ORISSA ECONOMICS ASSOCIATION

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## ORISSA ECONOMICS ASSOCIATION



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Dr. P. K. Das,
*Secretary,*
Orissa Economics Association,
College of Agriculture,
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*Editor :*

**Dr. BIDYADHAR MISRA,** M. A., Ph. D. (London)
*Professor & Head of the Department*
*of Analytical and Applied Economics*
Utkal University
BHUBANESWAR-4

ORISSA ECONOMICS ASSOCIATION
BHUBANESWAR

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# RICE YIELD IN ORISSA

Dr. BAIDYANATH MISRA

## Position of rice in Orissa's economy

Rice is the major food crop in the State of Orissa. But there is no notable break-through in the cultivation of rice. Of the total gross cultivated area of 7.4 million hectares, food crops account for 73 % and nonfood crops account for the remaining 27 percent. Rice alone accounts for twothirds of the gross cropped area. In terms of the gross value of the output, the food crops account for 63 per cent of the total agricultural production of the state. Within this group rice itself accounts for 55 per cent of the total gross value of the output.

TABLE 1

GROSS VALUE OF AGRICULTURE (PROPER) DURING 1969-70

| Item | Gross value of output ( Rs. Crores ) | Percentage to total |
|---|---|---|
| 1. Fod grains | 481.47 | 62.8 |
| (a) Rice | 418.45 | 54.6 |
| 2. Non-food grains | 207.96 | 27.1 |
| 3 By-products Including straw and fodder | 77.56 | 10.1 |
| Total | 766.99 | 100.00 |

*Source*: Communication from the Central Statistical Organisation. Derived from Table 1, Commerce Annual Number 1972, p, 148.

## Yield of rice

Yet, there has been no substantial increase in production of rice during the last 10 years as can be seen from Table 2.

TABLE 2

| Year | Production (in lakh tonnes) | Area (in lakh hectares) |
|---|---|---|
| 1964-65 | 44.01 | 43.32 |
| 1965-66 | 32.86 | 42.61 |
| 1966-67 | 36.92 | 42.53 |
| 1967-68 | 37.55 | 43.36 |
| 1968-69 | 42.12 | 43.11 |
| 1969-70 | 39.76 | 44.59 |
| 1970-71 | 41.00 | 45.11 |
| 1971-72 | 36.20 | 46.46 |
| 1972-73 | 39.89 | 44.76 |
| 1973-74 | 44.00 | 44.90 (Provisional) |

The above table shows that though the area has increased by about 4 per cent during the last 10 years, there has been no increase in total production of rice. On the other hand, there is fluctuation in the production of rice year by year showing thereby that there is no permanent improvement in rice yield.

The agricultural Department has given detailed estimates of the area, production and yield rate for the year 1972-73 for Autumn rice, Winter rice, Summer rice and total rice. As can be seen from Table 3, the most important is Kharif rice accounting for 96 per cent of the area and 94 per cent of production. The yield rate in Kharif rice is 8.70 quintals per hectare which is miserably low. The Summer rice is negligible, accounting for 4 per cent of the area and 6 per cent of production. Yield rate in Summer rice normal comes to 8.55 quintals and for high yielding variety 14.66 quintals per hectare.

Final estimates of area, production and yield rates of Autumn and Winter rice in Orissa during 1973-74 by the Agriculture Department are given in Table 4. It shows that total Kharif rice accounts for about 42 lakh tonnes. Detailed estimates of Summer rice are not available. But the production is in the neighbourhood of 2 lakh tonnes.

## TABLE 3

### AREA PRODUCTION AND YIELD RATE OF RICE FOR 1972-73

A=Area in hectares, P=Production in Tonnes, Y=Yield rate in Quintals per hectare

| Autumn Rice | | | Winter Rice | | |
|---|---|---|---|---|---|
| A | P | Y | A | P | Y |
| 769000 | 386000 | 5.02 | 3524000 | 3349000 | 9.5 |

| Summer Rice (Normal) | | | Summer Rice (HYV) | | | Summer Rice | | |
|---|---|---|---|---|---|---|---|---|
| A | P | Y | A | P | Y | A | P | Y |
| 32460 | 27750 | 8.55 | 150380 | 220370 | 14.66 | 182840 | 248120 | 13.57 |

| Total Rice | | | Total Kharif Rice | | | Production | Yield |
|---|---|---|---|---|---|---|---|
| A | P | Y | HVY | Normal | Total | | |
| 4475840 | 3983120 | 8.90 | 151330 | 4141670 | 4293000 | 3735000 | 8.70 |

*Source* : Directorate of Agriculture Statistics Section.

## TABLE 4

### FINAL ESTIMATES OF AREA, PRODUCTION AND YIELD RATE OF AUTUMN AND WINTER RICE IN ORISSA DURING 1973-74

A=Area in thousand hectares, P=Production in thousand tonnes of cleaned rice Y=Yield rate in quintals per hectare (cleaned rice)

| Districts | Autumn Rice | | | Winter Rice | | | Total Kharif Rice | |
|---|---|---|---|---|---|---|---|---|
| | A | P | Y | A | P | Y | A | P |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Balasore | 1 | 1 | 8.81 | 420 | 302 | 7.21 | 421 | 303 |
| Bolangir | 97 | 54 | 5.60 | 203 | 221 | 10.89 | 300 | 275 |
| Cuttack | 43 | 19 | 4.47 | 544 | 476 | 8.76 | 587 | 495 |
| Dhenkanal | 46 | 20 | 4.39 | 281 | 258 | 9.20 | 327 | 278 |
| Ganjam | 7 | 6 | 8.10 | 359 | 427 | 11.88 | 366 | 433 |
| Kalahandi | 114 | 56 | 4.89 | 158 | 160 | 10.12 | 272 | 216 |
| Keonjhar | 37 | 21 | 5.77 | 198 | 209 | 10.56 | 235 | 230 |
| Koraput | 61 | 32 | 5.16 | 352 | 375 | 10.66 | 413 | 407 |
| Mayurbhanj | 120 | 69 | 5.76 | 219 | 213 | 9.71 | 339 | 282 |
| Phulbani | 22 | 13 | 6.05 | 66 | 70 | 10.55 | 88 | 83 |
| Puri | 6 | 5 | 8.04 | 374 | 422 | 11.28 | 380 | 427 |
| Sambalpur | 216 | 160 | 7.40 | 361 | 418 | 11.58 | 577 | 578 |
| Sundargarh | 75 | 36 | 4.84 | 190 | 148 | 7.82 | 265 | 184 |
| Orissa Total | 845 | 492 | 5.82 | 3725 | 3699 | 9.93 | 5570 | 4191 |

The table further reveals that the yield rate varies from 5.82 quintals per hectare in Autumn rice to 9.93 quintals in Winter rice. As per the Statistical Abstract of India, 1970, the average yield rate of rice in Orissa for the year 1969-70 comes to 9.6 quintals per hectare whereas it is 17 quintals for India.

The position paper on Agriculture prepared by the Department of Agriculture in October, 1974, gives the following figures regarding area and production of rice.

TABLE 5

| Crop | Area in lakh hectares 1973-74 (Provisional) | Production in lakh tonnes 1973-74 (Provisional) |
|---|---|---|
| Rice | 46.90 | 43.47 |
| Wheat | 0.49 | 0.83 |
| Millets | 4.43 | 3.03 |
| Pulses | 9.23 | 4.57 |
| Total | 61.05 | 51.90 |

The table shows that rice covers 77 percentage of the total cultivated area devoted to food crops and per hectare production comes to about 9.3 quintals.

The National Commission on Agriculture in their Draft Report on Rainfall and Cropping pattern in Orissa State have given comparative data for yields as can be seen from Table 6.

TABLE 6

| Crop | Area in hectares as at the time of the Report ( In hectares ) | Orissa's yield as percentage of All India average |
|---|---|---|
| Autumn Rice | 3,60,600 | 35 to 40 per cent |
| Winter Rice | 38,99,000 | 86 per cent |
| Combined Rice | 42,58,000 | 85 per cent |

## Causes of low yield

This shows that the yield rate of Autumn rice compared to the all India average is significantly low and the yield rate of combined rice does not favourably compare with all India average. Though Orissa's economy depends mainly on production of rice, there has been no breakthrough in the productivity of rice. The causes of such low yield could perhaps be divided into four major groups.

1. Physical—Soil type, backward areas, climate, etc.
2. Technological—Seed, Fertiliser and Irrigation.
3. Economic Incentives, Disincentives, Prices, Taxes, Subsidies.
4. Institutional and Organizational—Land Tenure, Credit, Marketing, Extension Education.

## Physical features

There is no clear demarcation among these groups. For the sake of convenience, we only treat them separately. To begin with physical features, of the total reporting areas of 15.5 million hectares in Orissa, the net sown area is about 6 million hectares or 38 per cent against the national average of 45 per cent. Orissa has a population of about 22 million. Of the total population, the scheduled tribes account for 23 per cent and scheduled castes 15 pent. Thus 38 per cent of the population of the State is backward having no enterprise to increase the pace of development. The scheduled castes are distributed throughout the state, but scheduled tribes are concentrated in certain areas. The total tribal area (an area which has more than 50 per cent of tribal concentration) covers an area of about 56,000 km. which constitutes 35.92 per cent of the total area of the State and 36.31 per cent of the total rural area of the State. This area can be taken as backward area of the State where shifting cultivation is mostly prominent and yield of crops is abnormally low.

Apart from the fact that agricultural production (including rice production) in many regions in Orissa is handicapped due to sizeable areas being backward where shifting cultivation rather than permanent agriculture has been practised by the hill tribes, one important factor for low rice yields is that the crop is grown in areas with soils which are by no means suitable for rice. The soils of Orissa can be broadly classified into five groups : (i) Red and Yellow, (ii) Red sandy, (iii) Red loamy, (iv) Laterite, and (v) Coastal or deltaic alluvium.

Small areas of laterite are present in Cuttack, Puri, Ganjam and Koraput districts. Coastal or deltaic alluvium is a narrow coastal strip except in Balasore and Cuttack where the area under deltaic alluvium is larger. Red and Yellow soils cover the Western half of the State except for the central belt of red sandy soils in the belt including eastern half of Bolangir, central Sambalpur and eastern half of Sundargarh. Red and sandy soils cover almost entirely the northern districts of Mayurbhanj. Ganjam district has mainly red sandy soils with a pocket of laterite and red loamy soils in the north. In the rest of the State red loamy soils prevail with pockets of laterite. The soil reaction is acidic in more than 50 per cent of the cultivated land. Red soils of the northern plateau are more acidic than others. Liming appears to be necessary for 30 per cent of the cultivated land in the northern plateau, 18 per cent in the central table land, 25 per cent in the Eastern Ghat region and 20 per cent in the Coastal Plains.

Further, several areas in Orissa (particularly unirrigated upland constituting about 30 per cent of the cultivated area ) although not quite suitable for rice cultivation because the soil cannot hold water long enough after it has received it from rains, to ensure to the rice crop the quantities which it needs, are devoted to rice cultivation. When rice is grown in such marginal lands, average productivity per hectare becomes exceedingly low. Such marginal lands are better suited for certain upland crops, like ragi, tur, groundnut, maize, etc. provided drainage ( except in the case of ragi ) is ensured so that the water does not stand long in the field after heavy showers. The run off water from such fields into fields having lower lands would be useful in supplementing the water needs of the rice crop sown ( or planted ) in these fields. This would be specially useful for a more balanced crop production during low rainfall years because the risk of damage to the rice crop from drought would be considerably reduced due to run off water from the upland fields ( water harvesting ) helping the lower fields against too much desiccation.

In medium and low lands, where winter rice varieties are grown and which account for the major rice growing area in the State, about 70 per cent of the area grows the crop without irrigation. The uncertainties attendant upon complete dependence on monsoon are not compatible with the requirements of technological advances using high yielding varieties and the attendant package of practices.

Many farmers prefer to grow very short duration varieties of Autumn rice which, in spite of the low yields they give, are preferred because they provide food grain to the farmer early in the harvest season thus helping him against borrowings or starvation. This also lowers the average yield of rice in the State.

## Technological change :

### Seeds

The green revolution that has ushered in India since 1965-66 has been mainly due to technological break-through. Orissa is not even at the fringe of technological revolution. The availability of improved seeds is the first step towards a modern agriculture. But in case of Orissa, area under high yielding paddy comes to about 3.8 per cent of total area as against 11.5 per cent for India as a whole. The total area comes to about 1.71 lakh hectares. This is mainly due to three factors. Firstly there is virtually no seed industry in the State. The departmental farms are engaged in the production of seeds, the area of which is far from adequate. Secondly, there are no suitable high yielding varieties of rice for the major rice growing areas of Orissa, viz, the areas growing the sharad or Winter rice. Often heavy rain or run-off water causes the rice fields to suffer submergence which the local varieties can stand better, but which the dwarf high yielding varieties ( most of which have a duration which is not long enough to escape the ill effects of submergence which coincide with their heading or ripening period ) are not able to stand. Medium tall varieties with higher yield potential than the local varieties but with sufficiently satisfactory standing ability ( non-lodging capacity ) may prove to be more suitable for such conditions. Mahsuri ( a variety from Malayasia which has been gaining rapid popularity in Andhra Pradesh, Tamil Nadu and Eastern Madhya Pradesh ) has been introduced this year for exploring its possibilities in Orissa next year. Finally, extension activities to popularise high yielding variety are far from adequate.

**Fertilizers**

There has been noticeable increase in the consumption of chemical fertilizers, from 1.4 Kg. per hectare in 1964-65 to 5.91 Kg. per hectare in 1972-73. All the same, the current consumption of fertilizers is far below the national average, which comes to about 14.94 Kg. per hectare in Punjab, the per hectare average comes to 58.61 Kg. One difficulty in fertilizar consumption is that most of the cultivators being excessively poor cannot afford to use such a costly input, especially because rice is a high risk crop when there is little control over the water needed for its cultivation. In fact. there is hardly any application of fertilizer in Kharif paddy since there is heavy leaching of fertilizer due to run-off water. This is a disincentive to farmers especially when they are too poor to risk investment on fertilizer, plant protection, chemicals or even high quality seed. On the other hand, Punjab farmers while being better off than Orissa farmers, can manage to be more enterprising because of the more favourable weather during the rainy season (with plenty more sunlight and less cloudy weather ensuring better photosynthetic activity) and better control over water due to low rainfall and almost 100 percent rice area under irrigation.

Further, there is considerable lacunae in the distribution of fertilizers which is now done mostly through the cooperatives and private agencies. There is persistent complaint that a substantial part of fertilizer allotted to Orissa is smuggled to Andhra Pradesh either for agricultural use or for illicit liquor. It is obvious that unless fertiliser consumption is increased, there is no scope for increasing the yield of rice.

**Plant protection**

Plant protection measures are also inadequate in Orissa. Of the total gross cropped area of 83.8 lakh hectares in 1969-70, the plant protection measures covered an area of 3.7 lakh hectares or 4.4 per cent as compared with the national average of 21.2 percent. But unfortunately weather conditions in Orissa appear to be more congenial for the outbreak of pests and disease epidemics of rice besides suffering from the disadvantage of long spells of cloudy weather detrimental to high photosynthetic activity.

**Irrigation**

Of all the inputs, water is the most important for raising a good rice crop. Orissa depends mostly on South West Monsoon occurring during the period from July to September. About 88 percent of the total culturable area (200.48 lakh acres) in the State of Orissa is entirely dependent for crop production on South-West Monsoon. But the distribution of this rainfall is most erratic as a result of which the production is at a very low level. There are frequent losses to the Kharif crops on account of drought in erosional plain and flood occurring in alluvial plain. The average annual monsoon raifall for the State has been estimated as 1342 mm. If 75 per cent of this quantity is considered as useful rainfall for raising Kharif crops, then the quantity of rain available works out to 1007 mm. Paddy grown during the monsoon season requires 1500 mm. of water for its normal raising. Thus it may be seen that the water available through monsoon rain is insufficient to meet the requirements of paddy crop grown predominantly in the State during Kharif seasons.[1].

And further, some of the districts receive precipitation much below the average figures resulting in drought situations. There are 68 blocks in the State covering an area of about 13.5 thousand square miles which are chronically affected by drought during the Kharif season. The percentage of the drought affected area comes to about 27 percent of the total area of 10 districts in Orissa.[2]. The rainfall in drought years has been observed to be varying from 298 to 1002 mm. The loss of rice crop during the current year's drought is estimated to be more than 30 percent of Kharif crop. Besides irregular distribution

1. Ground Water Development in Orissa Vol. I, Irrigation & Power Development Govt. of Orissa.
2. Ibid p. 15

and inadequate rainfall, topography and soil condition also help in occurrence of drought. Undulated topography and sloping land facilitate quick run-off of rain water collected on surface as well-as in the sub-surface condition depriving the land of its capacity for storage and the crop of its normal requirement. Open textured sandy soils also facilitate early percolation of the rain water stored in the surface and thereby the available water is lost quickly.

Some areas of Orissa are frequently visited by flood. The major rivers of Orissa, i.e. Mahanadi, Brahmani, Baitarani, Subarnarekha, Jalaka, Budhabalanga and Kansabans, have frequent as well as continous flood during the Kharif season within the flood planes mostly confined to coastal districts stretching over miles together. Due to continuous submergence under flood water, the Kharif crop raised within the areas gets completely damaged. Though protective embankments along some of the rivers have been provided in some areas, yet a larger part of the area still remains unprotected within the basin of the abovementioned rivers. During the flood season, there are also frequent breaches of the flood embankment damaging even the protected areas. The total areas that become victim of flood every year come to 5238 square mils (3318 square miles of flood affected areas plus 1920 square miles of protected areas).[3] The extent of damage caused by flood depends on height of flood, its duration, frequency as well as the nature of the land and crop affected. In general 50 to 100 percent of the crop is damaged in the low lying areas though the loss in medium and high land are comparatively less.

Again, the coastal saline tract lying as a narrow strip of land along the sea coast experiences cyclonic weather during the month of October to November every year when the South-West monsoon comes to an end with a start of North-East monsoon. This change sets up low pressure in Bay of Bengal which in turn brings occasional cyclonic weather over the coastal regions. The rice crop at this time, usually in boot leaf stage or flowering, lodges due to high velocity wind blowing over the crop land, causing more than 50 percent losses. In extreme cases, the damage even goes up to

3. Ibid p. 13.

90 to 100 percent. The severity of cyclone causes tidal waves in the sea which spreads into inland damaging entirely the crop and human habitation.

This shows that the Kharif crop of paddy in Orissa is susceptible to many vagaries of nature causing low productivity. By providing assured irrigation facilities, the drought affected areas could be reduced substantially. However irrigation cannot prevent loss of production in rice during Kharif arising out of flood or cyclone. But the question is, if Kharif crop is somehow lost either by flood or cyclone, the farmers in many areas cannot raise a second crop of rice due to limited facility of irrigation. High inputs in the Kharif crop by way of clean cultivation and use of liberal doses of manure and fertilizers is a help to the Punjab farmers to get good yields in the rabi crops also. In Orissa, except where perennial irrigation is available, the rice crop in the Kharif season is not followed by any intensive cropping in the next season. Hence the incentive of high and profitable yields in rabi season, which is a motivation for the Punjab farmers, does not exist in the case of Orissa farmers.

**Water Management**

In case of Orissa, 17 to 18 per cent of the net sown area in the state benefits from irrigation. This is lower than All India average of 21.8 per cent in 1969-70. The main source of irrigation in Orissa are tanks (51 per cent) and canals (23 per cent). Of the total irrigation facilities available in the State, 86 per cent are utilised for rice. Not only the area covered by irrigation is less, but because of lack of scientific water management, irrigation has become a curse in many areas as indicated below.

(*a*) Waterlogged patches have been created in the lowlying lands due to use of water in excess of the crop requirement. Application of water to all the crops in general, and to paddy crop in particular, is much in excess, may be 3 to 4 times of water requirement. The farmers are using excess water because the water cess is collected on crop area but not on water measurement basis. And so far irrigating paddy fields canal water is allowed to flow into the field the whole night although one or two hours would have been sufficient.

(*b*) Productivity of soil is going down, because of inadequate aeration and disturbance of soil structure.

(*c*) Problems of pest and diseases are becoming serious year to year. Paddy cultivation may become out of question within a few years due to epidemic nature of gall fly and stem borer.

(*d*) Plant nutrients are lost from the fields. They are being leached to lower fields due to constant flow of water in paddy fields or flood system of irrigation from field to field.

(*e*) Application of granular insecticides is not possible due to uncontrolled supply of irrigation from field to field.

(*f*) The fields located at the tail end of the canal which are away from the canal do not get adequate water and even at times do not get water at all, although fields near the water course or on the upper reach of the canal get more than adequate water.

For efficient use of irrigation, two or three things are important for which sufficient attention has not so far been given. First is drainage. It is an essential adjunct of scientific water management. Irrigation supplies adequate moisture in the soil for satisfactory crop growth, while drainage is required to avoid excess moisture in the root zone. Second, there should be preparation of field channels for conveyance and distribution of water properly to each and every plot independently. This should be the responsibility of the farmers and not of the government. Thirdly, there should be lining of channels to avoid seepage loss. Further, irrigation water can be reutilised by means of dugwells and shallow tube wells in the Ayacut area and also by pumping water from the lowest valley or patch of the area nearby crop fields back to the irrigation distribution system. Finally, 25 to 35 per cent of the Ayacut area of flow irrigation system receives irrigation water during the dry season for second crop. In the area; which does not receive irrigation during the dry season, the programme of ground water development may be started for raising the second crop with the available ground water. On the whole, additional irrigation facilities and scientific water management are two essential inputs for crop production.

**Mechanization**

The pace of farm mechanization in Orissa is extremely slow as can be seen from Table 7 which gives a picture of progress in farm mechanization in Orissa as compared to India.

TABLE 7

PROGRESS IN FARM MECHANIZATION

| Items | Orissa | | India | |
|---|---|---|---|---|
| | 1951 | 1966 | 1951 | 1966 |
| 1. Tractors (per one lakh hectare of gross cropped area) | 1 | 4 | 8 | 14 |
| 2. Oil engines (per one lakh hectare of irrigated area, excluding canals) | 4 | 38 | 217 | 1231 |
| 3. Electric pumpsets per one lakh hectare of irrigated area). | 1 | 10 | 86 | 1084 |

*Source* : Reserve Bank of India Bulletin, Feb. 1972 pp 243-245.

We do not hereby say that there is much scope of farm mechanization in Orissa. Since agricultural production is being planned on the basis of small farms and the supply of unskilled labour is abundant, the scope for mechanisation is limited. However, if the pace of consolidation of holdings could be accelerated, the use of power tillers, power sprayers and pumpsets could be increased substantially for the benefit of agricultural production.

## Economic incentives

Regarding economic incentives, it may be mentioned here that the government has rather tried to subsidize agriculture in different possible ways. But none of these has contributed substantially to a breakthrough in agriculture. The direct and indirect incentives provided for increase in the production of rice can be stated as follows :

1. The price of rice has moved upwards as can be seen from Table 8.

TABLE 8

TREND OF PRICES OF RICE AND WHEAT

| Item | Unit | Jan. 63 | Jan. 64 | Jan. 67 | Jan. 68 |
|---|---|---|---|---|---|
| Rice (Common Mill) | Qnt L. | 51.88 | 57.55 | 85.00 | 94.75 |
| Rice (Hand pound) | —do— | 55.05 | 58.11 | 83.50 | 94.00 |
| Wheat | —do— | 44.75 | 45.53 | 47.48 | 71.93 |

*Source* : Supply Department, Bhubaneswar, Reproduced from Economic Review of Orissa, 1971, issued by Bureau of Statistics and Economics, Government of Orissa, p. 73,

The table shows that there is a continuous rise in prices since 1960-61. In recent years, the rise is much greater showing a favourable terms of trade for rice growers.

Further, the procurement prices of paddy have also been revised upwards in keeping with the market trends, and except for the last two or three years, procurement prices have been higher than the market prices. In recent years, when the government has fixed the procurement prices of paddy at a lower level than the prevailing market price, the amount of procurement by the Government has been insignificantly low so as not to create any disincentive to the cultivators. Table 9 shows the production and precurement of rice during the last three years.

TABLE 9

| Year | Production in lakh tonne | Procurement in Metric tonnes |
|---|---|---|
| 1971-72 | 36.20 | 1,67,004 |
| 1972-73 | 39.89 | 2,09,584 |
| 1973-74 | 44.00 | 2,10,384 (up to 30.9.74) |

This shows that the annual procurement of rice is of the order of 5 per cent of the total production. If marketable surplus is taken to be about 20 per cent of the total produce, the cultivators have sufficient surplus to dispose of in the open market at a higher price and compensate the loss arising from lower price fixed for procurement.

(2) Even in respect of inputs the application of which will substantially increase productivity, the government policy has been to supply these inputs at a concession rate. In case of fertilizers whose prices have increased in recent years, the farmer in India is not known to have refrained from the use of the fertilizer because of its high price[4]. The Committee on Fertilizers (1965) which looked into this problem stated that "Except in the rainfed areas where certain risks related to the dependency on seasonal rainfall exist, the field results appear to indicate that at present level of fertilizer application, the farmer in India finds adequate profitability in fertilizer use even at present price[5]. Fertilizers trials also show that even at present inflated prices, net return on fertilizer investment can be substantially high. Further, the Government also provides fertilizers free of cost in some of the demonstration plots so as to induce other cultivators to modernise agriculture by application of scientific inputs. This shows that there is no deliberate attempt to create disincentives for fertilizer application.

Yet the amount of fertilizer applied by farmers in Orissa is insignificantly low. Data collected from 360 holdings for the years

4. Cf. M. L. Dantwala, Incentives and Disincentives in Indian Agriculture. Indian Journal of Agricultural Economics, April—June 1967, No. 2.

5. Quoted in Dantwala, above cited.

1971-72 and 1972-73 under the Comprehensive Scheme of Cost and Returns on Agriculture organised under the auspices of the Directorate of Economics and Statistics, Government of India, and operated by Orissa University of Agriculture and Technology show the following break-ups in regards to fertilizer and insecticides.

TABLE 10

| Year | Total cost of fertilizer per hectare of paddy | Total cost of Instecticides per hectare of paddy | Total cost of hectare ot paddy |
|---|---|---|---|
| 1971-72 | 20.53 | 1.29 | 842.11 |
| 1972-73 | 22.03 | 1.83 | 880.00 |

This shows that application of fertilizer and insecticides is negligible in case of paddy cultivation in Orissa.

The estimates of cost made by the Directorate of Agriculture and Food Production of Orissa for the current year is given in Table 11.

TABLE 11

ESTIMATED COST OF FERTILIZER
(Transplated rice per acre)

| | High Yielding Variety paddy | | Improved paddy | | Local paddy | |
|---|---|---|---|---|---|---|
| Fertilizer Cost | Qnt (Kg) | Cost (Rs) | Qnt (Kg) | Cost (Rs) | Qnt (Kg) | Cost (Rs) |
| N | 39 | 185 | 16 | 76 | 4 | 10 |
| $P_2O_5$ | 26 | 226 | 9 | 53 | 2 | 12 |
| K O | 29 | 64 | 2 | 4 | .. | .. |
| Total Cost | | 1118 | | 638 | | 456 |

The cost of cultivation of the high yielding varieties and improved varieties are in respect of demonstrations under the multiple cropping demonstrations. Therefore, they cannot be taken to reflect the real situation in the state. At any rate, the local paddy which is the most important crop in the state does not seem to utilise sufficient amount of fertilizer to significantly change the yield of rice in the state.

(3) It is admitted by scientists that high pay-off of modern inputs depends primarily on assured water supply. The Government of Orissa has made heavy investments in different types of irrigation projects. But the water rate in Orissa is negligible. The Comprehensive Scheme findings show that the irrigation charges per hectare of paddy cultivation constituted 0.40 rupees in 1971-72 and Rs.3.07 in the year 1972-73.

As per the estimates of the Directorate of Agriculture and Food Production, irrigation charges per acre of paddy for the year 1973-74 came to Rs. 8/.

The irrigation rate fixed by the Government is Rs.24/- for Dalua paddy and Rs. 16/-. per Kharif paddy. But in most of the cases, canal irrigation is supplied free of cost for Kharif paddy.

(4) Besides the Government is also making investment in Socio-Economics infrastructure—Agronomic research, Soil testing laboratories, Fertilizer trials and demonstrations, Seed farms etc., all of which are improving the basic facilities for agricultural development. Yet, there has been no breakthrough in rice production. Growth rate in area, production and productivity of rice in Orissa during the period 1950-51 to 1971-72 are shown in Table 12.

TABLE 12

| | 1950-51 to 1960-61 | | | 1961-62 to 1971-72 | | |
|---|---|---|---|---|---|---|
| | Area | Production | Productivity | Area | Production | Productivity |
| 1. Linear | 0.38 | 1.30 | 1.02 | 0.85 | 0.80 | (—) 0.02 |
| 2. Compound | 0.36 | 1.14 | 0.88 | 0.79 | 0.73 | (—) 0.07 |

| 1950-51 to 1971-72 | | |
|---|---|---|
| Area | Production | Productivity |
| 0.98 | 2.07 | 0.89 |
| 0.92 | 1.69 | 0.77 |

This shows that the response of rice production to economic incentives is negligible. Three reasons may be attributed to this :

First, it is not correct to say that the higher the price offered to farmers, the more they will produce and bring the same to the market. This does not imply that farm prices should not be remunerative. This implies that the supply elasticity of rice is less than one. As Prof. Dantwala has pointed out, price factor is quite effective when a shift is desired in the relative production of two competing crops, say between jute and rice. Its effectiveness is considerably reduced when a simultaneous increase in the production of almost all agricultural crops is desired as is the case in Orissa[6].

Second, it is also seen that in the allocation of the area between rival food grains, price is not a vital consideration. 'In respect of food grains, price relative to weather becomes a feebler consideration, except and to the extent that food grains compete with crops other than rival foodgrains for area. Thus rainfall assumes that status which price does in the case of cash crops'[7]. This implies that weather determines rice production in Orissa.

Thirdly, the supply elasticity for rice is much lower than that of commercial crops. Apart from the attitude of farmers towards subsistence crops which is not favourable for providing incentives to protection due to rise in prices, another factor which accounts for low elasticity is this that the production of rice comprises a high proportion of the aggregate agricultural production, and therefore, respond much more like the aggregate, with consequently lower supply elasticities with respect to relative prices. It is conceivable that a crop taking up 10 per cent of the total acreage in an area could have a much more elastic supply response than the aggregate, but it is not conceivable for a crop taking up 90 per cent of the acreage.[8]

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6. Ibid p. 17.

7. Cf Dharm Narain—The Impact of Price Movements on Areas under Selected Crops in India. 1900-1939, Cambridge University Press, London, 1965.

8. Cf John W. Mellor, The Functions of Agricultural Prices in Economic Development, Indian Journal of Agricultural Econmics, Vol. XXIII, No. 1, January, March, 1968.

It follows from this that the most important factors which have hindered the productivity of rice are not low prices or rising costs of inputs, but of low income unfavourable weather, and traditional form of agriculture where aggregate supply response is low.[9] When yields per hectare are in the neighbourhood of 1 ton, it is a mockery to talk of incentives through higher prices. In fact there is a process of cumulative causation which explains the lagging growth of agriculture and rice yield in Orissa.

**Institutional and organisational factors**

Though there is a great deal of controversy regarding the efficiency of institutional and organisational factors in increasing agricultural production, and some of the technologists affirm that the institutional framework of agrarian economics is not a serious obstacle to growth, and that what is needed is concentration on specific questions relating to the mechanics of the technological change required in each case and the supply of necessary inputs, empirical investigation has shown that small farmers and tenants do not derive sufficient benefit from the rather expensive HYV cultivation. Apart from the question of distribution of grain arising from new technology, for the benefit of increased production and improvement in productivity, institutional barriers like non-availability of credit or insecurity of tenure should be prevented so that small farmers who number 66 per cent in the State can effectively participate in the adoption of new technology in rice cultivation. As can be seen from Table 13 on operational holdings, of the total cultivating households, about 88 per cent cultivate an area below 10 acres.

But unfortunately the rate of change in institutional factors has been far from satisfactory.

(1) Several attempts have been made to fix a ceiling on land holdings. The ceiling limit was originally fixed at 25 and 100 acres depending upon the class of land. This limit was reduced in 1965

9. According to Prof. Dantwala, the greatest disincentive in Agricultural farming in India is low income, scanty resource base of the cultivator and consequent low productivity. See Incentives and Disincentives in Agriculture, op. cit., p 18.

TABLE 13

OPERATIONAL HOLDINGS IN ORISSA

| Size group (acres) | Cultivating households | Area cultivated |
|---|---|---|
| Less than 1 | 9.2 | 0.8 |
| 1—2.5 | 30.8 | 10.1 |
| 2.5—5 | 27.8 | 19.5 |
| 5—10 | 21.4 | 27.4 |
| 10—15 | 6.4 | 14.4 |
| Above 15 | 5.4 | 28.1 |
| | 100.00 | 100.00 |

*Source* : Agricultural Prices Commission, Report on Price Policy for Kharif Cereals (Procurement Prices) for the 1967-68 Season, September, 1967, p. 30.

to 20 and 80 acres. In 1972 it has been reduced further to 10 to 45 acres. In the absence of land record, it is not known how many cultivators will be affected by this ceiling, the guess is, there are about 3000 cultivators having more than one lakh acres of surplus land. At any rate several changes in the Land Reforms Act have given rise to illegal transfers and created considerable uncertainty leading to erosion of private investment in agriculture.

(2) The capacity of small farmers and tenants to benefit from the expensive HYV cultivation is limited. In fact, the green revolution in Orissa has become a 'merely a small palace revolt' and while 10 per cent of the cultivators have made some progress, 90 per cent have been untouched by motivation and enterprise. Particularly, the econmic condition of tenants is worse off now than before, firstly because the tenancy laws are so indifferently implemented that the tenants are compelled to pay more to the landowner than what is their due (though according to law, in case of high yielding variety, the tenant is to pay 25 per cent of the produce, he actually pays 40 per cent to the owner in most parts of Orissa), and secondly, because there is mounting determination among owners not to permit the tenants to secure the rights of land since the ownership of improved land is prized high which results in concealed tenancy. It is not easy to estimate the number of tenants in Orissa. Many of

the small owner cultivators and agricultural landowners are either open and or concealed tenants. The guess is, the tenants are in the neighbourhood of 20 per cent and they are indifferent to increase the yield of land they cultivate.

(3) Institutional credit has not made much progress in the State. During 1970-71, the primary cooperative Societies advanced Rs. 8.7 crores to borrowers. The average loan advanced per borrowing member was Rs. 280 as compared to Rs. 514 for the country, and Rs. 1278 for Gujarat. The percentage of overdues to outstanding loans was quite high at 66 as against 41 for the country. At the end of December 1971, the Commercial Banks advances to agriculture amounted only Rs. 1.6 crores as compared to Rs. 78 crores for Maharastra, Rs. 56 crores for Tamil Nadu and Rs. 50 crores for Andhra Pradesh. Thus, the advances of these banks per hectare of the gross cropped area were only Rs. 2 in Orissa as compared to Rs. 81 for Tamil Nadu and Rs. 25 for the country.

(4) Marketing facilities in the State are not well developed. Out of the 80 markets in the State, 35 main markets and 25 submarkets were expected to be regulated by the end of the 4th Plan. In the Second Plan, the annual average arrival of agricultural commodities was valued at Rs. 2.66 crores. This was increased to Rs. 5.66 crores per year in the Third Plan. For the 4th Plan, it has been estimated to go up to Rs. 40 crores per year. At the beginning of the 4th Plan 5 grading units and 15 warehouses with 17000 tonnes capacity had been set up. The achievement in this regard by the end of the 4th Plan is expected to be 28 grading units and 28000 tonnes of warehousing capacity.

(5) Consolidation of holdings has been taken up as a plan programme with effect from 1970-71. The work has so far been confined to on pre-consolidation work i. e. disposal of revenue cases, correction of record rights, collection of relevant data, etc. The Orissa Consolidation of Holdings and Prevention of Fragmentation of Land Act, 1972 has since been passed. But real work of consolidation is yet to start.

It is not possible to determine to what extent these institutional barriers have inhibited the growth of rice yield. Institutional factors induce growth in all crops, and since rice is the main crop in Orissa, its productivity has been adversely affected by such impediments.

**Conclusion**

Our survey shows that there has been no breakthrough in rice cultivation in Orissa. This has been mainly due to slow technological changes, attributed probably due to low income of the cultivators. There is a vicious circle, starting from low income, lack of enterprise, lack of investment, unfavourable climate and institutional barriers, all leading to interlocking vicious circles. The first priority in the process of change should be technological without which institutional or organisational reforms are not likely to succeed. The organisational tasks are centred on the supply and intensive application of modern inputs. The institutional changes are necessary to provide economic incentives to small farmers to effectively participate in the process of change and derive gain from the change. But the main motivating factor is technology which has a high pay-off compared to institutional or organisational factors. Even natural hazards which frequently visit Orissa and lower the yield of rice can be considerably controlled by means of application of appropriate technological inputs. However, the specific changes that need immediate attention for a break-through in rice productivity are irrigation, water management, consolidation of holdings, crop planning for upland areas, flood control and improvement of institutional infrastructure. Change is multi-dimensional. Yet a few areas have to be selected to initiate the process of change and provide impetus for further change.

# FACTORS AFFECTING CONSUMPTION OF RICE BY CULTIVATOR HOUSEHOLDS IN PUNJAB (1951-70)

Dr. BENUDHAR BHUYAN
*Department of Agril. Economics,*
*College of Agriculture, Bhubaneswar*

In a planned economy the increase in investment gives rise to increase in real income of the individuals. It, in turn, increases consumer demand for different food grains. Unless provision is made to meet this increased demand prices may rise and cause serious difficulties. For this, information on factors affecting consumption of various foodgrains are essential. But in India not many studies have been made yet on consumer behaviour. In spite of many family budget studies conducted in India few studies have been conducted on consumer behaviour on regional basis. The present study being regional, aims at analysing consumption of rice by the farmers of Punjab for a period of twenty years. Rice is not grown widely in Punjab. So also rice is not consumed widely by the Punjab farmers. It is taken as a side item on special occasions. During special social occasions and festivals rice is consumed usually by all households in the rural area. The study proposes to estimate the influence of principal economic variables i. e., prices, income, tastes and time on consumption of rice by the cultivator families. The specific objectives of the study are :

1. to study the effect of a change in income on consumption of rice.

2. to analyse the effect of price on consumption of rice.

3. to study the influence of prices of related foodgrains on consumption of rice.

4. to study the trend of annual expenditure, retail prices and distribution of income on the variation in trend of expenditure elasticities.

**Methodology**

Time series data of a changing cross section of 583 households covering the period, 1951-52 to 1970-71 are obtained from the relevant Publications published by the Board of Economic Enquiry, Punjab. Annual data on total expenditure, total income, consumption, family consumption and prices of wheat, maize, rice and gram are used for the purpose. Income, expenditure and prices are used in real terms, the cost of living indices being the deflators. Total expenditure is taken as proxy for total income as the independent variable. The consumption, consumption expenditure on rice and total expenditure on the family have been standardised in order to eliminate the effect of sex and age composition of the family on consumption and expenditure. The standardisation has been done by means of the following regression model.

$$C_R = b_1x_1 + b_2x_2 + b_3x_3 \ldots\ldots\ldots (1)$$

**Where :**

$C_R$ = Consumption of rice in Kg per family per annum,

$x_1$ = Number of children in the family.

$x_2$ = Number of adult females in the family.

$x_3$ = Number of adult males in the family.

The parameters $b_1$, $b_2$ and $b_3$ have been estimated by the means of ordinary Least Squares. The ratios, $b_1/b_3$ and $b_2/b_3$ give adult male equivalents for child and adult female respectively for rice. The standard consumption unit selected is the adult male.

**Analytical Models used.**

The single equation analytical models used to explain consumer behaviour are given below.

$$C_R = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 \ldots\ldots (2)$$

$$E_{CR} = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 \ldots\ldots (3)$$

Where,

$C_R$=Quantity of rice consumed per consumption unit per annum.

$E_{CR}$=Annual expenditure on rice consumption per consumption unit.

$X_1$=annual total expenditure per consumption unit.

$X_2$=annual retail price of wheat per Kg.

$X_3$=annual retail price of maize per Kg.

$X_4$=annual retail price of rice per Kg.

$X_5$=annual retail price of gram per Kg.

$X_0$=trend variable in unit of years.

The single equation technique has been tried with three functional forms, viz. Linear, Log-linear and Semi-log to explain the effect of a change in prices, income and prices of related goods on consumption and consumption expenditure on rice.

The expenditure elasticities for individual years have been worked out by making use of the regression model as follows :

$E_{CR}=a+bx_0$......(4)

Where,

$E_{CR}$=annual expenditure on consumption of rice per consumption unit.

$X_0$=total expenditure in rupees per consumption unit per annum.

Four different functional forms, namely Linear, Loglinear, Semi-log and Log-log inverse are tried to work out the annual elasticities.

Variations in expenditure elasticities from year to year are sought to be explained by means of a regression model as given below :

$E = a + b_1x_1 + b_2x_2 + b_3x_3 \ldots\ldots (5)$

E=annual expenditure elasticities.

$X_1$=total expenditure per consumption unit per annum,

$X_2$=concentration ratio of income distribution,

$X_3$=annual retail price of rice.

Three different functional forms, i. e. Linear, log-Linear and Semi-log of the above model are used in this analysis.

**Results and discussion**

The trends in per unit consumption, per unit income and price of rice for the period 1951-70 are given below.

TABLE 1

TREND IN PER UNIT CONSUMPTION OF RICE

Annual Income and Retail Price of Rice

| Year | Annual consumption in Kg | Annual income in Rs | Annual retail price per Kg |
|---|---|---|---|
| 1951-52 | 3.91 | 137.00 | 0.57 |
| 1952-53 | 5.08 | 116.62 | 0.60 |
| 1953-54 | 4.51 | 140.62 | 0.68 |
| 1954-55 | 5.65 | 132.00 | 0.51 |
| 1955-56 | 4.77 | 127.35 | 0.53 |
| 1956-57 | 3.59 | 112.55 | 0.55 |
| 1957-58 | 2.75 | 118.28 | 0.61 |
| 1958-59 | 3.17 | 128.06 | 0.63 |
| 1959-60 | 2.60 | 122.70 | 0.73 |
| 1960-61 | 3.67 | 116.68 | 0.60 |
| 1961-62 | 5.19 | 98.81 | 0.53 |
| 1962-63 | 2.45 | 103.67 | 0.61 |
| 1963-64 | 3.73 | 105.22 | 0.59 |
| 1964-65 | 5.06 | 113.81 | 0.52 |
| 1965-66 | 2.83 | 112.69 | 0.46 |
| 1966-67 | 3.63 | 92.35 | 0.46 |
| 1967-68 | 3.53 | 100.80 | 0.50 |
| 1968-69 | 2.32 | 105.12 | 0.58 |
| 1969-70 | 2.46 | 111.77 | 0.62 |
| 1970-71 | 4.08 | 115.93 | 0.60 |

The average consumption of rice per annum per consumption unit is about 3.64 Kgs. for the period under study. The average consumption shows slight variation over the years. It varies from 2.60 Kgs. in 1959-60 to 5.19 Kgs. in 1961-62. Rice consumption is showing a slight rising trend alongwith income.

On the basis of goodness of fit and level of significance of the regression co-efficients the double-log function has been selected for presentation.

$$\log C_R = -2.75 + \underset{(0.12)}{0.48x_1^*} - \underset{(0.53)}{0.57x_2} + \underset{(0.48)}{0.009x_3} - \underset{(0.56)}{1.94x_4^*}$$
$$+ \underset{(0.33)}{0.28x_5} - \underset{(0.12)}{0.13x_6} \quad \ldots\ldots (1)$$

All exogenous variables except total expenditure and price of rice are found statistically non-significant. Hence, the analysis is re-run taking only total expenditure and price of rice. The resulting equation is :

$$\log C_R = -2.77 + \underset{(0.12)}{0.49x_1^*} - \underset{(0.53)}{1.75x_4^*} \quad \ldots\ldots (2)$$

$R = 0.19^*$

There are no changes in levels of significance and magnitudes of co-efficients, except for price of rice where the magnitude of co-efficient has declined slightly.

The use of expenditure per consumption unit on rice ($E_{CR}$) as the dependent variable in equation (3) has brought about some changes in the equation below :

$$\log E_{CR} = -3.18 + \underset{(0.10)}{0.54x_1^*} - \underset{(0.45)}{0.90x_4^{**}} \quad \ldots\ldots (3)$$

$R = 0.21^*$

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*= significant at one percent level

**= significant at five percent level

Figures in parentheses indicate standard errors.

The expenditure elasticity observed in equation (3) is 0.54, slightly higher than the quantity elasticity of equation (2), i.e. 0.49. The difference between the expenditure elasticity and quantity elasticity is a measure of quality elasticity. As this measure is found to be positive, the farmers seem to prefer better quality of rice for consumption with rising total expenditure. Such behaviour is in tune with the excepted behaviour of rational consumer.

The estimates of expenditure elasticity of demand for consumption of rice and price elasticity as obtained from equation (2), are 0.49 and —1.75 respectively. It means that on an average with one percent rise in total expenditure, the corresponding rise in the consumption of rice is 0.49 percent. The own price elasticity (—1.75) indicates that with hundred percent rise in the real price of rice, the corresponding fall in the quantity of rice consumed is 175 percent. Hence, the demand for rice consumption is very sensitive to its own price.

**Trend of expenditure elasticities**

Rice is not a popular staple food in the rural Punjab. Expenditure on rice constitutes approximately one percent of the total expenditure per annum. Hence, it is interesting to know the attitudes of the farmers towards their expenditure on rice consumption by means of the expenditure elasticity. Trend of annual expenditure elasticities has been derived for the period of study, 1951-70. The results of the analysis are given in Table 2.

As Table 2 reveals, there is wide variation in expenditure elasticities over the years. The range of variation is from 0.24 in 1962-63 to 2.42 in 1957-58. To explain such variation, multiple regression analysis taking expenditure elasticity as dependent variable ($E_R$) and total expenditure ($X_1$), concentration ratio of distribution of income ($X_2$) and price of rice ($X_3$) as independent variable is conducted making use of linear, log-linear and semi-log functional forms. But the data give poor fit in all functional forms. Total expenditure, income distribution and ratail price of rice fail to explain the variation in expenditure elasticity of demand. Probably other factors like food habits, customs and

## TABLE 2

EXPENDITURE ELASTICITIES OF CONSUMPTION OF RICE
FOR INDIVIDUAL YEARS, 1951-70
Log Log-Inverse Function

| Year | Expenditure elasticities | Standard errors |
|---|---|---|
| 1951-52 | 1.26 | 0.47 |
| 1952-53 | 1.17 | 0.57 |
| 1953-54 | 1.13 | 0.48 |
| 1954-55 | 0.36 | 0.89 |
| 1955-56 | 1.49 | 0.59 |
| 1956-57 | 1.32 | 0.80 |
| 1957-58 | 2.42 | 0.76 |
| 1958-59 | 0.27 | 0.16 |
| 1959-60 | 1.15 | 0.65 |
| 1960-61 | 0.48 | 0.74 |
| 1961-62 | 0.39 | 0.44 |
| 1962-63 | 0.24 | 0.24 |
| 1963-64 | 0.64 | 0.65 |
| 1964-65 | 0.35 | 0.28 |
| 1965-66 | 0.76 | 0.45 |
| 1966-67 | 0.68 | 0.14 |
| 1967-68 | 0.71 | 0.42 |
| 1968-69 | 0.88 | 0.26 |
| 1969-70 | 0.57 | 0.10 |
| 1670-71 | 0.83 | 0.05 |

conventions play a major role to cause the variation in the expenditure elasticities.

**Difference in expenditure elasticities between home-produced rice and purchased rice**

To distinguish between the expenditure elasticity of home-produced rice from that of cash purchased rice, two least square regression analysis are conducted. In the first equation, expenditure on home-grown rice is regressed on total expenditure and in the second equation expenditure on purchased rice is related to total expenditure. Log-linear functional form is selected on the basis goodness of fit for analysis. The results are given in the table below.

The elasticities are significant at one per cent level. The difference between the two elasticities for home-produced and

## TABLE 3

### LOG-LINEAR FUNCTION

| Overall expenditure elasticity | Expenditure elasticity of home-produced rice | Expenditure elasticity of purchased rice |
|---|---|---|
| 0.52<br>(0.10) | 0.10<br>(0.06) | 0.50<br>(0.11) |

Figures in parentheses are the standard errors.

market purchased consumption indicates that with increase in total expenditure, the increase in consumption out of market purchase are likely to be more than increases out of home production.

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# EXPLORATION OF CROP RESPONSE FUNCTIONS AND CRITERIA FOR THEIR SELECTION

SHRI L. K. PATI

*Department of Statistics*

*Orissa University of Agriculture and Technology, Bhubaneswar*

## 1. Introduction

A production function imposes only the restriction of nonnegativity on the set of outputs and inputs. As the maximum attainable output for any set of stipulated inputs is unique, the production function is single valued. Economists have traditionally assumed certain convenient properties for the production function. These properties facilitate economic analysis in connection with optimizing models of economic agents. The following assumptions are usually associated with the production functions ( Ferguson, 1971 ).

(*i*) The production function is continuous over the relevant range of inputs yielding nonnegative outputs.

(*ii*) It possesses continuous first and second order partial derivatives.

(*iii*) Inputs are continuously variable, i.e. the inputs are real variables defined over positive quadrant of the input space.

The concept of production function has been in use in agricultural research over a long period. After the passage of the Hatch Act of 1887 a number of agricultural experiment stations in U. S. A. started estimating points on the production surface. Experimental research conducted on crops and livestock used discrete input combinations to determine corresponding estimates of outputs. Techniques of interpolation were applied to the empirical results to find estimated responses corresponding to unobserved or untested input levels. Gradually, however, physical and biological scientists became acquainted with the concept of production function. Mitscherlich ( 1909 ) was the first agriculturist to suggest a nonlinear relationship between inputs and outputs. Subsequently more useful production functions of the Cobb-Douglas type were developed and employed. Then the idea of estimating the entire production surface rather than points on the surface have become common in agricultural research.

In this note an attempt has been made to discuss some production functions and to evolve criteria of suitability. Special reference has been given to quadratic functions which are proved to be suitable for crop response studies.

## 2. Forms of production functions

Various algebraic forms of equations are used for approximating production functions. Selection of these functional forms typically depends on the knowledge of the biological or the other physical factors. It is, therefore, common for functional forms to vary with the agroclimatic conditions like soil type, soil fertility level, growing season, climate and other crop characteristics, and also with the prevailing technology. In short, production function needs to be appropriate for the production process being studied.

Two types of algebraic forms are widely used in agriculture for crop response studies—polynomial production functions and the power functions of the Cobb-Douglas type. Other functional forms due to Spillman or Mitscherlich are of historical interest, but are not widely used.

### Polynomial production function

The polynomials have the characteristic of approximating large class of functions. When the form of a true response function is either unknown or very complicated it may be approximated by a polynomial over a narrow region of the factor space. Over the sufficiently small region of interest the polynomial approximation gives results similar to those of the true response function. As a basis for these assertions a few polynomials of different orders are considered as approximation to some unknown true production function ( which is assumed to be continuous ). Consider the production function.

$$Y=f\ (X) \qquad (2.1)$$

As a Taylor's series expansion where $X=(X_1, X_2,\ldots X_k)$ is the input factor corresponding to the levels of K independent factors $X_1, X_2,\ldots, X_k$, and y is the response.

For simplicity, two inputs $X_1$ and $X_2$ are considered and the production function f (X) is assumed to be continuous with continuous first partial derivatives everywhere in the factor space. The function f (X) may be expanded in a Taylor's series about the point X=C where $C=(C_1, C_2)$ as :

$$Y=f\ (c)+\frac{\partial f(c)}{\partial X_1}(X_1-C_1)+\frac{\partial f(c)}{\partial X_2}(X_2-C_2)+O\ (X-C)^2 \quad (2.2)$$

For sufficiently small deviations of (X—C) the terms of higher order in (X—C) are ignored and the expression (2.2) is represented as a linear function :

$$Y=B_0+B_1X_1+B_2X_2 \qquad (2.3)$$

$$\text{Where } B_0=f\ (c)-C_1\frac{\partial f(c)}{\partial X_1}-C_2\frac{\partial f(c)}{\partial X_2}$$

$$B_1=\frac{\partial f(c)}{\partial X_1} \text{ and } B_2=\frac{\partial f(c)}{\partial X_2}$$

Just as a linear production function is obtained by including only the first order terms in the Taylor's series expansion of f (X) about X=C the second order terms when included give the quadratic.

$$Y=B_0+B_1X_1+B_2X_2+B_{11}X_1^2+B_{22}X_2^2+B_{12}X_1X_2 \quad (2.4)$$

All the coefficients of the quadratic as well as the coefficients of the linear response function are functions of C, the point around which the Taylor's series expansion is obtained. The location of the point C (which is called the search center) is a key factor in determining the optimal approximating function. The choice of the initial search center C is usually based on prior knowledge about the approximate location of the optimal responses (Mihram, 1972). If the optimum point is close to the boundary lines of the experimental region (domain of X) or outside the region, the Taylor's series approximation of the true response function to a quadratic is likely to be very poor. Detailed procedures for the selection of optimal search center are discussed in Box and Wilson (1951), Mihram (1972), and Wilde (1964).

Polynomials of higher order are not discussed here as they are of little significance in approximating production surfaces found in agriculture. A major difficulty with the use of a higher order polynomial is that as the degree of the polynomial and the number of factors increase, the number of terms in the Taylor's series expansion increases rapidly. Consequently, the degrees of freedom available for statistical testing decreases. Owing largely to the above limitation, lower order polynomials like quadratic have been widely used in the past in crop response studies.[1]

**Power functions**

The Cobb-Douglas (CD) production function (the most common of the power functions) for two resource inputs $X_1$ and $X_2$ is represented by $Y = b_0 X_1^{b_1} X_2^{b_2}$ (2.5)

Where y is the response, $b_0$ is the efficiency parameter, $b_1$ and $b_2$ are the elasticities of production. A measure of scale is given by $b_1+b_2$. Constant, increasing or decreasing to scale prevail according to whether $b_1+b_2$ is equal to 1, greater than 1 or less than 1, respectively. The function exhibits diminishing total productivity (the marginal products declining but never reach zero). So the maximum output is undefined. The CD production function has been widely used in agriculture and other industry studies.

## 3. Selection Criteria

Criteria for the selection of crop response functions are summarized below.

1. See for example, Anderson and Dillon (1968), Colyer and Kroth (1968), Doll (1972) Heady and Dillon (1961).

(*i*) The response function must satisfy the assumptions of the Dillon's theory of response.[2] Diminishing marginal productivities for all input levels is a common characteristic of the functions representing the crop responses to fertilizer, and these functions should allow negative marginal productivities.

(*ii*) Adequacy of the function to fit empirical data.

(*iii*) The function is amenable to economic analysis in transforming useful information into pay-offs.

(*iv*) It can be easily subjected to algebraic manipulation.

(*v*) The function lends itself to an easy estimation procedure.

Let us consider the advantages and disadvantages of different forms of production functions in meeting some of the criteria set above. A CD type power function does not allow the total product to decrease with the increase in input levels. "Unless an economic optimum is defined for small magnitudes of inputs this function overestimates the input of X" (Heady and Dillon, 1961). This function being exponential in nature results in unattainable yields with high input levels under a given state of technology or through technological progress. These functions are more suitable for industry studies due to their aggregative nature with undefined output. This function being log linear allows direct application of ordinary least squares estimation technique.

The condition of diminishing marginal returns is not satisfied for a first degree polynomial as the marginal physical products are constants. All second order partial derivatives being zero restricts the suitability of a first degree polynomial as a production function in crop response studies.

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2. Dillon's assumptions for a simple theory of response (Dillon. 1968) are : (i) There is a continuous smooth relation between the inputs and output ; (ii) Diminishing returns prevail with respect to each input; (iii) Decreasing returns to scale prevails so that a proportionate increase in all inputs results in a less than proportionate increase in output.

A third degree polynomial which depicts both increasing and decreasing returns to scale (a special form of this function for one variable has been treated in Heady and Dillon (1961) may be more suitable for certain kinds of commodities, but when used as an estimated production function gives less number of degrees of freedom for the estimation of error. This function is not easily algebraically manipulated, and enough study has not been done to judge its suitability to fit empirical data arising out of crop responses.

A second degree polynomial allows diminishing returns to scale, and was found adequate to fit empirical data in crop studies in the past. In favour of this function are some of its properties which have already been pointed out. To cite a few of them, a quadratic is readily estimated by ordinary least squares technique, it represents a more general class of functions as does the Cobb-Douglas, it is readily amenable to economic analysis and, finally, the function lends itself to easy algebraic manipulation (Anderson, 1971).

On the basis of the above consideration a quadratic production function may be more suitably employed in estimating the crop response relationships.

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# ECONOMICS OF IRRIGATION IN ORISSA

Dr. PRAFULLA KUMAR DAS
*Orissa University of Agriculture and Technology*

The importance of irrigation needs hardly any emphasis. Irrigation helps agriculture in the following ways :

(*i*) It contributes directly to increased production per unit of land from a particular harvest.

(*ii*) It makes feasible for the succesive production of two or more crops on the same year from the same land.

(*iii*) It creates a favourable condition to shift to crops that yield a larger cash return per unit of land, as it is observed that almost all the cash crops are grown on the condition of assured supplies of water.

(*iv*) It increases the capacity of the areas to absorb productively traditional inputs like human and bullock labours, and modern inputs like fertilizers, pesticides and farm machineries.

(*v*) It acts as an insurance against recurring famines due to weather uncertainty which in turn stabilises agricultural production.

These are all what we say the direct benefits from irrigation the society derives. It is also alleged that irrigation input accentuates the existing regional disparities. However, irrigation resource seems to be the necessary condition whereas ferfilizer and new seeds are taken as sufficient condition for maximising output. Beacause this factor of production provides the base for augmenting production.

## Irrigation potential in Orissa

Orissa lags much behind the states like Punjab, Haryana, Tamil Nadu and Andhra Pradesh so far as irrigation potential is concerned. In the year 1968-69 the net area irrigated as percentage of net sown area in case of Orissa came to 16.3, whereas the corresponding figures for Punjab, Haryana, Tamil Nadu, Andhra Pradesh and Uttar Pradesh were 58.4, 32.2, 43.2, 27.2 and 32.4 respectively. The irrigation potential created in Orissa was even lower than all India average which stood at 19·7 against Orissa's 16·3. Mainly due to the constraint of irrigation input Orissa ranked 16 in the year 1969-70 with regard to area covered under high yielding varieties programme in cereal crops. Between 1967-68 and 1969-70 the average net income per hectare came to 1155 rupees in case of Orissa whereas it was 2223 rupees for West Bengal, 1859 rupees for Punjab, 1447 rupees for Uttar Pradesh, 1367 rupees for Tamil Nadu and Haryana states. Therefore irrigation potential is considered as one of the important economic indicators to measure the progress of economic development of an agrarian state.

## Objective

This paper seeks to analyse the impact of irrigation in agriculture sector of the economy.

## Sampling technique

The sampling technique adopted for the field investigation was based on stratified random sampling. The study pertains to Nayagarh area of Orissa and it relates to the year 1973-74. Two villages from each of the two catagories namely (1) canal irrigated and (2) unirrigated were selected for the purpose of this study. The holdings were divided into three size groups namely (1) below 2·5 acres, (2) 2·5 to 5 acres and (3) above 5 acres. However the maximum size of holding has been limited to 10 acres to keep the third size as homogeneous as possible. From each size group of farms in each category of villages five holdings were selected at random for the purpose of this study. The unirrigated villages were taken as control to estimate the impact of irrigation in crop husbandry.

## Results and discussion

One of the measures to study the impact of irrigation on agriculture is to make a comparison of the size of farm business between irrigated and unirrigated farms in same area. The size of farm business is generally expressed in the forms of (*i*) net area sown, (*ii*) gross cropped area, (*iii*) Intensity of cropping, (*iv*) value of farm investment mostly in forms of capital inputs used, (*v*) Total labour used, (*iv*) farm productivity, and (*vii*) farm returns. An attempt has been made to estimate the various measures of farm business.

## Crop intensity

Table 1 shows, (*a*) areas farmed or net area sown, (*b*) acres seeded or gross cropped area, and finally (*c*) the intensity of cropping which is derived from the earlier two, (*a*) and (*b*).

TABLE 1

ESTIMATED CROP INTENSITY IN IRRIGATED AND UNIRRIGATED FARM SITUATIONS

(No of farms in each size group=5)

| Particulars | Unirrgated farms | | | Irrigated farms | | |
|---|---|---|---|---|---|---|
| | Below 2.5 | 2.5-5.0 acres | Above 5 acres | Below 2.5 | 2.5-5.0 acres | Above 5 acres |
| Net area sown. | 7.07 | 24.75 | 31.55 | 12.60 | 18.37 | 31.57 |
| Gross cropped area. | 17.15 | 46.00 | 69.75 | 30.30 | 43.95 | 72.20 |
| Intensity of cropping. | 187.98 | 184.81 | 187.87 | 240.47 | 239.18 | 260.32 |

The estimated figures of crop intensity reveals that the average intensity in case of unirrigated farms was 189 percent whereas it came to 250 in irrigated farms. In other words, the crop intensity was one and half times more in irrigated condition than that of unirrigated condition. So far as farm size is concerned, it is observed that it has no influence on crop intensity.

## Cropping pattern

The cropping pattern of the sampled farms with respect to year under reference is presented in Table 2. The following observations can be made from this table.

### TABLE 2

CROPPING PATTERN FOLLOWED IN IRRIGATED AND UNIRRIGATED FARM SITUATIONS

| | Unirrigated farms | | Irrigated farms | |
|---|---|---|---|---|
| | Crops | Area in percentage | Crops | Area in percentage |
| Kharif crops | Local paddy | 48.91 | Local paddy | 23.08 |
| | Ragi | 2.79 | H. Y. V. Paddy | 6.55 |
| | Jute | 2.17 | Groundnut | 2.39 |
| Rabi crops | Black gram | 12.55 | Potato | 16.10 |
| | Green gram | 16.00 | Wheat | 6.13 |
| | Horse gram | 3.62 | Mustard | 2.87 |
| | Khesari | 11.99 | Winter vegetables | 2.39 |
| | Mustard | 1.05 | | |
| Summer crops | Nil | Nil | H. Y. V. Paddy | 15.65 |
| | | | Groundnut | 10.74 |
| | | | Ragi | 6.61 |
| Year round crop | Nil | Nil | Sugar cane | 7.47 |
| | | 100.00 | | 100.00 |

(*i*) Under irrigated condition the area under high yielding varieties of paddy came to 22.11 percent (6.55 percent in Kharif and 15.56 percent in summer). Due to obvious reasons, the same varieties of paddy did not find place in unirrigated farms.

(*ii*) In unirrigated farms different kinds of pulse crops dominated the cropping pattern in Rabi season, as these crops could be grown by the help of retained moisture condition. It is interesting to observe that almost entire sown area during Rabi was saturated with pulses in unirrigated farms, whereas pulses were completely rooted out in irrigated farms. High remunerative cash crops were grown in irrigated farms in lieu of less remunerative pulse crops.

## Irrigation and fertilizer use

Table 3 shows per acre distribution of the value of fertilizer used in unirrigated and irrigated conditions and with respect to different farm sizes.

TABLE 3

PER ACRE VALUE OF FERTILIZER USED IN IRRIGATED AND UNIRRIGATED FARM SITUATIONS. (IN Rs. PER ANNUM)

| Size groups (in acres) | Unirrigated farm | Irrigated farm |
|---|---|---|
| I (below 2.5) | 21.82 | 257.14 |
| II (2.5-5.0) | 25.03 | 276.80 |
| III (above 5) | 31.60 | 285.74 |

The figures in Table 3 indicate that per acre use of fertilizer was ten times higher in irrigated farms than unirrigated farms. So far as the farm size is concerned we observed higher size farms used more fertilizer per unit of land. This study corroborates our earlier findings that irrigation creates very favourable conditions by which high productive input like fertilizers get greater scope for absorption.

## Irrigation and labour utilization

Man continues to be the most important source of farm power in this area. Data in table 4 shows the per acre labour employment

TABEL 4

PER ACRE HUMAN LABOUR UTILISATION IN IRRIGATED AND UNIRRIGATED FARM SITUATIONS

(in man days)

| Size group | Unirrigated farms | | | | Irrigated farms | | | |
|---|---|---|---|---|---|---|---|---|
| (in acres) | Kharif | Rabi | Summer | Total | Kharif | Rabi | Summer | Total |
| I (below 2.5) | 66.05<br>(80.25) | 16.00<br>(19.75) | | 82.05<br>(100.00) | 83.67<br>(35.83) | 92.08<br>(39.43) | 57.79<br>(24.74) | 230.54<br>(100.00) |
| II (2.5 to 5.0) | 62.66<br>(80.55) | 13.69<br>(19.45) | — | 76.35<br>(100.00) | 75.59<br>(34.52) | 85.71<br>(39.13) | 57.73<br>(26.35) | 219.03<br>(100.00) |
| III (above 5) | 56.98<br>(81.35) | 14.21<br>(18.65) | — | 70.19<br>(100.00) | 76.95<br>(36.40) | 61.66<br>(29.17) | 72.77<br>(34.43) | 214.38<br>(100.00) |

(Figures in parenthesis indicate percentage) in irrigated and unirrigated farm conditions. From this table it can be seen that the unirrigated farms on an average used 76 man days per acre per annum, whereas irrigated farms used 221 man days. Thus the labour utilisation in irrigated farms was more or less three times of the requirement of unirrigated farms in the same area. It is obvious from the table that labour distribution is uneven in unirrigated areas, as 80.72 percent of labour days engaged in farming only during Kharif and the remaining 19.28 percent were used during Rabi season. But in irrigated area the employment was evenly distributed, the year round. It was further observed that small farms utilised more labour per acre in both the cases. Table 4 suggests that the seasonality of employment could be corrected to a great extent through the introduction of water resources in farming.

**Gross Expenditure**

Gross expenditure on crop production or total cost of cultivation per acre will give an idea about the influence of irrigation in changing investment pattern in different conditions of farming. In this study the gross expenditure per acre per annum has been estimated for different sizes of holdings and this has been indicated in table 5. The table reveals that on an average gross expenditure in irrigated farms was four times larger than that of unirrigated farms. Adoption of more capital intensive but more remunerative crops and higher crop intensity in irrigated condition obviously raised the size of investment fourfolds as compared to extensive type of cultivation in unirrigated situation. Growing of high yielding varieties of paddy

TABLE 5

GROSS EXPENDITURE PER ANNUM PER ACRE IN IRRIGATED AND UNIRRIGATED FARM SITUATIONS (AMOUNT IN Rs.)

| Size group (in acres) | Unirrigated farm | Irrigated firm |
|---|---|---|
| I (below 2.5) | 462.31 | 1937.97 |
| II (2.5 to 5.0) | 493.39 | 2009.97 |
| III (above 5) | 515.93 | 2060.81 |
| Average | 490.54<br>(100.00) | 2002.91<br>(408.30) |

both during Kharif and Summer in irrigated farms has acclerated the investment process with the ambition of higher profit.

**Gross income**

Gross income is one of the measures to study farm efficiency though it varies with price fluctuations and yield uncertainties. Gross income analysis is done with a view to study the influence of irrigation on farm income, and the estimated figures have been presented in table 6.

This table shows that there is wide difference between gross income of farms under unirrigated and irrigated conditions. In case of canal irrigated farms the gross income was Rs. 3607 per acre whereas in case of unirrigated farms it was Rs. 752 per acre. In other words the gross income generated under irrigated condition could be four and half times larger than that of unirrigated situation. Hence it may be concluded that the increase in gross farm income is more than proportional to the increase in gross expenditure in farming.

TABLE 6

ESTIMATED GROSS EXPENDITURE PER ACRE PER ANNUM IN IRRIGATED AND UNIRRIGATED SITUATIONS (AMOUNT IN Rs.)

| Size group (in acres) | Unirrigated farm | Irrigated farm |
|---|---|---|
| I (below 2.5) | 695.28 | 3488.69 |
| II (2.5 to 5.0) | 761.51 | 3607.83 |
| III (above-5) | 799.81 | 3824.89 |
| Average | 752.22<br>(110.00) | 3607.13<br>(479.53) |

**Net Profit**

"Per acre net profit" may be viewed as one of the true indicators to measure the farm efficiency. Since the year under reference was fairly a normal year from the point of view of agro-climatic situation. From table 7 it would be clear that the net profit per acre was about Rs. 1637 in irrigated farms whereas the same was only Rs. 262 in unirrigated farms. This difference is quite large. The study has fully established that the irrigation facilities could increase the economic condition of the rural people to a great extent provided this critical input is properly utilised.

TABLE 7

ESTIMATED NET PROFIT PER ACRE IN IRRIGATED AND UNIRRIGATED FARM SITUATIONS (AMOUNT IN Rs.)

| Size group (in acres) | Unirrigated farms | Irrigated farms |
|---|---|---|
| I (below 2.5) | 232.97 | 1550.72 |
| II (2.5 to 5.0) | 268.12 | 1597.86 |
| III (above-5) | 383.96 | 1764.08 |
| Average | 261.68 | 1637.88 |
| | (100.00) | (625.90) |

**Irrigation and regional disparities**

Table 7 further brought out that irrigation input act as a catalyst in accentuating the already existing disparities of income between regions. The disparities in income between irrigated and unirrigated regions is complex of several imbalances. The favourable points that we have so far noticed in this study of the irrigation economics such as high crop intensity, inclusion of high value crops in the cropping pattern, intensive use of labour and capital inputs, timely operations and finally reduction of weather uncertainties to a considerable extent influence the factor productivities to increase in irrigated farms which accentuated regional imbalances. Since irrigation stands as a pre-condition for the use of fertilizer and high yielding seeds, the income disparities would therefore largely mean as an effect of irrigation.

Farm management studies conducted in India during fifties and early sixties did not show the income disparities to such a large extent between irrigated and unirrigated areas. The impact of irrigation was mainly visualised through the reduction of weather uncertainty and consequent increase in crop yield or farm income. There was not much difference in the use of crop inputs between irrigated and unirrigated farms. Therefore the impact of irrigation was not so conspicuous. However, during late sixties the introduction of high yielding varieties programme and interrelated strategic factors in our farming system made a significant impact only under irrigated condition. In absence of dry or unirrigated land use technology, the creation of irrigation potential in a few regions unfortunately created such an imbalance in agrarian society.

From this point of view it does not mean that irrigation should be given less priority. With the emphasis for rapid development of irrigation infrastructure efforts should be directed towards improving the dry land technology and creating supplementary occupations like dairy, poultry, piggery etc. in the unirrigated tracts, to avert the unavoidable growing disparties of income.

It may be pointed out here that the irrigation potential in the area under study has not been fully exploited. It is therefore suggested that much attention should be given to supply of tangible inputs like quality seeds, fertilizers, pesticides in order to derive full benefits of irrigation. Much more attention should also be given towards intangible inputs such as soil and water management and selection of crops.

# NOT GOING FAR WRONG : AN EMPIRICAL VERIFICATION*

SHRI D. TRIPATHY, I. E. S.

The shadow wage rate (SWR) for Social Cost Benefit Analysis of Projects represents society's loss of marginal worker in alternative employment. Traditional analysis equated this with the marginal product of marginal worker in the lowest productivity sector, namely agriculture. In underdeveloped overpopulated economies of South East Asia, in the presence of high disguised unemployment, the marginal product of labour is assumed to be zero. Nurkse in his 'Rio' lectures states that disguised unemployment is a situation in which, assuming unchanged techniques of production, withdrawal of substantial number of rural population engaged in agriculture will not lead to a fall in agricultural production. This led him and several others to conclude that the consumption of these withdrawal workers can be a saving potential if their consumption basket is withdrawn along with them to their new place of work and those who remain on farm are also not allowed to increase their consumption.

Though the above situation will be an ideal one, so far as the capital formation is concerned in a situation in which savings and investments are sub-optimal, it has been thought that this will not be practicable. In many models, of industrial project analysis, it has been assumed (and quite realistically) that any extra wage paid to the newly employed workers will be fully consumed because of the new environment in which they work and their high propensity to consume. It is also quite reasonable to assume that the consumption of the on-farm workers will not be restricted to their former level

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—Asst. Director, P.E.O., Planning Commission

as their levels of consumption may be below the minimum required.

In recent years there has been consensus about taking into account not only the output foregone elsewhere due to withdrawal of the marginal farmer, but also the costs of increased consumption associated with extra employment, specifically in a situation of suboptimal saving and investment, in the determination of shadow wage rate. Though conceptually it is very easy to understand the direct opportunity cost of labour, the empirical estimation of it becomes exceedingly difficult. When the primary problem is one of under-employment rather than visible unemployment, the identification remains conceptually easy but becomes empirically difficult."[1] Probably nothing less than a detailed study of the consequences of production of withdrawing labour from traditional sectors will provide a suitable framework for estimating direct opportunity costs (UNIDO).

Little Mirrless also pointed out the same difficulties regarding a good estimation of direct opportunity cost of labour in the lowest productivity sector like agriculture.

They wrote : "Unfortunately so much data about individual plots would be required to get a good estimate of marginal productivity that few countries can adopt such direct method. The trouble is that agricultural production tends to vary from plot to plot according to particular land and weather conditions, the skill of the workers, and the farmer or managers, that one needs a very large number of observations before one can average out these differences. The problem is made yet more difficult because it is hard to get accurate information about the quantity of produce and the number of hours worked."[2] However they pointed out... "one can take half the average productivity as a measure of marginal productivity and may not go far wrong by so doing."[3] An attempt has been made in the following section to test the above hypothesis in case of a developing state like Orissa.

1. UNIDO, p. 204.
2. Manual of Industrial Project Analysis in Developing Countries, vol. II, Social Cost Benefit Analysis.
3. Ibid, p. 172.

II

**Methopology**

Eight villages were selected at random from Ganjam District in Orissa and 72 small farmers were selected from these villages, by simple random sampling. A small farmer is defined as a farmer having 2.5 to 5 acres of land. Data were collected from them for the year 1973-74 on cost accounting method adopted by the Ministry of Food and Agriculture for their Farm Management studies.

Out of 72 farmers, 30 farms were found to be purely family labour based farms and 42 were found to be employing hired labour marginally at peak periods. The cuitivators of the latter farms also work as agricultural labourers after the completion of their farm operations.

So at peak period not only there is demand for labour from the medium and big farms but also from the small farms and the labour market at such periods becomes nearly competitive. In the following analysis the data were analysed for all the 72 farms taken together and 42 farms employing labour marginally. The productivity of labour on the latter type of farms has not been studied earlier. The following are the notations and Cobb-Douglas production functions of the following type were used to analyse the data.

**Notation**

Q—Value of total output.
$X_1$—Net irrigated area.
$X_2$—Number of Fragments.
$X_3$—Number of mandays.
$X_4$—Net sown area.
$X_5$—Value of Fertilisers and Farm Yard Manures.
$X_6$—Value of Minor Implements.
$X_7$—Bullock labour (pair days).
C—Constant term.

**Equation**

1. $\text{Log } \theta = \log C + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 \ \beta_7 \log X_7.$

2. $\text{Log } \theta = \log C + \beta_1 \log X_1 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + \beta_7 \log X_7.$

3. $\text{Log } \theta = \log C + \beta_1 \log X_1 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 \ \beta_6 \log X_6.$

4. $$\frac{\beta}{X_4} = C.\left(\frac{X_1}{X_4}\right)^{\beta_1}\left(\frac{X_2}{X_4}\right)^{\beta_2}\left(\frac{X_3}{X_4}\right)^{\beta_3}(X_4)^{\beta_4}\left(\frac{X_5}{X_4}\right)^{\beta_5}\left(\frac{X_6}{X_4}\right)^{\beta_6}\left(\frac{X_7}{X_4}\right)^{\beta_7}$$

**Limitions of the study**

1. One main factor whose contribution to production is highly significant is the rainfall. It is not the actual rainfall but the effective rainfall which is most important. As reliable data regarding average daily rainfall were not available, they were not included. This means, very important factor of production has been excluded.

2. The fertility of land varies from plot to plot even in a particular district. The management, the skill of the workers, the factors which are assumed to be homogeneous may vary widely.

3. The data collected through interview method regarding the number of hours worked are only broad approximations and are not exact as in the case of industries. Similarly the data regarding the quantity of produce are only broad approximations.

It would be really extremely difficult to get accurate farm data for the rural areas where accounts of the farming operation are hardly kept. Short of a better method, the interview method can give though not the best at least the second best data to reach certain broad conclusions.

III

In first three equations, it was found that the 't' values for the labour co-efficients are not significantly different from zero both in the case of all the small farms and in the case of 42 farms hiring labour marginally at peak periods. Though the result in the case of former is quite expected the result in case of the latter is quite striking and not in conformity with the general theory. It is generally contended that the farmers employing hired labour weigh the value of the marginal product (MPL) that the additional worker would produce with that of the wages (W) to be paid to that worker.

So MPL $\geqslant$ W.

Though it is a theoretically sound proposition for the purely hired labour based or highly hired labour based farms, this is not likely to be the case where hired labour is employed to assist the family labour for a few days at peak periods. Though the cultivators on such farms employ labour during peak periods they themselves offer to work even before the end of the peak period. So they try to complete the work early and make themselves ready to work immediately after. In their anxiety to complete the work they are likely to overestimate their expected marginal productivity. As they equate their expected marginal productivity (EMPL) with the market wage (W) and as EMPL>MPL some of the labourers at the margin might be really redundant. So it is not only true that the marginal productivity of labour is close to zero in purely family labour based farm, it may also be true that in a large number of small farms where the requirement of hired labour is only marginal, the marginal productivity of labour is not significantly different from zero. This result is quite in contrast with the results of Dr Bardhan. He did not use the bullock labour and farm implements in his equations in order to avoid the effects of multi-colinearity. And he himself admits : "Since our estimated marginal productivity of labour in a sense includes the marginal productivity of all these complementary factors as well, its being higher than the wages rate may just be a statistical articraft." Coming to the calculation of average productivity, Little Mirrlees points out that the total agricultural production divided by the total agricultural labour force will provide though not very accurate, but accurate enough average productivity for the purpose. And as in most developing countries the average productivity is very low, one may not go far wrong by taking half the average productivity as marginal productivity.

In the case of sample farms, it is assumed that the agricultural labour force work on an average for 250 days in a year. By dividing the total output by the number of labour days on the above basis it was found that the average productivity for manday equals Rs. 4.50. Little-Mirrlees pointed out that the items of output should be valued at accounting prices. Market prices are used to value the output in this calculation. Assuming the worked price to be half of the market price; it comes to Rs. 2.25 and half of this (to equate with MPL) is equal to Rs. 1.25. It seems that one may go far wrong if one takes half of the average productivity, of labour as marginal productivity, specifically if the project is a very highly labour intensive project and the net present value of benefits are highly sensitive to the changes in SWR.

REGRESSION RESULTS FOR ALL 72 FARMS

| Equia-tion | X1 | X2 | X3 | X4 | X5 | X6 | X7 | R2 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.06938 | 0.022556 | —0.12425 | 0.13481 | 0.18960 | 0.87811 | 0.21030 | 36* |
| | (2'19313)* | (0.13896) | (—0.64764) | (0.49873) | (1.63454) | (2.85220)** | (0.97752) | |
| 2 | 0.06861 | | —0.11829 | 0.14004 | 0.19239 | 0.88704 | 0.20063 | 36* |
| | (2.21926)* | | (—0.63741) | (0.52721) | (1.69672) | (2.96851)** | (0.99303) | |
| 3 | 0.08600 | | —0.14412 | 0.32052 | 0.17085 | 0.87615 | | 35** |
| | (3.37475)** | | (—0.78439) | (1.65457) | (1.53529) | (2.93436)** | | |

1) Figures in the bracket are computed t values.
2) * Asteric denotes significant at 5% level.
3) ** denote significant at 1% level.

REGRESSION RESULTS FOR 42 FARMS HIRING LABOUR
AT PEAK PERIODS

| Equation | X1 | X2 | X3 | X4 | X5 | X6 | X7 | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.09765 | 0.01908 | —0.04633 | 0.10580 | 0.03693 | 0.95651 | 0.02861 | .51* |
| | (2.81754)** | (0.10608) | (--0.23723) | (0.33376) | (0.28411) | (3.16068)** | (0.11550) | |
| 2 | 0.09710 | | —0.04064 | 0.11302 | 0.03741 | 0.96514 | 0.01852 | .51* |
| | (2.87474)** | | (—0.21955) | (0.37035) | (0.29215) | (3.35885)** | (0.08215) | |
| 3 | 0.099851 | | —0.04090 | 0.13012 | 0,03303 | 0.96345 | | .51* |
| | (3.43648)** | | (—0.22410) | (0.59096) | (0.28770) | (3.40889)** | | |
| 4 | 976,210 | —195.074 | 1.090 | 2730.650 | 2.223 | 93.016 | —5.912 | .45* |
| | (1.645) | (—1.236) | (0.496) | (2.707)* | (0.692) | (3.137)** | (—0.284) | |

1) Figures in the brackets are computed t values.
2) * Asteric denotes significant at 5% level.
3) ** Asteric denotes signficant at 1% level.

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