0 in 1966/67, to 400.7 in 1991/92. Where as non-agriculture commodities raised from 83.3 in 1966/67 to 458.8 in 1991/92. It is a clear evidence that, indexes of non-agriculture commodities increased faster rate than agriculture commodities. This leads to unfavorable terms of trade towards agriculture sector. This is one of the important drawback, where agricultural development is still in volatile nature in India.

However, there is another evidence that, the total food group noticed a rise in index from 81.5 in 1966/67, to 411.1 in 1991/92.

As against this total non-food group raised at 81.8 in 1966/67, was later gone up to 453.4 in 1991/92 respectively. Here also it was recognised that, the index of non-food group increasing faster rate than food group. This is another important cause for unfavourable growth in Indian agriculture.

Compound growth rates with respect to index numbers of whole sale prices of rice, indicate a 4.21 % per annum growth rate in 1971/72, and 3.78 % per annum growth rate in 1991/92. Wheat index accounted 3.78 % growth per annum in 1971/72, and it raised at a rate of 4.12 % in 1991/92. Jowar index showed positive growth rate of 4.10 % per annum in 1971/72 and 3.82 % in 1991/92. Whereas cotton noticed 12.10 % growth per annum in 1971/72, and raised at a rate of 10.65 % per annum in 1991/92. Ground nut experienced negative growth of -0.16 % in 1971/72, and increased at positive growth rate of 2.81 % per annum in 1991/92. Next is the sugar cane which gone up at a rate of 7.25 % in 1971/72 and 2.34 % in 1991/92 respectively.

However petroleum inputs noticed, i.e petrol, at a growth rate of 10.44 % in 1971/72, was later a growth rate of 2.70 % per annum in 1991/92. In case of diesel oil it recorded a growth rate of 1.27 % in 1971/72, later growth was 0.02 in 1991/92. Light speed diesel oil accounts for a rate of 20.87 % in 1971/72, and noticed 0.00 % in 1991/92. High speed diesel oil raised at a rate of 9.16 % in 1971/72 and a negative growth of -0.07 % in 1991/92. Electricity noticed 2.34 % per annum in 1971/72, which was gone up to 3.07 % in 1991/92. Against this the animal feed raised at the rate of 8.48 % per annum in 1970/71, and later raised at a rate

of S. 16 % per annum in 1991/92. Regarding fertilizers the rate of growth was S. 74 5i per annum in 1971/72, and 0.03 % in 1991/92 respectively. Interestingly, nitrogen, phosphate, and potassium fertilizers witnessed, 13.28, 13.14, and 11.17 % in 1976/77, which later recorded 0.00 %, -9.12 %, and 0.00 % growth rates in 1991/92 respectively.

Pesticides accounted, 3.13 % per annum in 1976/77, which further raised at a rate of 2.29 % per annum in 1991/92. However, tractors noticed a growth rate of 12.51 % per annum in 1976/77, and 2.82 % per annum in 1991/92. Agricultural sprayers recorded 8.95 % growth in 1976/77, later it increased at a rate of 1.44 % per annum in 1991/92. Irrigation equipment such as diesel engines, power driven pumps, and electric motors also recorded a growth rate of 6.85 %, 10.37 %, and 7.32 % in 1976/77, and 3.52 %, 5.43 %, and 3.96 % per annum in 1991/92 respectively.

On the other hand agricultural commodities noticed a growth rate of 4.95 % per annum in 1971/72, which further increased at a rate of 3.96 % per annum in 1991/92. Mean while, non-agriculture commodities increased at 5.55 % in 1971/72, and 2.35 % per annum in 1991/92. Total food and non food group index raised at a rate of 4.82 % per annum in 1971/72, which has increased later at a rate of 0.97 % and 2.77 % per annum in 1991/92 respectively.

3.10 SUMMARY AND CONCLUSIONS:

In this chapter, the data analysis has undertaken to identify the factor shares and substitution possibilities in Indian

agriculture and selected states. Along with **this** some **indicators** such as labour absorption under selected crops, value of inputs and **output**, number of cultivators and agricultural labourers, total draught power, **index numbers of agricultural labourers**, and index numbers of **different agricultural commodities** and inputs were **also** analyzed.

Firstly, the data analysis with respect to labour absorption **witnessed** that sugar cane demanding more labour force, next is rice, cotton, ground nut, wheat, and Jowar **respectively**. Because sugar cane cultivation involves several operations, next to rice cultivation, consisting of operations such as land preparation, plantation, **interculture**, winnowing, **threshing**, and **transplantation** etc. This indicates that the labour absorption is still much high in **different crops**, even though **modern** technology was introduced in Indian agriculture. It implies that labour force is still **existing** along with **modern** technology. This conclusion gave raise to a **reasonable** support to the positive **economists**, where the arguments enlightened that **modern** technology improved the employment conditions in Indian agriculture.

Next total **value** of inputs **experienced** a twelve **times** increase in value i.e Rs. 3031 crores in 1966/67 to Rs. 38713 crores in 1991/92. This is a clear indication that, the input burden is raising at a faster rate in agriculture sector in **modern** agriculture. Due to this reason farmers shifted their production from food crops¹ to **commercial** crops, where **commercial** crops are **more** profitable while comparing with food crops.

Regarding Net State Domestic Production from agriculture, overall picture gave a impression that the year 1991/92 showed negative growth in almost all the states and whole India, due to substitution of modern technology in place of traditional tools such as wooden and iron ploughs. The farmers are facing more input burden, especially from 1980's onwards. Tractors population was increased drastically in recent years, especially agriculturally advanced states like Punjab, U.P, A.P. and Tamil Nadu respectively. It was also observed that out of six crops ground nut index increased faster rate than other five crops, next comes rice, Jowar, cotton, wheat, and sugar cane. It is further observed that, in case of sugar cane, which have high cost of production its own price has less increase in price index. This was the reason why farmers often raised the issue of support price to the sugar cane crop.

Finally, it is a clear evidence that, indexes of non-agriculture commodities increased faster rate than agriculture commodities. This leads to unfavorable terms of trade towards agriculture sector. This is one of the important drawback, where agricultural development is still in volatile nature in India. Here also it was recognized that, the index of non-food group increasing faster rate than food group. This is another important cause for unfavorable growth in Indian agriculture.

Based on these findings the next chapter will demonstrate the nature of agriculture mechanization in Indian agriculture and selected states.

CHAPTER 4-

MECHANIZATION IN INDIAN AGRICULTURE

4.0 INTRODUCTION

Farm mechanization is the main plank of modern agriculture and many of the progressive countries have already mechanized their agriculture. Of course, it is also true that the conditions in many of these countries were favourable for mechanization. Most important reasons for use of agriculture implements and machinery were high rate of agriculture labour, large size of farms, high cropping intensity, higher percentage of irrigated area and more adoption of high yielding technology.

As cultivable land resources are limited, increased agricultural production can only be attained in most countries of the world through increased yields per unit area of land and improved preservation of already produced commodities. Technological inputs must be applied wisely and economically to bring about the desired increased outputs of production. Mechanization is one of the critical inputs of production followed by preservation of food crops. Mechanization can increase yields through the improvement of water control, better soil preparation for planting, more efficient weed and insect control and the proper harvesting, handling, drying, storing and processing of food, feed and fiber crops. So that, agricultural mechanization is the art and scientific application of mechanical aids for

increased production and preservation of food and fiber crops with less drudgery and increased efficiency.

One of the interesting study is by *Ray. A.K(1993)*, who analyzed the status of agricultural mechanization in Indian agriculture. The main objectives of this study were that, (i) to examine the present status of agricultural mechanization in different states of India, (ii) to examine the constraints of mechanization of agriculture in different states of India. Data for this study have been mainly collected from the published secondary sources of the Ministry of agriculture. The period chosen for this study was from 1972 to 1987.

The main conclusions drawn from this study are the following. The use of traditional implements is much more popular as compared to the improved implements and machinery. A small farm size, low adoption of HYV seed, meagre percentage of area under irrigation, poor cropping intensity, higher wage rates and poor holding size are some of the constraints for non-adoption of agricultural implements and machinery in most of the states, in both the periods under study.

Binswanger. H.P(1978), has analyzed the economics of tractors in south Asia, by considering different studies in recent years. The main effort of this work is to review the studies and present their findings in a way which makes them comparable across agroclimatic zones.

The researcher have apparently two contradictory views

regarding the benefits of tractors. One is the substitution view which looks at tractors and animal-drawn implements as two different power sources which technically are 'perfect substitutes, i.e., any operation which a tractor with its implements can perform is assumed to be also feasible by a combination of animal power, animal-drawn implements, and hand labor. Under this view the switch from animal power to tractor power is primarily guided by factor prices (or factor scarcities). The second is the net contributor view of tractors, which in a more extreme form, argues that power is a primary constraint to agricultural production almost regardless of factor prices. The power of tractors allows more thorough or deeper tillage than with bullocks. Tractor machinery such as seeders, levellers, and interculture equipment also achieve a higher level of precision. Both factors would lead to higher yields. Furthermore, tractors may be able to reclaim land which cannot be operated by bullocks at all. Finally, the high power and speed of tractors would allow more timely operations, thus contributing both to higher yields and to a more extensive practice of double cropping. Higher yields and double cropping would lead to higher levels of output, requiring more labor in operations not performed by the tractor. The tractor could therefore contribute to increased production without necessarily displacing labor. Tractorization would be consistent with employment objectives, even in low-wage countries.

Cesar G. Salas, Sr. (1987), has done pioneering study on mechanized rice production in Philippines agriculture, during the period from July 1976 to June 1982. The mechanized farm operations done were of the nature of field and seed bed preparation,

transplanting, weed control, pest control, harvesting and threshing.

The main conclusions are, that the farm mechanization should be practiced by farmers especially in seed bed and field preparation because of the shorter time involved at the same cost. Adequate irrigation throughout the year will give the farmers all the chances to plant rice three times a year, thus, there is a greater possibility of increasing yearly income of the farmers. Mechanized method of transplanting and field care, on the other hand, is greater in cost than the non-mechanized. But in terms of labour requirement non-mechanized transplanting and field care is twice greater than the mechanized. By Taking the option of mechanized transplanting and field care it will give the farmer ample time for other farm activities to be done.

Total mechanization of rice production from seed bed preparation to threshing will deprive the peasant masses of their source of livelihood, since not all agricultural family have fields to be formed by mechanization. The livelihood of many of them depend on paid labour for transplanting rice, weeding and harvesting. Thus, field preparation and threshing which are the most laborious farm activities found its way to be mechanized first. Once these property-less workers will have alternative work in place of farm activity, the field mechanization of rice production will find its way as in developed country, where farm labour is scarce.

Balish,ter, et.al(1991), who did analytical work on impact of

farm **mechanization** on employment & farm productivity in **Mathur** district of U. P., where C.D block chairman was selected **purposively** out of 12 community **development** block in the district, **keeping in view** the larger number of tractors in use of modern inputs. Ten villages out of a total of 47 villages in the C.D. block, were selected randomly for this study during the period **1984-85** crop year.

The main conclusions that emerge from this study are, the average **value** of farm assets in mechanized farms was about 8 times more than that in non-mechanized farms and about 4 times more than that in partially **mechanized farms**. The average cropping intensity is the highest in mechanized farms (206.4%) followed by partially **mechanized farms** (176.6%) and the non-mechanized farms (143.8%). The mechanized farms allocate more area under high income crops as compared to partially mechanized and non-mechanized farms. In comparison to non-mechanized farms, the per hectare yield was high by about 10 to 27 percent in mechanized farms and by about 2 to 16 percent high in partially mechanized farms in all the major crops grown in these farms. The net returns per hectare in mechanized farms is about 49 percent higher than in the partially mechanized farms and about 29 percent higher than in the non-mechanized farms. The labour use per hectare of cultivated area is about 197 man days in non-mechanized farms, 208 man days in partially **mechanized farms** and 212 man days in mechanized farms. This indicates that in absolute terms there is no decrease in human labour employment due to **mechanization**. Rather there is an increase, which is due to increase in the cropping intensity and shift in cropping pattern from less labour intensive crops to

income crops) to more labour intensive crops (high income crops). The marginal value of productivity for land, seed, fertilizer is higher in mechanized farms than that in non-mechanized farms.

Another interesting study by Howard F. McCollly (1973), examined the factors influencing agricultural mechanization in different Asian countries.

The main conclusions of this study indicate that the rural sectors of the less developed countries is difficult and continues but possible slowly. Unfavorable land tenure patterns have sustained the poor traditional social and economic conditions in many of the Asian countries. Land reform program in Taiwan, Japan, Korea and a few other countries has stimulated agricultural production and rural development. Rural development can only come about through the increased returns per capita. Mechanization, if planned and timed properly with other technological inputs can play an important role in increasing productivity of land and man. Mechanization must enhance multi-cropping and diversification of crops.

One of the interesting counter study was by Bina Agarwal (1984), who traced out the cropping intensity effects of tractors and tube wells in the Punjab. The researcher identified some of the limitations existed in earlier studies. Firstly many of them do not take into account the tractors as a source of irrigation, the level of irrigation, farm size and agro-climatic zones, which could also significantly affect cropping intensity. Secondly, most studies use the ownership of a tractor as a proxy

for usage: farms where tractors are hired in are counted as bullock farms. Thirdly, in all the noted studies, cropping intensity is defined conventionally as the ratio (expressed as a percent) of gross cropped area to net sown area. While this index is straightforward to interpret, it suffers from one major weakness: it takes no account of the differences between farmers in their ability to intensify cultivation.

The data used relate to a sample of 237 farms taken from the principal wheat-growing areas of Punjab, and covering 20 tehsils spread across all the districts of the state. The data are for the crop-year 1971-72, and were collected under the 'Comprehensive scheme of studying the cost of cultivation of principal crops' by the Punjab agricultural university, for the Directorate of Economics and Statistics, New Delhi.

The main conclusions are, that tractors (in particular owned tractor) and tube wells were associated with higher cropping intensity, as measured by each of the indices, in comparison with bullocks and canals respectively. However, the advantage of tube wells over canals was much greater than that of tractors over bullocks. That irrigation, in particular, tube well irrigation, is a more important factor in increasing cropping intensity, than the use of tractors in lieu of bullocks, which has been emphasised in other studies as well. On individual farms, therefore, tractors need not lead to a diversion of land under fodder to other crops, and at the macro-level, say, for Punjab as a whole, whether or not tractorisation significantly reduces the area under fodder would depend on how substantial a reduction in bullock requirements and

hence in the bullock population that helps to bring about. On the whole, the cropping intensity advantages of tractorization in the Punjab appear to have been overstated.

4.1 AN OVERALL VIEW OF TRENDS IN AGRICULTURAL INPUTS

General trends in agricultural inputs, showed quite interesting picture. As stated in the table 4.1.1, It was observed that, the total geo-graphical area in Indian agriculture noticed 328.8 M. he in 1960/61, later maintained almost similar i.e 328.7 in 1992/93. Where as net sown area recorder! 137.2 M. he in 1960/61, was later raised to 142.2 M.he in 1992/93. As % of geo-graphical area witnessed it was 40.5 % in 1960/61, which has gone up to 43.4 % in 1992/93. On the other hand net irrigated area accounted 24.7 M.he in 1960/61 but raised to 47.4 M he in 1992/93. However, as V. of net sown area it recorded 18.5 % in 1960/61, and raised to 33.3 % by 1992/93 respectively.

Interestingly, gross cropped area recorded 152.8 M.he in 1960/61, later raised to 182.5 M.he in 1992/93, and as percentage of geo-graphical area it records 48.5 % in 1960/61, and increased to 53.6 % in 1992/93. Gross irrigated area witnessed 28.0 M. he in 1960/61, and has gone up to 61.8 M.he in 1992/93, a percent of gross cropped area it accounts nearly 18.3 % in 1960/61 and 33.4 % in 1992/93 respectively.

Area under HYVs, witnessed around 15.5 M.he in 1970/71, which has gone up to 66.1 M. he in 1992/93, as equivalent to 17 % in overall area in 1970/71. This has raised almost four times to 69 %

Table 4.1.1

AN OVERALL VIEW OF TRENDS IN AGRICULTURAL INPUTS, FROM 1960/61 TO 1992/93.

Year	1960/61	1970/71	1980/81	1985/86	1989/90	1990/91	1992/93
Item)	Unit						
Geographical Area.	Mln. hec	328.8	328.8	328.8	328.7	328.7	328.7
Net Sown Area.	Mln. hec	133.2	140.8	140.0	140.9	139.5	139.5
As X of Geographical Area.	X	40.5	42.8	42.6	42.9	42.4	43.4
Net Irrigated Area	Mln. hec	24.7	31.1	38.7	42.1	46.2	47.4
As % of NSA	%	18.5	22.1	27.6	29.9	33.1	33.3
Gross Cropped Area	Mln. hec	152.8	165.8	172.6	178.8	182.2	182.5
As % of Geographical Area	X	46.5	50.4	52.5	54.4	55.4	55.6
Gross Irrigated Area	Mln. hec	28.0	38.2	49.8	54.7	59.6	61.8
As X of GCA	X	18.3	23.0	28.9	30.6	32.7	33.4
Area under HYVs	Mln. hec	—	15.5 (17)	43.1 (45)	55.4 (58)	61.2 (65)	63.9 (69)
Rice	"	—	5.6 c 15)	18.2 c 45)	23.5 c 50)	26.2 (65)	28.1 (68)
Wheat	"	—	6.5	16.1	19.1	20.3	20.4
Jowar	"	—	0.8 C 36)	3.5 C 73)	6.1 C 83)	6.9 C 81)	6.7 C 91)
Fertilizer Consumption	Lakh Tonne	2.94	22.56	33.16	84.74	115.68	125.46
N	"	2.11 (71.8)	14.79 (65.6)	36.78 (66.7)	56.61 (66.8)	73.86 (63.9)	79.97 (63.73)
P	"	0.53 (18.03)	5.41 (24.0)	12.14 (22.03)	20.05 (23.7)	30.14 (26.1)	32.21 (25.7)
K	"	0.29 (9.9)	2.36 (10.5)	6.24 C 11.33	8.08 (9.5)	11.68 (10.1)	13.28 (10.6)
Per hectare Consumption of NPK	Kg.	1.92	13.61	31.96	47.39	63.49	66.59

Contd...

Table 4.1.1(Contd...)

AN OVERALL VIEW OF TRENDS IN AGRICULTURAL INPUTS, FROM 1960/61 TO 1992/93.

year—	1960/61	1970/71	1980/81	1985/86	1989/90	1990/91	1992/93
Item	Unit						
Pumps ets & Tractors							
Electrical Lakh Irrigation Nos	1.60	16.20	43.20	61.50	85.00	91.00	96.20
Pumpsets							
Diesel Irrigation Pumpsets	" 2.30	15.60	28.10	37.70	47.00	48.50	52.00
Power Consumption	Mln. Kw 833	4470	14489	23422	44056	49469	64000
Consumption of power in Agriculture Per 1000 ha of GCA	Kwh 5.5	27.0	83.9	131.0	241.8	273.2	350.7
Tractors	Lakh 0.31	1.40	5.20	9.00	13.16	14.68	17.58
	Nos						
Pesticides Consumption	'000 8.6	24.3	45.0	52.0	72.0	82.4	79.4
	Tonns						

Source: **CMIE:** Basic Statistics Relating to the Indian Economy, August, 1994.

in 1992/93. Rice noticed 5.6 M. he in 1970/71, that has gone up to 28.3 M. he in 1992/93. Where as wheat that has 6.5 M. he in 1970/71, later increased to 22.2 M. he in 1992/92. On the other hand jowar witnessed 0.8 M. he in 1970/71, which has further raised to 6.9 M. he in 1992/93 respectively.

Regarding fertilizer s, 2.94 lakh tonns was recorded in 1960/61, which has gone up to 121.52 lakh tonns in 1992/93. Out of

this Nitrogen fertilizers noticed P. 11 lakh tons in 1960/61, which has increased to 84.26 lakh ton in 1992/93, or in percentage terms 71.8 % share in total consumption in 1960/61, This has declined to 69.30 % in 1992/93. As against this, phosphate noticed 0.53 lakh tons in 1960/61, later raised up to 28.42 lakh tons in 1992/93. This is equivalent to 18.0 V. share in 1960/61 to 23.4 % in 1992/93. It implies that the phosphate fertilizer consumption has increased reasonably over a period of time. On the other hand Potassium consumption recorded 0.29 lakh tons in 1960/61, which raised to 13.28 lakh tons in 1990/91, later declined to 8.4 lakh ton in 1992/93. In percentage terms it is 9.9 V. in 1960/61, to 10.6 % in 1990/91, later down to 6.9 V. in 1992/93 respectively. Per hectare consumption of fertilizers(NPK) was accounted at 1.92 Kg/he in 1960/61, which raised to 66.59 Kg/he in 1992/93. As almost a thirty times increase in consumption from 1960/61 to 1992/93. This is a clear indication how fertilizers played an increasing role in Indian agricultural production.

Regarding mechanical devices for irrigation i.e electric and diesel pump sets the data indicates 1 BO and P. 30 lakhs in 1960/61, which raised up to 96.20 and 52.00 lakhs in 1992/93 respectively. However, power consumption noticed 833 M. kw in 1960/61. and increased to 84000 M. kw in 1992/93. As against this consumption of power per 1000 hectares of gross cropped area, it was 5.5 Kwh in 1960/61, and raised to 350.7 Kwh in 1992/93 respectively. This is a clear indication that, power consumption has increased almost sixty times more from 1960/61 to 1992/93.

Tractors were 0.31 lakhs in 1960/61, then raised to 17.68 lakhs in 1992/93, equal to a twelve times increase in tractors population from 1960/61 to 1992/93. Pesticides consumption was at 8.6 Thousand tons in 1960/61, which raised to 79.4 Thousand tons in 1992/93, equal to a nine times raise in consumption over this period.

As stated in table 4.1.2, the compound growth rates for total geo-graphical area noticed 0.00 % per annum in 1970/71, but it raised at a rate of 0.96 % per annum in 1992/93. As a percent of geo-graphical area it was 0.55 % per annum in 1970/71, which has gone up to 1.18 % per annum in 1992/93 respectively. Net irrigated area raised at 2.33 % in 1970/71, and 2.52 % per annum in 1992/93. As a percent of net sown area it increased at 1.79 % in 1970/71, to 1.54 % per annum in 1992/93.

Gross cropped area raised at 0.82 % per annum in 1970/71, and 0.37 % per annum in 1991/92. As a percent of geo-graphical area it recorded 0.41 % in 1970/71 and 0.46 % in 1992/93. Gross Irrigated area witnessed 3.15 % growth rate per annum in 1970/71, which further increased at a rate of 1.49 % in 1992/93. The percent of gross cropped area noticed 2.31 % in 1970/71, and in 1992/93 it was 0.46 % per annum.

Area under HYVs noticed 10.77 % per annum in 1980/81, which increased at a rate of 1.71 % per annum in 1992/93. However, rice area noticed 12.51 % per annum growth rate in 1960/61, but was later it increased at a rate of 0.36 % per annum in 1992/93. As against this wheat area increased at a growth rate of 9.47 % per

annum in 1980/81, and later it raised at a rate of 4.32 % in 1992/93 respectively. Jowar accounted 0.00 % in 1980/81, but it has gone up to a growth rate of 1.48 V. per annum in 1992/93 respectively.

Fertilizer consumption increased at 22.80 % per annum in 1970/71, that has further noticed negative growth rate of -1.58 % in 1992/93. The nitrogen fertilizers consumption recorded a growth rate of 20.77 % per annum in 1970/71, and raised a rate of 2.64 % per annum in 1992/93. The Phosphate consumption noticed 0.00 % per annum in 1970/71, later it experienced a negative growth rate of -6.07 % per annum in 1992/93. The Potassium fertilizers was also noticed similar trend i.e 0.00 V. in 1970/71, and later it experienced negative growth rate of -20.47 in 1992/93. In the same manner per hectare consumption of fertilizers increased at 21.63 % per annum in 1970/71, which later showed a negative growth rate of -1.96 % per annum in 1992/93 respectively.

Irrigation equipment such as electric and diesel pump sets increased at 26.05 V. and 21.10 % per annum in 1970/71, which increased at a rate of 2.8 % and 3.54 % per annum in 1992/93. The Power consumption witnessed 18.29 % growth per annum in 1970/71, which later raised slowly at a rate of 13.74 % per annum in 1992/93. Contrary to this consumption of power per 1000 hectares of gross cropped area recorded at 17.25 % growth per annum in 1970/71, which raised at 13.30 V. per annum in 1992/93 respectively.

Table 4.1.2

COMPOUND GROWTH RATES OF AN OVERALL VIEW OF TRENDS IN AGRICULTURAL INPUTS, FROM 1960/61 TO 1992/93.

Year		1960/61	1970/71	1980/81	1985/86	1989/90	1990/91	1992/93
Geographical Area.	Mln. hec	--	0.00	0.00	-6.00	0.00	0.00	0.00
Net Sown Area.	Mln. hec	—	0.56	-0.06	0.13	-0.25	0.00	0.96
As X of Geographical Area.	%	—	0.55	-0.05	0.14	-0.29	0.00	1.18
Net Irrigated Area.	Mln. hec	—	2.33	2.21	1.70	2.35	-2.38	2.52
As X of NSA	X	—	1.79	2.25	1.61	2.57	-2.41	1.54
Gross Cropped Area.	Mln. hec	—	0.82	0.40	0.71	0.47	-0.611	0.39
As X of Geographical Area.	X	—	0.81	0.41	0.71	0.46	-0.55	0.46
Gross Irrigated Area.	Mln. hec	—	3.15	2.69	1.90	2.17	0.66	1.49
As X of GCA	X	—	2.31	2.31	1.15	1.67	1.22	0.46
Area under HYVs	Mln. hec	—	—	10.77	5.15	2.52	4.41	1.71
Rice	"	—	—	12.51	5.24	2.76	7.25	0.36
Wheat	"	—	—	9.49	-16.59	32.94	0.49	4.32
Jowar	"	—	—	0.00	11.75	3.13	-2.90	1.48
Fertilizer Consumption	Lakh Tonne	—	22.60	9.35	8.97	8.00	ft. 46	-1.58
N	"	—	20.77	10.20	9.01	6.88	8.27	2.64
P	"	—	0.00	8.42	10.55	10.73	fi. 87	-6.07
K	"	—	0.00	10.21	5.30	9.65	13.70	-20.47
Per hectare Consumption of NPK	Kg.	—	21.63	8.91	8.20	7.59	9.12	-1.96

Contd.. .

Table 4.1.2 C Contd..)

COMPOUND GROWTH RATES OF AN OVERALL VIEW OF TRENDS IN AGRICULTURAL INPUTS, FROM 1960/61 TO 1992/93.

Year	1960/61	1970/71	1980/81	1985/86	1989/90	1990/91	1992/93	
Item	Unit							
Pumpssets & Tractors								
Electrical Irrigation Pumpssets	Lakh	—	26.05	10.31	7.32	8.43	7.06	2.81
Diesel Irrigation Pumpssets	"	—	21.10	e.06	6.05	5.66	3.20	3.54
Power Consumption	Mln. Kw	—	18.29	12.48	10.08	17.11	12.29	13.74
Consumption of power in Agriculture Per 1000 ha of GCA	Kwh	—	17.25	12.01	9.32	16.56	12.99	13.30
Tractors	Lakh Nos	—	0.00	14.02	11.59	9.97	11.55	9.43
Pesticides Consumption	*000 Tonns	—	10.95	6.36	2.93	8.48	14.44	-1.84

Source: CMIE: Basic Statistics Relating to the Indian Economy, August, 1994.

Interestliiyly, tractors population which Increased at 0.00 % in 1970/71, has raised at 9.43 % per annum in 1992/93 Where as pesticides consumption increased at a rate of 10.95 V. per flnrnum in 1970/71, has later experienced negative growth rate of -1.84 % per annum in 1992/93.

On the whole the inputs demand picture is quite clear. It has increased drastically from 1970/71 onwards, and agricultural machinery and power consumption witnessed very much impressive growth rates. This indicates that, there will be a greater demand for energy sources in near future. On this grounds the preceding section will analyse the nature of agriculture machinery and implements (mechanization) in Indian agriculture with respect to selected states, its demand over a period of time, and also look at the substitution possibilities of different agricultural equipment.

4.2 GENERAL NATURE OF FARM MECHANIZATION IN INDIAN AGRICULTURE:

Mechanization in Indian agriculture was over emphasised since Green revolution onwards (due to timely completion of operations in HYVs cultivation). Because of this reason substitution took place from traditional equipment replaced by modern machines. However, increasing application of machines, leads to not only increase in capital costs in agriculture production but also created demand for energy inputs. In view of this, the table 4.2.1 illustrates the general nature of farm mechanization in Indian agriculture.

The Gross cropped area was 155 M. ha in 1966/67, which has increased to 181 M. ha in 1991/92. Regarding tractors, there were 0.54 lakhs in 1966/67, which raised to 13.16 lakhs in 1991/92. Where as tractors per lakh hectares recorded 34 in 1966/67, later

Table 4.2.1

FARM MECHANIZATION IN INDIAN AGRICULTURE: 1966/67 TO 1991/92.

Item	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
GCA (Mn. hec)	155	166	171	173	179	181
	(--)	C 1.38)	C 0.75)	(0.23)	(0.68)	C 0.223
Tractors:						
Lakh No's	0.54	1.43	2.80	5.20	8.99	13.16
	(--)	(5.313	(11.58)	(13.183	(11.57)	(7.92)
Per Lakh Hectares	34	86	163	301	503	727
	(--)	(20.39)	f 13.643	(13.05)	(10.62)	(7.64)
Oil Engines						
Lakh No's	4.65	19.98	23.99	28.10	37.70	47.00
	(--)	(27.36)	(ft. 65)	(3.56)	(6.01)	C 4.51)
Per Lakh Hectares	295	7.25	1.34	1623	2088	2575
	(--)	(19.70)	(11.22)	(5.633	C 5.173	(4.28)
Electrically operated Pumpsets/Tubewells						
Lakh No's	5.13	16.20	27.34	43.24	61.52	85.00
	(--)	(25.86)	(11.04)	(9.60)	(7.31)	(6.68)
Per Lakh Hectares	330	977	1595	2505	3440	4658
	(--)	(24.24)	(10.303	C 9.45)	(6.55)	(6.25)
Consumption of power (KW/h) per '000' Hectares	171.4	27.0	51.0	84.0	731.0	241.8
	(--)	(16.84)	(13.56)	(10.49)	(54.14)	(-19.74)

Source: **CMIE: Basic Statistics Relating to the Indian Economy, 1994.**

(C). Figures in the brackets indicates compound growth rates from the previous year.

it has gone up to 727 in 1991/92 respectively. On the other hand the number of oil engines was 4.65 lakhs in 1966/67, it has gone up to 47.00 lakhs in 1991/92. The oil engines per lakh hectares was 295 in 1966/67, has raised to 2575 in 1991/92.

Interestingly, electrically operated pump sets were significantly increased from 5.13 lakhs in 1966/67, to 85.00 lakhs in 1991/92. Electrical pump sets per lakh hectare recorder) 330 in 1966/67 and raised to 4658 in 1991/92. This indicates that, the density of tractors, oil engines, and electric pump sets increased at faster rate from 1966/67 to 1991/92.

On the other hand, consumption of power per 1000 hectares accounted 12.4 KWH in 1966/67, was later raised to 241.8 KWH in 1991/92. This indicates a twelve fold increase in power consumption during 1966/67 to 1991/92. Nevertheless, increase in agriculture machinery and implements leads to much pressure on energy sources such as diesel oil, petrol, and electricity. Which means there is a direct relation between farm mechanization and energy resource demand in agriculture production.

With respect to compound growth rates, gross cropped area increased at 1.38 % in 1971/72, was increased at decreasing rate i.e 0.22 % per annum in 1991/92. Tractor population raised at 5.31 % per annum in 1971/72, which has increased at an increasing rate of 7.92 % per annum in 1991/92. As against this, tractors per lakh hectares raised at a rate of 20.39 % per annum in 1971/72, and has further raised at a rate of 7.84 % per annum in 1991/92.

Oil engines have increased at a rate of 27.36 % per annum in 1971/72, and at a rate of 4.5 % per annum in 1991/92. In other words the number of Oil engines per lakh hectare recorded 19.70 % growth per annum in 1971/72, and the growth rate diminished to 4.28

% per annum in 1991/92. On the other hand electrically operated pump sets grew at 25.86 % per annum in 1971/72, and later they have raised at a rate of 6.68 % per annum in 1991/92. Mean while electric pump sets per lakh hectares increased at a rate of 24.24 % per annum in 1971/72, and 6.25 % per annum in 1991/92. Consumption of power per thousand hectares recorded 16.84 % per annum in 1971/72, and later experienced negative growth of -19.74 % per annum in 1991/92 respectively.

4.3 TOTAL NUMBER OF AGRICULTURAL MACHINERY AND IMPLEMENTS IN INDIA AND SELECTED STATES:

Modernization of Indian agriculture gave path to raise in agricultural machinery and implements. Due to this reason substitution of agricultural equipment took place since 1966 onwards. Better equipment replaced the less efficient ones. The available agricultural machinery and implements from 1966/67 to 1991/92 in whole India and selected states is shown in tables 4.3.1 to 4.3.6.

Agricultural machinery and implements in A. F., measured by the number of wooden and iron ploughs were at 3510 and 85 thousands in 1966/67, and later they raised to a level of 4285 and 881 thousands in 1991/92 respectively. An equivalent of 8.11 % and 1.70% in 1966/67 and 8.6 and 11.3 % in 1991/92 respectively. Contrary to this sugar cane crushers run by bullock and power accounted for 227.11 and 47.48 hundreds in 1966/67, this has further increased to 225 and 103 hundreds in 1991/92, an equivalent of 3.56 % and 11.05 % in 1966/67 to 2.56 and 6.00 % in

1991/92 respectively. However, pump sets run by diesel and electricity were 47 and 37 thousands in 1966/67 to 399 and 703 thousands in 1991/92. In percentage terms this is equal to 10.41 % and 14.85 % in 1966/67 to 8.75 % and 8.3 % in 1991/92 respectively. Interestingly tractor population increased at a larger extent namely, 29 hundreds in 1966/67 to 388 hundreds in 1991/92 respectively.

Table 4.3.1

TOTAL NUMBER OF AGRICULTURAL MACHINERY AND IMPLEMENTS IN INDIA, 1966/67.

Item — State	Ploughs		Sugarcane Crushers		Pumpsets		Tractors
	Wooden (000's)	Iron	Bullock	Power	Diesel	Electric	
Andhra Pradesh	3238 (8.11)	54 (1.70)	22711 (3.56)	4748 (11.05)	46741 (10.41)	57225 (14.65)	2911 (5.39)
Bihar	3853 (9.65)	164 (5.17)	45881 (7.20)	2417 (5.63)	3698 (0.82)	6854 (1.76)	2132 (3.95)
Punjab	1472 (3.69)	478 (15.07)	91534 (14.35)	2111 (4.91)	8158 (1.82)	8774 (2.25)	15489 (28.70)
Tamil Nadu	3423 (8.57)	348 (10.97)	14740 (2.31)	5963 (13.88)	42852 (9.54)	208485 (53.39)	3278 (6.07)
Uttar Pradesh	7555 (18.92)	929 (29.30)	366147 (57.41)	3769 (8.77)	28146 (6.27)	10197 (2.61)	10139 (18.79)
West Bengal	2421 (6.06)	6 (0.19)	5072 (0.80)	688 (1.60)	41 (0.93)	629 (0.16)	1548 (2.87)
All India	39923 (100.0)	3171 (100.0)	637671 (100.0)	42959 (100.0)	449089 (100.0)	390505 (100.0)	53966 (100.0)

Source: Statistical Abstract of India, DESAg., Govt. of India, 1966 to 1970.

With respect to Bihar, wooden and iron ploughs recorded 3853 and 164 thousands in 1966/67, which has increased to 5345 and 744 thousands in 1991/92, as equivalent of 9.65 % and 5.17 % in 1966/67 to 10.7 % and 9.5 % in 1991/92 respectively. Where as Sugar cane crushers run by bullocks and power were 459 and 241 hundred in 1966/67, and later decreased to a level of 392 and 99 hundreds in 1991/92. It was almost equal to a growth rate of 7.20

Table 4.3.2

TOTAL NUMBER OF AGRICULTURAL MACHINERY AND IMPLEMENTS IN INDIA, 1971/72.

Item	Ploughs		Sugarcane Crushers		Pumpssets		Tractors (000)
	Wooden (000)	Iron (000)	Bullock (00)	Power (00)	Diesel (000)	Electric (000)	
Andhra Pradesh	3510 (8.93)	85 (1.59)	286 (4.22)	70 (8.05)	111 (7.12)	145 (8.96)	63 (4.25)
Bihar	4055 (10.32)	264 (4.935)	502 (7.40)	24 (2.765)	42 (2.705)	53 (3.28)	56 (3.78)
Punjab	654	755	780	95	248	79	424
Tamil Nadu	11665 (7.80)	14095 (11.40)	113 (1.67)	101 (11.61)	207 (13.29)	001 (42.09)	54 (3.64)
Uttar Pradesh	7990 (20.335)	1681 (31.375)	4011 (59.15)	285 (32.76)	203 (13.03)	106 (6.555)	276 (18.61)
West Bengal	1318 (3.35)	4 (0.07)	8 (0.12)	—	5 (0.32)	2 (0.12)	7 (0.47)
All India	39204 (100.05)	5359 (100.0)	1181 (100.0)	110 (100.0)	1558 (100.0)	1618 (100.0)	1483 (100.0)

Source: Statistical Abstract of India, DESAg., Govt. of India, 1971 to 1977.

% and 5.3 % in 1966/67 to 4.9 % and 5.7 % in 1991/92 respectively. Interestingly, diesel and power pump sets were 3.7 and 6.9 thousands in 1966/67, which later increased to 301 and 158 thousands in 1991/92. This is equal to a growth rate of 0.82 % and 1.76 % in 1966/67 to 6.4 and 1.9 % in 1991/92. On the other hand tractors population noticed 21 hundred in 1966/67, has gone up to 225 thousands in 1991/92. In percentage terms it is equal to 3.93 % in 1966/67 to 1.71 % in 1991/92 respectively.

Table 4.3.3

TOTAL NUMBER OF AGRICULTURAL MACHINERY AND IMPLEMENTS IN INDIA, 1976/77.

Item— State	Ploughs		Sugarcane Crushers		Pumpsets		Tractors (00')
	Wooden (000')	Iron	Bullock (00')	Power	Diesel COO)	Electric COO)	
Andhra Pradesh	3427 (8.35)	135 (2.07)	252 (3.77)	141 (12.95)	199 (8.44)	234 (9.50)	111 (4.02)
Bihar	4269 (10.40)	343 (S. 26)	441 (U. 60)	43 (3.95)	132 (5.60)	93 (3.81)	105 (3.80)
Punjab	602 C1.47)	907 C13.92)	755 (11.30)	166 C15.24)	323 C13.69)	129 (5.29)	667 (24.18)
Tamil Nadu	3057 (7.45)	583 C8.95)	101 (1.51)	121 (11.11)	239 M0.13)	785 C32.20)	65 C2.36)
Uttar Pradesh	7780 (18.96)	2188 (33.58)	4109 (61.48)	296 (27.18)	480 (20.34)	172 (7.05)	713 (25.84)
West Bengal	1318 (3.21)	4 CO.0B)	8 CO.12)	—	—	0.4 CO.02)	7 CO.253)
All India	41031 (100.0)	6516 C100.0)	6683 <100.0)	1089 (100.0)	2359 (100.0)	2438 M00.0)	2759 C100.0)

Source: Statistical Abstract of India, DESAg., Govt. of India, 1977 to 1986.

In case of Punjab, wooden and iron ploughs accounted 1472 and 478 thousands in 1966/67, which noticed further at 433 and 255 thousands in 1991/92. In other word a growth rate of 3.69 % and 15.07 % in 1966/67 to 0.9 % and 3.3 % in 1991/92 respectively. In case of sugar cane crushers run by bullock and power these were 915 and 21 hundreds in 1966/67 but increased to 893 and 572 in 1991/92. This fs equal to a percentage increase of 14.35 % and 4.91 % in 1966/67 to 11.20 % and 33.1 % in 1991/92 respectively. Diesel and power pump sets accounts 8.2 and 8.8 thousands in

Table 4.3.4

TOTAL NUMBER OF AGRICULTURAL MACHINERY AND IMPLEMENTS IN INDIA, 1961/62.

Item State	Ploughs		Crushers		Pumpsets		Tractors
	Wooden	Iron	Bullock	Power	Diesel	Electric	
Andhra Pradesh	3317 (7.77)	247 (3.69)	196 (2.85)	78 (6.46)	251 (7.62)	438 (12.23)	215 (4.15)
Bihar	4445 (10.42)	158 (2.36)	363 (5.28)	59 (4.88)	264 (8.01)	111 (3.10)	146 (2.82)
Punjab	581 (1.36)	107 (1.60)	758 (11.04)	295 (24.42)	448 (13.59)	215 (6.00)	1065 (20.54)
Tamil Nadu	3251 (7.62)	596 (8.91)	110 (1.60)	105 (8.69)	205 (6.22)	945 (26.39)	144 (2.78)
Uttar Pradesh	7952 (18.64)	2434 (36.39)	4419 (64.33)	395 (37.70)	822 (24.94)	279 (7.79)	1422 (27.43)
West Bengal	2439 (5.72)	60 (0.90)	33 (0.48)	4 (0.33)	195 (5.92)	13 (0.36)	19 (0.37)
All India	42665 (100.0)	6688 (100.0)	6869 (100.0)	1208 (100.0)	3296 (100.0)	3581 (100.0)	5185 (100.0)

Sources Statistical Abstract of India, DESAg., Govt. of India, 1987 to 1990.

1986/87, they further increased to 623 and 473 thousands in 1991/92, or 1.82 % and 2.25 % in 1986/87 to 13.3 % and 5.6 % in 1991/92 respectively. Where as tractors were 155 hundreds in 1986/87, has raised to 1725 hundreds in 1991/92, which in percentage terms equal to 28.40 % in 1986/87 to 13.1 % in 1991/92 respectively.

Table 4.3.5

TOTAL NUMBER OF AGRICULTURAL MACHINERY AND IMPLEMENTS IN INDIA, 1986/87.

Item— State	Ploughs		Sugarcane Crushers		Pumpsets	Tractors	
	Wooden	Iron	Bullock	Power	Electric		
Andhra Pradesh	4023 (8.83)	533 (7.2)	203 (2.83)	85 (0.06)	323 (8.6)	625 (10.1)	342 (3.8)
Bihar	5123 (11.23)	611 (8.33)	375 (5.33)	76 (5.43)	289 (7.7)	135 (2.2)	203 (2.3)
Punjab	412 (0.9)	225 (3.1)	861 (12.13)	371 (26.1)	545 (14.5)	398 (5)	1561 (17.43)
Tamil Nadu	3998 (8.8)	762 (10.3)	121 (1.7)	135 (9.53)	343 (9.13)	1023 (16.6)	165 (1.83)
Uttar Pradesh	7995 (17.53)	2923 (39.6)	523 (73.33)	423 (29.83)	945 (25.13)	375 (6.13)	1735 (19.33)
West Bengal	221 (4.8)	68 (0.93)	44 (0.63)	8 (0.6)	224 (5.93)	15 (0.23)	23 (0.3)
All India	45623 (100.0)	7375 (100.0)	7123 (100.0)	1419 (100.03)	3770 (100.0)	6152 (100.0)	8990 (100.0)

Source: Livestock Census of different States, from 1989 to 1991.
CMIE: Basic Statistics Relating to Indian Economy, 1992.

Tamil Nadu noticed 3423 and 348 thousands of wooden and iron ploughs in 1966/67, it later raised to 4123 and 898 thousands in 1991/92, or 8.57 % and 10.97 % in 1966/67 to 8.3 % and 11.5 % in 1991/92 respectively. On the other hand sugar cane crushers run by bullock and power were at a level of 147 and 60 hundreds in 1966/67, has gone up to 143 and 160 hundreds in 1991/92. This is equal to 2.31 % and 13.68 % in 1966/67 to 1.8 and 9.3 % in 1991/92 respectively. Mean while diesel and power pump sets data showed that there were 43 and 21 thousands in 1966/67, then raised to 391 and 1231 thousands in 1991/92, or 9.64 % and 53.39 % in 1966/67 to 8.3 and 14.5 % in 1991/92 respectively. With respect to tractors recorded, there were 33 hundred in 1966/67 and it has risen to 182 hundred in 1991/92, or 6.07 % in 1966/67 to 1.4 % in 1991/92.

Table 4.3.6

TOTAL NUMBER OF AGRICULTURAL MACHINERY AND IMPLEMENTS IN INDIA, 1991/92.

Item — State	Ploughs		Sugarcane Crushers		Pumpsets		Tractors
	Wooden	Iron	Bullock	Power	Diesel	Electric	
Andhra Pradesh	4285 (8.6)	881 (11.3)	225 C2.83	103 (6.0)	399 C8.53	703 C8.33	385 (2.9)
Bihar	5345 (10.7)	744 (9.5)	392 (4.9)	99 (5.7)	301 (6.4)	158 (1.9)	225 (1.7)
Punjab	433 (0.9)	285 (3.3)	893 (11.2)	572 (33.1)	623 (13.3)	473 (5.6)	1725 (13.1)
Tamil Nadu	4123 (8.3)	898 (11.5)	143 (1.8)	160 (9.3)	391 (8.3)	1231 (14.5)	182 (1.4)
Uttar Pradesh	8125 C16.33	3111 C39.93	5425 (68.3)	643 C37.23	1010 (21.5)	473 (5.6)	2123 C16.13
West Bengal	2641 (5.3)	83 (1.1)	58 C0.73	12 C0.73	240 (5.13)	23 (0.3)	31 (0.2)
All India	49785 (100.03)	7803 C100.0)	7941 C100.03	1727 C100.0)	4700 C100.0)	3500 C100.0)	13161 C100.0)

Sources: Livestock Census of different State., from 1991 to 1993.
 CMIE: Basic Statistics Relating to Indian Economy, 1994.

In the state of Uttar Pradesh there were 7555 and 929 thousands wooden and iron ploughs in 1966/67, which has raised to 8125 and 3111 thousands in 1991/92. An equivalent of 18.92 % and 29.30 % in 1966/67 to 16.3 % and 39.9 % in 1991/92. The sugar cane crushers run by bullock and power were 3661 and 38 hundreds in 1966/67 have increased to 5425 and 643 hundreds in 1991/92. It is equivalent of 57.41 % and 8.77 % in 1966/67 to 68.3 % and 37.2 % in 1991/92 respectively. Diesel and power pump sets which recorded 28 and 10 thousands in 1966/67, has gone up to 1010 and 473 thousands in 1991/92. It is equal to 6.27 and 2.61 % in 1966/67 to 21.5 and 5.6 % in 1991/92 respectively. Second highest tractors population was witnessed in U.P. where there were 101 hundreds in 1966/67 and that raised to 2123 hundreds in 1991/92, of 18.79 % in 1966/67 to 16.1 % in 1991/92.

The total number of wooden and iron ploughs in West Bengal accounted for around 2421 and 6 thousands in 1966/67, and they later increased to 2641 and 83 in 1991/92. In percentage terms it was 6.06 and 0.19 % in 1966/67 to 5.3 and 1.9 % in 1991/92 respectively. As against this sugar cane crushers run by bullocks and power were 51 and 7 hundreds in 1966/67, - which has raised to 58 and 12 hundreds in 1991/92 respectively. It is almost equal to a percentage share of 0.80 % and 1.60 % in 1966/67 to 0.7 % and 0.7 % in 1991/92 respectively. Where as diesel and power pump sets raised from 4.2 and 0.6 thousands in 1966/67, to 240 and 23 thousands in 1991/92, or from 0.53 and 0.16 % in 1966/67 to 5.1 and 0.3 % in 1991/92 respectively. On the other hand tractor population was negligible in West Bengal since it was as 15

hundreds in 1966/67, has risen to 31 hundred in 1991/92, or 2.87 % in 1966/67 to 0.2 % in 1991/92 respectively. On the whole it has been observed that, total number of agricultural machinery and implements were less in West Bengal, compared to other states in India. The reason for this may be institutional set up in the state.

All India picture shows quite positive trend in case of agricultural machinery and implements. For example the number of wooden and iron ploughs were 39923 and 3171 thousands in 1966/67, have raised to 49785 and 7803 thousands in 1991/92 respectively. As against this, sugar cane crushers run by bullock and power increased from 637 and 430 hundreds in 1966/67 to 7941 and 1727 hundreds in 1991/92 respectively. The diesel and power pump sets recorded a level at 449 and 391 thousands in 1966/67, they have increased to 4700 and 8500 thousands in 1991/92 respectively. However tractor population which was 11340 hundreds in 1966/67, has gone up to 13161 hundreds in 1991/92 respectively.

Considering compound growth rates of agricultural machinery and implements in Andhra Pradesh the growth rate of wooden and iron ploughs increased at 1.63 % and 9.50 % per annum in 1971/72, and later wooden ploughs was increased at a rate of 1.27 % per annum and iron ploughs increased at a rate of 10.51 % per annum in 1991/92. As against this sugar cane crushers run by bullocks and power noticed a growth rate of 9.73 % and 8.29 % per annum in 1971/72, was increased at a rate of 2.00 and 3.91 % in 1991/92 respectively. Diesel and power pump sets have raised at 18.75 and 20.53 % per annum in 1971/72, was later recorded at a growth rate

of 4.32 % and 2.38 % per annum in 1991/92 respectively. Tractors accounted for 15.78 % growth rate per annum in 1971/72, which later increased at a rate of 2.40 % per annum in 1991/92.

Bihar accounted, wooden and iron ploughs growth rates at 1.03 % and 9.99 % per annum in 1971/72, which further raised at 0.85 % and 4.05 % per annum in 1991/92. On the other hand sugar cane crushers run by bullocks and power recorded a growth rate of 1.81 % and 0.00 % per annum in 1971/72, and later raised at a rate of 0.89 % and 5.43 % per annum in 1991/92 respectively. Mean while diesel and power pump sets witnessed a growth rate of 52.56 % and 50.34 % in 1971/72, and has gone up to at a rate of 0.82 % and 3.50 % per annum in 1991/92 respectively. Tractors increased at a rate of 21.67 % per annum in 1971/72, and 2.08 % per annum in 1991/92 respectively.

Wooden ploughs in Punjab noticed a negative compound growth rate of -14.98 and iron ploughs a positive growth rate of 9.57 % per annum in 1971/72. These growth rates later become positive where in wooden and iron ploughs has a growth rate of 1.00 and 2.54 % per annum in 1991/92 respectively. On the other hand sugar cane crushers run by bullocks and power noticed growth rates of -3.14 % and 35.24 % per annum in 1971/72, and has gone up to 0.73 and 9.04 % per annum in 1991/92 respectively. Diesel and power pump sets increased at a rate of 97.76 % and 55.10 % per annum in 1971/72, and later raised at 2.71 and 3.51 % per annum in 1991/92 respectively. Where as tractors noticed a rate of growth at 22.29 % per annum in 1971/72, which has gone up at a rate of 5.02 % per annum in 1991/92 respectively.

Tamil Nadu noticed negative growth in wooden ploughs i.e -2.18 % and positive growth rate for iron ploughs of 11.92 % per annum in 1971/72, later raised at 0.62 % and 3.34 % per annum in 1991/92 respectively. In case of sugar cane crushers run by bullock there was negative growth of -5.12 % and for power units the growth rate was 1.98 % per annum in 1971/72, later both have increased at a rate of 3.40 % and 3.46 % per annum in 1991/92 respectively. Interestingly, diesel and power pump sets increased at 36.93 % and 100.54 % per annum in 1971/72, and later increased at a rate of 2.65 % and 3.77% in 1991/92 respectively. Tractors noticed a 10.35 % per annum in 1971/72, later increased at a rate of 1.98 % per annum in 1991/92 respectively.

U. P is the state, where there are highest number of agricultural machinery and implements. In case of wooden and iron ploughs the rate of growth was at 1.12 % and 12.59 % per annum in 1971/72, and later increased at a rate of 0.32 % and 1.25 % per annum in 1991/92. Sugar cane crushers run by bullock and power accounted a rate of 1.84 % and 49.63 % in 1971/73, was later noticed the growth rates at 0.76 % and 8.73 % per annum in 1991/92 respectively. Diesel and power pumps raised at 48.62 % and 61.35 % per annum in 1971/72, later increased at a rate of 1.34 % and 4.75 % per annum in 1991/92. However, tractors recorded a growth rate of 22.27 % per annum in 1971/72, and 4.13 % per annum in 1991/92 respectively.

Regarding West Bengal, wooden and iron ploughs experienced negative growth i.e -11.45 % and -7.79 % in 1971/72, later it was

become positive at 3.52 V. and 4.07 % per annum in 1991/92. However, sugar cane crushers run by bullocks and power noticed a growth rate of -30.69 % and 0.00 % per annum in 1971/72, then raised at 5.68 % and 8.45 V. per annum in 1991/92 respectively. Pump sets run by diesel and power accounted 3.55 % and 0.00 % per annum in 1971/72, then increased at a rate of 1.39 % and 8.92 % per annum in 1991/92 respectively. Tractor population also raised at a negative growth rate of -14.14 % in 1971/72, but later the growth rate was 6.15 % per annum in 1991/92 respectively.

In case of all India, wooden and iron ploughs increased at a rate of -0.32 % and 11.08 % in 1971/72, was later noticed the growth rate at 1.76 % and 1.13 V. per annum in 1991/92. However, sugar cane crushers run by bullock and power increased at 1.24 % and 15.14 V. per annum in 1971/72, and later raised at 2.29 % and 4.01 % per annum in 1991/92. As against this, the diesel and power pump sets raised at 28.25 % and 32.85 % per annum in 1971/72, and later it increased at a rate of 4.51 % and 6.68 % per annum in 1991/92 respectively. Mean while tractors increased at 22.39 % per annum in 1971/72, and later they raised up at a rate of 7.92 % per annum in 1991/92 respectively.

4.4 SUMMARY AND CONCLUSIONS:

The present chapter has analyzed the nature of mechanization in Indian agriculture and selected states. Along with this some other issues like, trends in agricultural inputs, and general nature of farm mechanization in Indian agriculture was also analyzed.

On the whole the inputs demand picture is quite clear. It has increased drastically from 1970/71 onwards, and agricultural machinery and power consumption witnessed very much impressive growth rates. This indicates that, there will be a greater demand for energy sources in near future.

The data analysis relating to agricultural machinery and implements in whole India and selected states has identified that, the traditional equipment like wooden ploughs, sugarcane crushers run by bullocks, and diesel pump sets were replaced by modern equipment such iron ploughs, sugarcane crushers run by power, and electric pump sets. It shows that, there is a substitution possibilities among the agricultural equipment in Indian agriculture. The highest tractor population was recorded in Punjab and U. P, next comes to A.P, Bihar, Tamil Nadu, and West Bengal. The lowest tractor population has witnessed in West Bengal. The states like Punjab, U. P, A. P, and Tamil Nadu were more attracted for adopting modern technology, whereas the states like Bihar and West Bengal still existing with traditional technology.

The next chapter will examines the nature of fertilizer and pesticides demand in Indian agriculture and selected states.

CHAPTER 5

FERTILIZER AND PESTICIDES CONSUMPTION IN INDIAN AGRICULTURE

5.0 INTRODUCTION:

Fertilizers play a vital role in the modern agriculture technology. Increased use of fertilizers has increased food production which is conspicuous in the last two and a half decades when the consumption of nutrients N, P, and K increased from 0.78 million tones(1965-66) to 10.3 million tones (1988-89). During this period the food grain production also increased to over 170 million tones from a level of 73 million tones. The projected food grain requirement of 240 million tones by the turn of the century is to be achieved mainly through fertilizer use and improved farm technology.

Several studies are available which attempt: (1) to estimate the contribution of fertilizers to increased agricultural output over time or (2) to estimate the proportion of agricultural output which is accounted for by the fertilizer input. In general, the developing countries have only a small proportion of total food output attributable to fertilizer use, but the contribution of fertilizer to subsequent increases in output is much higher. A more balanced relationship exists within most developed countries. The contribution of fertilizer depends heavily upon the sources of increased output increased area brought under cultivation or increased yield per hectare cultivated. Although fertilizer

applications may be necessary to bring new land under cultivation, its major influence is through the **yield-increasing** component.

The commercial energy required to produce a pesticide can be **substantial**. The raw materials for modern pesticides **mostly** come from the petrochemical industry, and further inputs of energy are required in manufacturing. Thus pesticides are the most energy **intensive** agricultural input. Nevertheless, continued growth in the use of pesticides appears unavoidable. Their expanded use is particularly needed in developing countries, where crop **loss(both** pre- and post harvest), because of inadequate pest control, are very large. The declining share of world pesticide use projected for the developed countries probably mainly reflects environmental **concerns**.

Raymond H. Ewell(1974), who examined the success failure of Green revolution in Developing countries by taking the fertilizer as **limitting** factor. The main issues focussed in this study are (1). of the three primary agricultural inputs - seeds, water and fertilizer- fertilizer is the most critical input since it involves the greatest investment both by individual farmers and by the national economy. (2) very large quantities of fertilizer will be required by the developing countries during the next decade in order for agricultural production to keep pace with population growth. (3) **Under-utilization** of fertilizer is likely to be the limiting factor in increasing agricultural production in the developing countries during the next decade.

The main conclusions drawn in this study are that,

under-utilization of fertilizer is likely to be the **limiting** factor in agricultural production in the developing countries during the **1970's** and **1980's** rather than under-utilization of improved seed varieties or under-utilization of agricultural water. Under-utilization of fertilizer in the developing countries is the most likely cause of the green revolution falling short of the **expectations**. (the world's people now have for it, if that should happen).

Another interesting study by **Chauhan.K.K.S** and **Misra.R.V(1989)**, who analyzed the Nitrogen fertilization in Indian agriculture. The main observations of this study are that, application of nitrogenous fertilizers is a key factor in the overall fertilization programme of Indian agriculture. Due to widespread nitrogen deficiency in Indian soils, need for adequate nitrogen fertilization is being felt more and more, especially with the increasing coverage under short duration of high yielding varieties and removal of substantial quantities of nitrogen in intensive cropping systems.

Nitrogen being an energy intensive and costly nutrient, it becomes necessary to plan for scientific and efficient use of nitrogenous fertilizers. The nitrogen requirements for different crops and varieties under various agro soil-climatic situations, promotion of efficient fertilizer materials, complementary use of organic , in-organic and biological sources of nitrogen, and a sound technology transfer programme should form essential components of the strategy to promote efficient use of nitrogenous **fertilizers**.

Tandon.HLS(1993), who examined the fertilizer consumption in Indian agriculture by taking data from fertilizer statistics, (**Fertilizer** Association Of India), during the period 1970 to 1992. The major findings are, The season-wise fertilizer consumption pattern has gradually undergone major changes over the years. During the 1970s and early 1980s, 60-65% of annual fertilizer consumption took place during the **post-monsoon(rabi)** season and **35-40%** in the monsoon season (**kharif**). This ratio has been narrowing down. Narrowing down of this ratio can be taken as an indicator for three possible developments (i) increasing acceptance of fertilizers on kharif crops particularly rice (ii) increasing fertilizer use on rain fed crops during kharif in the assured rainfall areas (e.g. kharif sorghum in Maharashtra), and (iii) widening of the base of fertilizer consumption.

Punjab is the only state to have application rate above 100 kg/ha for an individual nutrient(N). Highest mean consumption rates for **p₂o₅** are also found in **punjab** followed by Andhra Pradesh. Tamil Nadu and Kerala lead the other states in terms of mean potash application per unit area. Out of about 400 districts, 25% of the total fertilizer is used in 27 districts, 50% in 76 districts and 75% in 151 districts. This clearly demonstrates the concentration of fertilizers in a few favorably endowed areas. It is apparent that not all high-consuming districts have a high nutrient application rate per unit area. Some districts are in the high consumption category because of their large cropped area, some due to high application rates per hectare and others due to a combination of both area and intensity of use.

Donald **B. Ibach and Moyle S. Williams**(1971), has conducted the economic analysis of fertilizer use in agricultural sector in general. The main objectives of this work are that, the economics of changes in fertilizer use at different levels of other technology on the individual farm, and general changes in technology and fertilizer use and their effects and implications for agriculture as a whole. The main hypothesis farmed here is that, with continuous inputs such as fertilizers, irrigation water, plant population, the physical principle of decreasing increments of output provides the basis for the economic principle of diminishing returns.

The results gave an indication that through improved technology a specified higher total output occurs at the lower yield indexes, while at the same time less fertilizer in the aggregate is used. But it is emphasized that crop land-fertilizer combinations derived from yield responses reflect, in addition to the annual rate of application, residual effects of proceeding fertilizer use at rates that would sustain the associated yields. Improved technology, including profitable use of fertilizer, is **increasingly** essential as **farming** becomes more complex and production depends more on off-farm inputs. Individual farmers need to keep in close touch with, and act on, new developments. But in view of the general **effects**, commensurate **adjustments** in crop land area use as well as in capital to the economic health of agriculture.

One of the pioneering study by **Khera. M. S et.al**(1990),

analyzed the use of potassium in Indian agriculture. This study presents an overall view of the past, present and likely future trends of K use in Indian agriculture. It was observed that about one fifth of the districts in India fall in the Low-K category. Depletion of reserve **K** in soils especially with **intensification** of agriculture and consequently **more** areas likely to become deficient in K are emphasized. About **41%** of the total **low-K** districts in India were located in U.P alone. Goa, Meghalaya, Mizoram, Nagaland, Pondicherry and Tripura were in the low-K category, while the entire Gujarat was in the high-K category. Nearly 50% of total consumption of K fertilizers is accounted by southern zone in which Tamil Nadu state gets a major share. But the consumption figures of different states do not relate to their K fertility status. More than 50% of K fertilizers are being consumed by rice followed by wheat (15%).

Prem Narain, et.al(1990), analyzed the long **term** fertilizer use and yield sustainability in Indian agriculture, with the objectives, to identify the economics of long term fertilizer use in crop production, to estimate the yield trends from continuous application of fertilizer and, to trace out the factors affecting yield sustainability in long term fertilizer experiments. The data for the study have been drawn from the long term fertilizer use experiments conducted at 8 cooperative centers under All India coordinated research project on long term fertilizer experiments for the period 1971-86.

The results showed that, the economics of long term fertilizer use and yield sustainability in various agro-climatic

zones of the country indicated the need for applying balanced dose of NPK at recommended levels for increased crop productivity and economic returns. Response to application of **N** and **P** was conspicuous at all the centers except at Pantnagar. However, application of **K** did not show beneficial effect for 15 years of continuous cropping at Coimbatore, Jabalpur, Hyderabad and Pantnagar because of high availability of the nutrient in these soils. At most of the centers, the available data suggests that there is a need for revision of nutrient levels for obtaining sustainable crop yields.

In the scenario of agricultural modernization, fertilizers and pesticides are the important inputs to up lift the agricultural production at larger extent. The **former** will act as a direct input in production, the later act as a external factor which decide the level of production. At the same time much energy can be consumed in the production of these **inputs**. Higher consumption of fertilizers and pesticides accounts much amount of energy demand in agriculture sector. Due to this in the last two decades agricultural sector is experiencing much demand for energy resources. To examine this, the present section will concentrate on the nature of fertilizers and pesticides consumption in Indian **agriculture**.

5.1 AREA UNDER HIGH YIELDING VARIETIES OF FOOD GRAINS - ALL INDIA:

The introduction of HYVs in Indian agriculture from 1966 onwards, gave a path to much demand of inputs. So that, it is very

much essential, at foremost for discussion, to identify the area under high yielding varieties, which again will provide a path to identify the nature of fertilizers and pesticides demand in Indian agriculture.

The table 5.1.1 illustrate the area under HYV seeds in Indian agriculture from 1966/67 to 1991/92. The area under HYVs of rice in all India was accounted, to be 887 thousand hectares in 1966/67, and later it has gone up to 27235 T.he in 1991/92, from a 2.5 % share in 1966/67 to 62.7 % in 1991/92. As against this wheat area recorded 540 T.he in 1966/67,

Table 5.1.1
AREA UNDER HIGH YIELDING VARIETIES OF FOOD GRAINS - ALL INDIA
(Thousand Hectares)

Year Crop	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Rice	887 (2.53)	7410 C19.6)	13337 (34.6)	19687 (48.4)	24026 (58.43)	27235 (62.7)
Wheat	540 (4.2)	7860 C41.1)	14522 (69.4)	16751 (75.6)	19142 (82.8)	21237 C88.4)
Jowar	190 C1.13	686 (4.1)	2370 (15.0)	3882 (23.4)	5500 C34.5)	6125 C38.3)

Source: Indian Agriculture In Brief, DESAg, 22 edition.
Fertilizer Statistics, **FAI**, 1993.

which further raised to 21237 T.he in 1991/92. This shows that, a five fold increase in area from 1966/67 to 1991/92, or equivalent of 4.2 % in 1966/67 to 88.4 % in 1991/92 respectively. Jowar area witnessed, 190 T.he in 1966/67, was later recorded at 6125 T.he in 1991/92. This is almost equal to more than thirty times increase in area from 1966/67 to 1991/92 respectively. This is equal to 1.1 X share in 1966/67 to 38.3 % in 1991/92.

However, as stated in table 5.1.2, compound growth rates noticed, rice area increased at the rate of 52.9 % in 1971/72, and later increased at a rate of 2.54 % in 1991/92. Interestingly wheat area witnessed 70.84 % growth per annum in 1971/72, later increased to a rate of 2.10 %

Table 5.1.2

COMPOUND GROWTH RATES OF AREA UNDER HIGH YIELDING VARIETIES OF FOOD GRAINS - ALL INDIA

(Thousand Hectares)

Year Crop	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Rice		52.89	12.47	8.10	4.06	2.54
Wheat		70.84	13.06	2.90	2.70	2.10
Jowar	--	29.41	28.14	10.37	7.22	2.18

Source: Indian Agriculture In Brief, DESAG, 22 edition.
Fertilizer Statistics, **FAI**, 1993.

per annum in 1991/92 respectively. As against this **Jowar** area has 29.4 % per annum in 1971/72, which raised to a rate of 2.18 % per annum.

5.2 AREA UNDER HIGH YIELDING VARIETIES OF RICE, WHEAT, AND JOWAR IN SELECTED STATES AND WHOLE INDIA:

The area under HYV seeds in selected states and all India from 1966/67 to 1991/92 is shown in tables 5.2.1 to 5.2.6. Considering the states in India, the area under rice in A.P was at 275 T/he in 1966/67, and has gone up to **3861** T/he in 1991/92. As equal to 31.0 % share in 1966/67, later at 14.2 % share in 1991/92 respectively.

Bihar recorded 67 T/he in 1966/67, later it has raised to **2891** T/he in 1991/92. This is equal to 7.6 % in 1966/67 and 10.6 % in 1991/92. As against this, Punjab accounted 7 T/he in 1966/67, which increased to 2037 T/he in **1991/92**, in percentage terms from 0.8 % share in 1966/67 to 7.5 % in 1991/92. Tamil Nadu noticed

Table 5.2.1

AREA UNDER HIGH YIELDING VARIETIES OF RICE, 1966/67 TO 1991/92.
(*000 Hectares)

States——	A. P	Bihar	Punjab	T. Nadu	U. P	W. Bengal	ALL India
1966/67	275 (31.0)	67 (7.6)	7 0.83	152 17.13	69 (7.83)	26 (2.93)	888 (100.0)
1971/72	725 (9.8)	440 (5.93)	311 (4.2)	2245 (30.33)	994 (13.4)	704 (9.53)	7410 (100.0)
1976/77	2024 (15.2)	998 (7.53)	579 (4.3)	2170 (16.3)	1679 (12.6)	1290 (9.73)	13337 (100.0)
1981/82	3086 (15.73)	1500 (7.6)	1207 6.13	2300 (11.73)	2665 (13.53)	1807 (9.2)	19687 (100.0)
1986/86	3250 (13.53)	2748 (11.4)	1709 7.13	1860 (7.73)	3701 (15.4)	2244 (9.3)	24026 (100.0)
1991/92	3861 (14.2)	2891 (10.6)	2037 (7.5)	2213 8.13	4125 (15.2)	2623 (9.63)	27235 (100.0)

Source: Indian Agriculture In Brief, DESAg, 22 edition.
Fertilizer Statistics, FAI, 1993.

152 T/he in 1966/67, and later increased to 2213 T/he in **1991/92**, this is equal to 17.1 % in 1966/67 to 8.1 % in 1991/92 respectively. U.P recorded 69 T/he in 1966/67, which has increased to 4125 T/he in 1991/92, a share of 7.8 % in 1966/67 to 15.2 % in 1991/92. However, West Bengal noticed 26 T/he in 1966/67, which raised to 2623 T/he in 1991/92. The share equal to 2.9 % in 1966/67 to 9.6 % in 1991/92 respectively. All India level scenario showed that, 888 T/he in 1966/67, has raised up to 27235 T/he in 1991/92 respectively.

Considering compound growth rates of HYVs of **rice, Andhra Pradesh** recorded, 21.40 % in 1971/72, which increased at a rate of 3.51 % per annum in 1991/92. Bihar noticed 45.71 % per annum in 1971/72, was further increased at a rate of 1.02 % per annum in 1991/92. Interestingly, Punjab noticed 113.57 % per annum growth in 1971/72, and has gone up to a rate **of 3.57** % per annum in 1991/92. Tamil Nadu recorded 71.35 % per annum in 1971/72, later it has raised at 3.54 % per annum in 1991/92. Where as **U.P** witnessed **7.47** % growth per annum in 1971/72, and later it has gone by 2.19 % per annum in 1991/92. West Bengal recorded 93.43 %

Table **5.2.2**

COMPOUND GROWTH RATES OF AREA UNDER HIGH YIELDING
VARIETIES OF RICE, 1966/67 TO 1991/92.

States——	('000 Hectares)						
	A. P	Bihar	Punjab	T. Nadu	U. P	W. Bengal	ALL India
Years							
1966/67	—	--	—	—	~	—	—
1971/72	21.40	45.71	113.57	71.35	7.49	93.43	52.86
1976/77	22.80	17.80	13.24	-0.68	11.06	12.88	12.47
1981/82	8.80	8.49	15.83	1.17	9.68	6.97	8.10
1986/86	1.04	12.87	7.20	-4.16	6.79	4.43	4.06
1991/92	3.51	1.02	3.57	3.54	2.19	3.17	2.54

Source: Indian Agriculture In Brief, DESAg, **22** edition.
Fertilizer Statistics, **FAI**, 1993.

per annum in 1971/72, was further raised at a rate **of 3.11** X per annum in 1991/92. At all India level it was 52.86 % per annum in 1971/72, which slowly increased at a rate of 2.54 % per annum in 1991/92 respectively.

Area under HYVs of wheat in Bihar noticed 25 T.he in 1966/67, later it has gone up to 2425 T.he in 1991/92, which is equal to 4.6 % in 1966/67 to 11.4 % in 1991/92. Punjab accounted 59 T.he in 1966/67, which further increased to 3673 T.he in 1991/92. Which is

Table 5. 2. 3
AREA UNDER HIGH YIELDING VARIETIES OF WHEAT, 1966/67 TO 1991/92.
('000 Hectares)

States——	Bihar	Punjab	U. P	W. Bengal	ALL India
Years					
1966/67	25 (4.63)	59 (10.9)	363 (67.2)	8 (1.5)	540 (100.0)
1971/72	1213 (15.43)	1695 (21.6)	2200 C 28.03	385 (4.93)	7860 (100.0)
1976/77	1417 (9.83)	2376 (16.4)	4800 (33.1)	600 (4.1)	14522 (100.0)
1981/82	1800 (9.8)	2883 (15.7)	6193 (33.8)	389 (2.1)	18325 (100.0)
1986/86	2100 (11.03)	3178 (16.63)	7431 C 38.8)	397 (2.1)	19142 (100.0)
1991/92	2425 (11.4)	3673 (17.3)	8241 (38.8)	532 (2.53)	21237 (100.0)

Source: Indian Agriculture In Brief, DESAg, 22 edition.
Fertilizer Statistics, FAI, 1993.

equal to 10.9 % in 1966/67 to 17.3 % in 1991/92. As against this U.P accounted 363 T.he in 1966/67, and later raised to 8241 T.he in 1991/92, in percentage terms from 67.2 % in 1966/67 to 38.8 % in 1991/92. Contrary to this West Bengal witnessed 8 T.he in 1966/67 to 532 T.he in 1991/92, which equivalent to 1.5 % per annum in 1966/67 and 2.5 % in 1991/92. At all India level it recorded , 540 T.he in 1966/67, later increased to 21237 T.he in 1991/92 respectively.

Regarding compound growth rates, Bihar witnessed 117.36 % per annum in 1971/72, which further raised to 2.92 % per annum in 1991/92. Punjab noticed 95.73 % per annum in 1971/72, and

Table 5.2.4
COMPOUND GROWTH RATES OF AREA UNDER HIGH YIELDING VARIETIES OF WHEAT, 1966/67 TO 1991/92.

('000 Hectares)

States—— years	Bihar	Punjab	U. P	W. Bengal	ALL India
1966/67					
1971/72	117.36	95.73	43.38	117.01	70.84
1976/77	3.16	6.99	16.89	9.28	13.06
1981/82	4.90	4.78	5.23	-8.30	4.76
1986/86	3.13	1.97	3.71	0.41	0.88
1991/92	2.92	2.94	2.09	6.03	2.10

Source: Indian Agriculture In Brief, DESAg, 22 edition.
Fertilizer Statistics, **FAI**, 1993.

increased at a rate of 2.94 % per annum in 1991/92. As against this **U.P**, noticed 43.38 % per annum in 1971/72 to 2.09 % per annum in 1991/92. Interestingly, West Bengal recorded, 117.01 % per annum in 1971/72, and later it raised at a rate of 6.03 % per annum in 1991/92. Where as all India picture showed a70.84 % per annum in 1971/72, and2.10 % per annum in 1991/92 respectively.

Area under HYVs of Jowar in A.P noticed 36 T.he in 1966/67, which was raised to 510 T.he in 1991/92. which is equal to 19.0 % from 1966/67 to 8.3 % in 1991/92. Tamil Nadu recorded 10 T.he in 1966/67, which further raised to 385 T.he in 1991/92, this is

equal to 5.3 % growth in 1966/67 to 6.3 % growth in 1991/92. On the other hand U.P noticed 2 T.he in 1966/67, which has later recorded 3 T.he in 1991/92. This is equal to 1.1 % in 1966/67 to 0.1 % in 1991/92 respectively. At all India level it was observed

Table 5.2.5
AREA UNDER HIGH YIELDING VARIETIES OF JOWAR, 1966/67 TO 1991/92.
(C'000 Hectares)

States— Years	A. P	T. Nadu	U. P	ALL India
1966/67	36 (19.0)	10 (5.3)	2 C1.13	190 (100.0)
1971/72	37 (5.4)	18 (2.63)	1 CO. 2)	686 (100.0)
1976/77	150 (6.3)		2 (0.1)	2370 (100.0)
1981/82	449 (11.6)	185 (4.53)	1 CO. 03)	3882 (100.0)
1986/86	450 (8.2)	404 (7.4)		5500 (100.0)
1991/92	510 (8.3)	385 (6.33)	3 CO. 13	6125 (100.03)

Source: Indian Agriculture In Brief, DESAg, 22 edition.
Fertilizer Statistics, FAI, 1993.

that, 190 T.he was the area under HVV in 1966/67, was further it has gone up to 6125 T.he in 1991/92 respectively.

Compound growth rates recorded in A.P was 0.55 % per annum in 1971/72, was later raised 2.54 % per annum in 1991/92. Where as Tamil Nadu noticed, 12.47 % per annum in 1971/72, to -0.96 % growth in 1991/92. U.P noticed almost 0.00 % growth in 1971/72 to 1991/92. All India level picture witnessed 29.28 % per annum in 1971/72, which has later increased at a rate of 2.18 % per annum in 1991/92 respectively.

Table **5.2.6**
 COMPOUND GROWTH RATES OF AREA UNDER HIGH YIELDING VARIETIES OF JOWAR,
 1966/67 TO 1991/92.

States ——— Years	C'000 Hectares)			
	A. P	T. Nadu	U. P	ALL India
1966/67				
1971/72	0.55	12.47	0.00	29.28
1976/77	32.31		0.00	28.14
1981/82	27.18		0.00	10.32
1986/86	-2.08	16.91	0.00	7.22
1991/92	2.54	-0.96	0.00	2.18

Source: Indian Agriculture In Brief, DESAg, 22 edition.
 Fertilizer Statistics, **FAI, 1993.**

5.3 THE QUANTITY OF PLANT NUTRIENTS RECEIVED FROM SOIL BY DIFFERENT CROPS:

Fertilizers absorption from soil can differ from crop to crop according to its biological structure. As we know the legume crop will demand less amount of fertilizers as compared to other crops such as rice, wheat, **jowar**, sugar cane and cotton. According to *ICAR (1987)*, fertilizer absorption can differ from crop to crop and region to region due to soil differences. The tables 5.3.1 to 5.3.1 discusses the fertilizer absorption by different crops under consideration.

Table **5.3.1**
 THE QUANTITY OF PLANT NUTRIENTS RECEIVED FROM SOIL BY DIFFERENT
 CROPS (Kg. per hectare)

Crop	Yield Grain (Kg/ha)	N	P ₂ O ₅	K ₂ O
Rice	2240	34	22	67
Wheat	1568	56	24	67
Jowar	1792	56	15	46
Sugar cane	67200	90	17	202
Groundnut	1904	78	22	45
Cotton	448	30	17	45

Source: ICAR Hand Book of Agriculture: Facts and figures for farmers, Students and all interested in farming 1987.

Regarding rice crop, it was noticed that 2240 Kg/he yield can demand 34 kg. nitrogen, 22 Kg phosphate, and 67 Kg **potassium**. As against this, wheat with 1568 Kg/he will demand 56 Kg nitrogen, 24 Kg phosphate, and 67 Kg Potassium. On the other hand jowar demands 56 Kg nitrogen, 15 Kg phosphate, and 46 Kg potassium, which produces 1792 Kg/hectare of output. However, sugar cane with 67200 Kg/he yield, demands 90 Kg nitrogen, 17 Kg phosphate, and 202 Kg potassium respectively. Meanwhile Ground nut with 1904 yield, consumes **78** Kg nitrogen, 22 Kg phosphate, and 45 Kg potassium. Next comes to cotton with 448 Kg/he productivity, which demands 30 kg nitrogen, 17 Kg phosphate, and 45 Kg potassium. respectively. It was observed that sugar cane demands high amounts of **fertilizers** while comparing with other **crops**. Next comes ground nut, wheat, jowar, rice, and cotton respectively.

Another study by FAK1990), identified the potassium removal ratios to nitrogen and phosphate for million tonns of yield production for different crops. It showed that, Rice **demands** 20.1

Table **5.3.2**
K REMOVALS RELATIVE TO N AND P/MT OF YIELD PRODUCTION FOR DIFFERENT CROPS UNDER FIELD CONDITIONS IN INDIA.

Crop	Kg/tonne Produce			Ratio of K_2O and P_2O_5 relative to N		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Rice	20.1	11.2	30.0	100	55.7	149.3
Wheat	24.5	8.6	32.8	100	35.1	133.8
Ground-Nut	58.1	19.6	30.1	100	33.7	51.8
Cotton	44.5	28.3	74.7	100	63.6	167.8
Sugar-cane	1.7	0.2	2.0	100	11.8	117.6

Source: Soil fertility and Fertilizer **use**, Vol. IV, 1990.

nitrogen, 11.2 phosphate, and 30.0 potassium for Kg/he production. With respect to wheat, it recorded 24.5 nitrogen, 8.6 phosphate, and 32.8 **potassium** for kg/he of production. Ground nut demands 58.1 nitrogen, **19.6** phosphate, and 30.1 potassium for Kg/he production. Next to cotton and sugar cane demand 44.5 and 1.7 nitrogen, 28.3 and 0.2 phosphate, and 74.7 and 2.0 potassium for Kg/he production respectively.

On the other hand the ratio of potassium and phosphate relation to nitrogen showed that, (by considering nitrogen is 100) rice noticed 55.7 Kg phosphate and 149.3 Kg potassium, wheat accounts 35.1 and 133.8 Kg phosphate and potassium respectively. Where as ground nut noticed 33.7 and 51.8 kgs phosphate and

potassium respectively. Mean while cotton and sugar cane noticed 63.6 phosphate and 11.8 **potassium**, and 167.8 phosphate and 117.6 **potassium** respectively.

On the whole it is observed that, the rate of phosphate and **potassium** increasing at faster rate in Indian agriculture. But according to this study it has been observed that, the soil which have abundant **potassium** will demand less potassium, where as the soil which had scarce potassium demands more amount of potassium.

5.4 FERTILIZER CONSUMPTION IN INDIAN AGRICULTURE:

Fertilizer consumption is steadily increasing in Indian agriculture over a period of time. Due to this, the demand for fertilizers increased at a faster rate, in India. Especially chemical fertilizers consumption is increasing at faster rate than farm yard manures. The chemical fertilizers are expected to give immediate results in agricultural production. On these grounds the present section will discuss fertilizer consumption in Indian **agriculture**.

As stated in table 5.4.1, fertilizer consumption in India recorded, nitrogen at 738 Thousands in 1966/67, and it increased to 8046 T.t in 1991/92. Phosphate fertilizers accounted for 558 T.t in **1966/67**, has gone up to 3321 T.t in 1991/92 respectively. However, potassium fertilizers consumption recorded 114 T.t in 1966/67, has later gone up to 1361 T.t in 1991/92. On the whole total fertilizer (NPK) witnessed 1101 T.t in 1966/67, which has raised to 12728 T.t in 1991/92.

Table 5.4.1
FERTILIZER CONSUMPTION IN INDIAN AGRICULTURE: 1966/67 TO 1991/92.

(Thousand tons of Nutrients).

Nutrients	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Nitrogen(N)	738	1798	2457	4069	5716	8046
	(--)	(19.49)	(6.45)	(10.62)	C 7.03)	C 7.08)
Phosphate(P₃)	249	558	635	1322	2079	3321
	(--)	(17.51)	(2.62)	(15.80)	(9.48)	(9.82)
Potassic(K)	114	301	319	673	850	1361
	(--)	C 21.43)	(1.17)	(16.10)	C 4.78)	(9.87)
Total(NPK)	1101	2657	3411	6064	8645	12728
	(--)	(19.27)	(5.12)	(12.19)	(7.35)	(8.05)
Kgs. Per hectare of cropped area	7.0	16.1	20.4	34.6	48.9	69.7
	(--)	C 18.13)	C 4.85)	(11.15)	(7.16)	(7.35)
Subsidies (Rs. crores)			60	381	1898	4800
			(--)	(44.73)	(37.87)	C 30.39)

Source: Fertilizer Statistics, Fertilizer Association of India 1966 to 1991.

C). Figures in the brackets indicates compound growth rates.

Interestingly per hectare consumption of fertilizers recorded 7.0 Kgs in 1966/67, has increased to 69.7 Kgs in 1991/92. Mean while the subsidy on fertilizers accounted for 60 crores in 1976/77, which has raised to 4800 crores in 1991/92 respectively.

Contrary to this compound growth rates for nitrogen noticed 19.49 % per annum in 1971/72, which raised at a rate of 7.08 % per annum in 1991/92. Phosphate fertilizers increased at rate of 17.51 % in 1971/72, and further gone up at a rate of 9.82 % growth per annum in 1991/92. Similarly potassium fertilizers increased at 21.43 % per annum in 1971/72, which was later raised at a rate of 9.87 % per annum in 1991/92 respectively. The total NPK accounted for a growth rate of 19.27 % per annum in 1971/72, was later increased at a rate of 8.05 % per annum in 1991/92 respectively.

On the other hand fertilizer consumption per hectare of cropped area increased at 18.13 % per annum in 1971/72, which increased at a rate i.e 7.35 % per annum in 1991/92 respectively. Where as subsidies raised at 44.73 % per annum in 1981/82, was further raised at a rate 30.39 % per annum in 1991/92 respectively. The above analysis showed that, the fertilizer consumption is increasing at decreasing rate over a period of time from **1966/67** to 1991/92. The reason for this is due to, raise in prices of fertilizers since 1973 onwards.

5.5 FERTILIZER CONSUMPTION IN INDIAN AGRICULTURE WITH RESPECT TO SELECTED STATES:

Fertilizer consumption differs from state to state, according to their requirements and utilization pattern under different crops. On the other hand soil differences between state to state will also influence the consumption of fertilizers. On these grounds the table 5.5.1 illustrate the fertilizer consumption with respect to states and whole India.

Fertilizer consumption in A.P noticed 2.3 lakh tonns in 1966/67, and later it increased to 16.3 lakhs in 1991/92 respectively. This is equivalent to 13.29 % share in total consumption in 1966/67 to 12.54 % in 1991/92. As against this Bihar recorded 0.9 lakh tonns in 1966/67, and further gone up to 6.0 L.t in 1991/92, equal to 5.20 % in 1966/67 to 4.62 % in 1991/92. Punjab accounted 2.4 L.t in 1966/67, which raised at **11.8** L.t in 1991/92. This is equal to 13.87 % in 1966/67 to **9.08** X in 1991/92.

Table 5.5.1

FERTILIZER CONSUMPTION IN INDIAN AGRICULTURE, FROM 1966/67 TO 1991/92.

(Lakh tonns)

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh	2.3 (13.29)	3.0 (11.28)	4.3 (12.61)	6.6 (10.89)	9.0 (10.30)	16.3 (12.54)
Bihar	0.9 C 5.20	1.1 C 4.14	1.8 (5.28)	2.1 (3.47)	5.3 (6.06)	6.0 C 4.62
Punjab	2.4 (13.87)	2.9 (10.90)	3.5 (10.26)	8.2 (13.53)	11.2 (12.81)	11.8 C 9.08
Tamil Nadu	3.0 (17.34)	3.8 (13.16)	4.0 (11.73)	5.3 (8.75)	6.7 (7.67)	9.2 (7.08)
Uttar Pradesh	4.2 (24.28)	4.6 (17.29)	5.1 (14.96)	12.7 (20.96)	17.7 (20.25)	23.5 (18.08)
West Bengal	0.7 C 4.05	1.0 (3.76)	1.9 (5.57)	2.6 C 4.29	5.0 (5.72)	8.4 (6.46)
All India	17.3 (100.0)	26.6 (100.0)	34.1 (100.0)	60.6 (100.0)	87.4 (100.0)	130.0 (100.0)

Source: Indian Agriculture in Brief, Various issues 1966 to 1991.
Fertilizer Statistics, Various issues 1981 to 1993.

Tamil Nadu noticed 3.0 L.t in 1966/67, later it has raised to 9.2 L.t in 1991/92, which is equal to 17.34 % in 1966/67 to 7.08 % in 1991/92 respectively. Where as U.P accounted 4.2 L.t in 1966/67, which raised to 23.5 L.t in 1991/92, in percentage terms 24.28 % in 1966/67 to 18.08 % in 1991/92. Mean while West Bengal noticed 0.72 L.t in 1966/67, and later increased to 8.4 L.t in 1991/92 Which is equal to 4.05 % in 1966/67 to 6.46 % in 1991/92. All India picture shows that it was 17.3 L.t in 1966/67, which has increased to 130.0 L.t in 1991/92 respectively.

As stated in the table 5.5.2, compound growth rates of fertiliser consumption in A.P accounted, 5.46 % per annum in 1971/72, was later raised at an increasing rate of 12.61 % per

annum **in** 1991/92. Bihar noticed 0.20 % per annum in 1971/72, and

Table 5.5.2

COMPOUND GROWTH RATES OF FERTILIZER CONSUMPTION IN **INDIAN** AGRICULTURE, FROM **1966/67** TO **1991/92**.

(Lakh tonns)

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh		5.46	7.47	8.15	6.40	12.61
Bihar		0.20	10.31	3.13	20.34	2.51
Punjab	—	3.86	3.83	18.56	6.43	1.05
Tamil Nadu		3.13	2.71	5.79	4.80	6.55
Uttar Pradesh		1.84	2.08	20.02	6.87	5.83
West Bengal		0.00	0.00	6.39	13.97	10.93
All India		8.98	5.09	12.19	7.60	8.26

Source: Indian Agriculture in Brief, Various issues 1966 to 1991. Fertilizer Statistics, Various issues 1981 to 1993.

further raised at a rate of 2.51 % per annum in 1991/92. Interestingly Punjab accounted 3.86 % per annum in 1971/72, which was gone up at a rate of 1.05 % per annum in 1991/92. However, Tamil Nadu noticed, 3.13 % growth per annum in 1971/72, which has further increased at a rate of 6.55 % per annum in 1991/92. U.P was accounted 1.84 % per annum in 1971/72, **and**5.83 % per annum in 1991/92.

West Bengal has no **growth**(0.00 % **growth**)in 1971/72, but later it has increased at 10.93 % per annum in 1991/92. All India picture showed that, 8.98 % per annum in 1971/72, which has further raised at a rate **of**8.26 % per annum in 1991/92 respectively.

5.6 PER HECTARE CONSUMPTION OF FERTILIZERS IN INDIAN AGRICULTURE
WITH RESPECT TO SELECTED STATES:

Per hectare consumption of fertilizers are differing from state to state over a period of time since last two **decades**. Fertilizer consumption per hectare is one of the important component for deciding yield rate in agriculture production. Theoretically as *Recardo* said , land have original and indestructible powers, in fact which have been slowly declined in recent years, due to over exploitation of land resource. To compensate this fertilizers came in to existence, so that

Table 5.6.1

PER HECTARE CONSUMPTION OF FERTILIZERS IN **INDIAN** AGRICULTURE, FROM **1966/67** TO **1991/92**.

	(Kg. per hectare)					
States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh	17.7	23.5 CS. 835	30.2 (5.14)	50.3 (10.74)	77.1 (8.92)	124.0 (9.97)
Bihar	8.7	10.1 (3.03)	14.4 (7.35)	19.3 (6.03)	50.6 (21.26)	57.9 (2.73)
Punjab	41.8	50.6 C 3.90)	62.9 (4.45)	118.3 (13.47)	154.6 (5.50)	168.3 (1.71)
Tamil Nadu	38.4	45.3 C 3.36)	41.7 C -1.64)	74.2 (12.22)	103.6 (6.90)	130.1 C 4.66)
Uttar Pradesh	15.7	20.1 (5.06)	32.0 C 9.75)	51.3 (9.90)	66.6 (5.36)	89.0 C 5.97)
West Bengal	9.0	13.1 (7.80)	19.8 (8.61)	34.9 (12.00)	60.8 (11.74)	90.7 (8.33)
All India	10.1	16.1 (12.34)	20.8 (5.26)	34.3 (10.52)	48.9 (7.35)	70.7 (7.65)

Source: Indian Agriculture in Brief, Various issues 1966 to 1991.
Fertilizer Statistics, Various issues 1981 to 1993.

(C). Figures in the brackets indicates compound growth rates.

fertilizer **consumption** will pave a path to declining in yield structure in Indian agriculture. By keeping this in view the table 5.6.1 will look at the per hectare **consumption** of fertilizers over a period of time from 1966/67 to 1991/92 in whole India and selected states.

Per hectare consumption of fertilizers in A.P noticed, 17.7 Kg in 1966/67, which has later increased to 124.0 Kg/he in 1991/92, this is equal to a nine times increase in consumption of fertilizers per hectare. Bihar accounted, **8.7** Kg/he in 1966/67, which has further been increased to 57.9 Kg/he in 1991/92. As against this Punjab witnessed tremendous change i.e **41.8** Kg/he in **1966/67**, to 168.3 Kg/he in 1991/92. Tamil Nadu witnessed 38.4 Kg/he in 1966/67, and was later recorded 130.1 Kg/he in 1991/92 respectively. However, **U.P** noticed 15.7 Kg/he in 1966/67, and is further gone up to 89.0 kg/he in 1991/92. Mean while West Bengal recorded 9.0 Kg/he in 1966/67, and later to 70.0 Kg/he in 1991/92 respectively.

Compound growth rates of per hectare consumption of fertilizers in A.P, witnessed 5.83 X per annum in 1971/72, and 9.97 % per annum in 1991/92 respectively. Bihar noticed 3.03 % per annum in 1971/72, which has later increased at a rate of 2.73 % per annum in 1991/92. As against this, Punjab recorded 3.90 % per annum in 1971/72, and further increased at a rate of 1.71 % per annum in 1991/92 respectively.

Tamil Nadu experienced, 3.36 % per annum in 1971/72, which raised to 4.66 % per **annum** in 1991/92. U.P recorded 5.06 % per annum in 1971/72, and later raised at a rate of 5.97 % per annum in 1991/92 respectively. West Bengal showed **7.80** % per **annum** in 1971/72, and later **gone** up at a rate of **8.33** % per annum in 1991/92. All India picture witnessed a growth rate of 12.34 % per annum in 1971/72, and later raised at a rate of 7.65 % per **annum** in 1991/92 respectively.

5.7 TOTAL PESTICIDE CONSUMPTION IN INDIAN AGRICULTURE AND SELECTED STATES:

Adoption of HYVs technology gave path to much increase in pesticide demand in Indian agriculture, due to increase in plant diseases. To remove pest problem, pesticides and insecticides demand has been increased, at larger extent, over a period of time. As discussed above, pesticide production requires larger amount of energy, which is again used in agricultural production. This shows the extent of energy demand in Indian agriculture. The table 5.7.1 explains the nature of pesticides consumption in selected states and whole India from 1966/67 to 1991/92 **respectively**.

Pesticides consumption in A.P noticed, 2.3 thousand tonns in 1966/67, and later it increased to 16.7 thousands in **1991/92**, ora growth rate of 14.29 % share in 1966/67 to 19.69 % in 1991/92. A seven times increase took place in pesticides consumption in A.P from 1966/67 to 1991/92 respectively. As against this Bihar

noticed 0.6 T.t in 1966/67, later increased to 3.9 T.t in 1991/92. As equivalent of 3.73 % in 1966/67 to 4.60 % in 1991/92. Punjab experienced 1.5 T.t in 1966/67, later gone up to **8.9** T.t in 1991/92. This is equal to 9.32 % share in 1966/67 to 10.50 % in 1991/92 respectively.

Table 5.7.1

TOTAL PESTICIDES CONSUMPTION IN INDIAN AGRICULTURE, FROM **1966/67** TO **1991/1992**.

(Thousand **tonns**).

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh	2.3 (14.29)	7.6 C29.46	10.4 C30.14	15.5 (32.98)	9.1 (13.525)	16.7 (19.695)
Bihar	0.6 (3.73)	1.7 C6.595	1.8 (5.22)	2.6 (3.31)	2.0 (2.975)	3.9 C4.60
Punjab	1.5 (9.32)	2.3 (8.91)	3.5 (10.14)	4.4 (9.365)	5.8 (8.625)	8.9 (10.505)
Tamil Nadu	1.8 (11.18)	3.0 (11.63)	5.3 (15.36)	8.5 (18.095)	11.0 (16.345)	13.3 C15.74
Uttar Pradesh	1.2 (7.455)	3.4 (13.185)	5.1 (14.785)	8.2 (17.45)	6.6 (9.815)	9.5 (11.20)
West Bengal	0.7 C4.355	1.2 C4.655	1.9 (5.515)	2.7 (5.745)	5.1 (7.585)	7.2 (8.495)
All India	16.1 (100.0)	25.8 (100.0)	34.5 (100.05)	47.0 (100.0)	67.3 (100.05)	84.8 (100.05)

Source: Indian Agriculture in Brief, various issues 1966 to 1991. Agricultural Statistics at Glance, 1991, 1992, and 1994.

Tamil Nadu accounts, **1.8** T.t in 1966/67, which raised to 13.3 T.t in 1991/92, or 11.18 % in 1966/67 to 15.74 % in 1991/92. Uttar Pradesh recorded at 1.2 T.t in 1966/67, further gone up to 9.5 T.t in **1991/92**, or 7.45 % in 1966/67 to 11.20 % in 1991/92. West Bengal witnessed 0.7 T.t in 1966/67, and later increased to 7.2 T.t in 1991/92. This is equal to 4.35 % in 1966/67 to 8.49 % in

1991/92 respectively. All India picture recorded a 16.1 T.t in 1966/67, and further raised to **84.8** T.t in 1991/92 respectively.

As stated in the table 5.7.2, compound growth rates of pesticides consumption in A.P noticed, 27.00 % per annum in 1971/72, and later increased at a rate of 12.91 % per annum in

Table 5.7.2
COMPOUND GROWTH RATES OF TOTAL PESTICIDES CONSUMPTION IN INDIAN AGRICULTURE, FROM 1966/67 TO **1991/1992**.

(Thousand tonns).

States	1966/67	1971/72	1976/77	1981/82	1986/87	1991/92
Andhra Pradesh		27.00	6.47	8.31	-10.10	12.91
Bihar		-0.40	1.15	7.63	-5.11	14.29
Punjab		8.92	8.76	4.68	5.68	8.94
Tamil Nadu	—	10.76	12.06	9.91	5.29	3.87
Uttar Pradesh		23.16	8.45	9.96	-4.25	7.56
West Bengal		3.55	9.63	7.28	13.56	7.14
All India		9.89	5.98	6.38	7.45	4.73

Source: Indian Agriculture **in** Brief, various issues 1966 to 1991. Agricultural Statistics at Glance, 1991, **1992**, and 1994.

1991/92. As against this, Bihar experienced negative growth of -0.40 % per **annum** in 1971/72, and later a growth rate of 14.29 % per annum in 1991/92. Punjab recorded, 8.92 % growth per annum in 1971/72, was further gone up to 8.94 % in 1991/92 respectively.

Tamil Nadu witnessed 10.76 % per annum in 1971/72, which was further increased at a rate **of**3.87 % per annum in 1991/92. Where

as U.P noticed 23.16 % per annum in 1971/72, which was raised at a rate of 7.56 % per annum in 1991/92. On the other hand West Bengal witnessed 3.55 % per annum in 1971/72, has later increased at a rate of 7.14 % per annum in 1991/92. At all India level **9.89** % per annum in 1971/72, was noticed and it further raised at a rate of 4.73 % growth per annum in 1991/92 respectively.

5.8 SUMMARY AND CONCLUSIONS:

In this chapter, the fertilizer and pesticides consumption in Indian agriculture and selected states was analyzed. Along with this some other indicators such as area under HYV seeds, the quantity of plant nutrients received from soil by different crops, and per hectare consumption of fertilizers were analyzed.

At first, the data analysis relating to quantity of plant nutrients received by different crops was observed that sugar cane demands high amounts of fertilizers while comparing with other crops. Next comes ground nut, wheat, jowar, rice, and cotton respectively. Next the data analysis for fertilizer demand in Indian agriculture is observed that, the rate of phosphate and potassium increasing at faster rate in Indian agriculture. But according to this study it has been observed that, the soil which have abundant potassium will demand less potassium, where as the soil which had scarce potassium demands more amount of **potassium.** Application of nitrogenous fertilizers is a key factor in the overall fertilization programme of Indian agriculture. Due to widespread nitrogen deficiency in Indian soils, need for adequate nitrogen fertilization is being felt more and more,

especially with the increasing coverage under short duration of high yielding varieties and removal of substantial quantities of nitrogen in intensive cropping **systems**.

In case of per hectare consumption of fertilizers in all India and selected states, the analysis indicate that Punjab has showed highest per hectare consumption of fertilizers, next comes to Tamil Nadu, A.P, West Bengal, U.P, and Bihar respectively. Finally, the data analysis with respect to pesticides consumption in all India and selected states has shown that, Andhra Pradesh is demanding much amount of pesticides, next to Tamil Nadu, U.P, Punjab, West Bengal, and Bihar respectively. The preceding chapter will examines the nature of energy demand and energy intensities in Indian agriculture and selected states.

CHAPTER 6

ENERGY DEMAND IN INDIAN AGRICULTURE SECTOR

6.0 INTRODUCTION:

Energy is a basic requirement of human life, just like in agriculture, industry, transportation, communication and all other economic activities of the present civilization. So far India is concerned, agriculture constitutes foundation for the socio-economic structure, Seventy percent of the population is engaged in activities related to crop-animal-aqua production, processing and marketing.

Man gets his energy from the food he eats, An average Indian lives on a diet of 2000 food calories(unit of food calorie = 1000 units of calorie or 1 food calorie = 1kcal), and produces 60 watts of power when he works for 8 hours a day. Thus he generates energy roughly equal to 0.5 kwh. At a rate of Rs.5/day/man, this amounts to a cost of Rs. 10 per kwh for heaved energy. A human being is an expensive source of energy. It is better to use him to organize, manage, steer, direct and govern rather than as a energy source.

Energy is both fuel and feed stock for agriculture. Primary energy is the fuel, solar energy is the feed stock material. Both are essential in industrialized agriculture concern for the efficient and proper use of energy, is evidenced from many questions, non-agricultural sources. Widely differencing proposals have been made for changes in agricultural policy in response to

the energy-related concerns. Controversy exists over the correctness and feasibility of many of these proposals. It is of **extream** importance, therefore, to identify the energetic relationships of agricultural systems and to be understood. We must be able to correctly identify and measure the flow of energy in the system comparing the crop and livestock production, food processing, distribution and preparation. We call such activities as agricultural **energytics**.

Agriculture is the business of capturing solar energy in growing plants and using them for organisms sustained by that energy to produce food and fiber needed by human beings. Like most other aspects of alternative energy in agriculture, **energy-efficient** cropping is a long-range proposition. At least, it is for most commercial **farmers**. There are short-term ways to conserve energy in crop production, irrigation, harvesting, and crop processing. But, for the most part, this involve **trade-offs**. Either production is decreased for all or part of the acreage of a substantial investment, or alternative energy system is required to maintain production currently achieve by impact of purchased **energy**.

Now an exercise will be made to review the existing literature in this regard, and understand the energy flow pattern in different farm systems in agriculture, in general, and Indian agriculture in particular.

One of the interesting study in this regard was by **Singh.L.R** and **Singh.B(1976)**, who conducted a farm survey in Tarai region of **U.P.** The main objective was to estimate the energy use pattern and

its cost on bullock and tractor operated farms. In this study **information** was procured **from** a survey conducted in five purposefully selected villages in **Rudrapur** block of **Nainital** district during the year 1974-75. The original sample of 25 farms was selected to represent small(<3 hec), medium (3 to 6 hec) and **large**(6 to bellow 12 hec) size farms from these five villages, and were **reclassified** in two categories i.e. bullock farms and tractor **farms**.

The energy used in different farm operations, supplied by different power sources and the cost of energy was calculated as follows. To account for the energy supplied from various sources like - human, bullock and mechanical and converted into energy by using the conversion factor: one adult man on an average develops 0.10 H.P of energy and one pair of bullock develops 1.00 H.P of energy. In case of mechanical power **sources**, their individual rated H.P was taken in to account. The cost of hired human labour, bullock labour as well as hired machinery used in different farm operations was estimated at the prevailing rate, in the study area. The cannal irrigation water was also converted into equivalent of tube-well irrigation water.

The main observations drawn in this study are, paddy, wheat, sugarcane crops are more energy intensive as compared with other principal crops. This is one of the often noticed observation in many studies. This study also noticed that tillage operation consume the bulk of energy, in the production of **crops**. irrigation and threshing are the other operations where too a size-able amount of energy is used. Energy use per hectare, of operated area, by the tractor operated farm is more than double of that

used on a bullock operated **farms**. Approximately nine-tenth of energy content is supplied through Mechanical sources.

This micro-level observation is a land **mark**, even though it pertain to a single district. The investigation under taken, here refers to macro-level coverage of Indian agriculture. The **main** objective is to compare the micro-level study with macro-level and check the reliability of information. It is often **observed** that, the micro-level information does not match with the macro-level, due to data bottle-necks prevailed in various studies.

Singh. R.P, et.al(1976), have made an attempt to estimate the level of energy consumption of the two important crops, namely bajra and wheat from different sources. They also examine the operation wise use of power in bajra and wheat separately and to estimate the power requirements for getting **maximum** production from high yielding varieties of bajra and wheat crops with full package of **practice**.

Their study basically focused on Gurgan and **Rothak** districts of Haryana which comprise the main zone of bajra-wheat cultivation. The data from 40 farmers having National demonstration plots during 1974-75 and following, bajra(HB-3), wheat(K-227) rotation were collected from the N.D diaries maintained by the Haryana Agricultural University Experts.

The study shows that cultivation of high-yielding varieties of wheat consumed energy three times more than the growing of hybrid bajra. In both the crops nearly 82 percent of the total power used was observed before harvesting and remaining 18 percent

was used in harvesting, threshing and winnowing operations.

Roger **Revelle(1978)**, who did analytical study on requirements for energy in the rural areas of developing countries, to find the economic feasibility of different energy sources in agricultural sector.

The main conclusions drawn in this study imply that in choosing **among** energy sources and uses for the rural areas of developing countries, we must be concerned with scarce resources and their most economical allocation, both the natural resources like land, water, fertilizers, metals, and fuels, and the human resources of capital labour, human energy **etc.** A second need for new sources of energy is to reduce costs. The most expensive form of energy is human energy, as can easily be seen if we consider how much food it takes to keep a man going at hard manual **work.** **Animal** energy also expensive. Consider for example the opportunity costs of feeding bullock. A farmer can use part of his land to grow fodder for his bullock, but he could grow wheat or rice or corn on that same land.

According to this study, any energy source for developing countries at the present time should be manpower-intensive rather than capital-intensive. Its development should use people rather than capital, because people are less expensive and **more** abundant than capital in most less developed countries.

One of the interesting study by David **Pimentel(1973)**, analyzed the food production and the energy crisis in **U.S** agriculture, during the period from 1945 to 1970. The approach is

to select a single crop, corn(maize), **which** typifies the energy inputs for crops in general, and to make a detailed analysis of its production energy inputs. With the data on input and output **for** corn as a **model**, an examination is then made of energy needs for a world food supply that depends on modern energy intensive agriculture. When energy resources become expensive, significant changes in agriculture will take place.

To investigate the relationship of energy inputs to crop production, he selected corn for the following reason. Corn generally typifies the energy inputs in U.S. crop production for it is intermediate in energy inputs between the **extremes** of high energy-demand fruit production and low energy-demand tame hay and small grain production. The main observations are, Corn yields increased about 240 percent from 1945 to 1970, the labour input per acre decreased more than 69 percent. Intense mechanization reduced the labour input. Fuel consumption for all farm machinery rose from slightly more than 3.3 billion gallons. The use of fertilizer in corn production has been rising steadily since 1945. The use of pesticides in corn has been increasing rapidly during the past 20 years and this parallels the general increase in pesticide use in the United **States**. The trends in energy inputs and corn yields confirm several agricultural evaluations which conclude that the impressive agricultural production in the United States has been gained through large inputs of fossil energy. He also suggested the alternative energy resources to reduce the commercial energy resources in U.S agricultural.

Gasser. J.K.R(1977), has analyzed the efficiency of energy used in the production of carbohydrates and lipids in U.K

agriculture. The period under consideration was, from 1950 to 1970. The notable conclusions are, under **most normal** farming practice, increases of 5-10 percent of average yields are sufficient to justify the energy involved in production and use of fertilizer. In most situations, economic criteria will restrict fertilizer use before energy criteria. When considering energy input/output relationship for fertilizers, it appears desirable to consider the total energy output of the crop and not restrict the balance to the main product.

Bhatia.R.C, et.al(1992), did extensive work on energy use pattern in 15 villages of different zones of punjab. The main objective of the study was, to analyze the Zone-wise variation in the amount and type of energy use for agricultural activities, to find out the type of energy used in agriculture and to estimate the share of each type of energy to total energy used in agriculture, to study the relationship between the farm sizes and the agricultural energy consumption level, to determine the factors responsible for low or high level of energy consumption in agriculture.

The method of data collection involved day-to-day details of the sample farms are carefully recorded on specifically prepared and pretested **schedules**. To determine the **factors** responsible **for** low or high level of energy consumption in agriculture, six independent variables viz., annual income, family size, total cropped area, irrigated cropped area, unirrigated cropped area and cropping intensity have been included. The main conclusions are, the zone-wise and source-wise energy use pattern which shows that the form of energy use varies from 1.60 percent of chemical energy

to 27.25 percent of fertilizers. The electricity occupy the second place which requires 2724796 Mj of energy per annum to cultivate crops in 741.42 hectares of land. On the average it consumes 18964.71 **Mj** of energy per hectare of crop area per annum for agriculture operations. Energy input through fertilizer for zone III was maximum as compared to other zones because total cropped area under zone III was much larger than other zones. Energy input through fertilizer for wheat was more than all other crops and the energy input used through diesel was larger for paddy as compared to other crops. On the whole, energy requirements per hectare for raising paddy has more than wheat but less than sugarcane. Energy input through fertilizer for raising sugarcane crop was 10.725 Mj per hectare which was greater than the recommended dosage.

One of the important study was by *Mittal.J.P, et.al(1985)*, who did analytical work on Energy requirements in agricultural sector, under the supervision of Indian council of agricultural research, All India-coordinated research project, with the **objectives:to** study crop potentiality on **important** crop rotations by adopting increased inputs and machinery having more efficient **systems**, and to make an economic engineering study of the existing power and energy sources in agriculture on all India basis their limitations by carrying out studies on sample forms in various regions, to investigate the energy requirements for all farming systems, i.e, crop, livestock and **agriculture-cum-aquaculture** production system including household activities, to investigate the energy requirements for each soil, agronomic region and for all operations from tillage to transportation by using simple human, animal, and mechanical and electrical power with machinery **implements**, and machinery having greater efficiency at various

intensities.

The field studies were conducted at the farms fields with a view to find the energy requirements for crop production at the existing level of farm technology. The farms were classified as, bullock-farms(farm having bullocks as source of draft power and not tractors), Tractor - farms (farms having tractor as source of draft power and not bullocks), mixed-farms(farms having both tractor and bullocks as source of draft power). This study was under taken during the period from 1971 to 1981, at different research centers and field surveys.

The main conclusions of this study are, the irrigation of crops was found to be energy intensive operation. Efforts should be made to minimise the energy and also to minimise conveyance losses. The use of energy for the cultivation of various crops had direct relationship with the productivity of farms. About 69 to 95 percent of the total energy for the cultivation of crops was only for chemicals, fertilizers and seeds. The field operations had average share of less than 7 percent, hence research effort should be directed towards reducing the components of chemicals, fertilizers, and seed through better application and proper management. It was found that the irrigated farms required an additional amount of 375.83 mj/ha of bullock energy, 770.46 mj/ha of human energy and about 16107.12/mj/ha of electrical energy over rain fed farms. Irrigation operation was the highest energy consuming operation for puddling of paddy, planted sugarcane and ratoon crop of sugarcane. In case of maize and wheat crops, the highest energy consuming operation were seed bed preparation and threshing. In sugarcane crop, harvesting and collection of

sugarcane was a costlie operation which required about 29 to 30 percent of total energy. The manual operation of paddy transplanting was costliest operation which accounted for 26 to 34 percent of the total energy cost.

The yield of paddy was found to be highest on tractor farming i.e 40q/ha followed by bullock farming 33q/ha and by power tiller farming 26.2 q/ha. The yield on tractor farms was high because of good quality of puddling. The total output-input(energy intensity) ratios in tractor farming was found to be highest (11.0 followed by bullock farming 9.37 and power tiller farming 7.61). The tillage operation consumed 30 to 31 percent of the direct energy followed by irrigation 28 to 30 percent. Harvesting and threshing operations consumed 20-25 percent of the direct energy, The tillage, irrigation, harvesting and threshing operations consumed together about 85 percent of the direct energy.

Rutger.J.N and Grant.W.B(1975), had estimated the energy use in rice production in U.S agriculture, during the period 1974 to 1976. The main conclusions are, rice is grown on about 1 million hectares per year in the U.S. Average rice yields at 5.1 rot/ha were more than double the world average yield of 2.4 mt/ha. Irrigation is supplemented by rainfall during the growing season in all areas except California. Even though the greatest amount of irrigation water per hectare is used in California, irrigation energy costs in California are lowest, since at least three-fourths of the irrigation is from surface water collected behind dams and distributed largely by gravity or with relatively low lifts. California's low irrigation energy costs and high grain yields result in the highest output/input ratios(1.76) among the

Table 6.0.1

ENERGY INPUTS PER HECTARE OF RICE, SACRAMENTO VALLEY, CALIFORNIA,
1977.

Item	Quantity/ha	Kcal/ha
Labour	23.6 hr	
Machinery	37.7 kg	742460
Gasolin	55.2 l	558017
Diesel	225.4 l	2572716
Electricity	29.7 kwh	85031
Nitrogen	132.3 kg	1944810
Phosphate	56.0 kg	168000
Zinc	9.8 kg	49000
Furadan	0.5 kg	42650
Parathion	0.085 kg	7387
Molinate	3.4 kg	294440
MCPA	0.6 kg	59946
Copper sulphate	11.2 kg	56000
Seed	180.5 kg	722000
Irrigation	250.0 cm	2138886
Drying	6969.0 kg	1393800
Transportation	451.3 kg	115984
Total		10951127
	Output	
Rice yields	6513.0 kg	19226376
Protein Yield	373.8 kg	
	Kcal output/kcal input	1.76
	Kcal output/hour of labour	814.677

Source: Pimental. D (1980).

O.S rice areas. The above table 6.0.1 illustrate the energy inputs per hectare of rice, in California, 1977.

Briggle.L.W(1976), estimated the energy use in wheat production in O.S agriculture, during the period 1970 to 1972 respectively. The main conclusions drawn are, more energy is required for producing wheat user irrigation than under any other management system. Heavier rates of fertilizer are used, **more** tillage operations are required if one includes land leveling, ditching, field corrugation, and similar operations relating to water application, and of course the energy required to pump water is probably the largest **expenditure**. **Under** rain **fed** management system in the eastern states, in the Palouse region of Pacific northwest, and in the higher rainfall area of the plains states heavier rates of fertilizer are required than in the central and western parts of the plains states where little or no fertilizer is used in some parts. Generally weeds are less of a problem where there is lower rainfall, so fewer herbicides are required. Considering only the wheat part of the double cropping system, less energy is required than if wheat was the only crop during that season. Yields are lower, however, than if wheat was seeded in tilled ground and usual rates of fertilizer were applied.

Another interesting study by Ray **Ricaud(1976)**, estimated the energy input and output for sugarcane in Louisiana state of U.S, during the period 1976 to 1977. The important observations identified in the study based on the data on energy input and output for sugarcane in Louisiana showed that, the quantity of each input is the best estimate available of the actual use of inputs by growers. Sugarcane requires large inputs in labour for

planting and in heavy equipment for cultivating and harvesting. Most of the crop is planted with hand labour. Diesel fuel is the largest single input because of the **numerous** operations required with large equipment.

The output in sugar yield is a state average over several years. There are many growers producing more or less than the average with similar inputs. The yield per hectare is usually smaller on large or medium size **farms**. Louisiana produces more hectares of sugarcane, but less sugar per **hectare**, than the other producing states. It has a relatively low ratio of energy output to energy input. This is mainly due to the short growing season in Louisiana as compared to the other states.

Sathyajith Mathew, et.al(1993), estimated the energy flow pattern in rain fed paddy cultivation under three puddling treatments using a bullock-drawn plough, a power tiller, and a **tractor**. the investigation was carried out at the KCAET farm, Tavanur in Kerala.

The main findings of this study are, Energy input in paddy cultivation was minimum when tractor was used for puddling and **maximum** when power tiller was used. Fertilizer and chemicals were found to be the most energy-intensive inputs. Hence, attempts should be made to reduce their share by conservation practices and substitution with bio-fertilizers. Involvement of human labour in transplanting and harvesting should be **minimised** by selective mechanization of these operations. **Output:input** ratio was maximum in the case of tractor, followed by that of bullock and power tiller.

Kamaruddin.A, et.al(1987), have been estimated the energy requirements in Indonesia agricultural, during the period from 1977 to 1981. The main objective was to determine, how energy is related to the production of food in Indonesia, It covers the problems of power availability as related to the mechanization strategy for the country. The discussions will also describe the comparison between the energy input situation particularly in wet and dry land paddy farming on Java and on the Outer islands.

The important conclusions drawn from this study are, Indonesia is already self sufficient in rice, and this condition can be maintained in the future at the current level of energy input, major energy conservation can be expected by substituting the current use of inorganic fertilizer to biomass fertilizer. Alternative energy may have greater role in post harvest activities (drying, threshing, storage) due to the increasing production output.

6.1 CONVERSION OF DIRECT AND INDIRECT SOURCES OF ENERGY:

The total consumption of energy in agricultural sector by different sources can take place through conversion process. All the energy sources can be converted into a single measure for estimation of energy demand under selected crops. The table 6.1.1 illustrates the conversion of different energy sources into a single measure i.e Giga joules. According to the *ICAR (1988)*, the conversion of energy sources were analyzed as stated in the preceding manner.

Human energy can be measured in the form of man-hour, which was equal to 1.96 Giga Joules. Woman power is measured in woman hour i.e 1.57 Giga joules. Where as bullock power measured in

Table 6.1.1
EQUIVALENTS OF DIRECT AND INDIRECT SOURCES OF ENERGY

ITEM	UNIT	EQUIVALENT ENERGY(GJ)
Man	Man-hour	1.96
Woman	Woman-hour	1.57
Bullock	Pair-hour	10.10
Diesel	Litre	56.31
Petrol	Litre	48.53
Electricity	Kilowatt-hour	11.93
Prime movers other than electric motors	Kg	64.80
Farm machinery	Kg	62.70
Nitrogen	Kg	60.60
Phosphorous	Kg	11.10
Potassium	Kg	6.70
Paddy	Kg	14.77
Straw	Kg	12.50

Source: Indian Council of Agricultural research, 1988.

pair-hour, was equal to 10.10 Giga joules. However diesel and petrol energy was accounted in liter i.e 56.31 and 48.33 Giga joules. Electricity measured in Kw-hour, was around 11.93 Giga **joules**. Prime movers other than electric motors were **measured** in kgs i.e equal to 64.80 Giga **Joules**. farm machinery energy measured in Kgs, which equals to 62.70 Giga joules.

Nitrogen fertilizers energy can be accounted in Kgs i.e equal to 60.60 **Giga** Joules. Where as phosphate and potassium energy is measured in Kgs i.e 11.10 and 6.70 Giga joules. Energy component in paddy measured as Kgs i.e 14.77 Giga joules. Next comes to the straw, which accounted in Kgs, was equals to 12.50 Giga joules of energy equivalent. On the basis of this conversion rate, energy consumption per hectare under different crops were estimated and analyzed in the preceding sections. Among all the sources prime movers was accounted higher energy equivalent, next comes the farm machinery, nitrogen, diesel, petrol, and electricity respectively.

6.2 POWER UTILIZATION IN INDIAN AGRICULTURE:

Power consumption in Indian agriculture is increasing day by day due to much adoption of electric pump sets in place of diesel ones. Nearly 20-25 % of the total energy was utilized in agriculture sector in recent **years**. Electricity consumption was increased at faster rate especially from 1966 onwards, when the modernisation of agriculture took place with Green Revolution. The table 6.2.1 explains the power consumption in agriculture sector from 1966/67 to 1991/92 respectively.

The total power sold in agricultural sector was 29128 **MKW** in 1966/67, which increased to 207645 MKW in 1991/92. as equal to a seven times increase in power consumption from 1966/67 to 1991/92. Where as the power consumption percentage was noticed around 7.2% in 1966/67, which has later increased to **28.2** % in 1991/92. This is equal to a four times increase in power consumption in percentage terms from 1966/67 to 1991/92. Compound growth rates

Table 6.2.1

POWER UTILIZATION IN INDIAN AGRICULTURE: 1966/67 TO 1991/92

Year	Total Energy Sold(MKW)	Power Consumption(%)
1966/67	29128	7.2
	(--)	(--)
1971/72	43063	10.6
	(8.13)	CO. 97)
1976/77	66609	14.4
	(9.12)	(8.53)
1981/82	90245	16.8
	(6.26)	(10.51)
1986/87	135952	21.7
	(8.54.3)	(6.23)
1991/92	207645	28.2
	(8.84.3)	(11.45)

Source: CMIE: Basic Statistics Relating to the Indian Economy 1994.

C). Figures in the brackets indicates compound growth rates.

of total energy sold in agriculture sector recorded, 8.13 % per annum in 1971/72, and later it increased at a rate of 8.84 % per annum in 1991/92 respectively. Contrary to this, the percentage consumption of power raised at 0.97 % per annum in 1971/72, which increased at a rate of 11.45 % per annum in 1991/92 respectively.

This analysis implies that the power utilization in agriculture sector increased at a faster rate, especially since last two decades due to more electrification of pump sets in agriculture sector. The main reason for this is that, due to unfavorable rainfall. A major part of Indian agriculture depends up on ground water irrigation. On the other hand, through ground water utilization, the farmers are in a position to supply water for crops in time, a guaranteed way, which provides stable agricultural production.

6.3 ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN INDIAN AGRICULTURE:

The rate of energy consumption by different resources can differ from crop to crop, due to the operations involved in crop production. Energy consumption in agriculture sector under principal crops has been classified in to direct and indirect energy sources, depends on the replenishment. So that, human, bullock, seeds, and FYM can be treated as renewable energy sources, where as electricity, diesel, fertilizers, and farm machinery considered as non-renewable energy sources. By considering this, the present section will look at the nature of energy consumption by different crops in Indian agriculture.

6.3.1 AVERAGE ENERGY REQUIREMENTS FOR PRINCIPAL CROPS IN INDIAN AGRICULTURE:

The table 6.3.1.1 illustates the average energy consumption under selected crops in Indian agriculture, rice crop noticed, 47498 Mega joules, out of this human energy accounts 3604 M.J, animal, seed, and FYM energy was around 648, 459, and 2476 M.J respectively. On the whole the total renewable energy for rice crop recorded at 7187 M.J per hectare. On the other hand the total non-renewable energy recorded 40311 M.J per hectare, out of this diesel, electricity, fertilizer, and machinery was nearly 17298, 10670, 11509, and 834 M.J per hectare respectively. It was observed that in rice production much energy was consumed from diesel and next comes the fertilizers, electricity, and canal etc respectively.

Per hectare average energy **consumption** for wheat accounted for 15771 **M.J**, out of this human, animal, seed, and **FYM** recorded, 853, 286, 1383, and 245 respectively. Overall the total renewable

Table 6.3.1.1

AVERAGE ENERGY **REQUIREMENTS** UNDER PRINCIPAL CROPS IN **INDIAN** AGRICULTURE

Crop Energy Source	(Mj/ha)					
	Rice	Wheat	Jowar	Ground Nut	Cotton	Sugarcane
Human Labour	3604	853	1098	5221	1623	7035
Animal Labour	648	286	996	349	358	788
Seed	459	1383	358	1388	449	35525
FYM	2476	245	2362	16174	381	9553
Diesel	17298	5293	9202	2346	3107	30492
Electricity	10670	752	2543	131	408	3119
Fertilisers	11509	6268	2181	10295	4074	7974
Machinery	834	691	742	327	334	4462
Canal	4098	364	52	10	529	479
Total Renewable	7187	2767	4814	23132	2811	52881
Total Non-Renewable	40311	13004	14668	13099	7923	46047
Grand Total	47498	15771	19482	36231	10734	98928

Source: ICAR: Energy **Requirements** in Agriculture, All India **Co-ordinative** Research Project, 1985 to 1988.

energy consumed was 2767 M.J per hectare. Where as the total non-renewable energy accounted for 13004 M.J, out of this **diesel**,

electricity, fertilizers, and machinery witnessed 5293, 752, 6268, and 691 **M.J** respectively. On the whole it **was** identified that **much** energy is consumed **from** fertilizers and then comes to **diesel**, seed, human energy etc respectively.

Jowar noticed 19482 M.J per hectare of total energy, of this human, animal, seed, and FYM energy accounted, 1098, 996, 358, and 2362 M.J per hectare respectively. Overall the renewable energy accounted 4814 MJ per hectare. However, total non-renewable energy was **14668** MJ per hectare, out of this diesel, electricity, fertilizers, and machinery recorded at 9202, 2543, 2181, and 742 MJ per hectare **respectively**. Jowar **demanding** much amount of diesel, next is electricity, FYM, fertilizers, and human energy.

Ground nut noticed, 36231 MJ total energy per hectare, out of this renewable energy accounted 23132 MJ per hectare, with human energy, animal energy, seed, and FYM i.e 5221, 349, 1388, and 16174 respectively. **Non-** renewable energy noticed, 13099 MJ per hectare, **having** 2346, 131, 10295, and 327 with diesel, electricity, fertilizers, and machinery respectively. Out of this, ground nut consumes much amount of FYM, fertilizers, human labour, and diesel energy respectively.

Cotton demands 10734 MJ total energy per hectare, out of this renewable energy accounts 2811 MJ per hectare, with 1623 MJ/he human labour, 358 MJ/he animal, 449 MJ/he seed, and 381 MJ/he respectively. As against this non-renewable energy accounted at 7923 MJ/he, having 3107, 408, 4074, and 334 MJ/he of diesel, electricity, fertilizers, and machinery respectively. Overall **picture** showed that, cotton crop demanding much amount of

fertilizers, next comes to diesel, human energy, and seed **respectively**.

Finally, sugar cane demands 98928 MJ total energy per hectare, out of this renewable energy accounted 52881 MJ/he ,with 7035 human energy, 788 MJ/he animal, 35525 MJ/he seed, and 9553 MJ/he FYM respectively. On the other hand, total non-renewable energy recorded at **46047** MJ/he , in which 30492 MJ/he diesel, 3119 MJ/he electricity, 7974 MJ/he fertilizers and **4462** MJ/he machinery respectively. The overall observation showed that, sugar cane crop demands much amount of seed, then comes FYM, fertilizers, human, and machinery **respectively**.

0.4 ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN ALL INDIA AND SELECTED STATES:

Energy consumption by different sources were increasing at faster rate in Indian agriculture. Especially since 1966 onwards, the rate of energy consumption was very much high, which accounts more than 20 % in all resources. The tables 6.4.1 to 6.4.7 illustrates the energy demand pattern under crops in selected states, in Indian agriculture.

The estimated total energy consumption under principal crops in Andhra Pradesh noticed that rice **demands 1467.21 Lakh/MJ** in 1966/67, has increased to 2932.83 Lakh/MJ in 1991/92. An equivalent of 8.76 % share in 1966/67 to 14.59 % in 1991/92. Wheat accounted, 2.05 Lakh/MJ in 1966/67, has later decreased to 1.26 Lakh/MJ in 1991/92. This is equal to 0.10 % share in 1966/67 to 0.03 % share in 1991/92.

As against this, **Jowar** witnessed 445.94 **Lakh/MJ** in 1966/67, which was declined to 209.43 Lakh/MJ in 1991/92, or equal to 12.68% share in 1966/67 to **8.54 %** share in 1991/92. However,

Table **6. 4. 1**

ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN ANDHRA PRADESH.

Year / Crop	(Lakh Mega Jouls)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	1487.21 (8.76)	1444.41 C 8.053	1693.30 C 9.26)	1816.32 C 9.393	1642.96 (8.40)	2932.83 (14.593)
Wheat	2.05 C 0.10)	3.31 (0.11)	3.63 (0.11)	2.68 C 0.07)	1.89 C 0.05)	1.26 (0.03)
Jowar	445.94 (12.68)	493.28 (14.79)	398.02 (12.95)	431.33 (13.34)	322.62 (10.38)	209.43 (8.54)
Groundnut	370.28 (14.003)	555.42 C 20.413	380.79 (14.923)	525.71 (19.533)	569.19 (22.50)	904.33 (28.78)
Cotton	33.92 C 4.033	35.96 C 4.293	30.91 C 4.18)	50.77 (5.873)	44.12 (5.923)	76.00 (9.20)
Sugarcane	113.77 C 5.003	117.72 C 4.983	144.43 (5.09)	178.07 C 5.63)	136.52 (4.483)	200.82 C 5.36)
Total	2433.17 C 8.683	2650.11 (8.79)	2651.08 (8.61)	3002.48 (9.163)	2717.30 (8.33)	4324.67 (12.76)

Source: **ICAR: Energy requirements in agriculture sector**, All India Co-ordinative Research Project, 1985 to 1988.

ground nut recorded, 370.25 Lakh/MJ in 1966/67, was further increased to 904.33 L.MJ in 1991/92. This is in percentage **terms 14.00 %** share in 1966/67 to **28.78 %** share in 1991/92. Cotton crop witnessed, 33.92 Lakh/MJ in 1966/67, which gone up to 76.00 Lakh/MJ in **1991/92**, or equal to 4.03 % in 1966/67 to 9.20 % in 1991/92 respectively.

Mean while sugar cane demands 113.77 Lakh/MJ in **1966/67**, it further increased to 200.82 Lakh/MJ in 1991/92. This in percentage

terms 5.00 X in 1966/67 and 5.36 % in 1991/92. The total energy consumption under six crops noticed 2433.17 **Lakh/MJ** in 1966/67, which later increased to 4324.67 Lakh/MJ in 1991/92. This is almost similar to **8.68 %** share in all India in 1966/67 and **12.76%** in 1991/92 respectively.

Bihar noticed 2434.75 Lakh/MJ of energy in rice production in 1966/67, was later decreased to 2276.10 Lakh/MJ in 1991/92, which

Table **6.4.2**

ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN BIHAR.

(Lakh Mega Jouls)						
Year / Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	2434.75 (14.54)	2570.12 (14.33)	2522.14 (13.79)	2549.69 (13.19)	2549.69 (13.04)	2276.10 (11.33)
Wheat	472.61 C 23.34)	220.32 C 7.30)	306.75 (9.30)	258.64 C 7.41)	290.19 (7.95)	309.58 (8.54)
Jowar	1.95 CO. 06)	0.97 C 0.03)	5.22 CO. 17)	5.22 C 0.16)	1.17 C 0.04)	2.37 CO. 10)
Groundnut						
Cotton						
Sugarcane	106.84 C 4.69)	140.48 (5.94)	126.63 C 4.47)	122.67 C 3.88)	110.80 (3.64)	143.45 (3.83)
Total	3016.14 (10.75)	2931.89 C 9.73)	2960.74 C 9.62)	2936.23 (8.96)	2951.84 (9.05)	2731.51 (8.06)

Source: **ICAR: Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.**

in percentage terms equal to 14.54 % in 1966/67 to 11.33 % in 1991/92 respectively. Where as energy consumption under wheat crop noticed 472.61 Lakh/MJ in 1966/67, was further decreased to 309.58 Lakh/MJ in 1991/92. Which is equal to 23.34 % in 1966/67 to 8.54 % share in 1991/92. The lowest energy was consumed in jowar i.e 1.95 Lakh/MJ in 1966/67, was slowly it raised to 2.37 Lakh/MJ in **1991/92**, or from 0.06 % in 1966/67 to 0.10 % share in 1991/92.

On the other hand ground nut and cotton noticed nil energy consumption **from** 1966/67 to 1991/92, due to negligence of these crops, is the state of nature. In case of sugar cane these were 106.84 **Lakh/MJ** in 1966/67, which raised to 143.45 **Lakh/MJ** in 1991/92, or 4.69 % in 1966/67 to **3.83** % share in 1991/92. Interestingly total energy consumption in the state under four crops accounted for 3016.14 Lakh/MJ in 1966/67, was later decreased to 2731.51 Lakh/MJ in 1991/92 or from 10.75 % share in 1966/67 to **8.06** % in 1991/92 respectively.

In Punjab the energy consumption under rice production was 143.92 Lakh/MJ in 1966/67, which has further increased to 985.11 Lakh/MJ in 1991/92, or from 0.86 % in 1966/67 to 4.90 % share in 1991/92. Where as wheat accounted **266.85Lakh/MJ** in 1966/67, has

Table 6. 4. 3

ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN PUNJAB.

		(Lakh Mega Jouls)					
Year	Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
	Rice	143.92	213.74	320.14	603.23	859.24	985.11
		C 0.86)	(1.19)	(1.75)	(3.12)	C 4.393	(4.90)
	Wheat	266.85	368.25	406.73	460.04	502.83	509.88
		(13.18)	(12.20)	(12.33)	C 13.173	(13.793)	(14.07)
	Jowar						
	Groundnut	72.46	63.04	59.42	33.33	15.58	4.35
		C 2.74)	(2.32)	(2.33)	C 1.24)	C 0.623	C 0.14)
	Cotton	42.51	50.99	59.79	73.31	60.86	70.84
		C 5.05)	(6.09)	(8.09)	(8.483	(8.16)	(8.58)
	Sugarcane	118.71	101.90	111.79	104.86	95.96	107.83
		(5.223	C 4.31)	(3.943	(3.323	C 3.15)	(2.88)
	Total	644.45	797.92	957.87	1274.77	1534.58	1678.01
		(2.303	(2.65)	(3.11)	(3.883	C 4.703	C 4.953

Source: **ICAR: Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.**

raised to 509.88 Lakh/MJ in 1991/92. This is equivalent of 13.18 % share in 1966/67 to 14.07 % in 1991/92. Energy consumption under Jowar crop showed nil energy consumption, due to negligence of jowar crop in the state. On the other hand ground nut experienced diminishing demand for energy i.e 72.46 Lakh/MJ in 1966/67, was later to 4.35 Lakh/MJ in 1991/92. This in percentage terms from 2.74 % in 1966/67 to 0.14 % share in 1991/92.

Cotton showed 42.51 Lakh/MJ in 1966/67, which later increased to 70.84 Lakh/MJ in 1991/92, or from 5.05 % in 1966/67 to 8.58 % share in 1991/92 respectively. On the other hand energy consumption under sugar cane recorded 118.71 Lakh/MJ in 1966/67, was later decreased to 107.83 Lakh/MJ in 1991/92. This is equal to 5.22 % in 1966/67 to 2.88 % share in 1991/92. As against this the total energy consumption under five crops noticed 644.45 Lakh/MJ in 1966/67, which further increased to 1678.01 Lakh/MJ in 1991/92, or from 2.30 % share in 1966/67 to 4.95 % share in 1991/92 respectively.

Energy consumption under rice crop in Tamil Nadu noticed, 1114.30 Lakh/MJ in 1966/67, which has decreased to 1089.13 Lakh/MJ in 1991/92, or from 6.66 % in 1966/67 to 5.42 % share in 1991/92. The energy consumption under wheat noticed negligible change over a period of time from 1966/67 to 1991/92. Jowar recorded 142.41 Lakh/MJ in 1966/67, which was decreased to 112.61 Lakh/MJ in 1991/92, or from 4.05 % in 1966/67 to 4.59 % share in 1991/92. Ground nut accounted 306.51 Lakh/MJ in 1966/67, which was gone up to 373.54 Lakh/MJ in 1991/92. This is equivalent to 11.59 % in 1966/67 to 11.89 % share in 1991/92 respectively.

Table 6.4.4

ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN TAMIL NADU.

		(Lakh Mega Joules)					
Year Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92	
Rice	1114.30 (6.66)	1278.17 (7.13)	1084.85 (5.433)	1171.78 (6.063)	928.59 C 4.753	1089.13 (5.42)	
Wheat							
Jo war	142.41 (4.053)	139.69 C 4.27)	164.04 (5.343)	130.33 C 4.03)	142.22 C 4.583	112.61 C 4.593	
Groundnut	306.51 (11.59)	404.70 (14.873)	322.46 (12.64)	367.02 (13.64)	324.99 (12.85)	373.54 (11.893)	
Cotton	34.89 (4.15)	33.60 (4.013)	25.76 (3.493)	25.76 C 2.98)	25.55 (3.433)	28.34 (3.433)	
Sugarcane	105.85 C 4.65)	115.75 C 4.90)	153.34 (5.41)	198.85 (6.30)	193.90 (6.37)	229.51 (6.13)	
Total	1703.97 C 6.08)	1971.90 (6.54)	1750.45 C 5.69)	1894.74 C 5.78)	1615.24 C 4.953	1833.13 C 5.41)	

Source: ICAR: Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.

Cotton and sugar cane noticed, 34.89 and 105.85 Lakh/MJ in 1966/67, which changed to 28.34 and 229.51 Lakh/MJ in 1991/92. This is equal to 4.15 and 4.65 % share in 1966/67 to 3.43 and 6.13 % in 1991/92 respectively. On the other hand total energy consumption in the state under five crops accounted, 1703.97 Lakh/MJ in 1966/67, which raised to 1833.13 Lakh/MJ in 1991/92. Equivalent of 6.08 % in 1966/67 to 5.41 % share in 1991/92 respectively.

Total energy consumption under rice crop in U.P witnessed, 2006.32 Lakh/MJ in 1966/67, then raised to 2516.44 Lakh/MJ in 1991/92. This is equal to 11.98 % in 1966/67 to 12.52 % share in 1991/92 respectively. The wheat crop recorded, 736.66 Lakh/MJ in

Table 6.4.5

ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN UTTAR PRADESH.

Year / Crop'	(Lakh Mega Jouls3					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	2006.32 (11.98)	2242.86 (12.513)	2210.08 (12.08)	2559.67 (13.24)	2632.34 C13.463	2516.44 (12.52)
Wheat	736.66 (36.38)	953.51 C31.593	1044.67 C31.66)	1225.72 (35.10)	1325.55 C36.343	1360.41 (37.54)
Jowar	172.61 C4.91)	120.98 (3.75)	136.96 (4.463)	133.65 C4.13)	112.80 (3.63)	100.53 (4.10)
Groundnut	141.66 (5.36)	118.84 C4.373	140.94 (5.52)	94.56 C3.513	44.56 (1.76)	57.61 (1.83)
Cotton	6.66 (0.79)	6.01 (0.72)	2.47 (0.33)	3.22 (0.373)	2.36 CO.32)	1.50 CO.183
Sugarcane	933.88 C41.033	1260.34 C53.313	1440.39 (50.80)	1634.29 (51.74)	1660.01 C54.503	1862.81 C49.70)
Total	3997.79 (14.25)	4702.54 (15.603)	4975.51 (16.16)	5651.11 (17.24)	5777.63 (17.71)	5899.30 (17.41)

Source: ICAR : Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.

1966/67, and raised to 1360.41 Lakh/MJ in 1991/92. This is equal to 36.38 % in 1966/67 to 37.54 % share in 1991/92 respectively. Jowar decreased from 172.61 Lakh/MJ in 1966/67, 100.53 % Lakh/MJ in 1991/92. It is equal to 4.91 % in 1966/67 to 4.10 X share in 1991/92 respectively. Ground nut recorded 141.66 Lakh/MJ in 1966/67, which reduced to 57.61 Lakh/MJ in 1991/92, or from 5.36 % in 1966/67 to 1.83 % share in 1991/92 respectively. Cotton and sugar cane noticed 6.66 and 933.88 Lakh/MJ in 1966/67, which changed to 1.50 and 1862.81 Lakh/MJ in 1991/92. This is equal to 0.79 and 41.03 % in 1966/67 to 0.18 and 49.70 % share in 1991/92 respectively. Total energy consumption under six crops in whole state recorded at 3997.79 Lakh/MJ in 1966/67, which has raised to 5899.30 Lakh/MJ in 1991/92 respectively. An equivalent of 14.25 % in 1966/67 to 17.45 % share in 1991/92 respectively.

West Bengal noticed, 2010.59 **Lakh/MJ** energy consumed under rice crop in 1966/67, and later increased to 2698.36 Lakh/MJ in 1991/92. This is equal to 12.01 % share in 1966/67 to 13.43 % in 1991/92. However, wheat recorded 42.11 Lakh/MJ in 1966/67, and further increased to 42.42 Lakh/MJ in 1991/92. This is equal to **2.08** % in 1966/67 to 1.17 % share in 1991/92. Energy consumption under jowar, groundnut, and cotton noticed almost no change, due to negligence of area under respective crops.

Sugar cane witnessed 22.75 Lakh/MJ in 1966/67, and later it decreased to 11.87 Lakh/MJ in 1991/92, or from 1.00 % in 1966/67 to 0.32 % share in 1991/92 respectively. Overall it was observed that, the total energy consumption in the state under three crops recorded at 2043.91 Lakh/MJ in 1966/67, which has further raised

Table 6.4.6

ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN WEST BENGAL

(Lakh Mega Joules)

Year / Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	2010.59 (12.01)	2370.63 (13.22)	2472.27 (13.52)	2474.65 (12.805)	2553.49 (13.06)	2698.36 (13.43)
Wheat	10.57 C0.52)	66.55 (2.20)	81.22 (2.465)	33.75 C0.97)	62.77 (1.72)	42.42 C1.175
Jowar						
Groundnut						
Cotton						
Sugarcane	22.75 (1.00)	33.64 (1.42)	29.68 (1.05)	22.75 C0.725	12.86 (0.425)	11.87 C0.32)
Total	2043.91 (7.295)	2470.81 (8.20)	2583.17 C8.345	2531.15 (7.72)	2629.12 C8.065	2752.66 C8.125

Source: **ICAR: Energy requirements in agriculture** sector, All India Co-ordinative Research Project, 1985 to 1988.

to 2752.66 Lakh/MJ in 1991/92. This is equal to 7.29 % share in 1966/67 to **8.12** % in 1991/92 respectively.

In case of All India, the total energy consumption under rice crop was around 16743.52 Lakh/MJ in 1966/67, which raised to 20095.45 Lakh/MJ in 1991/92. Where as wheat crop noticed, **2024.68** Lakh/MJ in 1966/67, and later increased to **3624.18** Lakh/MJ in 1991/92. Jowar noticed 3517.28 Lakh/MJ in 1966/67, and slowly decreased to 2453.17 in 1991/92. Energy consumption under ground nut recorded 2644.50 Lakh/MJ in 1966/67, and further increased to 3141.95 Lakh/MJ in 1991/92 respectively.

Interestingly cotton and sugar cane witnessed 841.12 and 2276.33 Lakh/MJ in 1966/67, and later gone up to 825.98 and 3745.41 Lakh/MJ in 1991/92. It was observed that, overall the total energy consumption under six crops in all India raised from

Table 6.4.7
ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN ALL INDIA.

Year / Crop	(Lakh Mega Jouls)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	16743.52	17934.29	18291.95	19335.49	19553.50	20095.45
Wheat	2024.68	3018.41	3299.61	3492.33	3647.99	3624.18
Jowar	3517.28	3268.50	3072.70	3233.82	3106.99	2453.17
Groundnut	2644.50	2720.95	2551.75	2691.60	2529.65	3141.95
Cotton	841.12	837.25	739.04	864.84	745.80	825.98
Sugarcane	2276.33	2364.38	2835.28	3158.77	3045.99	3745.41
Total	28047.43	30143.78	30790.33	32776.84	32629.92	33886.15

Source: ICAR: Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.

28047.43 **Lakh/MJ** in 1966/67 to **33886.15 Lakh/MJ** in 1991/92 respectively. Energy consumption under rice, wheat, ground nut, and sugar cane increased at faster rate, where as jowar and cotton showed declining trend in energy consumption over a period of time.

As stated in the tables 6.4.8 to **6.4.14**, compound growth rates of energy consumption under principal crops in A.P i.e rice, noticed negative growth at -0.31 % in 1971/72, and later increased at a rate of 12.29 % per annum in 1991/92. As against this wheat show 10.06 % per **annum** in 1971/72, and later negative growth of -7.79 % in 1991/92. Jowar crop accounted a growth rate of 2.04 % per annum in **1971/72**, and later a negative growth of -8.28 % in 1991/92. Where as ground nut accounted **8.45** % per annum in 1971/71, which increased at a rate of 9.70 % per annum in

Table G. 4.8

COMPOUND GROWTH RATES ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN ANDHRA PRADESH.

Year — Crop †	(Lakh Mega Jouls)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice		- 0.31	3.23	1.41	- 1.99	12.29
Wheat		10.06	1.86	- 5.89	- 6.75	- 7.79
Jowar		2.04	- 4.20	1.62	- 5.64	- 8.28
Groundnut	—	8.45	- 7.27	6.66	1.60	S.70
Cotton		1.17	- 2.98	10.43	- 2.77	11.49
Sugarcane		0.68	4.17	4.28	-5.18	8.02
Total		1.72	0.00	2.52	- 1.98	9.74

Source: **ICAR: Energy requirements in agriculture** sector, All India **Co-ordinative** Research Project, 1985 to 1988.

1991/92. Cotton and sugar cane recorded 1.17 and 0.68 % per annum in 1971/72, which further increased at a rate of 11.49 and 8.02 % per annum in 1991/92. On the whole total energy consumption in the state under six crops recorded a growth rate of 1.72 % per annum in 1971/72, and then raised at a rate of 9.74 % per annum in 1991/92 respectively.

Bihar witnessed, energy consumption increase at 1.09 % per annum in 1971/72, and later experienced a negative growth of -2.24 % per annum in 1991/92. Wheat recorded negative growth of -14.16 % in 1971/72, and later become positive at a rate of 1.30 % per annum in 1991/92. At the same time jowar noticed negative growth i.e -13.30 % in 1971/72, and further increased at a rate of 15.16 % per annum in 1991/92. Sugar cane recorded, 5.63 % per annum in 1971/72, which raised at a rate of 5.30 % per annum in 1991/92.

Table 6.4.9

COMPOUND GROWTH RATES ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN BIHAR.

Year / Crop	(Lakh Mega Joules)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice		1.09	- 0.38	0.22	0.00	- 2.24
Wheat		- 14.16	6.84	- 3.35	2.33	1.30
Jowar		- 13.30	- 27.70	0.00	- 25.85	15.16
Groundnut						
Cotton	--					
Sugarcane		5.63	- 2.05	- 0.63	- 2.02	5.30
Total		- 0.56	0.20	- 0.17	0.11	- 1.54

Source: ICAR: Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.

Total energy consumption under four crops in the state experienced negative growth rate of -0.56 % in 1971/72 and -1.54 % in 1991/92 **respectively**.

On the other hand energy consumption in Punjab for rice crop noticed has 8.23 % per **annum** in 1971/72, which was further

Table 6. **4.10**

COMPOUND GROWTH RATES ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN PUNJAB.

Year, — Crop ¹	(Lakh Mega Joules)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice		8.23	8.42	13.31	7.33	2.77
Wheat		6.65	2.01	2.49	1.80	0.27
Jowar	..					
Groundnut		- 2.75	- 1.18	- 10.92	- 14.13	- 22.50
Cotton		3.75	3.24	4.16	- 3.65	3.08
Sugarcane		- 3.01	1.87	- 1.27	- 1.76	2.36
Total		4.36	3.72	5.88	3.78	1.80

Source: **ICAR: Energy requirements in agriculture sector, All India Co-ordinative** Research Project, 1985 to 1988.

increased at a rate of 2.77 % per annum in 1991/92. Where as wheat reported a 6.65 % growth rate per annum in 1971/72, and later it has gone up at a rate of 0.27 % in 1991/92. Ground nut recorded negative growth rate of -2.75 % in 1971/72 and -22.50 % in 1991/92 **respectively**. Energy consumption under cotton and sugar cane raised at 3.75 and 3.01 % per annum in 1971/72, which has further increased at a rate of **3.08** and 2.36 % per annum in 1991/92. On the whole the total energy consumption under five crops recorded

4.36 % per annum in 1971/72, which has increased at a rate of 1.80 % per annum in 1991/92 respectively.

Mean while energy consumption under principal crops in Tamil Nadu recorded a growth rate of 2.78 % per annum in 1971/72, which has later increased at a rate of 3.24 % per annum in 1991/92.

Table 6.4.11

COMPOUND GROWTH RATES ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN TAMIL NADU.

Year _____ Crop'	(Lakh Mega Joulsi					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice		2.78	- 3.23	1.55	- 4.55	3.24
Wheat						
Jowar		- 0.39	3.27	- 4.50	1.76	- 4.56
Groundnut		5.71	- 4.44	2.62	- 2.40	2.82
Cotton		- 0.75	-5.18	0.00	- 0.16	2.10
Sugarcane		1.80	5.79	5.34	- 0.50	3.43
Total		2.97	- 2.36	1.59	-3.13	2.56

Source: ICAR: Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.

Where as jowar noticed negative growth of -0.39 % per annum in 1971/72 and -4.56 % in 1991/92. Ground nut witnessed 5.71 % per annum in 1971/72, and 2.82 % per annum in 1991/92. Cotton crop experienced negative growth rate of -0.75 % in 1971/72, and further it become positive at 2.10 % per annum in 1991/92. Sugar cane recorded 1.80 % growth per annum in 1971/72, and later increased at a rate of 3.43 % per annum in 1991/92. Overall it has witnessed that, total energy consumption under five crops recorded a growth rate of 2.97 % per annum in 1971/72 and 2.56 % per annum in

1991/92 respectively.

Total energy consumption under principal crops in U.P recorded a growth rate of 2.25 % per annum for rice in 1971/72, and later experienced negative growth of -0.90 % per annum in 1991/92. Wheat crop recorded positive growth of 5.30 % per annum

Table 6.4.12

COMPOUND GROWTH RATES **ESTIMATED** TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN UTTAR PRADESH.

Year / Crop	(Lakh Mega Joules)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice		2.25	- 0.29	2.98	0.56	- 0.90
Wheat		5.30	1.84	3.25	1.58	0.52
Jowar		- 6.86	2.51	- 0.49	- 3.34	- 2.28
Groundnut		- 3.45	3.47	- 7.67	- 13.97	5.27
Cotton		- 2.03	- 16.29	5.45	- 6.02	- 8.67
Sugarcane	--	6.18	2.71	2.56	0.31	2.33
Total		3.30	1.13	2.58	0.44	0.42

Source: **ICAR: Energy requirements in agriculture sector**, All India **Co-ordinative** Research Project, 1985 to 1988.

in 1971/72, and was increased at a rate of 0.52 X per annum in 1991/92. Jowar experienced negative growth rate of -6.86 % in 1971/72 and -2.76 X in 1991/92. Where as ground nut recorded negative growth of -3.45 % per annum in 1971/72, and further raised at a positive growth rate of 5.27 % per annum in 1991/92. Cotton crop also experienced negative growth of -2.03 X in 1971/72 and -8.67 % in 1991/92. In case of sugar cane, it increased at a rate of 6.18 % in 1971/72, and further raised at a rate of 2.33 %

per annum in 1991/92. However, total energy consumption under six crops raised at 3.30 % per annum in 1971/72, which has been increased at a rate of 0.42 % per annum in 1991/92 respectively.

With respect to West Bengal, rice crop noticed a growth rate of 3.35 % per annum in 1971/72, and later increased at a rate of 1.11 X per annum in 1991/92. Wheat recorded 9.59 % per annum in 1971/72. and later experienced negative growth of -7.54 % in

Table 6.4.13

COMPOUND GROWTH RATES ESTIMATED TOTAL ENERGY CONSUMPTION UNDER PRINCIPAL CROPS IN WEST BENGAL.

Year Crop	(Lakh Mega Joules)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice		3.35	0.84	0.02	0.63	1.11
Wheat		44.48	4.06	- 16.11	13.21	- 7.54
Jowar						
Groundnut	—					
Cotton						
Sugarcane		8.14	- 2.47	-5.18	-10.78	--1.59
Total		3.87	0.89	- 0.41	0.76	0.92

Source: ICAR: Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.

1991/92. On the other hand sugar cane recorded, 8.14 % per annum growth in 1971/72, and later experienced negative growth of -1.59 % per annum in 1991/92. Total energy consumption in the state witnessed a growth rate of 3.87 % per annum in 1971/72, and further increased at a rate of 0.92 % per annum in 1991/92 respectively.

Energy consumption in all India under principal crops witnessed a growth rate of 1.38 % per annum for rice in 1971/72, which has **further** increased at a rate of 0.55 % per annum in 1991/92. Wheat, noticed **8.31** % per annum in 1971/72, and later experienced negative growth of -0.13 % in 1991/92. Where as **Jowar** experienced negative growth of **-1.46** % in 1971/72 and -4.62 % in 1991/92. Ground nut recorded 0.57 % per annum in 1971/72, and

Table 6. 4.14

COMPOUND GROWTH RATES **ESTIMATED** TOTAL ENERGY CONSUMPTION UNDER **PRINCIPAL** CROPS IN ALL INDIA.

		(Lakh Mega Jouls)					
Year	Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
	Rice		1.38	0.39	1.12	0.22	0.55
	Wheat		8.31	1.80	1.14	0.88	- 0.13
	Jowar		- 1.46	- 1.23	1.03	- 0.80	- 4.62
	Groundnut		0.57	- 1.28	1.07	- 1.23	4.43
	Cotton		- 0.09	- 2.46	3.19	- 2.92	2.06
	Sugarcane		0.76	3.70	2.18	- 0.72	4.22
	Total		1.45	0.43	1.26	- 0.09	0.76

Source: ICAR:Energy requirements in agriculture sector, All India Co-ordinative Research Project, 1985 to 1988.

later it raised at a rate of 4.43 % per annum in 1991/92. Cotton experienced negative growth rate of -0.09 % in 1971/72, and later it become positive at a growth rate of 2.06 % per annum in 1991/92. Sugar cane noticed 0.76 % growth per annum in 1971/72, and further increased at a rate of 4.72 % per annum in 1991/92. On the whole the total energy consumption in India witnessed a growth **rate** of 1.45 % per annum in 1971/72, and later increased at a rate

of 0.76 % per annum in 1991/92 respectively.

6.5 ENERGY INTENSITIES UNDER PRINCIPAL CROPS IN INDIA AND SELECTED STATES:

So far in the earlier sections, much emphasis has been given to energy consumption in selected crops over a period of time across the states. But according to efficiency point of view, one should look at the productivity of energy resource in agricultural production. As discussed earlier, before 1966 Indian agriculture was depended on traditional energy sources such as human, bullock, and traditional equipment. After 1966 onwards efficiency of energy resource substitution had increased at larger extent as a process of modernization of agriculture. There is a need to identify the energy intensity ratios in the production of agriculture output. In general energy intensity in agriculture production can be derived as, Energy used per unit of output in agriculture sector. On the basis of this, this section will discuss the energy productivity in different crops over a period of time in whole India and across the states. Energy intensity can be measured by taking the following formula..

$$\text{Energy Intensity} = \frac{\text{Total Agricultural Production (T.t)}}{\text{Total Energy Consumption(Lakh/MJ)}}$$

The tables 6.5.1 to 6.5.7 illustrates the energy intensites for selected crops in all India and selected states from 1966/67 to 1991/91. Energy intensity ratio under rice crop in Andhra

Pradesh noticed, 2.73 **Lakh/MJ** per unit of thousands tonns of output in 1966/67, which has raised to 3.23 **lakh/MJ** in 1991/92. Where as wheat accounted **0.98** Lakh/MJ per unit of thousand tonns of output

Table 6.5.1
ENERGY INTENSITIES UNDER PRINCIPAL CROPS IN ANDHRA PRADESH.

(Thousand quintal Output/Lakh M. J Energy)

Year / Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	2.73	3.26	2.91	4.33	4.01	3.23
Wheat	0.98	3.32	3.86	4.10	2.65	5.56
Jowar	2.42	2.31	2.68	3.09	3.08	3.21
Groundnut	2.74	2.10	1.53	2.73	2.30	2.47
Cotton	4.25	4.87	8.44	13.06	13.80	17.29
Sugarcane	77.25	89.80	71.18	84.02	75.34	73.86

Source: **ICAR:Energy** requirements in agriculture sector, All India **Co-ordinative** Research Project, 1985 to 1988.

in 1966/67, and further raised to 5.56 Lakh/MJ in 1991/92. As against this **jowar** witnessed 2.42 Lakh/MJ in 1966/67, which has increased to 3.21 Lakh/MJ in 1991/92. In case of ground nut the intensity ratio recorded at 2.74 Lakh/MJ in 1966/67, was later slightly come down to 2.47 Lakh/MJ in 1991/92. Cotton and Sugar cane witnessed 4.25 and 77.25 Lakh/MJ in 1966/67, which has further increased to 17.29 Lakh/MJ in cotton crop and a decline trend showed in sugar cane crop of **73.86** Lakh/MJ in 1991/92 respectively.

On the whole it was observed that, energy was much efficient in sugar cane production, while comparing with other crops,

followed by cotton, rice, wheat, jowar, and ground nut respectively. Which reflect that energy used in sugar cane production was producing efficient level of output over a period of time.

Interestingly, energy intensity ratio in Bihar under rice recorded, 1.73 **Lakh/MJ** per unit thousands tonns of output in 1966/67, and later it raised to 1.96 Lakh/MJ in 1991/92. Wheat recorded, 1.90 Lakh/MJ in 1966/67 and 11.52 Lakh/MJ in 1991/92.

Table 6.5.2
ENERGY INTENSITIES UNDER PRINCIPAL CROPS IN BIHAR.

Year / Crop	(Thousand quintal Output/Lakh M. J Energy)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	1.73	2.05	1.88	1.67	2.37	1.96
Wheat	1.90	11.32	8.05	8.51	9.86	11.52
Jowar	3.08	2.06	1.15	1.34	4.27	1.27
Groundnut						
Cotton						
Sugarcane	37.39	31.78	32.98	34.08	33.66	49.33

Source: **ICAR: Energy requirements in agriculture sector**, All India **Co-ordinative** Research Project, 1985 to 1988.

Where as jowar showed a declining trend in intensity i.e **3.08** Lakh/MJ in 1966/67 to 1.27 Lakh/MJ in 1991/92. As against this sugar cane noticed highest energy intensity i.e 37.39 Lakh/MJ in 1966/67, and later it has gone up to 49.33 Lakh/MJ in 1991/92 **respectively**.

In Punjab, the energy intensities accounted under rice crop

was around **2.81 Lakh/MJ** per unit of thousand tonns of output in 1966/67, which has increased to 6.86 Lakh/MJ in 1991/92. Wheat noticed 11.89 Lakh/MJ in 1966/67 to 24.11 Lakh/MJ in 1991/92. On

Table 6.5.3

ENERGY INTENSITIES UNDER PRINCIPAL CROPS IN PUNJAB.

(Thousand quintal Output/Lakh M. J Energy)

Year Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	2.81	4.30	5.44	6.22	7.01	6.86
Wheat	11.89	15.26	15.42	18.59	18.81	24.11
Jowar						
Groundnut	2.91	2.90	2.52	2.70	2.70	2.76
Cotton	17.55	20.18	19.03	17.32	27.79	33.27
Sugarcane	36.44	39.55	54.30	58.36	63.67	64.18

Source: **ICAR: Energy** requirements in agriculture **sector**, All India **Co-ordinative** Research Project, 1985 to 1988.

the other hand ground nut noticed a declining trend of intensities i.e 2.91 Lakh/MJ in 1966/67 to 2.76 Lakh/MJ in 1991/92. Cotton and sugar cane witnessed significant increase in the intensities i.e 17.55 and 36.44 Lakh/MJ in 1966/67, which further increased to 33.27 and **64.18** Lakh/MJ in 1991/92 respectively.

In case of Tamil Nadu energy intensities under rice crop accounted 3.59 Lakh/MJ per unit of thousand tonns of output in **1966/67**, and later increased to 5.44 Lakh/MJ in 1991/92. where as especially for jowar, positive intensities were recorded i.e 3.66 Lakh/MJ in 1966/67 to 6.24 Lakh/MJ in 1991/92. On the other hand

ground nut experienced positive trend i.e 2.68 **Lakh/MJ** in 1966/67, which has raised to 3.53 Lakh/MJ in 1991/92. Cotton and sugarcane witnessed higher intensity i.e 10.35 and 75.80 Lakh/MJ in 1966/67, and further gone up to 15.42 and 102.03 Lakh/MJ in 1991/92 **respectively**.

Table 6.5. 4

ENERGY INTENSITIES UNDER PRINCIPAL CROPS IN TAMIL NADU.

(Thousand quintal Output/Lakh M. J Energy}

Year / Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	3.59	4.15	3.89	4.79	5.74	5.44
Wheat						
Jowar	3.66	3.69	4.83	4.10	4.63	6.24
Groundnut	2.68	3.15	2.43	3.37	3.36	3.53
Cotton	10.35	12.23	13.51	10.79	10.88	15.42
Sugarcane	75.80	83.16	92.90	101.62	111.42	102.03

Source: **ICAR: Energy requirements in** agriculture sector, All India **Co-ordinative** Research Project, 1985 to 1988.

U.P recorded, energy intensities for rice crop at 1.50 Lakh/MJ per unit of thousand tonns of output in 1966/67, and further increased to 3.62 Lakh/MJ in 1991/92. Wheat and jowar showed, 7.24 and 2.50 Lakh/MJ in 1966/67, which has been raised to 14.82 and 3.84 Lakh/MJ in 1991/92. Ground nut noticed, inefficient ratio i.e 2.00 Lakh/MJ in 1966/67 to 2.00 Lakh/MJ in 1991/92. As against this, cotton and sugar cane witnessed highest intensities of 4.65 and 37.25 Lakh/MJ in 1966/67, which has later increased to 10.67 and 58.21 Lakh/MJ in 1991/92 respectively.

Table 6.5.5
ENERGY INTENSITIES UNDER PRINCIPAL CROPS IN UTTAR PRADESH.

Year / Crop	(Thousand quintal Output/Lakh M. J Energy)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	1.50	1.68	1.94	2.30	2.85	3.62
Wheat	7.24	7.92	8.55	10.40	12.25	14.82
Jowar	2.50	1.88	3.53	4.53	4.15	3.84
Groundnut	2.00	1.54	1.65	2.69	2.49	2.00
Cotton	4.65	4.49	5.67	6.83	7.63	10.67
Sugarcane	37.25	39.16	45.28	46.77	51.05	58.21

Source: **ICAR: Energy requirements** in agriculture sector, All India **Co-ordinative** Research Project, 1985 to 1988.

With respect to West Bengal, energy intensities for rice crop has at 2.49 Lakh/MJ in 1966/67, and later it raised to 4.36 Lakh/MJ in 1991/92. Where as wheat showed, 6.39 Lakh/MJ in 1966/67, which

Table 6.5.6
ENERGY INTENSITIES UNDER PRINCIPAL CROPS IN WEST BENGAL.

Year / Crop	(Thousand quintal Output/Lakh M. J Energy)					
	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	2.49	2.75	2.41	2.36	3.31	4.36
Wheat	6.53	13.84	12.94	11.53	10.88	12.49
Jowar	--	~	—	—	—	—
Groundnut	--	—	—	—	—	—
Cotton	—	—	—	—	—	—
Sugarcane	47.08	49.26	61.05	62.02	58.86	72.37

Source: **ICAR: Energy requirements** in agriculture sector, All India **Co-ordinative** Research Project, 1985 to 1988.

increased to **12.49 Lakh/MJ** in 1991/92. Finally sugar cane noticed reasonably high intensities i.e **47.08** Lakh/MJ in 1966/67, and 72.37 Lakh/MJ in 1991/92 respectively.

At an all India level it has been observed that, all **most** all the crops showed progressive trend in case of energy consumption with respect to output production over a period of time, from

Table 6.5.7

ENERGY INTENSITIES UNDER PRINCIPAL CROPS IN ALL INDIA.

(Thousand quintal Output/Lakh M. J Energy)

Year Crop	1966/67	1971/77	1976/77	1981/82	1986/87	1991/92
Rice	1.82	2.40	2.29	2.75	3.10	3.67
Wheat	5.63	8.75	8.79	10.72	12.15	15.20
Jowar	2.62	2.36	3.43	3.73	2.97	3.41
Groundnut	1.67	2.27	2.06	2.68	2.32	2.25
Cotton	6.26	8.30	7.90	9.12	9.26	11.91
Sugarcane	40.78	48.03	53.97	59.00	61.09	66.55

Source: **ICAR: Energy requirements** in agriculture sector, All India **Co-ordinative** Research Project, 1985 to 1988.

1966/67 to 1991/92. Energy intensity for rice crop noticed at **1.82** Lakh/MJ per unit of thousand tonns of output in 1966/67, has later increased to 3.67 Lakh/MJ in 1991/92. In case of wheat and **jowar** it was 5.63 and 2.62 Lakh/MJ in 1966/67, which has raised to 15.20 and 3.41 Lakh/MJ in 1991/92 respectively. Ground nut also noticed improvement trend from 1.67 Lakh/MJ in 1966/67, to 2.25 Lakh/MJ in 1991/92. Next comes cotton and sugar cane which also noticed positive trend of 6.26 and 40.78 Lakh/MJ in 1966/67, and further gone up to 11.91 and 66.55 Lakh/MJ in 1991/92 **respectively**.

6.6 REGRESSION EQUATIONS FOR SELECTED CROPS AND STATES:

In the earlier chapters the importance of energy in agricultural production has been discussed. The agricultural output has been changing across the states due to, the intensity of use of energy for different crops. It has been noticed that the energy demand is expressed not only in terms of direct energy used but also in terms of indirect energy applicable for agricultural operations. The type of energy used for electric engines or oil engines and tractors is direct energy. The energy used in fertilizers and pesticides is also energy but it is in the indirect form. Similarly the energy used by human beings (labour) and animals (draught power) is also a kind of indirect energy. But ICAR considered this as a form of direct energy. There is a need to explain the variations in agricultural output in a functional form.

Based on the literature reviewed so far, it is logical to specify the agricultural output relationship (production function) as a function of the following independent variables: labour, draught power, oil engines, electric engines, tractors, fertilizers, pesticides, and energy. It has been pointed out that the variations in the extent of rainfall at various states (under examination here) have an impact on the crop output. Similarly the land utilization based upon the type of irrigation also play an important role on the crop output. The variations in agricultural output across states can also be due to the the factor endowments.

6.6.1 OUTPUT MODEL:

Thus for a specific type of crop i , in the state j the following production function has been specified:

$$Y_{ij} = f(L_{nj}, L_{bj}, D_{pj}, O_{ej}, E_{ej}, T_{rj}, F_{ej}, P_{ej}, E_{nj}, r_{aj})$$

(...6.6.1.1)

i = Crop type i.e Paddy, wheat, Jowar, Groundnut, Cotton, and Sugarcane

j = Specific state i.e Andhra Pradesh, Bihar, Punjab, Tamil Nadu, Uttar Pradesh, and West Bengal

The variables are specifically defined in the following manner.

Y = Total output under crop(thousand tonns.)

L_n = Total Land under crop(thousand hectares.)

L_b = Labour power(physical units in lakhs.)

D_p = Draught power(thousands in number.)

O_e = Oil engines(thousands.)

E_e = Electric engines(thousands.)

T_r = Tractors(hundreds.)

F_e = Fertilizers(lakh tonns.)

P_e = Pesticides(thousand tonns.)

E_n = Energy(mega-jouls.)

R_a = Rainfall millimeters.)

A classical production function approach has been adopted here. By assuming a neutral type of technological progress, the above function can be expressed as

$$Y_{ij} = f(Ln_j, Lb_j, Dp_j, Oe_j, Ee_j, Tr_j, Fe_j, Pe_j, En_j, ra_j, T) \quad (\dots 6.6.1.2)$$

Where T stands for time series which augments the technological progress in a disembodied manner. The production can be explained in a linear or a non-linear form as".

Linear:

$$Y_{ij} = a_{0ij} + a_{1ij} Ln_j + a_{2ij} Lb_j + a_{3ij} Dp_j + a_{4ij} Oe_j + a_{5ij} Ee_j + a_{6ij} Tr_j + a_{7ij} Fe_j + a_{8ij} Pe_j + a_{9ij} En_j + a_{10ij} Ra_j + a_{11ij} T \quad \dots (\dots 6.6.1.3)$$

Non-linear:

$$Y_{ij} = b_{0ij} + Ln_j^{a_{1ij}} Lb_j^{a_{2ij}} Dp_j^{a_{3ij}} Oe_j^{a_{4ij}} Ee_j^{a_{5ij}} Tr_j^{a_{6ij}} Fe_j^{a_{7ij}} Pe_j^{a_{8ij}} En_j^{a_{9ij}} Ra_j^{a_{10ij}} T^{a_{11ij}} \quad (\dots 6.6.1.4)$$

This in the double log form can be written as:

$$\log Y_{ij} = a_{0ij} + a_{1ij} \log Ln_j + a_{2ij} \log Lb_j + a_{3ij} \log Dp_j + a_{4ij} \log Oe_j + a_{5ij} \log Ee_j + a_{6ij} \log Tr_j + a_{7ij} \log Fe_j + a_{8ij} \log Pe_j + a_{9ij} \log En_j + a_{10ij} \log Ra_j + a_{11ij} \log T \quad (\dots 6.6.1.5)$$

Where $a_{0ij} = \log(b_{0ij})$

The co-efficients a_{1ij} to a_{11ij} in the linear equation will represent the responsiveness of the independent variable on the dependent variable respectively. In case of the non-linear equation, expressed in the double log form, the co-efficients indicate the elasticity of the dependent variable with respect to

the corresponding independent variable, with the exception **oftrend** variable. The sign and size of the **co-efficients** will indicate the degree and responsiveness. The data used for this analysis is the same as the data analyzed earlier, under different headings. The data covers six **time** periods of 5 years interval each in six states under consideration. The **estimation** procedure includes cross-section of time series data consisting of 36 observations. In this procedure the regressions were estimated for individual crops, under consideration here, by introducing the state wise dummy variables (*Gujarati 1984*). The estimated regression equation with dummy variables is written as:

Linear:

$$\begin{aligned}
 Y_i = & a_{0i} + a_{1i} Ln_i + a_{2i} Lb_i + a_{3i} Dp_i + a_{4i} Oe_i + \\
 & a_{5i} Ee_i + a_{6i} Tr_i + a_{7i} Fe_i + a_{8i} Pe_i + a_{9i} En_i + a_{10i} \\
 & Ra_i + a_{11i} T + d_1 DY1 + d_2 DY2 + d_3 DY3 + d_4 DY4 + d_5 \\
 & DY5 + d_6 DY6. \quad \dots \quad (\dots 6.6.1.6)
 \end{aligned}$$

Where **DY1**, **DY2** **DY6** represent the dummy variables for the states Andhra Pradesh, Bihar, Punjab, Tamil Nadu, Uttar Pradesh, and West Bengal respectively. The dummy variables are introduced with 1 0 0 0 0 0 for **DY1**, next to 0 1 0 0 0 0, 0 0 1 0 0 0, 0 0 0 1 0 0, 0 0 0 0 1 0, and 0 0 0 0 0 1 for **DY2**, **DY3**, **DY4**, **DY5**, and **DY6** respectively.

In the case of non-linear type of production function the dummy variables have been introduced in the equation form as :

$$\log Y_i = a_{0i} + a_{1j} \log Ln. + a_{2i} \log Lb. + a_{3j} \log Dp. + a_{4i} \log Oe. + a_{5j} \log Ee. + a_{6j} \log Tr. + a_{7i} \log Fe_i + a_{8i} \log Pe. + a_{9j} \log En. + a_{10i} \log Ra. + a_{11i} T + d_1 DY1 + d_2 DY2 + d_3 DY3 + d_4 DY4 + d_5 DY5 + d_6 DY6. \quad (. . . .6.6.1.7)$$

The significance (statistical) of dummy variable indicates that the variation in crop output in that particular state is **significantly** different from other states. In other words the variation across states is estimated for each crop i by using the relevant dummy variables.

6.6.2 ENERGY DEMAND MODEL (INVERSE MODEL) :

It is well established economic theory that the factor demand functions are inverse functions of the production **functions**. In other words the demand for factor input is a function of output, other input **variables**. Thus the derived demand **function** for one of the input, energy, is expressed as:

$$En = g(Y, Ln, Lb, Dp, Oe, Ee, Tr, Fe, Pe, Ra, T). \quad (. . .6.6.2.1)$$

Here En is the energy demand as expressed earlier, and all other variables as independent, defined earlier. In a linear **form** this demand equation can be written as :

$$En_i = b_{0i} + b_{1i} Y_i + b_{2i} Ln + b_{3i} Lb + b_{4i} Dp + b_{5i} Oe + b_{6i} Ee + b_{7i} Tr + b_{8i} Fe + b_{9i} Pe + b_{10i} Ra + b_{11i} T \quad (. . . .6.6.2.2)$$

The respective **co-efficients** indicates the direction and magnitudes of the response of independent variables on the dependent variable. Here *i* stands for the respective crop.

In a non-linear form, particularly, double log form, the demand equation is written as:

$$\log E_{ni} = b_{0i} + b_{1i} \log Y. + b_{2i} \log Ln + b_{3i} \log Lb + b_{4i} \log Dp + b_{5i} \log Oe + b_{6i} \log Ee + b_{7i} \log Tr + b_{8i} \log Fe + b_{9i} \log Pe + b_{10i} \log Ra + b_{11i} T \text{ (---6.6.2.3)}$$

In this double log form the **co-efficients** indicates the elasticity of the dependent variable with respect to the independent variables. Depending up on the size and sign of the **co-efficients** the degree and direction of elasticity can be explained. These demand equations are also estimated using the time series of cross section data spread over 6 states and 6 time periods of five year intervals.

It has been observed, in the literature, that the demand for energy varies according to the type of crop and also across the states. Thus it is important to analyze the variations in the energy demand across states by a dummy variable technique to check **for** the inter state **variations**. The demand equations are estimated for individual crops . The estimated equations are of the form:

Linear:

$$\begin{aligned}
 E_{ni} = & b_{0i} + b_{1i} Y_i + b_{2i} Ln_i + b_{3i} Lb_i + b_{4i} Dp_i + b_{5i} Oe_i + b_{6i} \\
 & Ee_i + b_{7i} Tr_i + b_{8i} Fe_i + b_{9i} Pe_i + b_{10i} Ra_i + b_{11i} T + \\
 & d_1 DY1 + d_2 DY2 + d_3 DY3 + d_4 DY4 + d_5 DY5 + \\
 & d_6 DY6. \quad (6.6.2.4)
 \end{aligned}$$

Non-linear:

$$\begin{aligned}
 \log E_{ni} = & b_{0i} + b_{1i} \log Y_i + b_{2i} \log Ln_i + b_{3i} \log Lb_i + b_{4i} \log Dp_i \\
 & + b_{5i} \log Oe_i + b_{6i} \log Ee_i + b_{7i} \log Tr_i + b_{8i} \log Fe_i + \\
 & b_{9i} \log Pe_i + b_{10i} \log Ra_i + b_{11i} T + d_1 DY1 + d_2 DY2 + d_3 \\
 & DY3 + d_4 DY4 + d_5 DY5 + d_6 DY6. \quad (6.6.2.5)
 \end{aligned}$$

The significance (statistical) of these dummy variable **co-efficients** will indicate the variations that are due to the **geo-graphical** location. These equations were estimated with the cross sections of time series data, using ordinary least squares method of estimation.

6.6.3 ANALYSIS OF THE ESTIMATED RESULTS:

As explained earlier the output equations and the energy demand equations were estimated using the time series of cross section data, from 1966/67 to 1991/92, over the specified six states. Ordinary least square method of estimation has been applied for the reported equations. Whenever dummy variables are used, to check for inter state variations, the constant was removed **from** the estimated **equations**, to avoid estimated **problems**. In some equations dummy variables are showed significant, which

reported in that particular equation depends up on the availability of that particular crop in selected states. Some crops are almost neglected in particular states, in that sense few equations will show four or five dummies but not six.

First, the output equations are estimated for the specified six crops, namely Rice, Wheat, **Jowar**, Groundnut, Cotton, and Sugarcane, in that order. The reported equations are the best equations selected on the basis of statistical significance as well as consistency of economic theory. All other equations that are not reported here are not satisfactory in that sense.

6.6.4 ESTIMATED OUTPUT EQUATIONS:

In case of output equations the above specified equations were estimated for per hectare terms instead of aggregate output terms for all the crops except jowar. It means that per hectare variations are more **important** for all the crops except jowar. Whenever the per hectare dependent variable is used the corresponding independent variables are also expressed in per hectare terms for labour, draught power, oil engines, electric engines, tractors, fertilizer, pesticides, energy, except for rainfall variable. This decision was taken because land variable showed collinearity with all other variables. It is also important to note that, oil engines and electric engines are substitutes for each other and thus showing a problem of **multi-collinearity**. Whenever the problem of multi-collinearity arises the oil engines were removed from that estimation.

WHEAT:

The estimated equation for wheat is shown in the table 6.6.4.2. Here a non-linear equation is more relevant than the linear equation. In case of wheat the per hectare output equation, indicating significant variations across the states in India, can be explained by the presence of dummy variables. In this equation, the significant co-efficients are electric engines, fertilizers, pesticides, rainfall, and trend co-efficient, at 5 % level. The sign on electric engines and fertilizer is negative where as for other variables it is positive. It explains that, wheat crop will demand less water while comparing with other wet crops, that's why electric engines showed negative relation with output.

Where as pesticides, rainfall, and trend showed positive relation with output, indicating that as output per hectare of wheat increases with the presence of pesticides, rainfall, and trend on the other hand when the rainfall variable showed positive trend with output, obviously there should be a less amount of fertilizers and electric engines. The co-efficient on trend variable is positive indicating the technical progress. The estimated \bar{R}^2 is 0.9221 indicating that 92.21 % of the variation in the dependent variable is explained by this equation.

In this equation, the significant **co-efficients** are land, **labour**, pesticides, and rainfall. The sign on labour, pesticides, and rainfall is negative, where as for land it is positive. It **indicates** that as aggregate out for jowar crop increases, the land **variable** showed positive relation, where as labour, **pesticides, and** rainfall with negative relation, in the sense that the jowar crop demand less amount of labour, pesticides, and water, which is treated as dry land crop in that sense.

Table 6.6. 4. 3

Jowar: **Aggregate(without** oil engines) Non-linear equatlor

S.NO	VARIABLE	CO-EFFICIENT	STANDARD ERROR	T-STATISTIC
1	CONSTANT	9.0867	2.3821	3.8146
2	LLn	1.1102	0.1201	9.2447
3	LLb	- 0.8951	0.1575	- 5.6851
4	LDp	- 0.1963	0.2457	- 0.7987
5	LEe	- 0.0429	0.0510	- 0.8570
6	LTr	0.1870	0.1106	1.6903
7	LFe	0.3047	0.1697	1.7960
8	LPe	- 0.2233	0.0890	- 2.5072
9	LEn	- 0.1787	0.1028	- 1.7378
10	LRa	- 0.6329	0.1475	- 4.2921
11	Trend	0.0431	0.0237	1.8215

Number of observations = 24

$R^2 = 0.9976$

Durbin-Watson = 1.7795

Degrees of freedom = 13

See = 0.1088

Significant at 5 percent

GROUNDNUT:

The estimated equation for groundnut is shown in the table 6.6.4.4. Here a non-linear equation is taken in to consideration. In case of groundnut the per hectare output equation indicates significant variations across the states in India, which

isdemonstrated by the presence of dummy variables. The significant co-efficients in this equations are draught power, oil engines, and fertilizers(at 5 % level). The sign on the draught **power,oil** engines, and fertilizers is positive. It explains that, as output per hectare increases, as reflected bythe increase in draught power, oil engines, and ferlilisers. The dummy variables alsoshowed significant variations across the states. Here the main interesting feature is that groundnut isdemanding much amount of **fertilizers(FYM)**, by using draught power. When oil engines showed significance with output, electric engines are not at all significant in the equation. The estimated R^2 is 0.7538 indicating 75.4 % of the variation in the dependent variable is expressed by this equation.

Table 6. 6. 4. 4

Groundnut: Per **hectare(with oil engines)** Non-linear equation.

S.NO	VARIABLE	CO-EFFICIENT	STANDARD ERROR	T-STATISTIC
1	LLb	- 0.2950	0.1631	- 1.8091
2	LDp	0.5416	0.1899	2.8525
3	LOe	0.1402	0.0459	3.0539
4	LEe	- 0.1030	0.0559	- 1.8417
5	LTr	- 0.2018	0.1260	- 1.6016
6	LFe	0.3069	0.1351	2.2708
7	Lpe	0.2000	0.1293	1.5463
8	LEn	- 0.2400	0.2300	- 1.0439
9	LRa	0.1412	0.1633	0.8646
10	D1	9.3834	1.3633	6.8831
11	D2	9.7942	1.2692	7.7171
12	D3	9.3543	1.3395	6.9833
13	D4	9.5484	1.4566	6.5554

Number of observations = 24

Durbin-Watson = 2.4113

See = 0.1141

$R^2 = 0.7538$

Degrees of freedom = 11

Significant at 5 percent

COTTON:

The table 6.6.4.5 represents the estimated **co-efficients** of the cotton output equation expressed in per hectare terms. Here a non-linear equation is more relevant than linear equation. Here tractors, fertilizers, trend variable showed significance at 5 % level. Out of this tractors and fertilizers is showed positive co-efficient where as trend variable expressed negative **co-efficient**. It means that as the per hectare output of cotton crop increases, the use of tractors and fertilizer increase in their quantities. Which means there is a direct relationship between per hectare output and tractors and fertilizers. The estimated \bar{R}^2 is 0.8409 indicating 84.1 % of the variation in the dependent variable is explained by the equation. The trend variable is negative indicating that, over time the per hectare cotton output is declining.

Table **6.6.4.5**

Cotton: Per **hectare(with** oil engines) Non-linear equation.

S.NO	VARIABLE	CO-EFFICIENT	STANDARD ERROR	T-STATISTIC
1	CONSTANT	8.9968	1.4598	6.1632
2	LLb	0.7354	0.4727	1.5558
3	LDp	- 0.3545	0.2448	- 1.4481
4	LOe	0.0078	0.0877	0.0886
5	LEe	0.0663	0.1043	0.6350
6	LTr	0.4966	0.2373	2.0930
7	LFe	0.7553	0.2235	3.3796
8	LPe	0.1659	0.1797	0.9231
9	LEn	0.4262	0.3870	1.1014
10	LRA	- 0.1570	0.2083	- 0.7537
11	Trend	- 0.1297	0.0492	- 2.6351

Number of observations = 24

Durbin-Watson = 1.9890

See = 0.2313

R^2 - 0.8409

Degrees of freedom = 13

Significant at 5 percent

SUGARCANE:

The estimated equation for sugarcane is shown in the table 6.6.4.6. Here non-linear equation is more relevant than the linear equation. In this equation, the significant co-efficients are electric engines, tractors, and energy(at 5 % level). The sign on electric engines showed positive, where as tractors and energy become negative. This indicates that the per hectare output as a response to increases, electric engines increased, in the sense that sugarcane crop treated as wet crop which demand much amount of water, for that more electric engines are used in the production of sugarcane output. Once the electric engines are increases it reflects the complimentary problem with energy and tractors. The estimated R is 0.7464 indicates that 74.6 % of the variation in the dependent variable is explained by the equation.

Table 6.6. 4. 6

Sugarcane: Per hectare(with oil engines) Non-linear equation.

S.NO	VARIABLE	CO-EFFICIENT	STANDARD ERROR	T-STATISTIC
1	CONSTANT	13.8443	0.9900	13.9843
2	LLb	- 0.0268	0.1169	- 0.2293
3	LDp	0.1108	0.1677	0.6610
4	LOe	- 0.0343	0.0387	- 0.8874
5	LEe	0.0873	0.0384	2.2737
6	LTr	- 0.1762	0.0521	- 3.3798
7	LFe	0.1251	0.1034	1.2099
8	LPe	0.0923	0.0932	0.9902
9	LEn	- 0.4375	0.1731	- 2.5275
10	LRa	- 0.0373	0.1199	- 0.3108

Number of observations =	36	R² =	0.7464
Durbin-Watson =	1.9653	Degrees of freedom =	26
See =	0.1868	Significant at	5 percent

6.6.5 ESTIMATED ENERGY DEMAND EQUATIONS:

The energy demand equations are derived as inverse of production functions. The energy demand equations are estimated for individual crops taking into account of dummy variables if necessary, to test for variations across the states. The reported results are the best equations, in statistical sense, as well as that are in support of economic relevance.

The equations are estimated in per hectare **terms(energy consumption per hectare)** for all the variables, for all the crops except the **paddy**. For the reasons explained earlier the per hectare equations are **preferable** than the aggregate **equations**. Since the oil engines and electric engines are found to be substitutes to each other, which reflects the problem of **multi-colinearity**. Whenever the problem of roulti-colinearity traced out, the oil engines were removed from the estimation.

RICE:

In case of paddy, it is aggregate energy demand equation that has been estimated here in the linear form. Compared to the per hectare terras the aggregate equation is more suitable to explain the variation of paddy output. This is important to note **that,the** area under paddy crop is relevant for the explanation.

In the estimated equation, variables like output, land, draught **power,Tractors**, fertilizers are statistically significant

WHEAT:

The table 6.6.5.2 illustrate the estimated co-efficients of the energy demand equation for wheat in per hectare terms. Here non-linear equation is found to be more relevant than the linear equation. Since there are no dummy variables, state wise variations are not important for wheat crop. This equation indicates that the per hectare energy demand for wheat is explained significantly (at 5 % level) by the presence of draught power, electric engines, and pesticides. The estimated R is 0.8809 indicating 88.1 % of the variation in the dependent variable is explained by this equation. Here the draught power co-efficient is positive. It indicates that as draught power increases, the energy for hectare increased. It shows that draught power is more important in production of wheat output. Similarly positive sign on electric engines is an indication of better irrigation facilities which are used in wheat production. On the other hand negative sign on pesticides indicates that, wheat crop demands less amount of pesticides compared with other crops, due to better immunity of wheat crop. For example, wheat crop is dominant in Punjab and Uttar Pradesh, where less amount of pesticides use were reported compared with other states.

Table 6.6.5.2

Wheat: Per hectare(with oil engines) Non-linear equation.

S.NO	VARIABLE	CO-EFFICIENT	STANDARD ERROR	T-STATISTIC
1	Constant	2.4559	1.1596	2.1178
2	LY	0.1593	0.0810	1.9657
3	LLb	- 0.2220	0.1147	- 1.9351
4	LDP	0.9204	0.1781	5.1667
5	LOe	- 0.0424	0.0343	- 1.2341
6	LEe	0.1476	0.0609	2.4235
7	LTr	- 0.1472	0.0750	- 1.9620
8	LFe	0.0431	0.0968	0.4455
9	LPe	- 0.2770	0.0876	- 3.1636
10	LRa	- 0.2423	0.1344	- 1.8028

Number of observations = 30 $R^2 = 0.8809$
Durbin-Watson = 1.9201 Degrees of freedom = 20
See = 0.1459 Significant at 5 percent

JOWAR:

The estimated equation for **jowar** is shown in the table 6.6.5.3. Here a linear equation is more relevant than the non-linear equation. In case of jowar the per hectare energy demand equation is found to be significant by the presence of output per hectare, labour per hectare, draught power per hectare, electric engines per hectare, rainfall, and trend **co-efficients**, at 5 % level. The signs on output, labour, electric engines, rainfall is negative, whereas draught power and trend showed positive. It indicates that, as known from the literature, jowar is treated as a dry crop which can be used in most of the backward and dry land areas where there are less irrigation facilities. Due to this the yield level is found to be low even though there is much amount of energy used per hectare. The estimated R is 0.7649 indicating that 76.5 % of the variation in the dependent variable is explained by this equation.

Table 6.6.5. 3

Jowar: Per **hectare**(without oil engines!) Linear equation.

S.NO	VARIABLE	CO-EFFICIENT	STANDARD ERROR	T-STATISTIC
1	Constant	46.8896	12.5935	3.7233
2	Y	- 0.0456	0.0170	- 2.6889
3	Lb	- 17.6135	7.1525	- 2.4626
4	Dp	97.0497	26.9145	3.6058
5	Ee	- 0.1673	0.0777	- 2.1534
6	Tr	- 3.1168	1.9011	- 1.6395
7	Fe	180.3477	201.0983	0.8968
8	Pe	-14028.1400	7603.6600	- 1.8449
9	Ra	- 0.0250	0.0085	- 2.9461
10	Trend	1.5039	0.7131	2.1090

Number of observations = 24 $R^2 = 0.7649$
Durbin-Watson = 2.8177 Degrees of freedom = 14
 See = 7.0154 Significant at 5 percent

GROUNDNUT:

The estimated equation for groundnut is shown in table 6.6.5.4. Here linear equation is more relevant than non-linear equation. In case of groundnut the per hectare energy equation indicate significant variation across the states in India which can be explained with the presence of dummy **variables**. In this equation the significant co-efficients are output, labour, tractors, rainfall that are negative where as for fertilizers it is positive. It indicates that the energy per hectare is increasing, irrespective of decline trend in output, labour, tractors, rainfall. It is observed from national and international level that the yield per hectare of groundnut crop in India is very low even though India is treated as second in the world in groundnut production. This argument is an evidence for the above said observation, where the output, labour, tractors, rainfall

decreased at the cost of increase in energy in **demand**. The estimated R^2 is 0.8652 indicating that 86.5 % of the variation in the dependent variable is explained by this equation.

Table 6.6.5.4

Groundnut: Per hectare (without oil engines) Linear equation.

S.NO	VARIABLE	CO-EFFICIENT	STANDARD ERROR	T-STATISTIC
1	Y	- 0.0228	0.0098	- 2.3186
2	Lb	- 13.3457	4.4964	- 2.9681
3	Dp	1.6729	23.4390	0.0714
4	Ee	- 0.0464	0.0667	- 0.6966
5	Tr	- 2.9616	0.8492	- 3.4873
6	Fe	327.2620	123.3531	2.6531
7	Pe	1121.3710	6362.2570	0.1763
8	Ra	- 0.0213	0.0082	- 2.5795
9	D1	73.6810	14.0360	5.2494
10	D2	70.3882	12.7477	5.5217
11	D3	76.1626	18.8545	4.0395
12	D4	99.2188	19.1143	5.1908

Number of observations = 24

Durbin-Watson = 1.8424

See = 4.8538

R = 0.8652

Degrees of freedom = 12

Significant at 5 percent

COTTON:

The table 6.6.5.5 illustrate the estimated **co-efficients** of the cotton energy demand equation in per hectare **terms**. Here linear equation is considered. This equation indicates that the per hectare energy demand for cotton is explained **significantly** (at 5 % level) by the presence of labour, tractor, fertilizers, and rainfall. The estimated R^2 is 0.8381 indicating 83.8 % of the variation in the dependent variable is explained by this equation. Here the labour, tractor, and rainfall co-efficient is negative, where as fertilizer showed positive, and statistically significant. It explains that energy demand per hectare of cotton

crop increases, as a result of decline in labour, tractors, and rainfall. On the other hand the fertilizer input was showed positive relation with energy indicate that much amount of indirect energy used in cotton crop production. Here dummy variables are found to be significant indicating that, state wise variations are prevailed in cotton crop production. Another interesting feature is that the yield per hectare of cotton varies across the states, due to input demand variations prevailed in those states.

Table 6.6.5.5

Cotton: Per hectare(with oil engines) Linear equation.

S.NO	VARIABLE	CO-EFFICIENT	STANDARD ERROR	T-STATISTIC
1	Y	0.1519	0.0272	0.5580
2	Lb	- 12.8011	4.9492	- 2.5865
3	Dp	- 9.5014	27.6668	- 0.3434
4	Oe	- 0.2601	0.1468	- 1.7721
5	Ee	- 0.0035	0.0779	- 0.0444
6	Tr	- 2.2262	0.9949	- 2.2375
7	. Fe	311.1402	142.8759	2.1777
8	Pe	-1680.1900	7164.6890	- 0.2345
9	Ra	- 0.0287	0.0092	- 3.1193
10	D1	69.3150	17.4276	3.9773
11	D2	53.3916	17.1538	3.1125
12	D3	69.2728	23.3328	2.9689
13	D4	98.3172	23.4341	4.1954

Number of observations = 24

R = 0.8381

Durbin-Watson = 2.1087

Degrees of freedom = 11

See = 5.3197

Significant at 5 percent

SUGARCANE:

In case of **paddy**, as stated in the table 6.6.5.6 it is per hectare energy demand equation that has been estimated here in the non-linear form. Compared to the aggregate terms the per hectare equation is more suitable to explain the variations of sugar cane output, across the states with the help of dummy variables. Here

6.7 SUMMARY AND CONCLUSIONS:

In this chapter the energy demand and energy intensities under principal crops for whole India and selected states are examined. Along with this some other issues like energy conversion rates, power utilization, average energy consumption under principal crops were also analyzed. Among all the sources prime movers was accounted higher energy equivalent, next comes the farm machinery, nitrogen, diesel, petrol, and electricity respectively.

Next comes to electricity consumption in Indian agriculture, The analysis implies **that, the** power utilization in agriculture sector increased at a faster rate, especially since last two decades due to more **electrification** of pump sets in agriculture sector. The main reason for this is that, due to unfavorable rainfall. A major part of Indian agriculture depends up on ground water irrigation. On the other hand, through ground water utilization, the farmers are in a position to supply water for crops in time, a guaranteed way, which provides stable agricultural production.

Later, the average energy consumption by source under principal crops was also examined in order to identify the energy demand variations among the crops. It was emphasized that in rice production much energy was consumed from diesel and next comes the fertilizers, electricity, and canal etc respectively. Where as in Wheat, much energy is consumed from fertilizers and then comes to diesel, seed, human energy etc respectively. Jowar demanding much

amount of diesel, next is electricity, FYM, fertilizers, and human energy. Out of all the sources, ground nut consumes much amount of FYM, fertilizers, human labour, and diesel energy respectively. Cotton crop demanding much amount of fertilizers, next comes to diesel, human energy, and seed respectively. Sugar cane crop demands much amount of seed, then comes FYM, fertilizers, human, and machinery respectively.

The data analysis with respect to energy demand in principal crops was showed that, energy consumption under rice, wheat, ground nut, and sugar cane increased at faster rate, where as jowar and cotton showed declining trend in energy consumption over a period of time.

Finally, the crop wise energy intensities have been examined for selected crops in all India and selected states. The data suggests that, energy was much efficient in sugar cane production, while comparing with other crops, followed by cotton, rice, wheat, jowar, and ground nut respectively. Which reflect that energy used in sugar cane production was producing efficient level of output over a period of time. In the next chapter, the overall conclusions were summarized. Along with this some important policy recommendations and limitations of the study were also highlighted at the end.

CHAPTER 7

SUMMARY AND CONCLUSIONS

7.0 INTRODUCTION:

Agriculture is one of the dominant sector in India. After Green-revolution, this sector was seriously influenced by modern agricultural technology, such as farm machinery, HYV seeds, fertilizers, and pesticides. These transitional changes in agriculture led to more demand for energy. At the same time pressure on irrigation sources has increased to a larger extent due to unfavourable rainfall conditions. Due to this the area under ground water irrigation is increasing at a faster rate, which demands a large amount of energy sources in Indian agriculture.

It has been identified in several studies that, about 10 percent of energy sources are consumed by agriculture sector. But the energy consumption in agriculture sector in India must be around 15 to 20 percent, which may further increase in near future. On these issues the present chapter highlights the major conclusions drawn from the existing study.

There are several factors that influence the growth performance in Indian agriculture across the states. This can be traced out especially, from Green Revolution in Indian Agriculture. Because Green Revolution itself will demand a larger amount of inputs in production process. But all the states which

have been existing are not in a position to provide all the factors at larger extent. Due to this reason the disparities are over veiling in different states.

Irrigation is one of the important device in modern agriculture, where the HYVs seeds when implemented, will demand much amount of water resources. In recent years, the irrigation is affected due to unfavorable rainfall conditions. The area under irrigation is changing continuously over a period of time.

The area under canals has been slightly **declining**, where as the area under tube wells and other wells were increasing drastically. This is a clear indication that, the pressure on Energy sources such as Diesel and Electricity is increasing at faster rate. This is one of the important highlighting feature of Indian irrigation system and Indian agriculture environment. Due to this, the demand for energy is increasing continuously over a period of time especially from 1966 on wards, when the Green Revolution Programme was implemented in Indian agriculture. At the same time the area under rain fed was fluctuating, due to unfavorable rainfall conditions.

Here the interesting feature is that, sugarcane demands higher rate of fertilizers, as comparing with other crops, next comes to yield per hectare, real cost of production, rate of profit, average net income, labour absorption, and irrigation in sugarcane. On the other hand jowar consumes, low rate of fertilizers, yield, real cost of production, rate of profit, average net income, labour employment, and irrigation. It was

observed that labour employment can be improved by cultivating more of sugar cane. And the state scenario is showing that, for farmers point of view sugar cane cultivation is more profitable , next to cotton, rice, and jowar respectively.

In all most all the states, sugarcane is showing higher cost of cultivation compared with other crops, due to high application of inputs with more operational activities. However, with respect to employment, irrigation, and average net income is also very high in case of sugar cane. But at this stage even though sugar cane is much profitable than that of other crops, one should be aware of the availability of water resources, and other input equipment. For that alternative crops should be recommended in order to remove shortage in inputs and avoiding over water use, which is scarce resource in recent years in Indian agriculture.

7.1 CROPPING PATTERN AND CROPPING INTENSITY:

Due to changes in institutional set up in Indian agriculture i.e the changing of traditional agriculture to modern agriculture, the cropping pattern is changing over a period of time. Incidentally in early years, the farmer concentrated on subsistence crops, and later he diverted towards commercial crops, where commercial crops are more profitable than food crops. Because of this problem India still facing food scarcity, even though she is treated as agriculturally self sufficient. Changes in cropping pattern laid foundation to the several controversial problems such as resource crunch and input scarcity in Indian agriculture.

The whole scenario is shows that, the area under rice and jowar slowly declining, where as the area under wheat and sugar cane increasing at faster rate. However, cotton and ground nut showed fluctuations over a period of time, with changing shares in overall agricultural production.

There are several factors which influencing yield mechanism in Indian agriculture. Generally the yield component was influenced by several factors such as availability of water, fertilizers, energy and other inputs, especially application of inputs at efficient level, which talks about the farm management skills in production.

In general it was observed that the traditional input accounted for the bulk of total factor inputs during the pre-green revolution period while in the subsequent period (green revolution and post green revolution periods) the share of modern inputs has considerably increased. Due to green revolution the output growth has considerably increased in all most all the states. Undoubtedly, considerable growth has occurred in modern inputs during the post-green revolution period but productivity has also fallen steeply amongst the states. The states which has better resource endowments has realised the benefit of technological change in Indian agriculture.

7. 2 FACTOR SHARES IN INDIAN AGRICULTURE:

Draught power still is main source of energy in Indian

agriculture, due to its reasonable and most convenient source for small and marginal farmers. But most of the studies observe that, the maintenance of draught power is very much expensive than other sources. That's why the depletion of animal power took place especially in recent years, from Green revolution onwards. Here the interesting feature is that, animal feed (food energy) is much expensive as comparing with output energy produced by animal.

Indian agricultural production has experienced highly cost intensive during last three decades. The reason for this is that all most all the prices of agricultural inputs and allied equipment have increased drastically due to several reasons. Petroleum based inputs such as diesel, petrol, fertilizers, pesticides, and other lubricants prices gone up especially from 1973 onwards, where there was great oil price hick in world scenario. On the other hand agricultural machinery and implements prices raised at a faster rate while comparing with agriculture production.

The general observation is that prices of inputs increased at faster rate as comparing with prices of agricultural products. On the other side it was highlighted that energy input prices raised at faster rate than energy output prices (food price), due to this reason lot of changes took place in Indian agriculture especially since Green revolution.

7.3 MECHANIZATION IN INDIAN AGRICULTURE:

Farm mechanization is the main plank of modern agriculture

and many of the progressive countries have already mechanized their agriculture. Of course, it is also true that the conditions in many of these countries were favorable for mechanization. Most important conditions for use of agriculture implements and machinery were high rate of agriculture labour, large size of farms, high cropping intensity, higher percentage of irrigated area and more adoption of high yielding technology.

As cultivable land resources are limited, increased agricultural production can only be attained in most countries of the world through increased yields per unit area of land and improved preservation of already produced commodities. Technological inputs must be applied wisely, to economically bring about the desired increased outputs of production. Mechanization is one of the critical inputs of production and preservation of food crops. Mechanization can increase yields through the improvement of water control, better soil preparation for planting, more efficient weed and insect control and the proper harvesting, handling, drying, storing and processing of food, feed and fiber crops. So that, agricultural mechanization is the art and scientific application of mechanical aids for increased production and preservation of food and fiber crops with less drudgery and increased efficiency.

Mechanization in Indian agriculture was over emphasised since Green revolution onwards, due to timely completion of operations in HYVs cultivation. Because of this reason substitution took place from traditional equipment to modern machines. However, increasing in application of machines, leads to not only much

capital costs in agriculture production but also it noticed over demand for energy inputs. On the whole it was observed that, inputs demand increased drastically from 1970/71 onwards. On the other hand agricultural machinery and power consumption was very much impressive, i.e more over a period of time. This indicates that, there will be a greater demand for energy sources in near future. The present section will talk about the nature of agriculture machinery and implements (mechanization) in Indian agriculture with respect to selected states, its demand over a period of time, and also look at the substitution possibilities of different agricultural equipment.

It was observed from the analysis that, substitution between agricultural equipment, i.e less efficient to more efficient took place from 1966/67 to 1991/92 in Indian agriculture. For example, the number of wooden ploughs were declining, where as iron ploughs raised at faster rate. With respect to sugarcane crushers run by bullocks were replaced by sugarcane crushers run by power. In case of oil and electric pump sets, number of oil pump sets engaged in agriculture declined, where as electric pump sets raised at faster rate. The tractor population has also noticed to be highest in U.P next comes Punjab, Tamil Nadu, A.P, Bihar, and West Bengal respectively. The lowest tractor population was noticed in West Bengal, where still traditional agriculture exists. Interestingly, comparative analysis between two factors such as labour and tractors showed that, except Punjab all other states have showed positive relation, such that introduction of tractors did not affected the labour force participation. Where as Punjab has noticed a declining trend in labour force participation in

agriculture production. On the other hand still Bihar and West Bengal are depending much on traditional type of equipment, due to institutional set up.

7.4 FERTILIZER AND PESTICIDE CONSUMPTION IN INDIAN AGRICULTURES

Fertilizers play a vital role in the modern agriculture technology. Use of fertilizers in increasing food production was conspicuous during the last two and a half decades where the consumption of nutrients N, P, and K increased from 0.78 million tones(1965-66) to 10.3 million tones (1988-89). During this period the food grain production also increased to over 170 million tones from a level of 73 million tones. The projected food grain requirement of 240 million tones by the turn of the century is to be achieved mainly through fertilizer use and improved farm technology.

The introduction of HYVs in Indian agriculture from 1966 onwards, gave path to much demand of inputs. So that, it is very much essential as foremost discussion to identify the area under high yielding varieties, which again will provide a path to identify the nature of fertilizers and pesticides demand in Indian agriculture.

Several studies are available which attempt (1) to estimate the contribution of fertilizers to increased agricultural output over time or (2) to estimate the proportion of agricultural output which is accounted for by the fertilizer input. In general, the developing countries have only a small proportion of total food

output attributable to fertilizer use, but the contribution of fertilizer to subsequent increases in output is much higher. A more balanced relationship exists within most developed countries. The contribution of fertilizer depends heavily upon the sources of increased output-increased area brought under cultivation or increased yield per hectare cultivated. Although fertilizer applications may be necessary to bring new land under cultivation, its major influence acts through the yield-increasing component.

The commercial energy required to produce a pesticide can be substantial. The raw materials for modern pesticides mostly come from the petrochemical industry, and further inputs of energy are required in manufacturing. Thus pesticides are the most energy intensive agricultural input. Nevertheless, continued growth in the use of pesticides appears unavoidable. Their expanded use is particularly needed in developing countries, where crop loss(both pre- and post harvest) because of inadequate pest control are very large. The declining share of world pesticide use projected for the developed countries probably mainly reflects environmental concerns.

Nitrogen being an energy intensive and costly nutrient, it becomes necessary to plan for scientific and efficient use of nitrogenous fertilizers. The nitrogen requirements for different for different crops and varieties under various agro soil-climatic situations, promotion of efficient fertilizer materials, complementary use of organic , in-organic and biological sources of nitrogen, and a sound technology transfer programme should form essential components of the strategy to promote efficient use of

nitrogenous fertilizers.

In the scenario of agricultural modernization, fertilizers and pesticides are the important inputs to lift the agricultural production to larger extent. The former will act as a direct input in production, the later act as a external factor which decide the level of production. At the same time much energy can be consumed in the production of this inputs, which again used at higher level in the agricultural production in recent years. Higher consumption of fertilizers and pesticides accounts for large energy demand in agriculture sector. Due to this in the last two decades agricultural sector is experiencing high demand for energy resources.

Fertilizers absorption from soil can differ from crop to crop according to its biological structure. As we know the legume crop will demand less amount of fertilizers compared toother crops such as rice, wheat, jowar, sugar cane and cotton. According to ICAR (1987), fertilizer absorption can differ from crop to crop and region to region due to soil differences.

On the whole it is observed that, the rate of phosphate and potassium increasing at faster rate in Indian agriculture. But according to this study it has been observed that, the soil which have abundant potassium will demand less potassium, where as the soil which had scarce potassium demands more amount of potassium.

Fertilizer consumption is steadily increasing in Indian agriculture over a period of time. Due to this demand for

fertilizers increasing at faster rate in India. Especially chemical fertilizers consumption is increasing at faster rate than farm yard manures, in which chemical fertilizers will **give** immediate results in agricultural production.

Fertilizer consumption differs from state to state, according to their requirements and utilisation pattern under different crops. On the other hand soil differences between state to state will also influence the consumption of fertilizers.

Per hectare consumption of fertilizers are differing from state to state over a period of time since last two decades. Fertilizer consumption per hectare is one of the important component for deciding yield rate in agriculture production. Theoretically as *Recardo* said, land have original and indestructible powers, which have been slowly declined in recent years, due to over exploitation of land resource. To compensate this fertilizers came in to exist, so that much amount of fertilizer consumption pave a path to declining in yield structure in Indian agriculture.

Adoption of HYVs technology gave a path to much increase in pesticide demand in Indian agriculture, due to increase in plant diseases. To remove this pest problem pesticides and insecticides demand has been increased at larger extent over a period of time. As discussed above, pesticide production demands larger amount of energy, which again used in agricultural production. This shows a **clear** indication of energy demand in Indian agriculture.

7.5 ENERGY DEMAND AND ENERGY INTENSITIES IN INDIAN AGRICULTURE:

The demand for energy in agriculture is depends on a variety of factors such as, rate and pattern of agricultural growth and cropping pattern, cropping intensity, the development of agricultural technologies, efficiencies and economics of energy utilisation, government policies, agro-climatic conditions, and inter and intra farm variabilities in relation to levels of technologies applied to various crops.

Agriculture is the business of capturing solar energy in growing plants and using the light, organisms sustained by that energy to produce food and fiber needed by human beings. Like most other aspects of alternative energy in agriculture, energy-efficient cropping is a long-range proposition. At least, it is for roost commercial farmers. There are short-term ways to conserve energy in crop production, irrigation, harvesting, and crop processing. But, for the most part, this involve trade-offs. Either production is decreased for all or part of the acreage of a substantial investment in alternative energy system is required to maintain production currently achieve by impact of purchased energy.

The main conclusions were drawn in this study are, In choosing among energy sources and uses for the rural areas of developing countries, we are concerned with scarce resources and their most economical allocation, both the natural resources of land, water, fertilizers, metals, and fuels, and the human resources of capital, labour, human energy etc. A second need for

new sources of energy is to reduce costs. The most expensive form of energy is human energy, as can easily be seen if we consider how much food it takes to keep a man going at hard manual labor. Animal energy is also expensive. Consider for example the opportunity costs of feeding bullock. A farmer can use part of his land to grow fodder for his bullock, but he could grow wheat or rice or corn on that same land.

According to this study, Any energy source for developing countries at the present time should be manpower-intensive rather than capital-intensive. Its development should use people rather than capital because people are less expensive and more abundant than capital in most less developed countries.

The rate of energy consumption by different resources can be differ from crop to crop, due to the operations involved in crop production. Energy consumption in agriculture sector under principal crops was classified in to direct and indirect energy sources, depends on the replenishment. So that, human, bullock, seeds, and FYM can be treated as renewable energy sources, where as electricity, diesel, fertilizers, and farm machinery considered as non-renewable energy sources. Energy consumption by different sources were increasing at faster rate in Indian agriculture. Especially since 1966 onwards, the rate of energy consumption was very much high, which accounts more than 20 % in all resources.

The source wise average energy consumption under six crops considered here has witnessed interesting observations. Rice crop is demanding highest energy in the form of diesel, next comes to

fertilizers, electricity, and human labour. In case of wheat, highest energy consuming from fertilizers, next to diesel, seed, and human labour. In case of jowar, much energy used in the form of diesel, next comes to electricity, FYM, fertilizers, and human labour. Interestingly groundnut noticed highest energy from Farm Yard Manure, later comes to fertilizers, human labour, and diesel. Cotton crop demanding much energy from fertilizers, next to diesel, human labour, and seed. Where as sugarcane noticed greater energy from seed, later comes to diesel, FYM, fertilizers, and human labour.

On the whole it was observed that, sugarcane demanding highest energy per hectare, next comes to rice, groundnut, jowar, wheat, and cotton respectively. Regarding states wise picture showed that, with respect to Andhra Pradesh rice was demanding much energy, later comes to groundnut, cotton, jowar, and sugarcane. Bihar recorded highest energy demand in rice, next comes to wheat, and sugarcane respectively. Where as Punjab noticed highest energy in rice, next comes to wheat, sugarcane, and cotton. Tamil Nadu was witnessed much energy demand in rice, later comes to groundnut, sugarcane, and jowar respectively. In case of U.P, rice is demanding higher energy, which follows sugarcane, wheat, and jowar. West Bengal was recorded highest energy demand in rice, later comes to wheat, and sugarcane respectively. All India level picture showed that, rice was demanding higher energy, next comes to sugarcane, wheat, jowar, **and** cotton respectively. It is clearly indicating from the above analysis that wet crops like rice and sugarcane demanding higher **energy** while comparing with other crops.

Based on regression analysis, a relation was established between output, land, labour, draught power, oil engines, electric engines, tractors, fertilizers, pesticides, energy, and rainfall, to know the production relations between the inputs. The empirical results showed significant relationship with respect to output under selected crops and states. Inverse function was estimated for energy demand, to understand the very nature of energy role in production.

It was observed that the relationship between output and energy showed significant in some crops such as cotton, groundnut, but where as in case of rice and sugarcane it was negative relation. It is often true that even though rice and sugarcane crops are more energy intensive, but due to lack of better irrigation as well as rainfall, the relation between energy and output showed negative for above said crops. It indicating that concentration on wet crops without providing enough water leads to less yields, which reflect the production with more demand for energy, leads to negative relation. To remedy this situation alternative food crops production has very much essential in Indian agriculture, which demands less water as well as energy inputs.

7.6 POLICY RECOMMENDATIONS:

After examining the energy demand in Indian agriculture with respect to selected states, one can come to the conclusion that, though the existing system of agriculture is fulfilling the basic

need of the country, i.e food frontier, there were enough variations among the states. The main reason is that, the Government is certainly concentrating on intensive agriculture in order to fulfill the required amount of food grains for public utilization. Because of this concentration on intensive agriculture belts a lot of variation between one region to another region is noticed. Keeping this idea under consideration, some drastic steps are needed in order to eliminate energy demand variations among states. Some in depth steps can be suggested to counter this problem of energy demand variations between states in the near future. Those are as follows..

(a). First and foremost, concentration on wet crops are creating more pressure on water, fertilizers, pesticides, and other inputs. So, the policy should be to encourage alternative food grains, which demand less amount of water and other inputs.

(b). Yield level is not uniform in selected states and all India. To remove this problem, conducting demonstrations to the farmers for improving skills in application of various inputs is required. So, that yield level can be maintained properly among the states. Here Government should take some initiative step to improve the management skills for farmers.

(c). Cropping intensity is changing over a period of time in Indian agriculture. Due to this agriculture production become volatile in every alternative year. Cropping intensity can be improved by encouraging investments in agriculture sector for **constructing** new irrigation projects, which will boost the area

under irrigation in Indian agriculture.

(d). Government price policy towards various crops should be reexamined. It should encourage alternative food crops, which can reduce demand side pressure on energy in Indian agriculture in near future.

(e). Supplying of public owned agricultural machinery and implements to the backward states at cheaper prices. This should prevent the energy demand variations and input burden in agriculture sector in selected states and all India.

(f) Rainfall is almost volatile in every alternative year in Indian agriculture. Due to this concentration on ground water irrigation is increasing for meeting the water requirements to wet crops cultivation. Because of this problem use of energy resources drastically increased in recent years. To overcome this problem encouraging alternative dry land crops is very much essential in near future for maintaining balanced growth in Indian agriculture.

(g). It can be observed that, increasing production through modern agricultural technology will always demand more energy resources in Indian agriculture. For that the encouragement of alternative energy sources such as solar, wind, and some traditional sources of energies are acceptable alternatives for meeting the future challenges.

(h). Finally, the most important recommendation to the Government policy makers is that, one should take some policy measures to

encourage the consumption of alternative food grains by existing population. This will reduce the more pressure on important cereal crops, such as rice and wheat, which demands larger amount of water as well as inputs. As stated by *Foreign Economists*, when the researcher visited for interaction on subject mater, she told that "solving food problem in Indian is difficult task". In the sense that each and every Indian(irrespective of their income) will consume much amount of rice and wheat without concentrating on any other alternative cereal crops. This is the important reason in the sense that, Indian agricultural facing draught conditions in every alternative year, this reflects less agricultural production, even though much amount of energy is consumed. Due to this reason it is suggested that, concentration on dry land crop cultivation is very much essential to meet the requirements of the existing population. This indicates, in near future Indian agricultural production and food consumption will concentrate on alternative food grain crops such as Bajra, Oats, and Jowar. This is a good symptom, in the sense that dry land crops will demand less amount of energy resources while comparing with wet crops. This type of policy implementation may solve the problem of food as well energy crisis in Indian agriculture.

(i). It has been noticed that, the most serious resources deficiency likely to diminish the prospects for bridging the gap between potential and actual farm yield will be energy. Apart from steps such as enhanced efficiency in energy conservation and use, and improved biological nitrogen fixation, the following are the other possible strategy measures.

1. Find un-discovered fuel resources.
2. Fully exploit renewable energy resources like bio-gas and biomass and hydel, and wind power.
3. Step up R & D efforts in solar energy harvest utilization, and
4. Develop nuclear power as a major source of energy.

Thus by considering the above mentioned recommendations, the energy demand variations between states can be reduced. At the same time the irrigation facilities have to be improved to fulfill the basic need of the country. Alternative energy sources like solar, wind, and other non-conventional etc., should be explored, so that the energy demand in future should be in a balanced manner.

7.7 LIMITATIONS OF THE STUDY:

The present study was under taken with the view to examine the energy demand in Indian agriculture along with selected states. There are some drawbacks or limitations in the present study, which can be stated, in the following manner,

(a). The data used in this study was collected from Government records, which may be considered as reliable in this respect. But a primary survey may be a better alternative even though it has some limitations.

(b). In India there is no institution providing basic data relating to the crop wise energy demand. Here the crop wise energy demand values are taken from ICAR(1988) project reports. This is

generally considered as reliable in this study. An individual survey in this regard is more preferable.

7.8 DIRECTIONS FOR FUTURE RESEARCH:

In sum, the researcher identified certain areas in which future research has to be streamlined and geared. In the first place there always exists a growing gap between the micro level studies and macro level studies. Here nearly 80 % of the research has been conducted at the micro level, which is not in conformity with the aggregate macro level observations. To bridge the gap, future research work has to be reoriented and channelised with a view to derive more realistic and pragmatic results.

Secondly, this study has identified that the Post Green-revolution symptoms certainly manifest that the energy consumption might more than 20 %, which may increase future, Hence the logical conclusion that one derives is that though our energy resources are much more efficient, we are unable to reap the desired fruits of benefits due to the vagaries of monsoon with unpredictable and uncertain water availability.

Thirdly, almost all the studies hypothesized that there exists a direct relationship between energy demand and food production. As diametrically antagonistic to their views our present study has established that the direct relationship has been falsified in case of certain crops, especially in case of wet crops like rice, sugarcane, etc due to draw backs in yield.

Finally, there exists some structural imbalance between energy demand and yield(productivity), The reason behind this is that through our energy system seems to be much efficient, it has been proved to be inefficient which ends in fiasco owing to the prevailing unprecedented and unpredictable draught conditions.

Hence the future research should be streamlined and reoriented not on the basis of alternative energy sources but it should be organized on the basis of the alternative food crops which will be draught resistant by becoming a constant reservoir of energy in providing alternative food grains to the teeming millions of people, which confront draught conditions every now and then. This will serve our two fold purposes of energy requirements as well as food supply.

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