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DEMAND AND SUPPLY
PROJECTIONS FOR
AGRICULTURAL
COMMODITIES

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DEMAND AND SUPPLY
PROJECTIONS
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DEMAND AND SUPPLY PROJECTIONS FOR MAJOR AGRICULTURAL
COMMODITIES IN PUNJAB

S. S. Johl and J. L. Kaul

I

Demand Projections

The process of economic development often brings about discernible changes in the demand for agricultural products, which affect the very nature and extent of their flow from farms to the consumers. If this flow is impeded or gets distorted, national growth may be greatly hampered. It is, therefore, essential to have reasonably accurate estimates of requirements of agricultural products, especially food products over the planned periods of development.

In this exploratory study the magnitudes and changes in food demand are investigated for the State of Punjab, as they would be at the end of the 4th, 5th and 6th plan periods. Estimation of demand for food can be made from two angles: (1) based on future requirements arising out of growth in population and increased per capita income as a result of planned development, (2) based on future requirements from the nutritional point of view. In this study the former approach has been adopted to estimate the effective demand for various food products. Such demand projections are based on past trends, current outlook and future possibilities in respect of quantity, quality and mix of the products consumed.

The manner in which per capita food consumption increases with economic development can be expressed in the relationship $d = g\eta$, where 'd' is the rate of growth in per capita food consumption, 'g' the rate of

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growth in per capita income \propto the elasticity of demand for food associated with changes in income. Each of these relevant variables is subject to different weights. The rate of per capita income growth might vary depending upon population growth affected by the birth and death rates, the success of the family planning programmes, as well as the overall growth of the national product. Similarly, the income elasticity of demand is dependent upon base period consumption, changes in consumption habits, customs and tastes over time and relative price levels of different commodities. Nevertheless, under certain reasonable assumptions, some logical bases can be built up at the macro level by utilizing available data on consumption expenditure, physical consumption and population. For this attempt to estimate the future requirements in respect of foodgrains, fruits, vegetables and milk products for the State of Punjab, at the end of the 4th, 5th and 6th five-year plans, the data are drawn from different sources: (1) base period per capita consumption levels of food products as estimated by N.S.S. in the 19th Round Enquiry¹ and (2) the official statistics of Punjab State for population, per capita income, etc.²

Population projections are usually based on a few vital assumptions such as those relating to fertility, mortality and migratory factors in particular and the impact of socio-economic development in general. The changes taking place in any or all of these factors will bring about accompanying changes in the population structure in the years to come. Long term growth trend in population cannot be estimated accurately for Punjab based on past data and performances, as this State has been

1. The data of 19th round is as yet being processed in the Board of Economic Enquiry, Punjab.

2. Statistical Abstract of Punjab, 1968.

seriously affected by partition, reorganization, the recent bifurcation and also by the impact of the conflicts with the China and Pakistan during the last two and half decades. Through the period 1951-61 population of the State grew at a rate of 2.3 per cent per annum³. This rate is believed to have increased further after 1961, and in the year 1968 it is estimated to be between 2.5 and 2.6. Further, in spite of the intensive family planning efforts, the population growth in the State is not likely to get stabilized in the near future. We have adopted 3 alternative population growth estimates for use in our demand estimates as in Table I.

Table 1

Growth Rates Used for Estimating Population Projections in Punjab 1965 through 1983

Year	Growth rates used		
	Alternative I	Alternative II	Alternative III
1965	2.4	2.4	2.5
1968	2.5	2.5	2.6
1973	2.6	2.6	2.7
1978	2.6	2.7	2.8
1983	2.5	2.7	2.8

The most conservative projection (alternative-I) is based on the assumption of a moderate growth rate which gets stabilized after a decade and then slowly starts declining. The second estimate (alternative-II) is based on the assumption of a moderate growth rate getting stabilized comparatively late. The third estimate (alternative-III) is based on the assumption of a high growth rate getting stabilized late. Table II shows population projections based on these three alternative assumptions.

Table II

Population Projection for Punjab with Different
Growth Rate Assumption 1965-1983

Year	G.R.	Situation I		
		Population		
		Rural	Urban	Total
1961	-	85,67,763	25,67,306	1,11,45,069
1965	2.4	91,86,432	30,62,144	1,22,48,576
1968	2.5	98,84,600	32,94,867	1,31,79,467
1975	2.6	1,12,48,675	37,49,558	1,49,98,233
1978	2.6	1,28,00,992	42,66,997	1,70,67,989
1983	2.5	1,44,77,921	48,25,974	1,93,03,895

(Contd. below)

Year	G.R.	Situation II		
		Population		
		Rural	Urban	Total
1961	-	85,67,763	25,67,306	1,11,35,069
1965	2.4	91,86,432	30,62,144	1,22,48,576
1968	2.5	98,84,600	32,94,867	1,31,79,467
1975	2.6	1,12,48,675	37,49,558	1,49,98,233
1978	2.7	1,28,57,235	42,85,745	1,71,42,980
1983	2.7	1,46,95,819	48,98,606	1,95,94,426

(Contd. below)

Year	G.R.	Situation III		
		Population		
		Rural	Urban	Total
1961	-	85,67,763	25,67,306	1,11,35,069
1965	2.5	92,19,837	30,73,279	1,22,93,116
1968	2.6	99,57,424	33,19,141	1,32,76,565
1975	2.7	1,13,81,335	37,93,778	1,51,75,114
1978	2.8	1,30,65,773	43,55,258	1,74,21,031
1983	2.8	1,49,99,507	49,99,836	1,99,99,343

Actual growth rate of Punjab population has been 2.3 over the period 1951-61.

The estimates of Director of Economics & Statistics, Punjab show higher population estimates at 1,36,10,856 in 1968. This is due to growth rate of 3.1 assumed by them for the period 1961-66 and 2.90 for 1966.

Further a breakdown in the rural and urban population was considered to be necessary, as per capita expenditure on different consumption items in rural areas differs significantly from that in urban areas, as will be shown later. The break up of rural and urban population is based on the assumption of a higher rate of growth in urban population because of migration from rural to urban areas, and also because some villages will get defined as urban areas (towns) as their population grows. The new agricultural technology, rapid farm mechanization and increasing industrialization are also likely to influence this trend. Thus the ratio of rural-urban population which remained stable at 77:23 through the period 1951-68 is assumed to become 75:25 during the period under reference.

Base Period Consumption

Estimates of the per capita consumption of different farm products in Punjab are available for the year 1964-65 from the N.S.S. 19th Round data. This forms the basis for our projections of consumption requirements in the future and also for working out the elasticity coefficients for different food items. Table III provides the estimated monthly per capita food consumption for Punjab, separately for the rural and urban sectors in the year 1964-65.

The composition of foodgrains consumed in the rural as well as urban areas in Punjab thus turns out to be predominantly wheat followed by maize and pulses. Consumption of grains and milk and milk products is generally higher in rural sector whereas consumption of fruits and vegetables is higher in the urban sector. It is interesting to note that base period (1964-65) consumption of cereals in Punjab is as high as one estimate of cereal consumption in India in the year 1983-84⁴. This suggests that the elasticity of consumption of cereals in the state should

4 S.K. Ray: Demand for Food in India 1968-69 to 1983-84.

Table III

Estimates for Average Monthly Per Capita Consumption of Various Commodities (Kg./month) for Rural and Urban Areas in Punjab in the base period 1964-65

Items	Rural	Urban
Rice	0.89	0.51
Wheat	11.42	9.92
Maize	2.01	1.16
Other cereals	0.38	0.13
Total cereals	14.70	11.72
Pulses	1.04	0.88
Foodgrains	15.74	12.60
Fruit and vegetables	2.23	3.07
Milk and milk products	5.90	4.20

be very low, may be zero, in the future.

Estimates of Per Capita Income

Per capita income projections depend upon the rate of growth of population and the overall growth of National Income. Bases for population projections have been discussed already in the earlier section. On the basis of the investments proposed in the Fourth Five-Year Plan, the total income of the State is expected to go up by 6.7 per cent per annum (compound) as against 5 per cent of the country as a whole. But the past performance does not seem to justify this high growth rate. State income at 1952-53 prices increased at the rate of 3.7 per cent during the period 1952-53 through 1960-61. It grew at a rate of 4.8 per cent per annum during the period 1960-61 through 1965-66. The corresponding rates of growth of income for the country as a whole were 3.8 and 4.2 per cent respectively at 1948-49 prices. The consistently higher rate of growth

of the State's income compared to the all-India income, provides justification in assuming a higher rate of growth of State income in the years ahead. Consequently, in this analysis, we assume state income to grow at the rate of 6% per annum during the Fourth Plan period, 7 per cent during the Fifth Plan period and 8 per cent during the Sixth Plan period. In view of the vast economic potentiality of the State, we do not presume the rate of growth of the State's income to slacken in at least the coming two or three decades⁵.

If these assumed rates of growth of income are realised, projections of the disposable income will depend on further assumptions about the rate of domestic savings. Because of the difficulties involved in projections of disposable income, we have based our demand projections on per capita income and income elasticity coefficients. The estimates of per capita income for the rural and urban sectors are obtained from the following relations.⁶

$$Y_r = C Y_u$$

$$\text{and, } Y_u = Y/c_p_r + P_u$$

where Y_r = per capita income for rural sector

Y_u = per capita income for urban sector

P_r = Population in rural sector

P_u = Population in urban sector

Y = Estimate of aggregate income

C = Ratio of per capita expenditure for the rural

5. In any case, the assumed rates of growth are only rough estimates, and we do not propose to be rigid about them.

6. These formulae have been adopted from "Demand for Food in India," by S.K. Ray.

and urban sectors as obtained from the N.S.S. 19th Round (which worked out to be .86)

The projections of the State income and per capita income, so worked out separately for all the three situations and for rural and urban sector are shown in Table IV.

Estimates of Income Elasticities of Demand

The income elasticities of demand were worked out by fitting a double logarithmic function, i.e., $\log y = \log a + b \log x$, where the estimates of income elasticity are given by the parametre 'b'. 'y' stands for per capita consumption (in physical quantities) and 'x' for per capita disposable income. The elasticities were worked out for rural and urban sector separately, based on the data on consumption quantities and expenditure obtained from the National Sample Survey 19th round, 1964-65. The elasticities are given in Table V. With the passage of time, however, the elasticity coefficients might change depending upon the nature of the food products consumed and the current level of their consumption. The current level of per capita consumption of some of the products, such as cereals, is higher in the State as compared to India as a whole. One has, therefore, to be cautious while making use of fixed elasticities (of the year 1964-65 in this case) for such products. This is especially true for the products where the current consumption level is high and income elasticity also works out to be high in the base period 1964-65. We have, therefore, assumed somewhat different income elasticities for such products while projecting per capita demand. For example, our estimates for 1973-74 for cereals are 16.70 kg. per month for rural

Table IV

Projections of State and Per Capita Income at Constant Prices (1951-52) in Rural and Urban areas of Punjab

Year	State income (Rs. crores)	Situation I			Situation II			Situation III		
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
1965-66	532.1*	417.57	485.55	434.41	417.57	485.55	434.41	415.91	483.62	432.84
1968-69	636.70	464.18	539.75	483.09	464.18	539.75	483.09	460.79	535.81	479.56
1973-74	852.00	545.85	634.72	568.06	545.86	634.72	568.06	539.49	627.32	561.44
1978-79	1195.00	672.76	782.28	700.14	669.81	778.85	697.07	659.12	766.42	685.90
1983-84	1755.00	873.59	1015.80	909.14	860.63	1000.74	895.65	843.20	980.47	877.53

* Actual as required in statistical abstract of Punjab 1968. Total capital income as well as its break up in rural and urban per capita income have, however, been based on our population estimate as given in Table II.

Table V

Income Elasticities of Demand

Item	Rural	Urban
Wheat	.5176	.3383
Maize	-.0845	-.2574
Rice	.0593	-.2951
Cereals	.5950	.2882
Pulses	.43251	.3408
Foodgrains	.4433	.2785
Fruit & vegetables	1.0700	.9500
Milk	1.5100	.7092

sector in case of income projections given by situations I and II in Table IV and 17.29 Kg. per month in case of situation III. The estimated per capita consumption for urban sector for the same period is 12.50 Kg. per month in case of situations I and II and 12.72 Kg. in case of situation III. For rural sector this is the maximum average consumption of cereals (17.29) that can be achieved. Even this is too high. At such a high level of cereal availability, the consumption pattern would change in favour of more protective foods and increased production of cereals would be diverted to feeding animals. If, however, we project further with the same income elasticity, the estimated per capita demand would work out between 26 and 28 Kg. per month for 1978-79 and 1983-84 respectively which are absurd figures. We, therefore, make an assumption of zero elasticity for total cereals, for rural sector, from 1973-74 onwards. Since maize consumption shows negative income elasticity, this permits other cereals (especially wheat) to keep increasing. But by 1978-79 even the income elasticity of demand for wheat should go down to zero.

In using these elasticity coefficients for demand projections it is further assumed that the structure of population, its occupational sub-divisions, as well as the relative prices of agricultural commodities (food products) will remain unchanged over the period of projection. The assumption is not very unrealistic, as the demand for agricultural commodities is less susceptible to changes due to high degree of stability in tastes and habits of the people over a short period of time, i.e., a decade or so. To the extent, however, such changes do take place, the elasticity estimates and demand projections will go wrong.

Estimated Demand for Selected Commodities

To estimate the aggregate demand for food items, the methodology followed is to estimate the per capita

consumption in the rural as well as urban sector and to multiply it by the corresponding projected population at the end of the projected period. The estimate of per capita demand for each item, both for the rural and urban sectors, for all the three situations are determined by using the relationships:

$$d_{it} = \frac{d_{io}}{Y_o} (Y_o + e_i (Y_t - Y_o))$$

where d_{it} = consumption demand for i th commodity in the year t

d_{io} = consumption demand for i th commodity in base period

Y_o = per capita income in the base period

Y_t = per capita income in t period

e_i = Income elasticity coefficient

The projected per capita demand for the selected commodities worked out with the method described above is presented in table VI (i), VI(ii) and VI (iii) for the three alternative population situations and for rural and urban sectors separately.

As noted earlier, the Punjab is already at higher level of cereal consumption than the country as a whole. During the two decades since 1964-65 the per capita consumption of cereals is therefore estimated to increase to 16.70 and 15.06 kg. per month for rural and urban sector respectively for situation I, to 16.78 and 15.30 kg. per month for situation II, and 17.29 and 15.19 kg. per month for situation III from the base period consumption of 14.70 and 11.72 kg. per month for rural and urban sector respectively. Punjab is a mainly wheat eating region, where wheat forms about 80 per cent of the total

Table VI (i)-

Per Capita Consumption Demand for Different Food Items (kg./month)

SITUATION I

Item	1964-65		1968-69		1973-74		1978-79		1983-84	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Rice	.89	.51	.90	.53	.91	.55	.92	.60	.95	.67
Wheat	11.42	9.92	12.08	10.29	13.23	10.81	14.03	11.97	14.03	13.58
Maize	2.01	1.16	1.99	1.13	1.96	1.08	1.76	0.98	1.70	.83
Cereals	14.70	11.72	15.68	12.05	16.70	12.50	16.70	13.51	16.70	15.06
Pulses	1.04	0.88	1.09	.91	1.18	.96	1.21	1.06	1.53	1.17
Foodgrains	15.74	12.60	16.77	12.96	17.88	13.46	17.91	14.57	18.23	16.23
Fruits and vegetable	2.23	3.07	2.50	3.39	2.96	3.84	3.69	4.85	4.83	6.25
Milk and milk products	5.90	4.20	6.89	5.03	8.64	6.19	11.34	8.77	15.63	12.36

Table VI (ii)

Per Capita Consumption Demand for Different Food Items (kg/month)

SITUATION II

Item	1964-65		1968-69		1973-74		1978-79		1983-84	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Rice	.89	.51	.90	.53	.91	.55	.92	.60	.95	.67
Wheat	11.42	9.92	12.08	10.29	13.23	10.81	14.09	11.95	14.09	13.46
Maize	2.01	1.16	1.99	1.13	1.96	1.08	1.86	0.98	1.73	0.84
Cereals	14.70	11.72	15.68	12.05	16.70	12.50	16.78	13.76	16.78	15.30
Pulses	1.04	0.88	1.09	.91	1.18	.96	1.31	1.06	1.51	1.30
Foodgrains	15.74	12.60	16.77	12.96	17.88	13.46	18.00	14.82	18.29	16.60
Fruits and vegetable	2.23	3.07	2.50	3.39	2.96	3.54	3.67	4.83	4.76	6.16
Milk and milk products	5.90	4.20	6.89	5.03	8.64	6.19	11.28	8.71	15.35	12.13

Table VI (iii)

Per Capita Consumption Demand for Different Food Items (kg/month)

SITUATION III

Item	1964-65		1968-69		1973-74		1978-79		1983-84	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Rice	.89	.51	.90	.53	.91	.55	.92	.60	.94	.66
Wheat	11.42	9.92	12.06	10.28	13.18	10.91	14.37	11.88	14.37	13.37
Maize	2.01	1.16	1.93	1.13	1.96	1.07	1.89	.91	1.84	.85
Cereals	14.70	11.72	15.64	12.08	17.29	12.72	17.29	13.69	17.29	15.19
Pulses	1.04	0.88	1.09	.91	1.17	.97	1.30	1.05	1.50	1.19
Foodgrains	15.74	12.60	16.75	12.90	18.46	13.70	18.50	14.74	18.79	16.38
Fruits and vegetable	2.23	3.07	2.49	3.38	2.94	3.93	3.62	4.77	4.68	6.06
Milk and milk products	5.90	4.20	6.86	5.01	8.55	6.42	11.11	8.57	15.05	11.88

cereal consumption. Pulses are major source of proteins and form an important constituent of a balanced diet. But the projected trend of consumption of pulses does not show any significant increase. The largest increase, however, is likely to take place in case of fruits and vegetables and milk and milk products. For these two groups the consumption demand is likely to be more than doubled by 1983-84. Table VII provides the projected aggregate demand for selected items upto 1983-84 for all the three situations. separately based on different assumptions of population growth. Appendices 1 to 3 give the rural and urban breakdown of the corresponding estimates for all the three situations.

These projections throw up some interesting results on the consumption requirements for different items during the next three plan periods. As per the most conservative estimate (situation I) the total cereal requirement for consumption will increase from 23.36 lakh metric tons in 1968-69 to 37.73 lakh metric tons in 1983-84. For pulses the increase will be from 1.65 to 3.57 lakh metric tons. For all foodgrains demand will increase from 25.01 to 41.07 lakh metric tons during this period (almost double the quantity consumed in the year 1964-65). Under situation II of population growth, the cereal requirements for consumption will increase from 23.36 to 39.58 lakh metric tons, pulses from 1.65 to 3.42 lakh metric tons and foodgrains from 25.01 to 43.01 lakh metric tons during this period. In the case of situation III of population projections, based on the assumption of a higher rate of population growth, the consumption requirements for cereals in 1983-84 would go upto 41.30 lakh tons and all foodgrains to 44.78 lakh tons. Demand for fruits and vegetables and milk and milk products will be almost three times the estimated demand for 1968-69.

Table VII

Aggregate Projected Demand for Different Food Items in Punjab

SITUATION I								
('000 metric tons)								
	Rice	Wheat	Maize	Cereals	Pulses	Food-grains	Fruits & vegetable	Milk and milk products
1964-65	116.88	1623.36	262.24	2051.04	147.00	2198.04	358.56	804.72
1968-69	127.68	1839.72	280.68	2336.32	165.24	2501.56	430.56	1016.16
1973-74	147.60	2272.20	313.20	2816.65	202.44	3019.09	574.28	1444.68
1978-79	172.08	2732.09	343.44	3257.08	240.14	3497.22	815.16	2190.96
1983-84	202.88	3199.93	366.00	3773.52	333.56	4107.08	1201.08	3431.16
SITUATION II								
	Rice	Wheat	Maize	Cereals	Pulses	Food-grains	Fruits & vegetables	Milk & milk products
1964-65	116.88	1623.36	262.24	2051.04	147.00	2198.04	358.56	804.72
1968-69	127.68	1839.72	280.68	2336.32	165.24	2501.56	430.56	1016.16
1973-74	147.60	2272.20	313.20	2816.65	202.44	3019.09	574.28	1444.68
1978-79	172.80	2779.04	344.12	3296.52	256.56	3553.18	814.63	2188.32
1983-84	204.88	3291.81	372.12	3958.48	342.71	4301.19	1201.56	3440.00
SITUATION III								
	Rice	Wheat	Maize	Cereals	Pulses	Food-grains	Fruits & vegetables	Milk and milk products
1964-65	117.24	1629.36	265.16	2058.60	147.48	2206.08	360.00	807.60
1968-69	128.64	1850.52	270.79	2349.96	166.44	2516.40	432.12	1019.28
1973-74	149.28	2296.80	316.32	2940.48	204.00	3144.48	580.44	1460.04
1978-79	175.56	2953.56	347.03	3526.36	258.72	3785.08	816.84	2189.88
1983-84	208.80	3478.68	382.18	4130.68	347.40	4478.08	1206.00	3451.68

Non-Human Consumption

Since per capita cereal consumption is high in the State and the increase in it is likely to level off soon due to the increasing incomes, consumption of milk and milk products, meat and eggs is going to increase appreciably during this period. Milk and milk products is estimated to increase more than 3 times over this period. This development suggests higher utilisation of grains, especially maize, as animal feeds. The efforts of the State Government in the direction of development of dairy and poultry industry in the State is likely to elicit a favourable response from the farmers. On the other hand, wastage of grains will be reduced due to development of better handling and scientific storage facilities. Seed requirements will remain almost unchanged as a percentage of total consumption. If at all, it might decline somewhat due to introduction of high-yielding varieties of crops, which have high production-seed ratio. However, it is difficult to exactly quantify the possible increase in all these items of the non-human consumption. All the same, the direction is clear, and it may not be very unrealistic to assume the following increase:

Period	Assumed non-human consumption as percent of human consumption
1964-65 to 1968-69	10
1968-69 to 1973-74	11
1973-74 to 1978-79	13
1978-79 to 1983-84	15

This trend, or at least the pace, might however get arrested, if due to heavier demand from outside the State, prices of foodgrains shoot up and it becomes relatively less profitable to convert the grains into milk, meat and eggs. At this point of time, however, the situation seems

Table VIII

Human, Non-human and Total Cereal Consumption in
the State of Punjab under Three Population
Situations 1964-65 through 1983-84

(in '000 metric tonnes)

Year	Human consumption			Non-human consumption			Total demand		
	S I T U A T I O N			S I T U A T I O N			S I T U A T I O N		
	I	II	III	I	II	III	I	II	III
1964-65	2051.04	2051.04	2058.60	205.10	205.10	205.86	2256.14	2256.14	2264.46
1968-69	2336.32	2336.32	2349.96	233.63	233.63	234.99	2569.95	2569.95	2584.95
1973-74	2816.65	2816.65	2940.48	309.83	309.83	323.45	3126.48	3126.48	3263.93
1978-79	3257.08	3296.52	3526.36	423.42	428.54	458.42	3680.50	3725.06	3984.78
1983-84	3773.52	3958.48	4130.68	566.02	593.77	619.60	4339.54	4552.25	4750.28

to be encouraging and it does not seem to be unrealistic to make these assumptions about non-human consumption of grains. The total cereal consumption on this basis will be as given in Table VIII.

Table IX summarizes the increase in the food requirements of the State in terms of percentage increase in total demand for various items during the next 15 years period, i.e., 1968-69 through 1983-84 indicating relative importance and shifts in importance of different items in consumers demand over this period.

Table IX

Percentage Increase in Consumers Demand
during 1968-69 through 1983-84

Items	Situation I	Situation II	Situation III
Rice	58.89	58.89	62.31
Wheat	73.99	78.92	87.95
Maize	30.71	32.58	41.13
Cereals	61.53	69.43	75.77
Pulses	101.86	107.40	108.72
Foodgrains	64.18	71.94	77.95
Fruits & vegetables	178.95	179.07	179.09
Milk and milk products	237.66	238.52	239.82

Amongst cereals, the maximum percentage increase in demand is thus noticed in case of wheat followed by rice and maize. Of all the items, demand for milk would record the highest percentage increase, about 2.38 times. Next highest increase is for fruits and vegetables with about 1.79 times increase in demand in the three alternative situations.

II

Supply Projections of Selected Agricultural Commodities

In this section an attempt is made to project the supply of major foodgrains⁷ in the State of Punjab as it would be at the end of the Fourth, Fifth and Sixth Five-Year Plan periods, i.e., 1973-74, 1978-79 and 1983-84. Four crops, i.e., wheat, maize, bajra and paddy have been considered in this study. These crops cover 79 per cent of the acreage under foodgrains and account for 90 per cent of the total foodgrain production in the State. All cereals together account for 91 per cent of the total foodgrains. This means 97 per cent of the cereal crop is accounted for by these four crops. Per cent share of cereals in total foodgrains production has increased from 76 per cent in 1960-61 to 91 per cent in 1967-68, as detailed below:

Year	Foodgrain production ('000 metric tonnes)	Cereal production ('000 metric tonnes)	Prod. of selected crops (wheat, maize, rice & bajra) ('000 metric tonnes)	Cereal as per- cent of total food- grains produc- tion	Selected cereal produc- tion as per cent of total food- grain produc- tion
1960-61	3198	2442	2390	76.3	74.7
1967-68	5368	4883	4732	90.9	88.1

Production of a crop depends upon the acreage under the crop and the yield per acre. Yield of the crop in turn

⁷ Supply here is taken as equal to production. The State being surplus in foodgrains, whole of the additional productions becomes supply in the absence of any sizable storage capacities with the farmers.

depends upon the use of several factor-inputs such as manures and fertilizers, irrigation, improved seeds, efficient control of diseases through plant protection measures, along with such other factors that are beyond the control of the farmer, viz., variation in rainfall, temperature, humidity, etc. In projecting the supply of these commodities only the controllable factors have been taken into consideration. Certain assumptions with regard to the direction and tempo of economic development, behavioural responses of the farmer to the price of the products and to the policies of the Government have been made. It is assumed that developmental investment in agriculture will continue at a trend rate and farmers will respond to price incentives and disincentives as they would affect the profitability of different crops. Since India has been facing acute shortages in foodgrains and is still importing, it is assumed that the Government policies will not turn the terms of trade unfavourable to the producer of foodgrains in India. Supply of foodgrains here has been assumed to be directly dependent upon the magnitude of the changes in the following variables:

- (i) Expansion of acreage
- (ii) Irrigation
- (iii) Fertilizer
- (iv) Improved seed
- (v) Control of diseases and insect pests.

Acreage

At present the extent of culturable waste land in the State is estimated at about 168 thousand hectares. Appendix 4 gives the details of culturable waste land in the State during 1950-51 through 1967-68. These data when plotted in graph (I) show two distinct slopes. The decline in culturable waste land was rapid during the period 1950-51 to 1962-63; thereafter the decrease is very slow and appears

to have almost ceased. We assume that the decrease in culturable waste shall follow the trend since 1962-63. The trend in culturable waste land for the period 1963-64 through 1968-69 can be represented by a straight line

$$Y = 192.4 - 4.6x$$

where Y refers to culturable waste land in '000 hectares and x refers to time period.

Based on this trend line we projected the culturable waste land at the end of each plan. This worked out to be as under:

	1973-74	1978-79	1983-84
Culturable waste land ('000 hectares)	141.8	118.8	95.8
Additional area that may come under plough ('000 hectares)	23.0	23.0	23.0

This gives us an estimate of the area that shall come under plough during this period.

This increase in cultivated area is not much and as such the main burden of increasing foodgrains production will be on the expected rise in per acre yield rate of the crops. Thus we need to estimate the changes that will be brought about in the yield increasing factor-inputs such as, irrigation, fertilizer, etc.

Irrigation

Indian agriculture has remained and shall continue to remain for a long time to come heavily dependent upon the vagaries of nature. Uncertain rainfall has been the major cause of droughts and floods causing failure of agricultural crops in the country. Hence the importance of assured and

timely water supply through irrigation in reducing the dependence of agriculture on nature cannot be denied. New high-yielding varieties of crops have a higher water requirement and need assured irrigation. In Punjab net sown area that is irrigated has grown from 53.8 per cent in 1960-61 to 57.3 per cent in 1967-68. The major sources of irrigation have been canals, tube-wells and other wells. While canals play an important role in providing irrigational facilities, it is admitted that the entire area of the State cannot be covered by the source of irrigation. There is in fact very limited scope for increasing the area under canals in future.

Punjab has large reservoirs of underground water suitable for irrigation purposes, except in a few pockets, such as parts of Bhatinda and Ferozepur districts. There is thus a tremendous scope of increasing tube-well irrigation in the State. It is all the more important to develop tubewell irrigation, because unlike canals it is a more assured source of irrigation. In Punjab large scale programmes for installing tubewells are being taken up and it is proposed to install 2 lakh additional tube-wells by the end of 1973-74. Presently some 70,000 tube-wells are in operation. The necessity of such an expansion in tube-well irrigation has been felt because of increasing requirements of water for the expanding acreage under high-yielding varieties of crops.

In fact, during the last decade, the expansion of irrigated area in the State has been due mainly to the increase in the number of tube-wells. The area irrigated by the canals has remained unchanged after reaching a peak in 1965-66. (See Appendix 5 & 6). On the other hand, there were almost six times as many tube-wells in 1968-69 as there were in 1960-61. The area irrigated per tube-well,

however, decreased. This is an indication of increase in the intensity of assured irrigation available per acre in the State which is a pre-requisite for growing crops of high-yielding varieties. Based on the trend line fitted to the area irrigated by wells as a function of number of tube-wells installed the following results were obtained:

$$A_T = 763.1066 + .00556N$$

where A_T indicates area irrigated by tube-wells in '000 hectares and N the number of tubewells installed. It was stated earlier that by 1973-74 2 lakh more tubewells are estimated to be installed in the State. This amounts to an increase of 1875 thousand hectares in the irrigated area of the State by the end of the Fourth Plan. (This compares well with the planned expansion of 1898 thousand hectares by the State Government during the Plan period). If this is achieved the net area sown irrigated will go up to 80 per cent of the total net area sown in the State by the end of 1973-74.⁸ With the likely increase in net area sown due to the cultivable waste land that will be put under plough, the area irrigated shall be about 79 per cent. It is provided in the Fourth Five-Year Plan that soil and water management work will be made obligatory in case of each tubewell installed, and special financial provisions will be made for the purpose. It is estimated that with this provision alone it will be possible to irrigate about 25 per cent of the additional acreage through the already existing water resources. There is therefore sufficient reason to believe

8. The calculations of net area irrigated as per cent of total net area sown have been made on the basis of present figures of total net area sown (3992 '000 hectares). The total net area sown is, however, likely to increase as is shown in section on acreage expansion.

that irrigation will not prove a serious constraint on the State's agriculture during the period under projection and the whole of irrigable land (by wells and tubewells) will be commanded by assured irrigation resources after the year 1973-74.

Fertilizers

Fertilizer is another crucial input for agricultural production. Consumption of fertilizers in the State of Punjab has gone up from 49,162 tonnes in 1961-62 to 5,45,256 tonnes in 1968-69 (Appendix 7). Taking into consideration the area under different crops and the probable area that will come under high-yielding varieties, the State has planned to raise the targets for application of nitrogenous fertilizers by about three times, phosphatic fertilizers by about eight times, and potassic fertilizers by about 20 times by the end of Fourth Five-Year Plan⁹. Surveys conducted by the Department of Agriculture in Punjab in 1963-64 have shown that on an average farmers apply less than 50 per cent of the recommended doses of fertilizer to all the foodcrops. This poses a problem of diffusion. Since this survey was conducted seven years ago and in the meanwhile new high-yielding crop varieties have been introduced with much greater profitability, it is quite reasonable to assume that the recommended doses will be applied upto 70 per cent by 1973-74, 80 per cent by 1978-79, and 100 per cent by 1983-84 in case of wheat, and upto 50 per cent by 1973-74, 75 per cent by 1978-79 and 100 per cent by 1983-84 in case of all other crops. On the crops other than wheat, a low percentage of recommended dose as compared to wheat is presently being applied.

9. Report on the Survey for Estimation of areas brought under improved agricultural practices, Punjab, 1963-64.

Improved Seeds

This variable is not assumed to pose any serious problem in the coming years in the extension of high-yielding programme. Even at present there is no shortage of seeds of improved variety. Surveys in Punjab¹⁰ have shown that farmers use the recommended quantities of seeds. It is therefore assumed that seed will not be a serious constraint on production programme, and in the year 1973-74 the recommended quantities and qualities of seed will be used by the farmers.

Plant Protection Practices

Cropping intensity in the State has been on the increase (Appendix 8). It has gone up from 117.67 in 1960-61 to 136.30 in the year 1967-68. With an emphasis on further increase in the cropping intensity, greater attention has to be paid to plant protection measures against pests and diseases. It is planned¹¹ to attain an annual target of seed treatment covering 12.7 lakh hectares under paddy, maize, bajra, groundnut, cotton, sugarcane, etc. Rat control measures will be extended to 13.3 lakh hectares whereas, 12 lakh hectares will be covered for the control of various pests in the areas that get seriously affected enblock.

All these measures shall go a long way in increasing yield per hectare of the crops. Therefore, the main efforts that shall account for raising total foodgrain production shall be through

- (i) Raising yield per acre
- (ii) Multiple cropping
- (iii) Increase in cultivated area.

10. Ibid

11. Draft Outline of Fourth Five-Year Plan, Punjab.

We now proceed to project the production of crops one by one. We shall, of course, have to make some assumptions that should appear reasonable under the set of conditions already explained. Projections here are made at three different levels corresponding to different sets of assumptions at each level.

Case I

This may be taken as a very conservative estimate. It has been assumed here:

1. That total area under crops shall not change over the projection period and only the distribution of this area under high-yielding varieties and local varieties will change.
2. That the level of inputs (fertilizer, seed, etc.) shall not change during this period and will remain at the current level. This implies that the average yield per acre of high-yielding varieties and local varieties shall remain constant during this period.

Case II

The first two assumptions have been allowed to be relaxed. It has been assumed:

1. That area under crops will grow and this increase shall be possible only through the reduction in culturable waste. This newly cultivated area will be distributed among the different crops in the same proportion as the current cropped area.
2. That the level of fertilizer application shall also change over this period. It has been assumed that the level of application shall change as already explained earlier.

Case III (Wheat only)

Fertilizer usage and the expansion of cultivated acreage remaining the same as in case II. An additional assumption made here is that the entire area under gram crop which competes with wheat will be put under wheat as it comes under the assured irrigation.

With these assumptions we proceed to project the production of each crop.

Wheat

During the year 1968-69 the area under wheat has been estimated at 2063 thousand hectares of which 1194 thousand hectares was under high-yielding varieties (Table X) and the rest, i.e., 869 thousand hectares under local varieties. Of the total area under wheat more than 70 per cent was irrigated. High-yielding varieties occupied about 60 per cent of the total area under wheat. It is envisaged that by the end of Fourth Five-Year Plan the area under high-yielding varieties shall be as much as 1418 thousand hectares¹² out of the total expected area under wheat of about 2000 thousand hectares, i.e., roughly about 70 per cent. Since the present area under wheat is more than what is envisaged to be at the end of Fourth Five Year Plan, we have assumed that the area under high-yielding varieties shall be 70 per cent of the present area and shall grow to 85 per cent at the end of the Fifth Plan and to 95 per cent at the end of Sixth Plan, leaving a margin of 5 per cent to other varieties.

Average Yield

Farm management surveys being conducted in Ferozepur district recorded the following average yields (quintals per hectare) for Mexican (i.e., high-yielding) varieties and local (desi) varieties for two years.

<u>Year</u>	<u>Mexican</u>	<u>Local</u>
1967-68	29.92	18.73
1968-69	22.46	13.63
<u>Average</u>	<u>26.19</u>	<u>16.18</u>

12. Target set in Fourth Five-Year Plan of Punjab

The ratio between Mexican and desi varieties range between 160:100 — 165:100. This shows that on the average Mexican varieties yield 60 to 65 per cent more than local. The average yield of the State has been estimated to be 21.77 quintals per hectare. This includes high-yielding and local varieties both. Knowing area under high-yielding varieties and local varieties we apportioned this yield into Mexican and local in such a way that it bears the ratio 162.25:100¹³. With this the yield worked out to be 26 quintals per hectare of Mexican and 16 quintals per hectare of desi. Under the assumption of constant technology the average yield for the State was thus taken to be 26 and 16 quintals per hectare for the period under projection. Holding the input use constant as assumed under case I the production projection worked out to be as shown in Table X.

Table X

Projections for Wheat Productions in Punjab

	1968-69	1973-74	1978-79	1983-84
Area under wheat ('000 hect.)	2063	2063	2063	2063
Area under H.Y.V.(Wheat) (")	1194	1444	1753	1960
Area under local varieties (")	869	619	310	103
Av.yield H.Y.V.(qtls./hec.)	26	26	26	26
Av.yield local varieties (qtls./hec.)	16	16	16	16
Fertilizer application	Same as is being used at present level.			
Production ('000 tonnes)	4494.8	4744.8	5053.8	5260.6

13. This is done as follows: Let the yields be 162.25 x and 100 x for Mexican and desi respectively.

Then $162.25 \times (\text{area under H.Y.V.}) + 100 (\text{area under desi}) = \text{yield}$

Total area

Solution gives value of x and hence yield of Mexican and desi bearing the given ratio.

Under these conservative assumptions as in case I the production of wheat shall increase to 4744.8 thousand metric tonnes by the end of Fourth Five-Year Plan, 5053.8 thousand metric tonnes by the end of Fifth Five-Year Plan and to 5260.6 thousand metric tonnes by the end of Sixth Plan.

Case II

In this case the first assumption of case I has been relaxed and the area under wheat is assumed to increase exclusively due to decrease in the culturable waste during the period under projection. Out of this additional area that comes under plough, the area devoted to wheat crop shall grow in the proportion that wheat bears to net area sown at present. The area under wheat as a per cent of net area sown comes to 44.83 in 1967-68 (Appendix 9). We therefore apportion 45 per cent of the reclaimed land to wheat crop. The area under wheat crop will thus grow as shown in Table XI.

The second assumption of constant technology has been relaxed. It has been assumed that during this period higher and higher percentage of fertilizer use shall be made. As already mentioned survey by the department of agriculture have shown that farmers used less than 50 per cent of recommended dose. Hence we assume that its use will go to 70 per cent, 80 per cent and 90 per cent of the recommendations in the three projected periods respectively. Taking the recommended dose to be 120 kg/hectare, i.e., the optimum for Mexican wheat, the corresponding yields have been obtained by using the production function for wheat crop for Punjab.

$$Y = 2209 + 29.010 \cdot N - .101N^2*$$

* Based on All India coordinated wheat trials.

The yield of local wheat has been kept maximum at 18 quintals per hectare. The production estimates in case II thus worked out to be as shown in Table XI.

Table XI

Projections of Production of Wheat in Punjab

Case II

	<u>1968-69</u>	<u>1973-74</u>	<u>1978-79</u>	<u>1983-84</u>
Area under wheat ('000 Hec.)	2063	2073.35	2083.70	2094.05
Area under high yielding varietes (")	1194	1451.34	1771.14	1989.35
Area under local (") varieties	869	622.01	312.56	104.70
Average yield of high-yielding varieties (quintals per hectare)	26	39.0	40.5	42.0
Average yield of (") local variety	16	17.0	18.0	18.0
Fertilizer level of recommended doze*	50%	70%	80%	100%
Production ('000 metric tonnes)	4494.8	6717.6	7735.7	8543.7

*Based on All India coordinated wheat trials.

Production under these assumptions thus will increase to 6717.6, 7735.7 and 8543.7 thousand metric tonnes by the end of Fourth, Fifth and Sixth Plan periods respectively.

Case III

Fertilizer and other inputs level remaining the same as in case II, the additional assumption is made here that

the area under gram shall be replaced by wheat on the additional acreage brought under irrigation. It can be seen that area under gram is decreasing steadily (Appendix 9). We have assumed the decline to continue at the same rate. We further assume that the area released from this crop shall go to wheat. The decline in gram area seems to be occurring at a constant rate and as such the straight line fitted to this data works out to be

$$Y = 946.89 - 49.06 t$$

Projecting the decline with the help of this equation the additional area that would go to wheat shall be as under:

	<u>1973-74</u>	<u>1978-79</u>	<u>1983-84</u>
Area transferred to wheat crop from gram '000 hectares.	270	515	530

Under these assumptions, the production has been estimated as shown in Table XII.

In this case wheat production will increase to 7592.46, 9647.62 and 10706.03 thousand metric tonnes at the end of Fourth, Fifth and Sixth Plan periods.

Table XII
Projected Production of Wheat in Punjab
Case III

	<u>1968-69</u>	<u>1973-74</u>	<u>1978-79</u>	<u>1983-84</u>
Area under wheat ('000 hec.)	2063	2343.35	2598.70	2624.05
Area under high yielding (") varieties.	1194	1640.35	2208.89	2492.85
Area under local (") varieties	896	703.00	389.81	131.20
Average yield of high yielding varieties. (Qtls. per hectare)	26	39.0	40.5	42.0
Average yield of local varieties (Qtls. per hectare)	16	17.0	18.0	18.0
Fertilizer level.	50%	70%	80%	100%
Production ('000 metric tonnes)	4494.8	7592.46	9647.62	10706.03

Area under paddy in the State has been estimated at 345 thousand hectares in the year 1968-69, of which only 26.30 thousand hectares was under improved (high-yielding) varieties and rest under local. Area under high-yielding varieties forms only 7.62 per cent of the total area under paddy. It has been envisaged to bring 142 thousand hectares under high-yielding varieties of paddy by the end of Fourth Plan period. This constitutes 40 per cent of the present area under paddy. With the higher yield potential of newly released paddy varieties, the area under paddy (high-yielding varieties) is assumed to go up to 75 per cent and 90 per cent by the end of 1978-79 and 1983-84. This is, because, once the rate of adoption has accelerated it will be higher in the beginning and will slow down at a later stage. Another encouraging feature is that high-yielding varieties of paddy require less water compared to local ones. Almost about 90 per cent of paddy area is already irrigated; as such there seems to be no reason why farmers should not go in for the new high-yielding varieties. In our estimates of shift to high-yielding varieties, we have left a margin of 10 per cent area for the fine local varieties that command a higher price.

High yielding varieties of paddy yield about 50 to 60 per cent more than local ones and as such we have assumed a ratio of 150:100 in this case for apportioning the present yield (in terms of husked paddy) in the State, i.e., 13.64 quintals per hectare to high-yielding and local varieties. The present average yield of high-yielding varieties of paddy works out to be 20.80 quintals per hectare and of local 13.60 quintals per hectare.

In case I the production works out to be as shown in table XIII.

Table XIIIProjected Production of Paddy (Rice) in Punjab

Case I

	1968-69	1973-74	1978-79	1983-84
Area under paddy ('000 hect.)	345.00	345	345	345
Adoption level for high yielding varieties	7.62%	40.00%	75%	90%
Area under high-yielding(") varieties.	26.30	142	258	310
Area under local (") varieties	318.70	203	87	35
Average yield - high-yielding varieties. (qtl. per hectare)	20.80	20.8	20.8	20.8
Average yield: local (") varieties	13.60	13.60	13.60	13.60
Fertilizer level	Same as in the base year			
Production: ('000 tonnes)	488.14	571.44	654.96	692.40

The production would thus increase to 571.44, 654.96 and 692.40 thousands metric tonnes by the year 1973-74, 1978-79, and 1983-84 respectively.

Case II

Area under paddy is assumed to grow following reduction in culturable waste. This crop bears a ratio of .08: 1 to net sown area. Hence 8 per cent of reclaimed land is assumed to go under paddy crop.

Again, so far as yield is concerned, it has been assumed that farmers will move to present optimum level¹⁴

14. It has been assumed that present optimum technology shall remain unchanged over this period.

of fertilizer use by 1983-84. The optimum yields have been worked out from the following production functions.¹⁵

$$Y_H = 1432.388 + 31.080 N - .106N^2$$

$$Y_L = 1067.900 + 22.160N - .100 N^2$$

Y_H refers to yield of high-yielding varieties in lbs. per acre

Y_L refers to yield of local variety in lbs. per acre.

Thus production of rice in the State worked out as shown in Table XIV.

Production of rice under case II thus increases to 841.81 1167.20 and 1365.52 thousand metric tonnes by the end of 1973-74, 1978-79 and 1983-84 respectively.

Table XIV

Projected Production of Rice in Punjab
Case II

	<u>1968-69</u>	<u>1973-74</u>	<u>1978-79</u>	<u>1983-84</u>
Area under paddy ('000 Hect)	345	346.84	348.68	350.52
Area under high-yielding ("), varieties	26.30	142	261.51	315.47
Area under local ("), varieties	318.70	204.84	87.17	35.05
Average yield: high yielding varieties (Qtls. per hectare)	20.80	32.74	37.74	40.75
Average yield: local ("), varieties	13.60	18.40	20.68	22.82
Fertilizer level		50%	75%	100%
Production ('000 tonnes)	488.14	841.81	1167.20	1365.52

15. Based on A.I.C. trial for high-yielding varieties, 1966-67.

Maize

Area under maize in the State has been estimated at 490 thousand hectares in the year 1968-69. Out of this 48.18 thousand hectares were under hybrid and 441.82 thousand hectares under local varieties. Hybrid maize was grown on 10 per cent of the area. It is envisaged to cover 20 per cent of the area by the end of Fourth Five-Year Plan.¹⁶ This crop is considered to be highly uncertain, because of its late maturity and pest attack. Farmers feel a little hesitant to grow this crop. Due to new varieties of wheat that can be sown as late as end of November, the problem of late maturity is however supposed to fade away. It is hoped that farmers shall start growing the crop in a larger area. Hence it is assumed that 20 per cent, 40 per cent and 60 per cent of the area under maize shall be covered by hybrid/composite maize by the end of Fourth, Fifth and Sixth Plan periods. Under the assumption of constant technology and fertilizer use, the present yield of 14.40 quintals per hectare has been apportioned to hybrid/composite maize and desi maize in the proportion of 125:100. Hybrid maize on an average yields 20 to 25 per cent more than the local one. The present yield thus works out to be 17.58 quintals per hectare for hybrid/composite and 14.06 quintals per hectare for desi. With these assumptions the production of maize worked out to be 723.43, 757.93 and 792.42 thousand metric tonnes by the end of Fourth, Fifth and Sixth Plan periods (Table XV).

16. Draft Fourth Five-Year Plan of Punjab.

Table XV
Projection of Production of Maize in Punjab

Case I

	1968-69	1973-74	1978-79	1983-84
Area under maize ('000 hect)	490	490	490	490
Area under high-yielding varieties ("")	48.18	98.00	196.00	294
Area under local varieties ("")	441.82	392.00	294.00	196
Average yield of high-yielding varieties (Qtls. per hect.)	17.58	17.58	17.58	17.58
Average yield of local ("") varieties	14.06	14.06	14.06	14.06
Fertilizer level	Same level as at present.			
Production ('000 metric tonnes)	705.90	723.43	757.93	792.42

Case II

Maize crop covers 12 per cent of the net area sown in the State and as such 12 per cent of additional area from reclaimed culturable waste land has been apportioned to this crop. The area under this crop increases as shown in Table XVI.

Again it has been assumed that the farmers shall gradually move towards the use of optimum doze of fertilizers by the end of 1983-84. The optimum works out to be 40.50 Kg. for hybrid and 29.64 Kg. for local. This is based on the production functions.

Table 16

Projected Production of MaizeCase II

	1968-69	1973-74	1978-79	1983-84
Area under maize ('000 hect.)	490	492.76	495.52	498.28
Area under high yielding (") varieties	48.18	103.05	198.20	298.96
Area under local (") varieties	441.82	389.71	297.32	199.32
Average yield of high yielding varieties (Qtl.per hect.)	17.58	31.88	35.68	40.50
Average yield of local (") varieties.	24.06	23.13	25.71	29.64
Fertilizer level		50%	75%	100%
Production ('000 tonnes)	705.90	1229.92	1471.58	1801.57

$$Y_H^* = 2201 + 18.97N - .042 N^2$$

$$Y_L^* = 1899 + 14.14N - .037 N^2$$

Y_H stands for yield/Kg. per hectare of hybrid.

Y_L stands for yield/Kg. per hectare of local.

The yields on the assumption of 50,75 per cent of the recommended dose of fertilizer use have been worked out for 1973-74 and 1978-79. Based on these assumptions projections of maize production work out at 1229.92, 1471.58 and 1801.57 thousand metric tonnes at the end of Fourth, Fifth and Sixth Plan periods (Table XVI).

* Based on All India Co-ordinated trials on Hybrid Maize.

Bajra

Area under Bajra in the State has been estimated at 193 thousand hectares in the year 1968-69. This was less by 16 thousand hectares over 1967-68 acreage. This decrease can be ascribed to the attack of ERGOT disease. Hybrid bajra covered an area of 81 thousand hectares in 1968-69 which forms 42 per cent of the total area. It has been proposed to cover 60 per cent of area under hybrid bajra during the Fourth Five-Year Plan. We have assumed the area to remain the same as it was in 1967-68, i.e., 209 thousand hectares and it is assumed that out of this area 60 per cent will be covered under hybrid bajra by the end of Fourth Five-Year Plan, about 75 per cent by Fifth Plan and 90 per cent by the end of Sixth Plan. The rest is assumed to remain under local bajra or fodder crop

Present yield of bajra crop has been estimated to be 10.55 quintals per hectare. This yield has been divided into 150:100 ratio knowing the area under hybrid and local. This ratio has been worked out on the basis of experimental yield of these varieties. Under the assumption of constant technology, the yields of two varieties have been assumed to remain unchanged during the period under study. Hence production of this crop works out to be 236.38, 241.32 and 263.65 thousand metric tonnes at the end of Fourth, Fifth and Sixth Plan periods in case I (Table XVII).

Case II

Area under bajra is 5.2 per cent of the net area sown in the State. Of the reclaimed area from culturable waste 6 per cent has been apportioned to this crop. The area under bajra is then assumed to grow as in Table XVIII.

The yield level is assumed to grow steadily towards the optimum by the end of 1983-84. Based on the production function:

$$Y_h = 13.74 + .2524N - .0008N^2$$

Table XVIIProjected Production of Bajra in PunjabCase I

	<u>1968-69</u>	<u>1973-74</u>	<u>1978-79</u>	<u>1983-84</u>
Area under Bajra ('000 Hect.)	193	209	209	209
Area under H.Y.V. (")	81	125.40	156.75	188.10
Area under local (")	112.0	83.60	42.25	20.90
Average yield H.Y.V. (Qrtl./ Hect.)	13.05	13.05	13.05	13.05
Average yield local (")	8.70	8.70	8.70	8.70
Fertilizer level	Same as in the base year			
Production ('000 tonnes)	203.15	236.38	241.32	263.65

The optimum works out to be 33.09 quintals per hectare in case of hybrid bajra. Since the data on local bajra was not available, no production function could be fitted to this variety. It is assumed to bear the same ratio of 150:100 throughout. Based on this ratio yield of local bajra has been obtained through the yield of hybrid bajra.

Under these assumptions, bajra production works out to be 471.16, 579.69 and 680.74 thousand metric tonnes by the end of Fourth, Fifth and Sixth Plan periods (Table XVIII).

Pulses

Figures show that the area under pulses has undergone a continuous decline during the period 1950-51 through 1968-69. This decline is mainly in the gram crop. We have taken this crop into consideration and have allocated its area to wheat crop under the assumption of growing

Table XVIIIProject Production of Bajra in PunjabCase II

	1968-69	1973-74	1978-79	1983-84
Area under bajra ('000 Hect.)	193	210.38	211.76	213.14
Area under H.Y.V. (")	81	126.22	158.82	191.82
Area under local (")	112	84.16	52.94	21.32
Acreage yield H.Y.V. (Qtl/Hec.)	13.05	26.00	29.97	33.09
Average yield local (")	8.70	16.99	19.59	21.58
Fertilizer level	50%	50%	75%	100%
Production ('000 tonnes)	203.15	471.16	579.69	680.74

irrigation. The area under other pulses have been steady, which, of course, is a negligible percentage and hence does not contribute much towards foodgrain production. This area can in future shift to bajra or maize crop depending upon soil conditions of different areas. We have, however, ignored these crops as such.

Table XIX gives a consolidated picture of the estimated production of foodgrains as it would be at the end of each plan period. Total foodgrains production in Punjab under Case I shall move to 6276.0, 6707.9 and 7009.0 thousand metric tonnes by the end of Fourth, Fifth and Sixth Plan periods.

In case II the foodgrain production should be 9260.4, 10954.1 and 12391.5 thousand metric tonnes by the end of plan periods. In case III which is more comprehensive and involves all the important related changes, the production of the food crops should move to 10135.2, 12866.0 and 14553.7 thousand metric tonnes by the end of plans.

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Table XIX

Estimated Production at the end of Three Plans
1968-69 through 1983-84

Crops	1968-69	1973-74	1978-79	1983-84
<u>Case I</u>				
Wheat	4494.8	4744.8	5053.8	5260.6
Maize	705.9	723.4	757.9	792.4
Rice	488.1	571.4	654.9	692.4
Bajra	203.1	236.4	241.3	263.6
TOTAL	<u>5891.9</u>	<u>6276.0</u>	<u>6707.9</u>	<u>7009.0</u>
<u>Case II</u>				
Wheat	4494.8	6717.6	7735.7	8543.7
Maize	705.9	1229.9	1471.5	1801.6
Rice	488.1	841.8	1167.2	1365.5
Bajra	203.1	471.1	579.7	680.7
TOTAL	<u>5891.9</u>	<u>9260.4</u>	<u>10954.1</u>	<u>12391.5</u>
<u>Case III</u>				
Wheat	4494.8	7592.4	9647.6	10706.0
Maize	705.9	1229.9	1471.5	1801.5
Rice	488.1	841.8	1167.2	1365.5
Bajra	203.1	471.1	579.7	680.7
TOTAL	<u>5891.9</u>	<u>10135.2</u>	<u>12866.0</u>	<u>14553.7</u>

Marketable Surpluses

In the first section we projected the demand for consumption of some selected agricultural commodities in the State under three different situations, each situation characterizing different assumptions regarding the population growth. Table 20 gives the total foodgrain consumption in Punjab as it would be at the end of Fourth, Fifth and

Sixth Plan period. Total demand for foodgrains include human and non-human consumption.

Table XX

Estimated Total Foodgrains Demand for Consumption
in the State through Three Plan Periods.

	Total demand ('000 metric tonnes)		
	Situation I	Situation II	Situation III
1968-69	2569.95	2569.95	2584.95
1973-74	3126.48	3126.48	3263.93
1978-79	3680.50	3725.06	3984.78
1983-84	4339.54	4552.25	4750.28

Supply of foodgrains in Punjab has also been worked out at three different levels. Even at the most conservative estimates, that is, when every thing remains same except that the distribution of area under foodgrains changes in favour of high-yielding varieties, there emerges surplus. If we compare the demand in situation III with the supply in case I we get the following annual surpluses in foodgrain at the end of three plan periods.

(Unit = '000 metric tonnes)

Year	Demand	Supply	Surplus
1968-69	2584.95	5891.90	3306.95
1973-74	3263.93	6276.00	3012.07
1978-79	3984.78	6707.90	2723.12
1983-84	4750.28	7009.00	2248.72

This shows that if the technology remains static, i.e., input per acre does not change, these surpluses would go

on diminishing in future. But if technology changes and other changes occur as we assume in situation II and III the foodgrain surpluses against demand conditions of situation III work out as under:

	Surpluses	
	Supply Situation II ('000 m.tons)	Supply Situation III ('000 m.tons)
1968-69	3306.95	3306.95
1973-74	5996.47	6871.27
1978-79	6969.32	8881.22
1983-84	7641.22	9803.42

With changing technology and input use, the state of Punjab is thus likely to produce ever increasing foodgrain surpluses to the tune of 6871,000 tonnes by the end of the Fourth Plan, 8881,000 tonnes by the end of the Fifth Plan and 9803,000 metric tonnes by the end of the Sixth Plan period.

Appendix 1

Aggregate Projected Demand for Various Food Items in Rural and Urban Sectors of Punjab

SITUATION I

('000 metric tonnes)

	1964-65		1968-69		1973-74		1978-79		1983-84	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Rice	98.11	18.77	106.73	20.95	122.86	24.74	141.36	30.72	164.05	38.83
Wheat	1258.85	364.51	1432.86	406.86	1785.84	486.36	2120.18	611.91	2413.50	786.43
Maize	220.57	41.67	236.08	44.68	264.61	48.59	293.33	50.11	317.93	48.07
Total cereals	1620.48	430.56	1859.88	476.44	2254.22	562.43	2565.31	691.77	2901.37	872.15
Pulses	114.65	32.35	129.26	35.98	159.25	43.19	185.86	54.28	265.81	67.75
Food-grains	1735.04	463.00	1989.15	512.41	2413.50	605.60	2751.18	746.04	3167.18	939.90
Fruits & vegetable	245.82	112.74	296.53	134.03	399.50	174.78	566.82	248.34	839.14	361.94
Milk & milk products	650.40	154.32	817.28	198.88	1166.26	278.42	1741.76	449.00	2715.48	715.68

Appendix 2

Aggregate Projected Demand for Various Food
Items in Rural and Urban Sectors of Punjab

SITUATION II

('000 metric tonnes)

	1964-65		1968-69		1973-74		1978-79		1983-84	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Rice	98.11	18.77	106.73	20.95	122.86	24.74	141.95	30.85	165.53	39.27
Wheat	1258.85	364.51	1432.86	406.86	1785.84	486.36	2164.48	614.56	2500.57	791.24
Maize	220.57	41.67	236.08	44.68	264.61	48.59	293.68	50.44	322.74	49.38
Total cereals	1620.47	430.56	1859.88	476.44	2254.22	562.43	2588.90	707.62	3059.15	899.33
Pulses	114.65	32.35	129.26	35.98	159.25	43.19	202.12	54.44	266.29	76.42
Food-grains	1735.04	463.00	1989.15	512.41	2413.50	605.60	2791.04	762.14	3325.43	975.79
Fruits and vegetable	245.82	112.74	296.53	134.03	399.50	174.78	566.23	248.40	839.42	362.14
Milk & milk products	650.40	154.32	817.28	198.88	1166.26	278.42	1740.38	447.94	2726.94	713.06

Appendix 3

Aggregate Projected Demand for Various Food Items
in Rural and Urban Sectors of Punjab

SITUATION III

('000 metric tonnes)

	<u>1964-65</u>		<u>1968-69</u>		<u>1973-74</u>		<u>1978-79</u>		<u>1983-84</u>	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Rice	98.44	18.80	107.54	21.10	124.28	25.00	144.20	31.36	169.20	39.60
Wheat	1263.49	365.87	1441.04	409.48	1800.12	496.68	2332.68	620.88	2676.54	802.18
Maize	222.38	42.78	225.78	45.01	267.61	48.71	299.47	47.56	331.19	50.99
Total cereals	1626.38	432.22	1868.81	481.15	2361.40	579.08	2810.88	715.48	3219.30	911.38
Pulses	115.07	32.41	130.20	36.24	159.84	44.16	203.81	54.88	276.99	71.41
Food-grains	1741.40	464.63	2001.02	515.38	2521.18	623.30	3014.71	770.38	3482.08	996.76
Fruit and vegetable.	246.72	113.28	297.52	134.59	401.53	178.91	567.54	249.30	842.38	363.62
Milk & milk products	652.70	154.90	819.70	199.58	1167.77	292.27	1741.93	447.95	2738.92	712.76

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Appendix 4Culturable Waste Land in the Punjab (Reorganised)
1950-51—1967-68

Years	Culturable waste ('000 hectares)
1950-51	511
1955-56	394
1960-61	251
1961-62	221
1962-63	216
1963-64	186
1964-65	184
1965-66	181
1966-67	174
1967-68	168

Appendix 5Area Irrigated by Tube-wells and Canals
in Punjab 1960-61 — 1967-68

	Area irrigated		Index	
	Wells	Canals	Wells	Canals
1960-61	824	1174	100	100
1961-62	740	1229	89	104.7
1962-63	853	1234	104	105.0
1963-64	825	1214	100	103.4
1964-65	842	1218	102	103.7
1965-66	887	1289	107	109.8
1966-67	982	1266	119	107.8
1967-68	989	1288	120	109.7

Appendix 6

Intensity of Irrigation in Punjab - An Indicator

Year	Area irrigated as a per cent of net area sown	Tubewells for irrigation	Area (net) irrigated per tubewell (hect.)
1960-61	53.8	7445	271.2
1961-62	52.2	7695	259.5
1962-63	55.0	9396	224.3
1963-64	55.3	11780	181.1
1964-65	54.1	12799	164.5
1965-66	59.6	26066	86.8
1966-67	58.6	30894	73.7
1967-68	57.3	44491	51.4

Appendix 7Consumption of Chemical Fertilizers in Punjab
(1962-63 to 1968-69)

Period	Sale (qtly.) M. tonnes	Index Base 1961-62
1961-62	49,162	100.0
1962-63	84,522	172.0
1963-64	140,889	286.6
1964-65	232,230	472.0
1965-66	236,154	480.0
1966-67	236,598	481.0
1967-68	385,206	783.7
1968-69	545,256	1109.1

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Appendix 8Cropping Intensity in Punjab
1950-51 - 1967-68

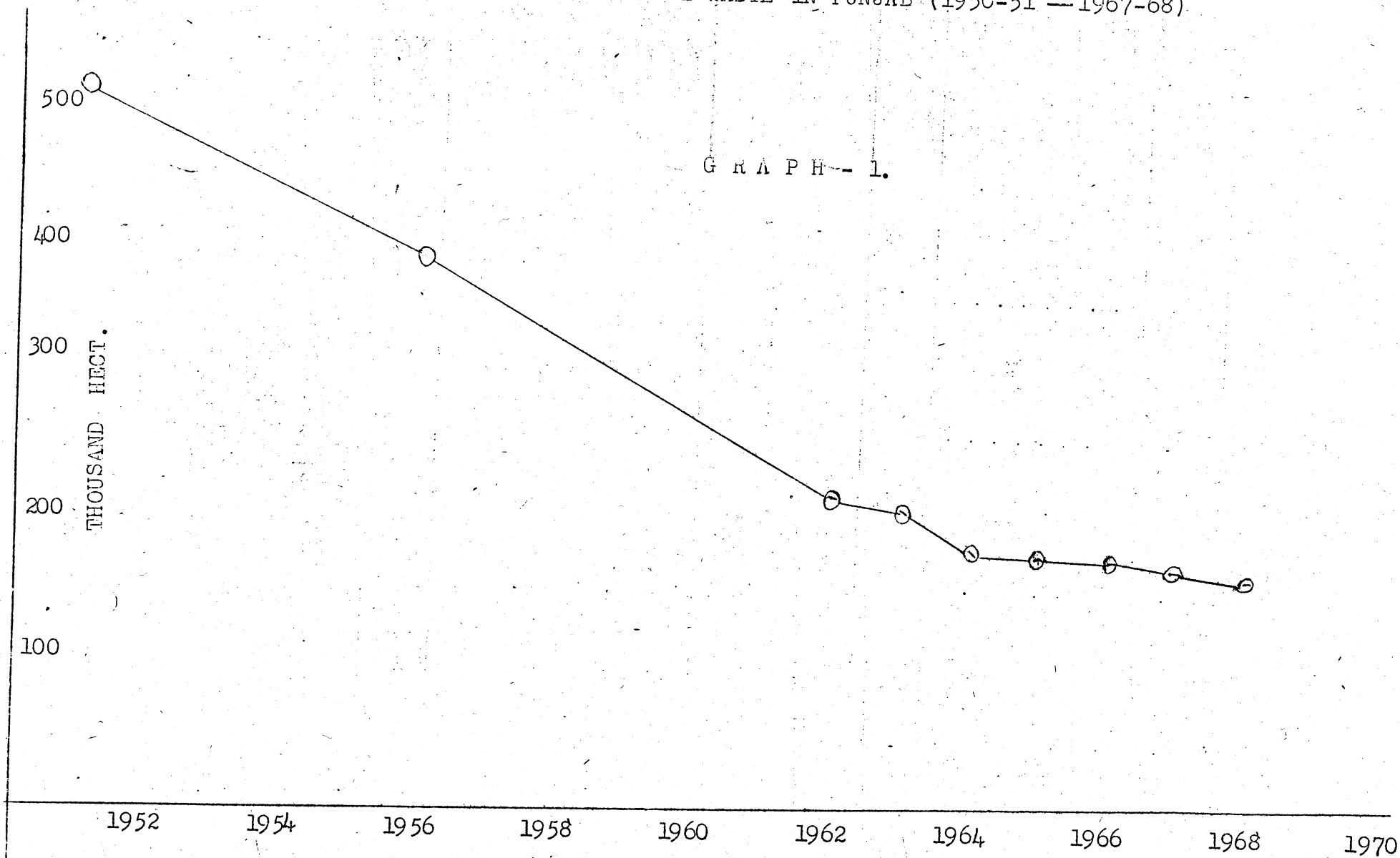
Period	Total cropped area	Net area sown	Cropping intensity
1950-51	4162	3537	117.67
1955-56	4567	3615	126.33
1960-61	4723	3750	125.95
1961-62	4800	3826	125.45
1962-63	4970	3833	129.71
1963-64	4875	3855	126.46
1964-65	5113	3895	131.27
1965-66	4878	3796	128.50
1966-67	5172	3886	133.09
1967-68	5441	3992	136.30

Appendix 9Area under Different Crops as a
Per Cent of Net Cropped Area

Year	Net sown area	Wheat	%	Rice	%	Maize	%	Bajra	%
1960-61	3750	1394	37.2	228	6.1	326	8.7	124	3.3
1961-62	3826	1433	37.4	228	6.0	323	8.4	142	3.7
1962-63	3833	1516	39.5	249	6.5	362	9.4	136	3.5
1963-64	3855	1510	39.2	257	6.7	354	9.2	105	2.7
1964-65	3895	1563	40.1	287	7.4	383	9.8	160	4.1
1965-66	3796	1548	40.8	293	7.7	385	10.1	156	4.1
1966-67	3886	1608	41.4	285	7.3	444	11.4	184	4.7
1967-68	3992	1790	44.8	314	7.9	476	11.9	209	5.2
For projected years (assumed)			45.0		8.0		12.0		6.0

TREND IN CULTURABLE WASTE IN PUNJAB (1950-51 — 1967-68)

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Appendix 10

Area under Different Crops and the Per Cent Irrigated
- in Punjab (1960-61 through 1968-69)

	Wheat		Rice		Maize		Bajra		Gram	
	Area ('000 hect.)	% irri- gated	Area ('000 hect.)	% irri- gated	Area ('000 hect.)	% irri- gated	Area ('000 hect.)	% irri- gated	Area ('000 hect.)	% irri- gated
1960-61	1394	57.4	228	81.1	326	64.1	124	38.7	871	27.3
1961-62	1433	58.5	228	78.1	323	61.6	142	33.8	849	28.5
1962-63	1516.	57.7	249	80.3	362	64.6	136	38.2	817	28.9
1963-64	1510	62.1	257	82.9	354	62.1	105	35.2	761	27.1
1964-65	1563	62.9	287	81.9	383	64.0	160	35.0	744	29.9
1965-66	1548	68.2	293	86.3	385	68.3	156	34.0	603	34.4
1966-67	1608	72.1	285	85.6	444	66.9	184	40.8	634	34.5
1967-68	1790	70.5	314	81.8	476	67.0	209	43.5	530	35.1