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SUMMARIES OF GROUP DISCUSSION

INDIAN AGRICULTURE AT THE CROSSROADS*

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It is believed that agriculture in the form of settled cultivation of land began nearly 10,000 years ago. India was one of the early centres of domestication of several important crop plants, including rice. Because of the diversity in soil and climate, the country is endowed with rich flora and fauna. From a predominantly pastoral country, emphasis shifted to crop husbandry and to mixed farming involving blends of agriculture and animal husbandry, and agriculture and aquaculture. As in all other agricultural systems, the early cultivators had to find solutions to the twin problems of depletion of soil fertility and incidence of pest epidemics. Prior to the introduction of chemical fertilizers in the last century, the restoration of soil fertility was achieved through practices such as shifting cultivation, conservation and use of animal refuse and farm wastes and the introduction of legumes in crop rotation leading to biological nitrogen fixation. By growing a mixture of crops in a field, the early agriculturists tried to insulate themselves from total crop failure caused by aberrations in weather or pest epidemics. However, the choice of crops grown together was largely based on the home needs of the farmer. During the colonial period, the demands of foreign markets also influenced cropping patterns in some parts of the country.

The 10,000-year evolutionary history of agricultural systems in our country gave us the capacity to produce about 50 million tonnes of foodgrains at the time of our Independence 30 years ago. Food production reached nearly 121 million tonnes in 1975-76. Thus, during the three decades of Independence, the quantitative dimension added to our annual food production capacity was a little more than that achieved during the entire period of agricultural evolution up to 1947. This is impressive in terms of the time dimension. However, considering the fact that in the next 20 years we will have to nearly double once again the current annual production capacity, it is obvious that hereafter, as the Red Queen said to Alice, we will have to run several times as fast to remain where we are. Also, we have to end the mismatch between the capacity to grow food and the capacity to consume it, if we are not to witness simultaneously comfortable food reserves and hungry and malnourished children.

It is in this context that trends of a lower growth rate and greater instability in food production to which V.S. Vyas drew attention in his Panse Memorial Lecture this year will have to be viewed. Why are we finding

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it so difficult to reach even the original Fourth Plan target of 129 million tonnes of foodgrain production? Why is our most important crop, rice, which had one of its early beginnings in parts of Orissa, so unhappy there and in other eastern States (Figure 1), while it gives high yield in its adopted homes in parts of our country like the Punjab as well as in Japan, Taiwan,

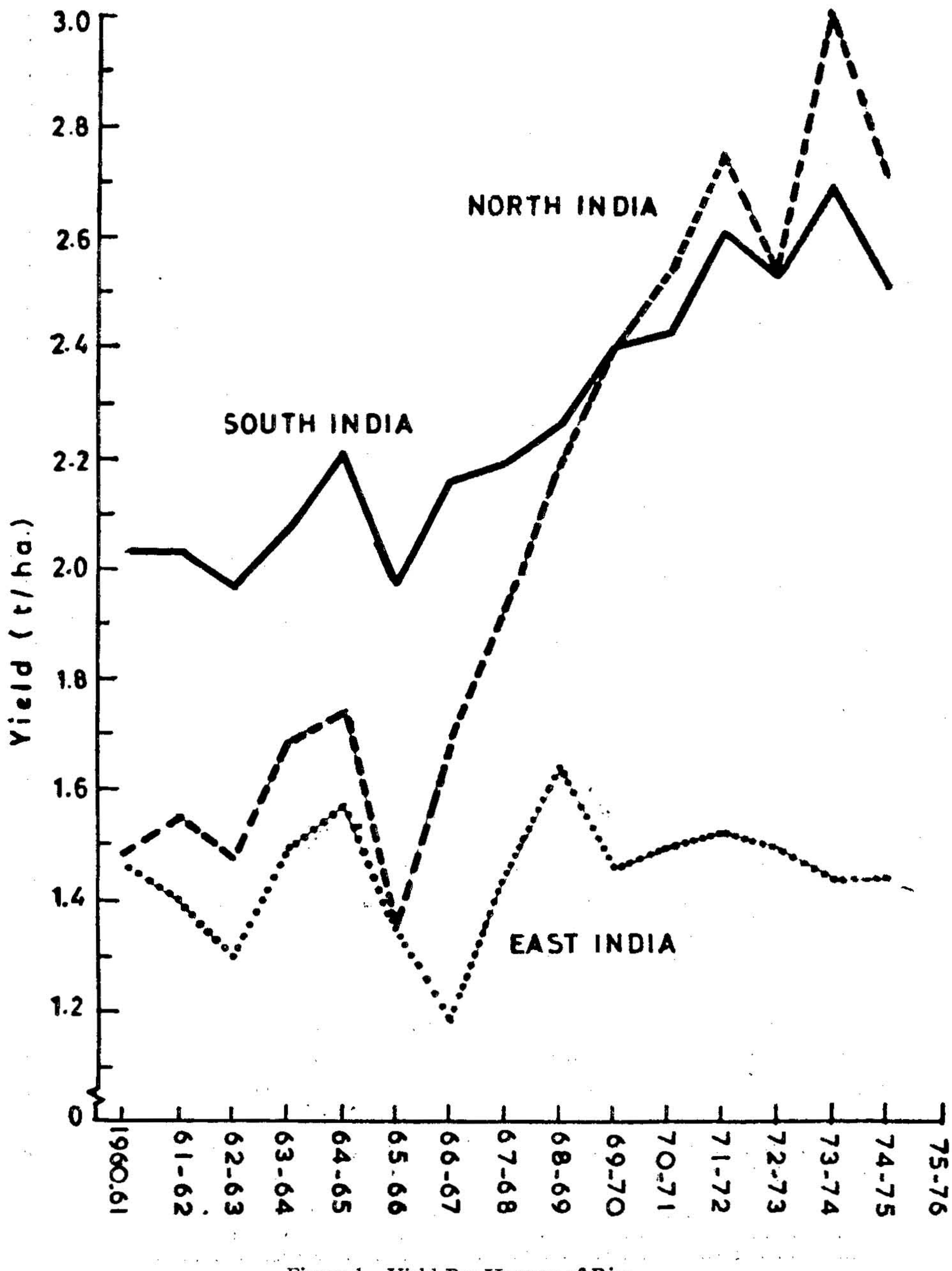


Figure 1—Yield Per Hectare of Rice

U.S.A., Australia and other places? To understand the reasons for this situation, we will have to go into certain basic issues involved in agricultural advance.

Firstly, as pointed out by the National Commission on Agriculture (NCA) a large contribution in the past towards improving food production came from an expansion in the area under different crops. The scope for further improvement in production in this manner is exceedingly limited since the only major source of additional land will be the area brought under multiple cropping. Therefore, productivity improvement will hold the key to further advances in production. Data on trends in productivity in a few crops and the projections of NCA are given in Table I. Following the introduction of high-yielding varieties, the relative contribution of productivity to total gain in production has increased in rice and wheat. Thus, the contributions of area and yield increases to the absolute gain in production in 1975-76, as compared to 1964-65, were 34.4 and 65.6 per cent respectively in rice and 38.7 and 61.3 per cent respectively in wheat.

TABLE I—CROP PRODUCTIVITY TRENDS AND PROJECTIONS (ALL-INDIA)

Year	Wheat (q/ha.)	Rice (q/ha.)	Jowar (q/ha.)	Gram (q/ha.)	Ground-nut (q/ha.)	Cotton (lint) (kg./ha.)	Sugar-cane (tonnes/ha.)
1950-51 ..	6.6	6.7	3.5	4.8	7.7	88	33.4
1955-56 ..	7.1	8.7	3.9	5.5	7.5	88	32.8
1960-61 ..	8.5	10.1	5.3	6.7	7.5	125	45.5
1965-66 ..	8.3	8.6	4.3	5.3	5.5	104	43.7
1970-71 ..	13.1	11.2	4.7	6.6	8.3	106	48.3
1971-72 ..	13.8	11.4	4.6	6.4	8.2	151	47.5
1972-73 ..	12.7	10.7	4.5	6.5	5.8	127	50.9
1973-74 ..	11.7	11.5	5.4	5.3	8.5	142	51.2
1974-75 ..	13.4	10.5	6.4	5.7	7.2	161	49.8
1975-76 ..	14.1	12.5	5.9	7.1	9.5	139	51.2

NCA Projections

Year	Wheat	Rice	Coarse cereals	Pulses	Oil-seeds	Cotton (lint)	Sugar-cane
1985 ..	21	16	9	9	7.8	230	60
2000 ..	29	25	13	14	10.2	380	82

(Data from the Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India.)

Second, with the passage of time, land holdings will get smaller and smaller. Compounding the problem of small size is the fragmented nature of holdings since land consolidation and levelling are yet to be carried out in most States. Under these conditions, scientific management of land, water and crops becomes difficult unless there is co-operation on the part of farmers in a village or a watershed. So far, the progress made in improving crop production and productivity has largely resulted from individual initiative of farmers aided by such help as Government has been able to render, rather than from group initiative. Co-operative endeavour has however stimulated the growth of the dairy industry in some parts of the country, the Kaira District Co-operative in Gujarat having shown its economic value to small farmers owning one or two buffaloes. The emerging agricultural technology, like integrated pest management, integrated nutrient supply and improved post-harvest technology, would demand for effective adoption of collective endeavour on the part of the farmers in a contiguous area or in a watershed. In other words, the problem now is to find institutional mechanisms for maximizing the opportunities for intensive agriculture which a small farm provides and for minimizing the handicaps of small farmers.

The third factor which requires examination is the reason for the relatively slow pace of progress in improving the yield of rice, pulses, oilseeds, jute, cotton and *kharif* crops as a whole. For example, it has been repeatedly pointed out that the production of pulses, which are grown predominantly in areas without irrigation, has remained more or less stagnant since 1962-63. With the expansion in the irrigated area, pulse crops have tended to shrink in hectarage. The largest reduction in area between 1964-65 to 1974-75 occurred in gram or chick pea, where the reduction was about 1.8 million hectares.

Fourthly, the entire field of water technology and on-farm management of water needs study. Why are we not deriving full benefit from the vast irrigation potential already created? What is our vision for the future? Fortunately, there is considerable thinking now being given to this. A recent perceptive analysis of the potential of the greater Ganga river basin is that of B.G. Verghese, who dealt with the "Gift of Ganga" in his Coromandel Lecture for 1977.

A fifth factor which needs study is the problem of soil health. Historically, it is an enigma as to why our farmers did not pay the same attention to soil health as for example the Chinese farmer. In China, the conservation and use of all organic wastes, including human excreta, has been developed into a fine art for a very long time. The Japanese farmer also paid serious attention to soil fertility. In contrast, in our country, soil which was described by Aristotle as "the stomach of the plant" has been largely neglected both by the peasant and the public, with the result that we find considerable damage occurring all the time to soil fertility. In areas of intensive agriculture, like the Punjab, problems of deficiencies of phosphorus and zinc as well as incidence of weeds are becoming major constraints to sustaining high yield. In nearly all parts of the country, the general nutrient status of soil is low. Micronutrient deficiencies are fairly widespread. Organic wastes are used mainly as fuel and only to a limited extent as fertilizer. Community biogas plants are yet to become popular. Brickmaking is consuming good top soil in an ever-increasing quantity. Social scientists can help us to understand the causes for the relative indifference to the maintenance of soil fertility in our country in contrast to China and Japan. If we continue to neglect soil health, we will be writing off the future of our agriculture.

Sixth, the agricultural technology so far developed and widely adopted in Europe and North America is based largely on the consumption of non-renewable forms of energy. In other words, improvement in productivity has been accompanied by an increasing consumption of energy based largely on fossil fuels. It is obvious that a finite resource cannot be exploited in an exponential manner. There is hence a need for striking a new path towards achieving enhanced productivity by means of a technology based largely on recycling principles and renewable resources. Priority in this matter should be given to key nutrients like phosphorus which are non-renewable assets.

Seventh, as the pressure of population on land increases, water will have to become as important a medium for producing food as soil. Therefore, the technologies adopted hereafter will have to be such that they can promote harmony and synergy between agriculture and aquaculture.

Another factor which needs emphasis in the future is linkages between production and post-harvest technologies. A mismatch between the two is one of the factors impeding rapid agricultural advance in several areas. For example, small farmers in the traditional rice belt still dry the harvested paddy on paved roads. The road or the roof constitutes the most important grain drying area for poor peasants in many parts of the country. If post-harvest technology is not improved, the triple role of agriculture in generating more and better quality food, more jobs and more income will not be achieved.

Finally, agriculture starts moving only when a package of economically viable technology is backed up by appropriate packages of services and public policies. It is in this area that the Central and State Governments have a key role to play. Implementation of land reform measures assuring the tiller a long-term stake in the land is the first need. A package of services that could enable all farmers, irrespective of the size of their holdings, to take to new technology is another urgent requirement. Similarly, public policies will have to provide incentives and assistance to marginal and small farmers for adopting scientific land use patterns through an integrated pricing policy for inputs and output and through measures like credit insurance. Landless agricultural and non-agricultural labour will have to be assisted in reducing the number of days when they remain unemployed and also to become owners of production units in the agro and rural industries and aquaculture sectors.

In these areas we are now at the crossroads. In my view the old approaches have by and large paid whatever dividend they could. We have now a sound infrastructure of research and educational institutions, mass media agencies, irrigation networks, power supply, and units producing inputs like seed, fertilizer, pesticide, and implements. We have the opportunity to derive full benefit from this infrastructure by bringing about the needed reorientation in the developmental pathway. I would like to discuss this problem from the following viewpoints:

I. The untapped production reservoir existing at current levels of technology in our major farming systems;

II. Constraints to improving productivity;

III. Emerging agricultural technology and its social implications; and

IV. Action needed to launch an era of accelerated agricultural advance.

I

ESTIMATION OF THE UNTAPPED PRODUCTION RESERVOIR

Various methods are currently in use to estimate the untapped production reservoir existing in different farming systems at current levels of technology. The International Rice Research Institute in the Philippines (IRRI) has been designating the difference between experiment station yield and actual farm yield as the "yield gap" and the factors responsible for such a gap as "yield constraints".[1] Recently, the IRRI has also advocated the use of a yield level intermediate between the actual farm yield and experiment station yield to calculate the size of the gap. This yield level is called the "potential farm yield" and is the yield obtained in a farmer's field from the introduction of improved technology.[2] From the national demonstrations conducted on farmers' fields from 1965 onwards as well as from the All-India Co-ordinated Agronomic Experiments, we have considerable data on the yields that can be obtained under farmer's field conditions with new technology, provided the farmer has access to the needed inputs. Based on the difference between yields in national demonstration plots and the other plots of farmers with similar growing conditions (*i.e.*, irrigated or unirrigated), an approximate estimate of the untapped yield reservoir available in different crops and in different parts of the country can be made. The Operational Research Projects of the Indian Council of Agricultural Research (ICAR) also provide an indication of the potential farm yield now possible.[3]

1. Kwanchai A. Gomez, "On-farm Assessment of Yield Constraints: Methodological Problems," in Constraints to High Yields on Asian Rice Farms—An Interim Report, International Rice Research Institute, Los Baños, Manila, Philippines, 1977.
2. Constraints to High Yields on Asian Rice Farms: An Interim Report, *ibid.*
3. ICAR Operational Research Projects, Indian Council of Agricultural Research, New Delhi, 1977.

An analysis of the results of national demonstrations has shown that the attainment of the yield target is independent of the total size of the holding of the farmer in the case of wheat.[4] The ratio between the average yield obtained by farmers and the yield of national demonstration plots ranged from 2 to 4 in different parts of the country in the case of wheat. The lowest ratio occurs in West Bengal, where the average yield of the crop has exceeded 2.5 tonnes per hectare during the last three years. This may be because farmers who took to this crop for the first time adopted all the recommended practices.

In rice, the ratio between the actual and potential farm yields ranges from 2 to over 5 at different places. The highest yield gap occurs in parts of Madhya Pradesh. In jowar, where, as can be seen from the data in Table I, the yield level has been practically stagnant over a long period of time, the difference between the actual and potential farm yields is quite high. The ratio goes up to 8 in some places in Maharashtra and Rajasthan. In gram (chick pea), *arhar* (pigeon pea) and groundnut, the size of the untapped yield reservoir ranges from 40 to 70 per cent in several trials. So also with sugarcane in north India and cotton in most parts of the country. Thus it is obvious that even with the technology available at present there is considerable scope for increasing production through improved productivity, provided the constraints are identified and removed.

To assess the production reservoir available in different parts of the country, it is desirable that studies on production gaps are undertaken with regard to an entire farming system and not just for an individual crop. The following major farming systems require careful analysis for measuring yield gaps and understanding the constraints responsible for the gap.

(*a*) *Multiple Cropping Systems in Irrigated Areas*

Various two, three and even four crop sequences are now being followed. Some new combinations like rice-wheat in Punjab and West Bengal require to be studied from the point of view of the total yield of the two-crop system. Delayed harvesting of rice leading to late sowing of wheat may reduce the yield of wheat. Factors like this will have to be considered while calculating yield gaps. While promoting multiple cropping systems, attention should be paid to ensuring that grain and fodder legumes find a place in the rotation. Also, crops having the same pests and diseases should not be grown in succession. Unscientific multiple cropping could compound pest and soil fertility problems.

(*b*) *Rainfed Farming*

Production possibilities in high rainfall areas are similar to those of irrigated areas. However in the unirrigated semi-arid areas, commonly

4. ICAR Annual Report, 1976.

referred to as dry farming areas, considerable production possibilities exist as would be observed from the following data obtained during 1976-77 under the All-India Co-ordinated Research Project for Dryland Agriculture.

1. *High annual production obtained in rainfed lands:* In crop sequence trials at the Co-operating Research Centres of the All-India Co-ordinated Research Project for Dryland Agriculture, the following sequences were found highly productive:

Centre	Crop sequence	Yield (q/ha.)		Total annual production (q/ha.)
		Kharif	*Rabi*	
Dehra Dun	Maize-Wheat	44.1	17.8	61.9
	Rice-Wheat	44.2	17.6	61.8
Ludhiana	Maize-Gram	20.3	23.5	43.8
Varanasi	Maize (fodder)-Barley	410.0 (fodder)	42.3 (grain)	—
Akola	Sorghum-Safflower	44.9	14.0	58.9
Indore	Maize-Gram	39.7	15.4	55.1
Bhubaneswar	Maize-Horsegram	35.5	7.9	43.4

2. *Effect of surface mulches on yield:* At Dehra Dun and Anand, the use of organic surface mulches (husk or some other farm waste) substantially increased the yields of wheat and *bidi* tobacco.

Centre	Crop	Practice	Yield (q/ha.)	C.D.
Dehra Dun	Wheat	No mulch	10.6	
		Mulch applied	19.1	1.57
Anand	*Bidi* tobacco	No mulch	11.8	
		Mulch applied	16.9	1.80

3. *Value of run-off recycling:* In most regions there is considerable run-off. This water could be stored and used for at least one supplemental irrigation to the non-rainy season crop if not required for a crop-life saving irrigation during the rainy season itself.

Centre	Crop	Practice	Yield (q/ha.)	C.D.
Ludhiana	Wheat	No irrigation	3.8	
		One irrigation	14.0	3.07
Dehra Dun	Wheat	No irrigation	9.0	
		One irrigation	31.8	5.17
Varanasi	Barley	No irrigation	24.0	
		One irrigation	35.2	5.09
Agra	Barley	No irrigation	21.9	
		One irrigation	27.7	4.84

4. *Stability of performance:* On the basis of results obtained during the last six years at the Hissar Centre, the superiority of *rabi* oilseed crops over gram appears to have been established both as regards stability of production and as more profitable crops. Existing land use patterns need to be reviewed on the basis of such information.

Crop	Grain yield (q/ha.)						Average
	Low rainfall years			High rainfall years			
	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	
Gram ..	4.6	3.5	2.3	8.8	31.0	31.0	13.5
Mustard ..	7.4	7.2	5.5	10.6	30.0	21.6	13.7
Rapeseed ..	5.6	N.A.	2.7	8.7	20.0	17.9	11.0
Taramira ..	12.8	8.1	10.8	11.7	9.3	14.1	11.0

5. *Improved sorghum production in Hyderabad district:* In co-operation with the District Administration, an area of 5,200 hectares of phosphorus-deficient black soils was covered with improved dryland practices—use of new seed ('CSH-5'), fertilizer application at the rate of 25 kg. nitrogen and 50 kg. P_2O_5 per hectare and timely seeding and weeding with adequate plant population. Yield data collected from the fields of 100 farmers in four villages are given below. Jowar is thus a crop with a vast untapped yield gap.

Block	Number of participating farmers	Range of yields (q/ha.)	
		Local practices	Improved practices
Chevella ..	100	10.0 to 13.0	30.0 to 35.0

(c) *Mixed and Inter-cropping*

Various combinations of crops are sown particularly in unirrigated areas by farmers. Not all the combinations currently grown are scientifically sound. Therefore, inter-cropping systems based on the extent of co-operation generated between the companion crops are now being developed. Among the major components of co-operation are

(*i*) efficient interception of sunlight,

(*ii*) ability to tap nutrients and moisture from different depths of the soil, and

(*iii*) non-overlapping pest sensitivity.

(*d*) *Multi-level or 3-Dimensional Cropping*

In garden lands, where a wide variety of plantation crops, fruit trees, palms and other tree crops are grown, it is possible to design a crop canopy where the vertical space is utilized in a more efficient manner. Crop planning in the future will have to take into account the effective use of both horizontal and vertical spaces. Efficiency in such a cropping system will again be based on the extent of co-operation generated among the crops in the system. For example, studies at the Central Plantation Crops Research Institute at Kasaragod have revealed that coconut, cocoa and pineapple form a good combination. They can intercept sunlight efficiently in a combined canopy and also remove nutrients and moisture from different depths in the soil profile. We need a careful study of all the major garden land cropping systems based on the extent of symbiosis and synergy that the different components of the system exhibit.

(*e*) *Kitchen Gardening*

Kitchen gardening can be one of the most efficient systems of farming from the point of view of solar and cultural energy conversion. If planned intelligently and scientifically, backyard gardens, roof gardens and other methods of growing vegetables and fruits from whatever space is available around mud huts as well as brick houses can make a substantial contribution to improved nutrition.

(*f*) *Forestry and Agro-forestry*

The importance of improving the productivity of forests cannot be overemphasized. Agro-forestry has been defined as a sustainable management system for land which increases overall production, combines agricultural crops, tree crops, forest plants and/or animals simultaneously or sequentially. Sylvi-pastoral, sylvi-horticultural and other combined land use systems are extremely important for meeting the food, feed, fuel and fertilizer needs (*i.e.*, through use of leguminous species) of tribal and hilly areas. These systems are yet to receive the detailed scientific and extension attention they merit.

(*g*) *Mixed Farming*

Mixed farming involving crops and animals can take the form of (*i*) crop-livestock systems, (*ii*) crop-fish systems, and (*iii*) crop-livestock-fish production systems. These systems offer considerable potential for generating additional income and employment as well as for efficient energy conversion.

The December 1976 issue of *The Ecologist* carries a detailed report of a debate on the question "Should an ecological society be a vegetarian one?" The question has been discussed from the scientific as well as moral angles.

Naturally, divergent views were expressed. However, the general conclusion was that there is need for a considerable change in dietary habits in the heavy meat consumption societies both in the interests of health and of food self-sufficiency. This would imply shifting the accent from "raising cattle" to arable farming. In our country, the ruminating animal has been an integral component of the farming system and the relationship between man and animal has by and large been a complementary one. It is widely recognized that well-planned animal husbandry and fisheries programmes can help to reduce under-employment and increase the purchasing power of the landless labour and marginal farmers. While cross-breeding and health cover programmes can be organized with relative ease, the most challenging problem will be finding adequate nutrition for our dairy cattle and other animals like goat, sheep and poultry.

In dairying, about 60 per cent of the cost of milk production is due to feeds. Information on the efficiency of conversion of feeds into milk could be categorised for the three groups of animals: high-yielding cows, buffaloes and *desi* cows. According to the National Dairy Research Institute (NDRI), Karnal, to produce 25 million tonnes of milk a year (the current estimated figure), approximately 30 million tonnes of dry matter would be necessary if fed through high-yielding cows, 50 million tonnes if obtained through buffaloes and 150 million tonnes if obtained through *desi* cows.

An approximate idea of the digestible protein (DP) and total digestible nutrient (TDN) components of various qualities of forages and grains can be obtained from the data of NDRI given below:

	Digestible protein (approximate values on 100 units of dry matter)	Total digestible nutrient (approximate values on 100 units of dry matter)
Straws	0	40
Grass hay	2	40
Legumes and high quality forages	12	50
Non-legume forages	5	50
Grains	8	75
Concentrate mixture commonly used with oilcake and other by-products (only 25 per cent grains)	12	70

The best energy and protein output obtained in the United States with high-yielding cows involves the use of 50 per cent high quality forage and 50 per cent dry matter through grains, giving an average DP and TDN of 9 and 65, a ratio of 1:7. This is when extensive pasture land is not used.

Under our conditions, this ratio of 1:7 can be obtained with 50 per cent green forage, 25 per cent straw and 25 per cent concentrate mixture. Assuming that a hectare of land under irrigated conditions can give about 10 tonnes of dry matter, about three million hectares of irrigated land may be needed to provide the dry matter needed by the high-yielding cows for giving 25 million tonnes of milk. While genetic upgrading will take time, milk yield can be improved immediately through the provision of better nutrition and health care to existing animals.

In addition to fodder production, we need to undertake a systematic programme of fortification of straws and all cellulosic wastes with urea, molasses, and other nutrients. Also, a programme of planting leguminous fodder shrubs and trees in all vacant lands would provide substantial additional animal food, besides enriching the soil through biological nitrogen fixation.

In the area of inland fisheries the experiments carried out under the All-India Co-ordinated Composite Fish Culture Project have revealed considerable scope for improved production as would be seen from the following data:

State	Number of case studies	Average fish yield (tonnes/ha./annum)
Orissa	28	3.4
West Bengal	54	3.6
Assam	3	3.2
Haryana	6	8.0
Uttar Pradesh	13	3.4
Tamil Nadu	15	3.0
Andhra Pradesh	8	2.4
Maharashtra	10	4.9
Pondicherry	1	1.1
Total	138	3.6
All-India average		0.6

In 91 demonstration centres laid out in 14 districts of West Bengal, the average fish production per hectare was 4.4 tonnes per annum. Taking the State average using traditional technology as 1 tonne/ha./year, the indices of untapped yield reservoir in the districts ranged between 3 and 5. In 88 per cent cases, the index was greater than or equal to 3.

(*h*) *Sea Farming*

With a coastline of about 6,000 km. we have great opportunities for spreading scientific sea farming practices involving a blend of capture and culture fisheries. Oysters, mussels, eels, lobsters, prawns, sea weeds and a variety of marine plants and animals can be cultured in different coastal areas. If sea space is assigned to landless labour for mariculture, new coastal settlements combining sea farming with the plantation of casuarina, cashewnut, coconut and other trees can be created. This will help to generate gainful employment and control sea erosion.

II

CONSTRAINTS RESPONSIBLE FOR THE YIELD GAP

A detailed and carefully planned study can alone reveal the precise constraints retarding production. Since the factors involved would vary widely, such a study will have to be undertaken in each block for the proper identification of the precise constraints responsible for the gap between potential and actual yields in farmers' fields. As mentioned earlier, the International Rice Research Institute (IRRI) had sponsored a study of constraints to high yields in several countries in Asia and the results have been published recently in an interim report. Since rice is a crop where we also have considerable untapped production potential, I give below a summary of some of the major conclusions of such IRRI-sponsored studies.

(*a*) *Bangladesh*

The study revealed that the productivity of rice can be improved by about one tonne per hectare by growing modern varieties with adequate levels of inputs during the *boro* season. However in transplanted *aman* rice, the spread of modern varieties was limited by deep water and by the need for photoperiod sensitivity in the case of late plantings.

(*b*) *Indonesia*

The yield gap in the area studied was very small in the wet season but was about 1.3 tonnes per hectare during the dry season. During the wet season poor pest control was a major yield-damaging factor. Therefore, increasing fertilizer application above the levels now used in the wet season crop in coastal areas does not seem to be profitable unless pests are controlled.

(*c*) *Philippines*

In the wet season the yield gap ranged from 0.4 to 2 tonnes per hectare, with fertilizer and insect control being responsible for nearly equal amounts of the gap at most locations. The gap ranged from 0.9 to 2 tonnes per hectare in the dry season, with fertilizer being responsible for about two-thirds of the gap. Insect damage was the second most important component of the yield gap accounting for 30-50 per cent of the difference between the potential and the actual yield.

(*d*) *Sri Lanka*

During the wet season, a yield gap of over one tonne per hectare was observed in four complex experiments. Fertilizer, insect control and weed control contributed to the gap, with insect control making the maximum contribution.

(*e*) *Taiwan*

Yields in farmers' fields ranged from 5 to 7.2 tonnes per hectare with farmers' inputs. The yield gap was 0.8 tonne per hectare, with fertilizer contributing about 60 per cent of the gap in both the seasons. Thus, rice production in Taiwan has reached an optimum level both from the physical and the socio-economic points of view. Under such conditions farmers respond to price incentives of products. Thus, economic factors act as the major determinants of the yield target which a farmer aims at.

(*f*) *Thailand*

Inadequate fertilizer use was the dominant constraint in all the three seasons during which the study was conducted. Fertilizer was responsible for a gap of about 0.5 tonne per hectare during the wet season and 1.5 tonne per hectare during the dry season. Insects and weeds reduced yields by 0.1-0.3 tonne per hectare.

Well-planned and carefully conducted studies of this kind would help to pin-point the precise factors responsible for the prevailing yield gaps in different parts of the country both in terrestrial and aquatic production systems. Obviously, such a study will be successful only if undertaken by a multi-disciplinary team involving both biological and social scientists. In areas of poor water management and drainage it will be difficult to make a precise study of the difference between potential and actual farm yields unless a group of farmers could be made to undertake co-operative water management. If this is not done, leaching losses of fertilizer could be heavy. Agricultural economists and statisticians should take the lead in organizing such studies. Since the emphasis is now on block-level planning, the block can be used as the unit for an analysis of gaps and constraints.

During 1977, the ICAR and the IRRI organized a joint survey of the rice-growing areas in eastern India (Bihar, Orissa and West Bengal) to identify the major factors influencing rice yield in this region during the south-west monsoon period. This team has made the following recommendations:

(*a*) Since the performance and profit of existing high-yielding varieties with costly inputs are uncertain, scientists should develop a technology which combines good yield with reliability and security of profit to farmers. In other words, we need *a high yield cum high stability technology*, if small and marginal farmers are to be helped to take to such technology. Out of a total rice area of 37 million hectares in the country, the area under deep (50 cm. and above), semi-deep (30 to 50 cm.) and intermediate (15 to 30 cm.) water depths is about 10 million hectares. Hence, rapid testing and release of promising strains for these areas are necessary.

(*b*) Diversification of varieties and periodic replacement of varieties are important ingredients of high-stability technology. For this purpose, States should develop the capacity and organization for multiplying and spreading seeds of new varieties rapidly and to change a variety once in 3 to 4 years.

(*c*) Early planting and short-duration varieties may reduce damage from floods and waterlogging in several areas. Community nurseries could help small and marginal farmers to adopt these practices.

(*d*) Fertilizer application poses problems in such areas. 'Super-granules' of urea could be placed under the soil. For this purpose, a simple implement to place the super-granules at the appropriate depth is necessary.

(*e*) Minor elements, particularly zinc, appear to be deficient in several soils. A suitable testing programme to assess the response to zinc is necessary. The role of sulphur in increasing yield also needs study.

(*f*) Pest surveillance needs to be strengthened. Pest-resistant varieties need to be popularised.

(*g*) Water-distribution systems, on-farm management of water and drainage need to be improved.

(*h*) Post-harvest technology involving the use of community grain driers using solar energy and organic fuels like paddy husk, coal, weed, etc., as well as the popularisation of cheap storage structures need attention.

The bulk of increased food production at least in the immediate future will come from the further expansion of irrigated area and from the application of the technology already available in areas with water availability. In temperate countries, the period of maximum precipitation coincides with the period of maximum solar interception. Unfortunately in our country, the period of maximum sunlight tends to be also the period of minimum precipitation. Therefore, the decision to make a major investment on a further expansion in the irrigated area is a wise one. While constraints relating to the effective use of water in every major irrigation project are yet to be carefully analysed, I would like to deal with the growth of irrigation facilities and the new problems which have cropped up in some of the irrigated areas.

The irrigation works in existence at the beginning of the 19th century included a large number of wells all over the country, numerous tanks in South India and several inundation canals in North India. The Grand Anicut built in the second century A.D. was by far the greatest engineering feat of ancient India. It was irrigating over 0.24 million hectares at that time. The Western Yamuna canal was dug in the 14th century and was used for irrigation.

Irrigation development under the British rule began with the renovation, improvement and extension of the then existing works. The main stress was on productive works. Kurnool-Cuddapah Canal, Upper Bari Doab, Sirhind Canal, Agra Canal, Lower Ganges Canal, Betwa Canal, Godavari Delta System, Western Yamuna Canal were completed during 1850-1890.

Following the great famine of 1876-1878 a special fund of Rs. 15 million known as the Famine Relief and Insurance Fund was set apart every year from 1882. Half of it was earmarked for the development of railways and irrigation if it was not spent on relief.

The First Famine Commission of 1880 emphasized the need for direct State initiative in the development of irrigation, particularly in vulnerable areas. But because of the comparatively good agricultural years from 1880 to 1895 no serious action was taken. The two great famines of 1897-1898 and 1899-1900 left the Government with no alternative, and a number of major and medium irrigation works were completed; before Independence a potential of more than 6 million hectares due to major and medium works was created compared to 4 million hectares in 1910 (Table II).

TABLE II—NEW IRRIGATED AREA IN INDIA FROM 1900 TO 1947

(*million hectares*)

Period	Irrigated area			
	Canals	Wells	Others	Total
1910-11 to 1914-15	4.0	4.4	6.1	14.5
1920-21 to 1924-25	4.4	4.7	6.9	16.0
1930-31 to 1934-35	5.0	4.8	7.3	17.1
1940-41 to 1944-45	6.0	5.4	7.6	19.0

One significant effect of the introduction of canal irrigation in Uttar Pradesh and parts of Punjab was a large number of wells went into disuse. The Royal Commission on Agriculture found a large number of abandoned wells. The Commission recommended systematic survey of sub-soil water and *taccavi* assistance to farmers for constructing wells.

The Famine Enquiry Commission of 1944 which was appointed to investigate the Bengal Famine recommended that it was not enough to extend irrigation through public works alone but private works would have also to be greatly expanded. The Grow More Food Campaign launched in 1943 and subsequently integrated with the First Five-Year Plan placed greater reliance on minor works.

At the time of Independence the total net irrigated area was 28.2 million hectares (15.2 million hectares by canals, 6.6 million hectares by wells, 3.3 million hectares by tanks and 3.1 million hectares by others). Of the canal-irrigated area, nearly 50 per cent was in the areas now forming part of Pakistan.

The progress of irrigation development since Independence is given in Table III.

TABLE III—PROGRESS IN IRRIGATION

(million hectares)

Year	Net area sown	Area irrigated by sources			Total net irrigated area	Total gross irrigated area
		Canals	Tanks	Wells		
1950-51	118.7	8.3	3.6	6.0	20.9	22.6
1960-61	133.2	10.4	4.6	7.3	24.7	28.0
1970-71	141.0	12.5	4.5	11.0	31.4	38.2
1972-73	136.9	13.0	3.6	13.0	31.8	39.1
1974-75	138.3	13.5	3.5	14.2	33.7	41.7

According to the latest estimate, a total potential of 53.8 million hectares of gross irrigated area is likely to be created by 1977-78 (Table IV).

TABLE IV—GROSS IRRIGATED AREA

(million hectares)

	Gross irrigated area				
	1950-51	1960-61	1968-69	1973-74	1977-78
1. Major and medium irrigation	9.7	14.3	18.1	20.7	25.0
2. Minor irrigation					
(*a*) Surface	6.4	6.4	6.5	7.0	7.8
(*b*) Ground	6.5	8.3	13.0	17.5	21.0
	22.6	29.0	37.6	45.2	53.8

Considering the high priority to irrigation for increasing agricultural production, the Government of India is proposing to create an additional 17 million hectares of irrigation during the next five years starting from April 1, 1978. Of this, 8 million hectares could be from major projects and 9 million hectares from minor irrigation (2 million hectares surface and 7 million hectares groundwater).

Estimates of the country's water resources have been made from time to time. At the beginning of the present century, the first Irrigation Commission had placed the surface water resource at 144 million hectare-metres. Later in the forties, A. N. Khosla, the then Chairman of the Central Waterways, Irrigation and Navigation Commission, estimated, on the basis of an empirical formula, that the total annual surface and groundwater resources of the country were about 167 million hectare-metres. In the basin-wise assessment of the report of the Irrigation Commission, the surface water resources of various river basins add up aggregate to 180 million hectare-metres. The National Commission on Agriculture carried out detailed studies on the water resources of the country and estimated that the total surface water resources derived from precipitation and brought in from catchments lying outside the country were 135 million hectare-metres and about 50 million hectare-metres were contributed by the precipitation water table. Thus, the total basic water resources of the country are estimated to be 185 million hectare-metres. There is considerable inter-change in various stages between the surface water and groundwater. Besides the renewable water resources, there are water resources which have accumulated above and below groundwater over long periods. Above the groundwater there are glaciers and permanent snow caps and there is trapped groundwater in certain geological formations. Most of the surface water is not utilizable for irrigation, as for example, the water of the Brahmaputra basin. The utilizable flow is estimated at 70 million hectare-metres and similarly only about 35 million hectare-metres of groundwater is utilizable. Some of this water will be needed for other purposes and the total water that can be made available for irrigation is estimated to be 77 million hectare-metres (51 million hectare-metres surface and 26 million hectare-metres ground). Estimating the depth of irrigation per cropped area to be 70 cm., the Irrigation Commission has estimated that the ultimate irrigation potential when the entire water resources are developed will be about 110 million hectares. This would be about 52 per cent of the sown area of 210 million hectares.

The total public sector expenditure on major and medium irrigation works during the Plan period up to 1973-74 has been more than Rs. 3,000 crores. The cost of irrigation has been increasing and now, on an average, it is about Rs. 7,000 per hectare of irrigated area. For the creation of additional potential of 8 million hectares a provision of more than Rs. 5,600 crores for the next Five-Year Plan will have to be made. This increase in expenditure will be justified if there is simultaneously an increase in agricultural production and greater stability of yield.

The experience so far has been that in most of the canal-irrigated areas agricultural production has not been of the same order as envisaged. Some of the canal command areas like Gandak, Kosi and Sone in Bihar, the Chambal command area in Rajasthan and Madhya Pradesh do not seem to have resulted in the desired production advances for several reasons. Large wastage of water in many of the project areas continues to occur. There are problems of waterlogging and management. It needs to be emphasized that water management in the areas having monsoon rainfall of 700 mm. and above is very difficult, particularly during the monsoon period. In many of the canal-irrigated areas, the supply of water during the *rabi* season is inadequate. For example, in the Ram Ganga canal command area of Uttar Pradesh a total of only 40 cm. of water is delivered at the canal slope and during its passage much water is lost; ultimately the farmer gets hardly 15 cm. of water, which is not adequate for crops like wheat. There are some other areas like the canal-irrigated areas of Punjab and Haryana where the supply is much better.

For the efficient utilization of irrigation water, good agronomic practices are necessary. Data on the increase in yield of wheat due to irrigation in different States of India are given in Table V, bringing out the importance of agronomic practices for the efficient utilization of water.

TABLE V—THE YIELD OF WHEAT AS AFFECTED BY IRRIGATION

	Grain yield (kg./ha.)			
	Irrigated 1973-74	Unirrigated 1973-74	Irrigated 1974-75	Unirrigated 1974-75
Uttar Pradesh	1,089	688	1,283	744
Bihar	1,235	840	1,096	733
Madhya Pradesh	1,400	720	1,468	769
Haryana	1,655	808	1,831	1,109
Punjab	2,250	969	2,475	1,508

Source: Estimates of Area and Production of Principal Crops in India, 1975-76, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1977.

Irrigation has not been an unmixed blessing. In a number of irrigation projects salinity and waterlogging have appeared within a few years of the introduction of irrigation. Within ten years of the introduction of canal irrigation in the Chambal command area of Rajasthan and Madhya Pradesh, about 25 per cent of the area is reported to have been waterlogged. Similar reports have also been made in other command areas, particularly in the black soil region. Unless adequate precautions to control waterlogging and salinity are taken in time, the provision of irrigation in many of the black soil areas may prove more a curse than a blessing. Unfortunately, the drainage of irrigated areas has not been taken up simultaneously in the planning process. Many of the so-called drainage works are, in fact, meant to take care of excess water rather than to provide drainage to the irrigated areas. Studies in the Bhakra canal command area have shown that within a period of ten years of the introduction of irrigation the water table has risen by about 8 metres. As in many of these areas the groundwater is saline, it is not possible even to utilize this water for irrigation. So drainage is important. In other areas where the groundwater is not saline every effort needs to be made to have more areas under tubewell irrigation.

The Command Area Development Authorities now set up should help to get better returns from our investment in irrigation. It is also the duty of agricultural scientists and economists to undertake anticipatory research in areas which are likely to receive irrigation water in the future, so that the most appropriate cropping patterns can be introduced when water becomes available.

Similarly, as regards soil health, we are yet to make a serious study, area by area, of the steps needed to arrest further damage to soil health and to build up soil fertility in a manner that will promote a continuous improvement in productivity. I would hence like to summarise briefly some of our major assets and liabilities with regard to soil.

(a) *Assets*

Four major soil groups are generally recognized in the country. They are: Red soils, Black soils, Alluvial soils and Laterite soils.

(*i*) *Red soils:* The red soils occupy nearly 72 million hectares in both medium and high rainfall zones. Soil depth and textures are variable. They are generally low in fertility status and medium in water-holding capacity. The soils are well drained and usually present no problems of salinity or alkalinity. They are mostly used for *kharif* crops under rainfed conditions.

(*ii*) *Black soils:* Black soils occupy nearly 64 million hectares in sub-humid to semi-arid areas. They are finer in texture, variable in depth, moderate to high in water-holding capacity and low to medium in fertility status. Shallow black soils are generally used for *kharif* crops whereas medium deep and deep soils with good storage capacity for moisture are used for *rabi* crops. The black soils have high shrinking and swelling properties. They exhibit deep and wide cracks in summer. Gilgai type of erosion is common in deep clayey soils. Many of the deep black soils especially those occurring in low relief are not well drained and as such they may pose problems of drainage, salinity and alkalinity upon irrigation.

(*iii*) *Alluvial soils:* Alluvial soils occupy an estimated area of about 64 million hectares, covering all the zones from arid to humid in the Indo-

Gangetic and Brahmaputra basins. They are generally deep soils. Textures which generally influence the available moisture capacity are variable within and between the areas. Except in depressions, the soils are better drained. Depending on the rainfall the soils are used for both *kharif* and *rabi* crops. A considerable area in the alluvial tract is under irrigation. At places, especially in the western parts, the water table is high enough to cause salinity and alkalinity problems. The fertility status of the alluvial soils is variable though in the majority of cases it may be said to be low to medium. In the very high rainfall zones the soils are leached of bases causing acidity problems.

(*iv*) *Laterite soils:* Occupying nearly 13 million hectares, the laterite soils are generally associated with undulating topography in regions of rainfall ranging from 1,200 mm. to 3,000 mm. Generally they are poor in bases, and the fertility status is variable. In the laterite region plantation crops are taken in the region of high relief leaving those in the depressions and valleys for paddy and annual crops.

In addition to these major groups, there are problem soils. Saline and alkali soils occupying nearly 7 million hectares need reclamation measures.

(*b*) *Liabilities*

(1) It is estimated that nearly 140 million hectares out of the total area of 328 million hectares are affected by erosion, wind or water, about 7 million hectares by waterlogging and salinity and about 20 million hectares by flood. Of the cultivated area of about 139 million hectares, nearly 80 million hectares require soil conservation measures. While it is not possible to easily compute the total loss as a result of erosion, certain estimates indicate that the losses may be heavy in some areas. In the Deccan Black soil area the top soil loss in a single year may be as high as 40-100 tons/hectares. It is estimated that the total soil loss as a result of erosion may work out to nearly 6,000 million tons. Apart from erosion, run-off losses are estimated at 20-25 per cent which is crucial especially in semi-arid and arid areas.

(2) It is estimated that the brick work for the house of a modest family of 5 members in an urban area would require about 120 tons of soil. Taking the urban population only, it is estimated that nearly 3,000 million tons of soil (mostly top soil) would have been excavated at one time or the other. Every year the amount excavated increases. Apart from the loss of fertile soil, unplanned excavation as at present leads to greater soil erosion and water stagnation, leading to salinity, etc.

Not many are aware that the formation of 1 cm. soil *in situ* may take about 500 to 1000 years depending on the nature of the parent material and the intensity of weather.

III

EMERGING AGRICULTURAL TECHNOLOGY AND ITS SOCIAL IMPLICATIONS

(1) *Energy Investment, Crop Production and Energy Output*

Until recently, the economics of crop production was assessed mainly in terms of monetary input and output. This will no doubt continue to be the major consideration with farmers in times to come. However, the recent awakening to the energy needs of technology has led to a critical analysis of the energy input-output relationship in agricultural production and food utilization. Since agriculture is predominantly a solar energy harvesting enterprise, discussions on energy requirements generally centre on the needs of industry, housing, travel, etc. Pimental *et al.*[5] showed that maize production in the United States gave a ratio of 1:2.82 for energy input and output. There was no consideration of straw in this study; otherwise this figure might be higher.

The major items of energy input in the United States, according to this study, were heavy machinery, gasoline and fertilizers. The last item was the most significant input. However, a further analysis showed that by the time farm produce reaches the consumer, more energy has been invested than harvested through its production in the field. Thus, the energy balance sheet shows a negative value for farm agricultural products utilized as food when they reach the consumer.[6]

Fortunately, in India the items of energy investment are relatively low and the energy used for food processing and marketing is near negligible as compared to the United States. Our farming practices involve a low input of mechanical energy but a relatively high investment of human and animal energy. The energy needs of the following four models of wheat farming are given in Tables VI to IX (calculations by S. K. Sinha of the Indian Agricultural Research Institute).

1. Low mechanical energy, average fertilizer and irrigation input;

2. High mechanical energy, average fertilizer and irrigation investment;

3. Low mechanical energy, high fertilizer and irrigation investment; and

4. High mechanical energy and high fertilizer and irrigation investment.

5. David Pimental, *et al.*, "Energy and Land Constraints in Food Protein Production," *Science*, Vol. 190, 1975, pp. 754-761.
6. S. H. Wittwer, "Food Production: Technology and the Resource Base," in Philip H. Abelson (Ed.): Food: Politics, Economics, Nutrition and Research, 1975, pp. 85-91.

TABLE VI—LOW MECHANICAL ENERGY INPUT SYSTEM AND AVERAGE INVESTMENTS IN FERTILIZERS AND IRRIGATION IN WHEAT

A. Items of energy investment	kcal./ha.
1. Seed-bed preparation	41,875
2. Sowing and planting	8,098
3. Interculture	6,040
4. Fertilizer application	1,428
5. Irrigation	1,41,386
6. Harvesting	6,794
7. Threshing	51,658
8. Transport	3,290
9. Fertilizers:	
60 kg. Nitrogen	11,28,900
30 kg. Phosphorus	1,13,090
30 kg. Potassium	91,000
10. Seed	3,60,000
Total	19,74,000
B. Items of energy output	
1. Grain: 30 q/ha.	1,08,00,000
2. Straw: 30 q/ha.	1,08,00,000
	2,16,00,000
C. Energy input/output ratio	
Total energy input/total energy output	11.05
Total energy input/grain energy output	5.47

TABLE VII—LOW MECHANICAL ENERGY INPUT SYSTEM AND HIGH INVESTMENT IN FERTILIZERS AND IRRIGATION IN WHEAT

A. Items of energy investment	kWh/ha.	kcal.
1. Seed-bed preparation	47.21	41,875
2. Sowing and planting	9.13	8,098
3. Interculture	6.81	6,040
4. Fertilizer application	1.61	1,428
5. Irrigation	435.0	3,76,975
6. Harvesting	30.6	27,142
7. Threshing	348.0	3,08,676
8. Transport	20.0	17,740
9. Fertilizers: Nitrogen	100 kg.	18,81,500
Phosphorus	60 kg.	2,26,080
Potash	60 kg.	1,82,000
10. Pesticides and insecticides		
11. Seed	100 kg./ha.	3,60,000
		34,37,554
		34.38
B. Items of energy output		
1. Grain	50 q/ha.	1,88,15,000
2. Straw	50 q/ha.	1,88,15,000
3. Root system	5 q/ha.	18,81,000
		3,95,11,000
C. Energy input/output ratio		
Total input/total output		11.49
Total input/grain output		5.47

TABLE VIII—HIGH MECHANICAL ENERGY INPUT SYSTEM AND AVERAGE INVESTMENT IN FERTILIZERS AND IRRIGATION IN WHEAT

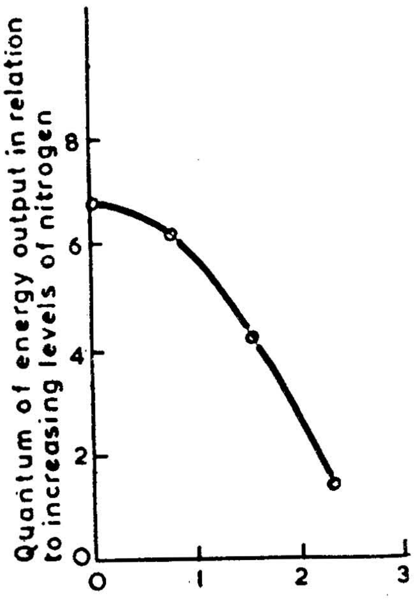
			kWh/ha.	kcal.
A.	Items of energy input		kWh/ha.	kcal.
	1. Seed-bed preparation		105.14	93,259
	2. Sowing and planting		32.26	28,650
	3. Interculture		6.54	5,800
	4. Fertilizer application		1.62	1,437
	5. Irrigation		174.12	1,54,338
	6. Harvesting		7.73	6,856
	7. Threshing		86.91	77,169
	8. Transport		4.93	4,435
	9. Fertilizers:	Nitrogen	60 kg./ha.	11,28,900
		Phosphorus	30 kg./ha.	1,13,040
		Potassium	30 kg./ha.	91,000
	10. Pesticides and insecticides			
	11. Seed		100 kg./ha.	3,60,000
				20,64,884 =20,65,000
B.	Items of energy output			
	1. Grain		30 q/ha.	1,08,00,000
	2. Straw		30 q/ha.	1,08,00,000
	3. Root system		30 q/ha.	10,80,000
				2,26,80,000
C.	Energy input/output ratio			
	Total energy input/total output			10.98
	Total energy input/grain energy output			5.23

TABLE IX—HIGH MECHANICAL ENERGY INPUT SYSTEM AND HIGH INVESTMENT IN FERTILIZERS AND IRRIGATION IN WHEAT

A.	Items of energy input		kWh/ha.	kcal.
	1. Seed-bed preparation		105.14	93,259
	2. Sowing and planting		32.26	28,650
	3. Interculture		6.54	5,800
	4. Fertilizer application		1.62	1,437
	5. Irrigation		435.00	3,76,975
	6. Harvesting		30.06	27,142
	7. Threshing		348.00	3,08,676
	8. Transport		20.00	17,743
	9. Fertilizers:	Nitrogen	100 kg./ha.	18,81,500
		Phosphorus	60 kg./ha.	2,26,080
		Potassium	60 kg./ha.	1,82,000
	10. Pesticides and insecticides			
	11. Seed			3,60,000
				35,09,259
B.	Items of energy output			
	1. Grain		50 q/ha.	1,88,15,000
	2. Straw		50 q/ha.	1,88,15,000
	3. Root system		5 q/ha.	1,88,10,000
				3,95,11,000
C.	Energy input/output ratio			
	Total input/total output			11.26
	Total input/grain output			5.36

It would be seen that the major items of energy investment for wheat production in India are fertilizer and irrigation. At high levels of mechanization, the ratio of input to output tends to decrease. In any event, the ratio of input-output of energy varies from 1:5.23 to 1:5.47 with respect to grains and 1:10.98 and 1:11.5 with respect to the total biological yield (*i.e.*, grain plus straw).

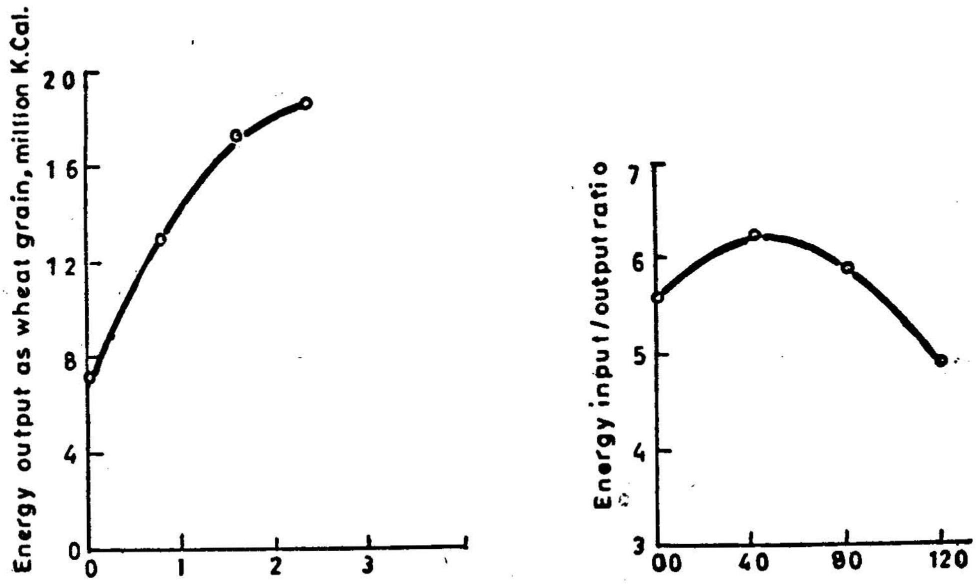
The relationship of energy output to varying levels of energy input such as nitrogen is shown in Figures 2 and 3. The initial investment of energy shows a high output of energy but starts levelling off after 1.5 million kcal. equivalent of nitrogen. In terms of kg. N/ha. the maximum energy input-output ratio was obtained at 40 kg./ha. in the All-India Co-ordinated Wheat Experiments. The quantum of energy output decreased with increasing levels of nitrogen. Considering the utility of biological nitrogen fixation, and the fact that many pulse crops may leave reasonable quantities of nitrogen in the field, this mechanism can provide a feasible method of saving non-renewable forms of energy. Besides the urgent need for more pulses, this is yet another reason for stressing the desirability of growing legumes in multiple and inter-cropping systems.



Energy input as nitrogen (million kcal.)

Figure 2

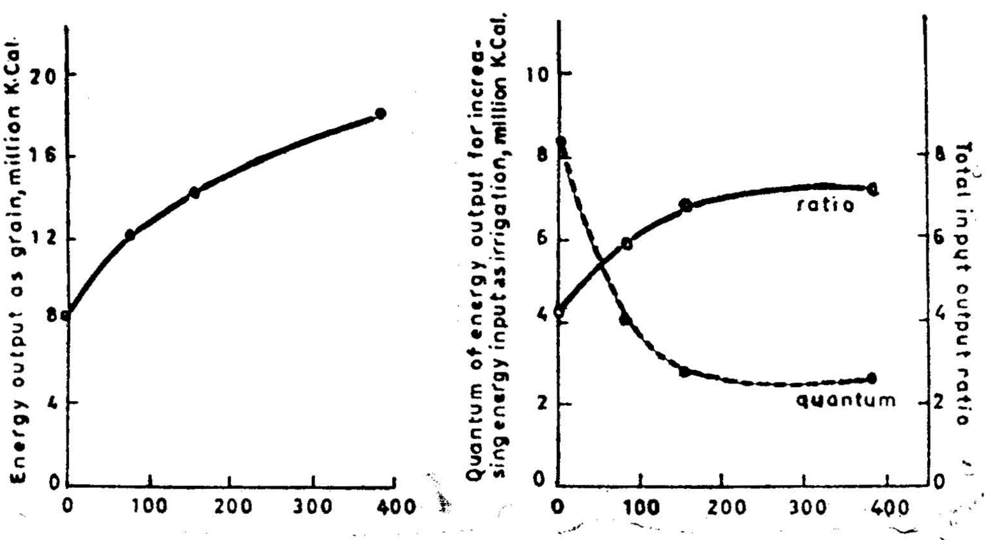
The relationship of energy output to varying levels of irrigation, keeping other factors constant, is indicated in Figure 4. The output of energy in response to irrigation energy is not as dramatic as that for nitrogen. However, it should be conceded that this relationship will vary with location and soil



Energy input as nitrogen (million kcal.)

Levels of nitrogen (kg/ha.)

Figure 3



Energy input as irrigation × 1000 kcal.

Energy input as irrigation × 1000 kcal.

Figure 4

characteristics. An understanding of this relationship is, however, important since we should derive the maximum benefit from our investment on water.

Developing techniques of increasing energy resources and their economic use will become an increasingly urgent task for scientists. This has to be accomplished without causing new environmental problems. Therefore in each farming system, a choice of the source of energy has to be made keeping the economic, environmental and ecological balance in mind. This depends upon the following major factors:

1. Atmospheric CO_2 concentration
2. Atmospheric temperature
3. Water pollution
4. Radioactivity.

Hayes[7] has compared the relative merits of fossil fuel, nuclear energy and solar energy. Fossil fuel can serve for several decades with the concomitant dangers of increasing CO_2 concentration in the atmosphere. It is reported that CO_2 emissions have grown from 2,000 million to 18,000 million tons per year during the period 1900 to 1975-76. An increase in the concentration of carbondioxide could lead to increased temperature and thereby exert serious effects on the climate.

The transport of petroleum and its products leads to a considerable pollution of oceanic waters. This may in the long-run reduce the biological productivity of oceans and the quality of fish. There is also not enough nuclear fuel available to depend predominantly on this source of energy. Equally important are the problems relating to the safe disposal of radioactive wastes. Therefore, according to Hayes,[8] the solar option is the most important one.

One of the major advantages of the solar energy is that it is clean from the ecological standpoint. Since plants only recycle the atmospheric CO_2, there is no possibility of polluting the environment by increasing CO_2 concentration. In addition to crop plants, there are several others including algae which can become important sources of energy. Solar energy coupled with bio-gas technology can provide a considerable proportion of the energy needed for enhanced productivity. The *gobar* gas technology based on animal refuse and cellulosic wastes is attracting worldwide attention. It is unfortunate that our efforts in combining technology and social action to make *gobar* gas utilization a mass movement are now behind those of several

7. Denis Hayes: Rays of Hope: The Transition to a Post-Petroleum World, W. W. Norton & Co., Inc., New York, U.S.A., 1977.
8. *ibid.*

other countries who originally took the technology from us. I agree with Hayes when he states: "Nuclear fusion research may well yield a Nobel Prize some day; no plausible line of research on biogas seems likely to win a trip to Stockholm. Nevertheless, biogas plants will almost certainly provide more energy to those who need it most, than fusion reactors ever will."

I hope the energy conversion data of S. K. Sinha (Tables VI to IX and Figures 2 to 4) cited here will stimulate well-planned studies in this area. Hereafter, the efficiency of the production technology recommended to farmers should be measured by the energy input-output return, in addition to yield and income. Energy input-output relationships also need to be worked out for mixed farming and crop-livestock-fish integrated production systems.

(2) *Integrated Pest Management*

For reducing the cost of production and for avoiding the harmful consequences of persistence of pesticide residues in grain, fodder or water, there is a growing emphasis on integrated pest management involving an appropriate blend of agronomic, genetic, biological and chemical methods of control. Crop sanitation itself could play an important role in reducing the build-up of pest populations. The ICAR had initiated operational research projects in rice and cotton in several States in order to understand the operational difficulties in transferring the concepts of integrated pest management to the field. A recent publication of the ICAR[9] summarises some of the major findings so far. What has become increasingly obvious is the fact that unless all farmers in an area co-operate, the efficacy of the integrated control measures will be low. In fact, even in a country like the United States, where each individual holding may be of the order of several thousand hectares, a study on the impact of integrated pest control in cotton revealed that the major constraint in the spread of technology is social rather than technological. This is an area where collective action will be needed on the part of a group of farmers, as is already in vogue in countries like Egypt in the case of cotton.

(3) *Integrated Nutrient Supply*

The integrated nutrient supply system depends on (*a*) preparation of a nutrient balance sheet for a village based on an assessment of crop yield and nutrient removal; (*b*) assessment of the manurial sources available in the village and estimating the contribution that organic manures and biological nitrogen fixation can make to compensate for the nutrients utilized by crops; and (*c*) development of an integrated strategy for the use of organic manures including green manuring, chemical fertilizers and atmospheric nitrogen in a

9. ICAR Operational Research Projects, 1977, *op.cit.*

manner that can help to achieve the production targets and maintain the fertility status of the soil. New sources of manure like blue-green algae, Azolla and non-symbiotic nitrogen-fixing organisms are now available and their value needs critical study under different cropping systems. It will however be wrong to either under-estimate the value of chemical fertilizers or slacken the pace of enhancing their production. For achieving high yields in the country as a whole chemical fertilizers are a must.

(4) *Integrated Post-harvest Technology*

As production advances, problems of harvesting, threshing, drying storage and marketing become important. Improved post-harvest technology in our country is important not only for minimizing losses in harvesting and for ensuring the nutritional and end-use quality of the product supplied to the consumer but is also essential for developing value-added products within the village itself. This will enable the generation of more income and employment within the village. Crop drying is exceedingly important to prevent the growth of fungi which cause the production of mycotoxins in food. Post-harvest technology operations, both in crop and animal husbandry, will be effective and economical if all people in a village co-operate.

(5) *Risk Distribution Technology*

Research on (*a*) the development of contingency plans based on alternative weather models for areas prone to drought, flood and cyclone, (*b*) crop-life saving techniques, (*c*) additional production measures in the irrigated areas to compensate for the loss in the rainfed areas during unfavourable seasons and (*d*) early warning of weather calamities and pest epidemics, is now in progress. These should help to impart greater stability to production. Obviously, for the effective adoption of the measures recommended for minimizing the impact of aberrant weather and for overcoming the harm caused by the triple alliance of pests, pathogens and weeds, both community action and public policy support will be essential.

(6) *Raising the Ceiling to Yield*

The drive for raising the ceiling to yield should not be relaxed by scientists, although the first priority should go to reducing the yield gap at existing levels of technology. Some of the projections on current yield levels in a few crops are given in Figures 5 to 8.

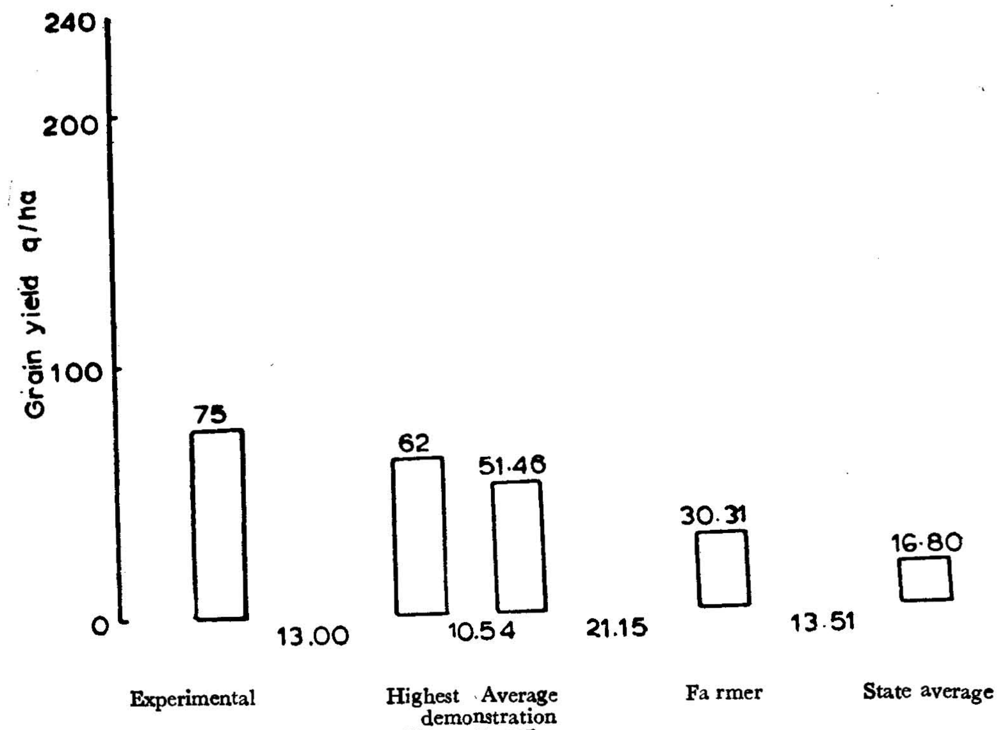
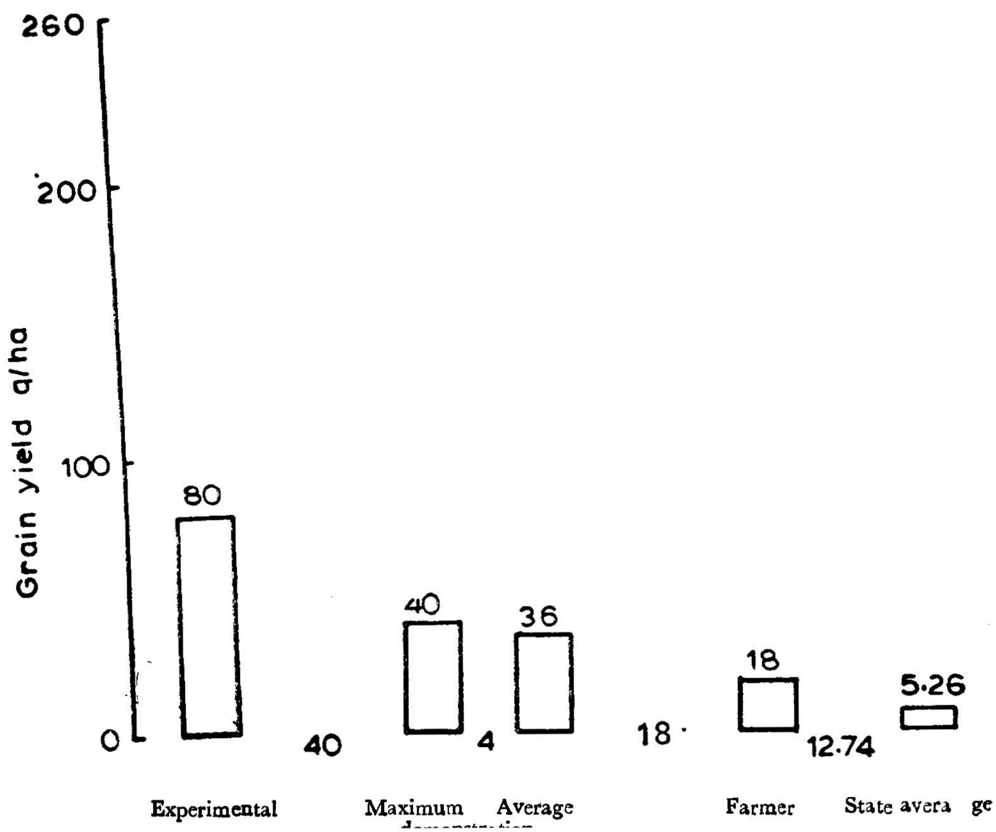


Figure 5—Wheat



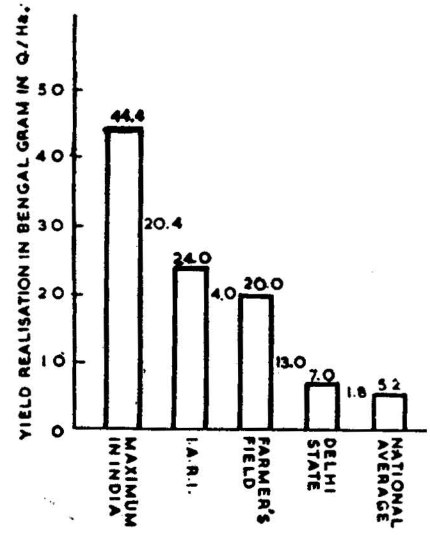


Figure 7—Gram

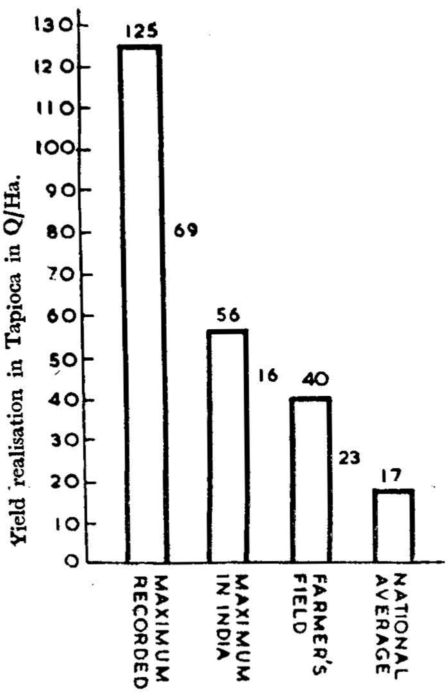


Figure 8—Tapioca

Plants depend for their growth on solar energy which is available in plenty. It is only in some crops, such as sugarcane, maize and sugarbeet, that the maximum utilization of 10 per cent of the photosynthetically active radiations has been realised. This is only about 2.5 per cent of the total solar energy. Therefore, theoretical limits to crop yield are very high if all the photosynthetically active light could be captured by plants. However, one could be more realistic in assessing realisable yield using the maximum productivity data. This results of such an analysis are shown in Figures 5 to 8 for wheat, maize, Bengal gram and tapioca. These crops represent the diverse nature of plant species with respect to their plant types. It would be seen from the figures that a very wide gap exists between the maximum experimental yields and the national or State average yields. The difference between the Delhi State average and the demonstration experiments is about 3 and 7 times in wheat and maize respectively. In Bengal gram, whereas the reports of the All-India Co-ordinated Project on pulses show yields up to 44 q/ha., the national average lingers around 5 q/ha. only. Again, good management including pest control on farmers' fields does result in a yield of 20 q/ha. or more. The story of sorghum is no different. In the All-India Co-ordinated Project of Sorghum Improvement yields up to 70 q/ha. have been obtained but the national average continues to be around 6 q/ha. Tapioca is an important crop of Kerala and is considered an efficient crop for conserving solar energy. This crop has given up to 125 tons/ha. yield in the West Indies whereas in India the maximum reported yield is 56 tons/ha. The national average is only 17 tons/ha. Thus with the available scientific knowledge and practices much more can be achieved. Most of the gap in production lies between potential and actual farm yields. In Punjab, this has been considerably reduced in the case of wheat and can be a pointer for our analysis in depth.

IV

MAJOR INGREDIENTS OF NEW PATHWAY OF AGRICULTURAL DEVELOPMENT

I started this address by referring to the progress we have made so far through action by individual farmers aided by Government agencies. We have reached a state of relative stagnation largely because of (*a*) the absence of the social infrastructure necessary for the rapid diffusion of technological benefits and (*b*) inadequate consumer purchasing power. In my view, hereafter a major advance in food production coupled with greater stability of production can be achieved only if we develop a new pathway of which the following need to be some of the major paving stones.

(*a*) *Strengthening Agricultural Assets and Reducing Agricultural Liabilities*

Bernard Shaw once said that teaching is too serious a business to be left to teachers alone, thereby implying that parents have an equal responsibility in the matter. Similarly in my view, farming is too serious a business to be left to farmers alone; the rest of the community will have to lend a helping hand. This can be done only if there is widespread appreciation of our agricultural assets and liabilities and of the methods of improving our assets and reducing our liabilities. The lack of awareness in the community as a whole concerning the damage occurring to our soil, plant, animal and water resources through neglect and improper use needs to be removed.

How can we achieve this? There is need for multi-pronged action. If we want to accord overriding priority to agriculture, we should introduce a compulsory course on "our agricultural balance sheet" in every class from the primary school to the University. Such a course should not be class-room-bound. It should involve taking long walks in the country at least once a month. The teacher who accompanies the students must have the capacity to discuss the beneficial and harmful impact of human activities on the biological potential of land and water. Obviously, some facilities for transport will have to be made available in the case of educational institutions in towns and cities. Reserving half a day for such a course once a month, will not make any serious inroads on the time available for formal teaching. What is needed is the will to promote the seeing eye and questioning mind. If however the teacher who accompanies the students is not equipped to stimulate this, the visits may degenerate into sterile picnics. Hence, teacher training must precede the introduction of such programmes. In the case of adults, the mass media, particularly the radio, the cinema and the local language newspapers can play a significant role in generating awareness and action to strengthen the ecological infrastructure essential for sustained agricultural growth. Finally, massive training programmes by mobile training teams which alone can reach easily rural women, and institutions like *Krishi* and *Udyog Vigyan Kendras* which can help to impart the latest skills through learning by doing, are essential.

(*b*) *Improving the Efficiency of Management through Social Action*

As mentioned earlier, management can be divided into two parts—one relating to what individual farmers can do and the other to what only a group of farmers can accomplish through co-operative action. We are yet to reap the benefits which collective management of certain farm operations like water and pest management and post-harvest technology may offer. A simple device like community nurseries in rice can help marginal and small farmers to overcome the difficulty experienced by them in the past in the choice of the correct variety and timely planting. We should, therefore, look more and more for institutional devices intended to help farmers with very low risk-taking and input mobilizing capacity to overcome their handicaps. The Government of India has recently constituted a Committee under the Chairmanship of Shri Asoka Mehta to examine the working of the *Panchayati Raj* institutions. One term of reference of the Committee relates to the role of *Panchayati Raj* institutions in integrated rural development. In my view, such a review could provide an excellent opportunity to give a structure and orientation to *Panchayati Raj* institutions which will help them to become catalysts in development. Different members of the *Gram Panchayat* can assume specific responsibilities for mobilizing group action in selected areas, such as water and pest management, tree planting, rodent control, etc. If such a restructuring can be accomplished, the social infrastructure for technological advance would have been created. Co-operative management within the framework of individuality of land holdings could then make a major contribution to the efficient adoption of the many features of the emerging agricultural technology to which I have made reference earlier. Without such a social infrastructure, the cost of production will tend to rise, efficiency of energy conversion will be low and the widespread adoption of recycling techniques will be difficult. Also, without it, land consolidation, land levelling and the raising of energy plantations will not be esay. Consequently, production and productivity will not rise to the needed extent. Further, instability will increase.

(*c*) *Public Policies*

Public policies appropriate to sustained agricultural advance obviously hold the key to converting goals and targets into accomplishments. Several aspects of public policy such as land reform, integrated input-output pricing policy, insulation of the economically handicapped sections of the farming community from risks through crop or credit insurance, allocation of sea space to landless labour for mariculture and reservation of specific industries for the rural sector as suggested by the National Commission on Agriculture require urgent action.

We are, thus, in an interesting but crucial phase of our agricultural evolution. We have many of the basic ingredients necessary for accelerated agricultural advance such as a receptive and hard-working farming community, a network of good research, education and extension centres and reasonable infrastructure like roads, communication, etc., in many parts of the country. What is now needed is a major thrust towards achieving an optimum blend of social action, technology transfer and Government initiative for reaping full benefit from the vast untapped yield reservoir existing in our terrestrial and aquatic production systems.

SUMMARIES OF GROUP DISCUSSION

SUBJECT I

ECONOMICS OF NUTRITION

RAPPORTEUR: P. G. K. Panikar*

The group discussion centred mainly on four issues, *viz.*, (1) Will economic growth and rise in per capita income lead to an improvement in the nutrition status of the masses? (2) Does an increase in food output necessarily make a dent on their level of nutrition?; (3) How effective are the nutrition intervention programmes implemented by the Government?; and (4) Can we view the nutrition problem in isolation? Can we envisage an integrated approach, involving food production and distribution, employment and income, investment and growth?

(1) As regards the first question, the Group generally agreed that as income increased, the intake of calories and proteins and other nutrients would also increase. However, it was noted that with economic growth and rise in per capita income, the nutrition requirements of the vulnerable sections who due to inadequate income and purchasing power are at present undernourished and/or malnourished will not be automatically taken care of. The improvement of their nutrition status will depend upon the pattern of income distribution accompanying the rise in per capita income. The main suggestions which came up in the course of the discussions were (*a*) redistribution of income in favour of the poor, (*b*) guarantee of minimum income through expanding employment opportunities and (*c*) an integrated income-price policy.

Furthermore, it was pointed out that nutrition status involved other variables, besides the level of nutrient intake. It was noted that the rate of assimilation and absorption of nutrients taken by a person would depend on his state of health, as governed by environmental sanitations and public health measures adopted by the Government. Therefore, the Group felt that provision of minimum standards of sanitation and dependable supply of protected water in the rural areas and urban slums should be given as high a priority as increasing the intake of nutrients through appropriate policy measures. It was pointed out that the recommended norms of calorie, protein or other nutrient intake presupposed the prevalence of minimum sanitary standards.

(2) The Group noted that the increase in food output is a necessary condition for the improvement of the level of nutrition of the masses, but not a

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sufficient condition. Our recent experience with a record output of food-grains is a clear example of increasing output not making a dent on the food intake of the masses. The marketable surplus has swelled, a large part of it being garnered by the Government by way of buffer stock and the rest held by the producers or traders hoping for better price in the future. We have a paradox of poverty and undernourishment in the midst of plenty. The farmers are not able to sell for want of buyers offering a reasonable price; the Government is not able to release the foodgrains for want of ideas of utilizing this wage good; the undernourished are not coming forward to clear the market for want of purchasing power. Some of the discussants pointed out that it would be possible to identify worthwhile projects which could be implemented using the stock of food and thereby making a simultaneous attack on employment, undernutrition and low rate of capital formation in the agricultural sector of the country.

(3) Regarding the efficiency of the nutrition intervention programmes of the Government, the general impression was that the programme failed to bring about any perceptible improvement in the nutrition status of the population groups for whom it was conceived. As to the reasons for the programme not fulfilling its objectives, it was pointed out that the programme concentrated on nutrition while neglecting public health, sanitation, protected water, etc. Further, there were instances of leakage and corruption among the functionaries which led to a dilution of the benefits of the programme. Despite the above shortcomings, the Group generally recognized that such programmes have a useful role in the present situation in the country. The Group felt that more thought and attention should be given to all stages of the programme, from its planning and conception through implementation. The main aspects emphasized were the suitability of the programme, taking into account social, cultural and other factors, involvement of persons with the right motivation, utilization of local resources and potentialities, etc. One concrete suggestion which was put forward in this connection was that the supplementary feeding programmes for children may be implemented through the schools by developing vegetable gardens there and involving well motivated school teachers.

(4) The Group came to the conclusion that the nutrition problem needed an integrated approach involving income and employment policies. It was recognized that the crux of the problem consisted of providing enough quantity of food to the sections currently denied the same for want of regular source of income. For this the obvious solution lay in creating employment opportunities which will ensure a reasonable level of income. The Group did not think that creation of productive employment was a serious problem, because there was so much to be done and the Government had such a large stock of the most important wage good, *viz.*, food.

SUBJECT II

STRATEGIES FOR INTEGRATED RURAL DEVELOPMENT

RAPPORTEUR: Sulabha Brahme*

Many of the participants illustrated the various problems of rural development in their respective areas drawing upon experiences therein or the field studies carried out in the area. A number of issues at conceptual and operational level were debated. The discussion on the major issues considered by the Group is summed up in the following.

The Group considered it important to define with precision the Integreted Rural Development (IRD) concept and to work out the indicators of integrated development. IRD would include integration of different agricultural activities and other land-based activities like animal husbandry, fishery, forestry and further integration of these with the non-primary activities. Such an activity integration will relate to a specific spatial unit. The spatial units will range from a village—group of villages—to a town/city, a hierarchy of functionally related settlement units.

IRD can be attempted with the objective of bringing about higher returns from a given investment and ensuring better integration between the local resource base and the productive activities and infrastructural facilities. If the rural-urban linkages are thus improved, the experience has been that it often leads to a decline of non-agricultural activities and loss of vigour of rural areas accentuating the dualism in the economy. In the IRD exercise emphasis is to be placed on improving the conditions of the weaker sections and ensuring that they get integrated in the developmental process in such a way that it does not lead to intensification of exploitation of these sections but they, in fact, get some share in the benefits of planned development.

The Group, then, discussed at length the rationale of the IRD approach. It was pointed out that the IRD concept emerged in rural development literature in India because of malallocation of resources between different sectors, leakage of benefits of investments made in the rural areas to metropolitan centres and the failure of the earlier rural development programmes to reach the weaker sections in the rural areas. Even the special schemes formulated exclusively for the uplift of the weaker sections, *viz.*, marginal farmers, agricultural labourers, artisans proved to be of limited significance. It was considered imporant to examine the factors that limited the efficacy of rural development schemes. Various financial and organizational constraints were discussed. It was contended, on the basis of past experience

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that the village level workers, bank officials and other agencies working in the rural areas usually reached a small number of substantial landowners; this was both easy and fruitful for them. Even the information about the various schemes, leave apart the actual benefits, often did not reach a large number of smaller landowners and the landless. The basic reason why the poorer and the weaker sections in the rural areas did not get included into the various developmental programmes was traced to the unequal distribution of assets, notably land. The help extended through the governmental and other agencies proves to be of little avail because of the lack of minimum resource base with the poorer sections. This basic weakness makes it difficult for them to procure credit and agricultural inputs. Due to their lack of contacts and information they fail to profit from various Government schemes. Their low risk-bearing capacity hinders experimentation. They are often compelled to make distress sales due to their lack of holding power.

The IRD approach aims to make direct intervention in favour of the weaker sections. The objective of IRD is to provide gainful employment to the rural poor and thereby increase their purchasing power. The job opportunities are to be generated through the application of science and technology to ensure optimum use of the local resources—human, animal, soil, water and other natural resources.

The action plan is to be suitably drawn in view of the local resources, needs and priorities and it is to be worked out on the basis of malady-remedy analysis. The task of implementation, co-ordination and monitoring of the programme will be entrusted to a special 'Principal Co-ordination Officer' who will work in co-operation with government departments and voluntary agencies. It is also laid down that the programme should be economically viable and capable of attaining self-reliance and should be replicable under different conditions.

The major limitations of the IRD model were discussed at length. IRD aims to augment the income of the target group within the constraint of the existing land distribution. Given the very small and fragmented nature and very often poor quality of the land resource with the target group, how far can the technology or additional doses of capital help improve the yields and the returns ? If the avenues for self-employment get restricted due to asset constraints, wage employment is the only alternative. The experience of rural works programmes shows that it is not possible to ensure that the new employment avenues are known to the target group, that they suit their needs, and that the target group population succeeds in getting gainful employment on the new works. The first bottleneck would, thus, come up in the very formulation of the schemes. The second problem relates to the nature of organization. The programme calls for decentralised decision-making and local level initiative and responsibility. How to build up such an organization and co-ordinate its functioning with the existing bureaucratic organization keeping the initiative with the local level organizations remains problematic.

In this context a basic question was raised. Is it possible to think in terms of socialistic goals like reduction of poverty and unemployment, participation of masses in the developmental process when the basic structure is capitalistic, *i.e.*, when there is private ownership of the means of production so that the decisions regarding investment, production pattern, technology, employment are taken in view of the private profit maximization goal and not in view of the social good? Can a Government-sponsored scheme change the direction of economic growth when the skew asset distribution is to remain undisturbed?

The Group also examined the issue as to whether it would be possible to evolve some schemes which integrate the interests of the various groups in the rural community. It was argued that the problems and priorities of various sections, *viz.*, big farmers, small farmers, landless labourers were different and on certain issues like wage rates, ceiling on land holding and distribution of surplus land, the interests of the various sections were conflicting. Some participants suggested that different schemes should be prepared in view of the needs of various groups and then integrated into rural development plan. It was, however, pointed out on the basis of experience of various schemes like dairy, poultry, silk-worm rearing, etc., that such schemes though designed for the weaker sections failed to reach them since they did not have the complementary resource, *viz.*, land. In this context the urgency of implementation of land reforms and land redistribution was stressed. As a pre-condition, it was considered necessary to prepare forthwith proper land records which are lacking in many States of India.

Special attention was drawn to the need to provide work to the landless labourers during the crucial period of unemployment when they have to resort to borrowing loans at exorbitant interest rates and at times even get into bondage. It was contended that if arrangement for sustenance during this critical period has been made, the dependence of the labourers could be significantly reduced. In the case of artisans a need to make provision for timely supply of raw materials, credit and arrangement for marketing of finished products so as to free them from the hold of trader-moneylender was emphasized.

The Group then considered the current strategies for IRD. IRD strategy is viewed as a model which will make it possible to integrate a number of objectives. Provision of agricultural inputs, marketing and processing facilities to help agricultural development, massive irrigation programme to increase production and employment, a minimum needs programme and a large public works programme formulated in view of the agricultural and irrigation development priorities were presented as the strategic elements of IRD. For this a micro level linear programming model has been worked out.

The model provides for expansion of employment and the minimum needs programme within administrative and financial constraints.

Limitations of a micro level model to help evolve IRD programme were pointed out by some of the participants. The issues raised were (*i*) how the local level optimization requirements can be reconciled with the State level optimization. (*ii*) Since the local economy is an open economy and depends on outside world for many of the inputs a comprehensive plan at the local level will have limited validity. (*iii*) The data base at the local level being weak, the margin of error in estimation of the variables would be considerable. Under such circumstances is it useful to work out a sophisticated planning model at the micro level? Doubts were also expressed as to how far the objective of generation of massive employment will be fulfilled through the IRD model when the agricultural development programmes, irrigation programmes and public works programmes taken up so far have not delivered the goods. The IRD approach does not seem to have any special element that will help achieve the objective of employment generation on a massive scale so as to eradicate unemployment within a decade.

It was suggested that a different approach was called for for formulation of local level plans. It was considered important that the approach to assessment of the resources at the micro level should be different from that adopted at the macro level. Many a local resource which can be activated at the local level does not find place in the national level resources balance sheet. Evaluation of a resource can change depending on whether it is or is not integrated into the market economy. In this context the policy planners' central problem is to identify the obstacles, whether technical or institutional, that come in the way of such integration. If the causes are technical like non-availability of a specific complementary resource essential for activating the existing physical resources in the region, then the growth of the region would depend on making the necessary resources available and integrating the region with the rest of the economy. On the other hand, if the causes are structural like the existence of feudal form of property relations the growth will have to be induced by removing the structural constraints so that the growth potential is materialised.

A need to treat the minimum needs programme as an integral element of the local level plan was stressed by some participants. In the existing socio-economic framework the benefits of economic development in the form of increase in productivity and income levels reach but a limited section of the population. The asset-poor do not have adequate incomes so that they do not have access to various basic amenities and are not able to enter the market to satisfy even their minimum needs. Under the circumstances it was considered necessary to provide certain basic amenities like protected water supply, health and educational facilities through public agencies and to provide essential foodgrains, oil and other items through public distribution system. Questions relating to the definition of basic needs and formulation of appropriate programme were raised during the discussion. For example, even when the public facility network is established, will it be accessible to the weaker sections? Will it be appropriate in view of their problems and needs? When undernourishment is the basic problem how far can the medical service network help the poor? Is the white-collar job-oriented formal education relevant and useful for the target group?

The Group emphasized the importance of association of village level institutions with the formulation and implementation of IRD plans. The formulation and execution of plans from above has left little initiative with the people and they are becoming increasingly helpless and more and more dependent on the Government. It was pointed out that in some of the States, the village panchayats and co-operative societies have become even defunct. Some of the participants stressed that even though association of the local level institutions is important, it is not likely to be rewarding in view of the fact that these institutions today are by and large controlled by the landed interests in the village. It is unrealistic to expect that they will be instrumental to the formulation and implementation of schemes for the benefits of the weaker sections in the village. In this context it was suggested that it would be important to evolve an alternative form of representation. Provision for proportional representation in view of the population size of each group, *viz.*, landless, small farmers, medium farmers, etc., may be made so that the overwhelming domination of the rich land owning sections can be diluted.

The IRD strategy, it was feared by some participants, might lead to wasteful use of resources. Additional resources made available for IRD might just get locked up in the expansion of bureaucratic machinery and other overheads. The programme might include very few schemes which would result in increase in production and help increase the size of the 'cake' significantly. It was maintained that Growth constituted the crucial variable; the experience in Punjab, Haryana and Western Uttar Pradesh showed that under the conditions of rapid agricultural growth the conditions of the rural poor could improve. It was, however, pointed out that it would be necessary to examine the character of natural resource base and the package of inputs made available in different regions. The green revolution strategy could lead to agricultural growth only in limited resource-rich regions. In these regions also, even though there is some improvement in income levels of the weaker sections, so far as their participation in the social and economic planning and other decision-making processes is concerned, the weaker sections are still left out, as the basic land distribution pattern and economic power distribution have not changed; the inequalities, in fact, remain quite sharp. Developmental process which cannot be defined as mere technological transformation of agriculture but release of creative initiative and energies of the masses did get off the ground.

The involvement of the people in shaping their future, *i.e.*, in plan formulation and plan implementation was stressed by many participants. It was contended that the schemes were formulated from above by the bureaucratic agency without taking into consideration the types of economic activity that the target group would prefer to get involved with, their present asset and skill levels, the new opportunities that could be opened up by modifying these, the priorities, as they saw it, to bring about improvement in their life. Unless the perception, priorities and needs of the people are fully grasped and this cannot be done from outside, the plans may have little relevance in relation to the need of the people and would fail to ensure the peoples' participation.

It was felt that this brought out the need to consider the IRD programme in the wider perspective of national goals and priorities. If the plan is to be evolved for the people to help release their creative energies and satisfy their creative urge, the entire approach to planning has to be changed. The use of efficiency criterion based on private profit maximization and the perpetuation of skew asset distribution which determines the investment priorities, choice of technology and production pattern will have to be altogether changed. Appropriate strategies for IRD could be evolved only if IRD is placed in such a new national developmental perspective. Else IRD strategy would turn out to be another 'community development programme' or similar exercise under a different name.

SUBJECT III

RETURNS FROM INVESTMENT ON AGRICULTURAL RESEARCH

RAPPORTEUR: Dayanatha Jha*

Methodological Issues

Considerable attention was devoted to methodological issues. A brief summary of alternative approaches to measurement of returns from agricultural research was followed by suggestions from the Group regarding 'missing elements' in such models. These are indicated below. It was also emphasized that such models must be based on a detailed specification of the underlying production function and the statistical and econometric implications of the estimation procedures used must be carefully looked into.

It was recognized that we have now reached a stage where methodological refinements and analytical rigour in model specification should be given more importance. Three specific areas were identified which needed attention. First, it was felt that more rigorous work was needed on the deter-

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mination of lags between investment and realisation of benefits and the subsequent time path of these benefits. Secondly, more sophistication was called for in identifying and sorting out the interacting influences of research, extension and education. Finally, the need to account for the contributions of research done in other regions was also emphasized. Studies were needed at more disaggregated levels so that a more balanced view on the productivity of research emerges. Aggregative national or State level analysis completely masks the relative performance of different sectors and therefore, could perpetuate inefficiencies if not backed by individual crop or region-based studies.

It was also pointed out that when research was directed towards multiple goals, measuring its contribution purely in terms of increments in output could be misleading. Specific mention was made regarding research directed towards yield stabilisation. In this case, there may be no incremental output to measure and this contribution may altogether be missed. And, in an area where instability is the dominant problem, we might end up with considerable under-estimation of benefits. This was recognized as an important measurement problem.

Inadequacies in research expenditures data prompted a discussion on the possibilities of using variables like scientific manpower or scientific publications in *ex post* evaluation models. The fact that these were found to give reasonably good results in cross-country comparisons was pointed out. But the Group was really concerned about the status of research expenditures data and it was opined that proxies will not be of much help once we move from the realm of *ex post* estimation of returns to *ex ante* resource allocation decisions. The Group was unanimous in expressing the view that properly classified data on research expenditures was a pre-requisite for good empirical work in this area. Several classificatory variables were indicated—sectorwise (Central, State, private), commoditywise, regionwise, problem areawise, etc. It was also clearly brought out that it was beyond the capacity of individual research worker to undertake such a compilation. It would require a multi-departmental/institutional effort. The Group came up with the recommendation that the Indian Council of Agricultural Research should assume the responsibility of collecting, compiling and publishing this data series. It was recognized that under the proposed, project-based budgeting procedure of the Indian Council of Agricultural Research it would be possible to obtain reliable data in the desirable form, but data for past years would still be needed. The Indian Council of Agricultural Research is ideally suited to undertake this task.

Efficiency and Equity Consideration in Agricultural Research

The Group spent considerable time discussing whether agricultural research should directly concern itself with issues like equity and employment

Some participants held the view that so far as inter-farm disparities were concerned, these were related more to biases in the factor markets or institutions and, therefore, should be tackled from this angle. Others argued that this was perhaps true for biological or chemical innovations which were, intrinsically, scale neutral but certainly not so for innovations which were primarily labour-saving. In the context of the former, it emerged that, primarily because of vested interests, institutional adjustments always lag behind technological developments and this resulted in accentuation of disparities. *Ex ante* identification of institutional adjustments needed in the wake of a proposed technological change, was described as a major analytical challenge facing agricultural economists working on agricultural technology. Such analysis would help in reducing the adjustment gap.

In the context of factor saving bias in technology, it was felt that economists must watch technologies being evolved from this angle. Technologies which are not consistent with factor endowments have to be identified and their implications pointed out to those who are responsible for research resource allocation.

Research Resource Allocation

The Group was of the opinion that a formal model for research resource allocation had not yet been satisfactorily evolved. The work done in this area was briefly reviewed and it was apparent that a lot more sophistication and flexibility were needed. It was argued that economists could contribute to the efficiency of research resource allocation by improving the information base available to the decision-makers. They could help them to see the costs and benefits a little more clearly and also indicate to them the likely impact of the proposed research projects on parameters like employment, income distribution, nutrition, etc. The research administrator would then have a more valid basis for decision-making. Moreover, as has been pointed out earlier, *ex ante* identification of constraints would be an integral part of this exercise and this has obvious importance in technology transfer.

It was emphasized that in order to accomplish this, it was essential to solicit information on expected benefits and costs in the project proposal format itself. And this information must be as objective as possible. The Group felt that the job of designing such a project proposal format needed immediate professional attention.

Elaborating on this theme further, the Group considered that the first step in such an exercise would be to conduct a feasibility study and this could be followed by benefit-cost calculations based on an uniform methodology. Subsequently, potential impact on employment, income distribution, price structure, crop mix, etc., ought to be analysed. The Group felt that programming techniques could turn out to be quite useful in such an exercise. It was felt that at each research centre and also at the national level, there should be a cell for this purpose.

In the final session, the Group discussed some aspects of organization of agricultural research. It was felt that economists should now look into different facets of organization like size and location of research centres, complementarity between research and teaching and so on. These have important bearing on the efficiency and productivity of the research system and thus on improving our research capabilities.

The Group concluded its deliberations with the perspective that economists have barely begun work in this area. There are several conceptual, methodological, empirical issues to be sorted out. Economists must face these challenges.