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INCOME DISTRIBUTION EFFECTS OF GREEN REVOLUTION IN INDIA: A REVIEW OF EMPIRICAL EVIDENCES

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Introduction

There are indeed differences among analysts whether the term "green revolution" is appropriate in characterizing the relatively recent trends that have set in, in Asian agriculture, with the introduction of modern varieties of cereals. These differences reflect the controversy that has arisen with regard to the distributional implications of green revolution in Asian agriculture. Even before the changes associated with green revolution were in the process of getting worked out, many analysts, as Schultz (1978) remarks, "turned to making predictions about the unfavorable social side effects of this type of economic dynamics".[1] Moreover many of these "predictions" were based on personal observations, impressions and fragmentary evidences. The conclusions/inferences drawn by many analysts in their studies were hasty and hypothetical, lacking in empirical authenticity.[2]

The main purpose of this paper, therefore, is to examine Indian empirical evidences on the green revolution, with a view to obtaining as far as possible an integrated picture of its (green revolution's) effect on selected dimensions of income distribution in India. The major credit for the present analysis should go to the painstaking efforts of several researchers who in the first instance collected and/or analyzed a large amount of field data, touching on the varied aspects of green revolution in several parts of the country. The enormity of evidences existing on green revolution in the country makes it difficult, if not impossible, to include each one of them in our review. Therefore, the choice of evidences cited in the course of this review is rather dictated by their usefulness and representatives in obtaining an integrated picture, keeping

in mind the conflicting views/hypotheses held in literature with regard to the income distribution effects of green revolution. This review has benefited a great deal from some of the earlier analytical studies/reviews on the subject. Among them a spacial mention may be made of those by C. H. H. Rao (1975), Vyas (1975), Dasgupta (1977) and K. Bardhan (1977).

The review has the following major dimensions in it's content:[3] (i) income distribution effects (of green revolution) among producers (and tenants) of a region; (ii) income distribution effects (of green revolution) on landless laborers; (iii) relative shares of factors of production in the increase in productivity due to modern varieties (MVs); (iv) green revolution vis-a-vis the regional income disparities.

The growing importance of MVs in the Indian economy may be appreciated from the fact that in 1976-77, the latest year for which data are readily available, one-third of the total cereals' area was sown with MVs.[4] That the major breakthrough in new seed-water-fertilizer technology,[5] both in terms of coverage in area and yield performance, has come about mainly in wheat crop and the reasons for being so are well documented by many researchers. Also the reasons for the relatively limited successes of new technology in respect of other cereals, especially rice, are critically examined in a number of studies. Likewise, the factors accounting for the differential adoption and performance of MVs of different cereals in the same region and of the same cereal in different regions are analyzed in several studies. Nevertheless, it may be pointed out that Indian empirical evidences relating to MVs of cereals refer (i) mainly to wheat and rice and (ii) mainly to IADP districts.[6] In addition to these limitations of crop and geographical biases in empirical evidences (in the sense MVs of crops other than wheat and rice and areas other than IADP districts are

relatively less studied), there is the limitation of "time bias", in the sense, most of these evidences flow from a first few years experience of green revolution in the country. Apart from these biases, most of the studies are conducted more or less independently in terms of research design and methodology making it difficult to subject their data for rigorous statistical exercises. Nevertheless, the welcome feature is that they do contain many common elements and cover a common set of issues.[7]

The mainstay of green revolution has been the fact that the MVs have high yield potential, being more responsive than the local varieties to higher levels of fertilization, effective water control and drainage measures and effective control of diseases and insects. These characteristic features of MVs lie at the root of both the problems and prospects that are germane/relevant to the income distribution effects of green revolution. In fact much of the heat that is generated in evaluating the impact of MVs on income distribution derives its fuel from varying perspectives in which MVs with their inherent characteristics are held to affect/benefit the different classes of the rural society.

At the outset it is of significance to mark the considerable amount of empirical evidence that exists by now which has established, even in field conditions, the economic superiority of MVs over traditional varieties -- in terms of yields and/or net returns per unit of area, more impressively in the case of wheat and maize, and less so in the case of other MVs of cereals.[8]

The fact of economic superiority of MVs over traditional varieties lends a special edge to the income distribution effects of green revolution among producers of a region (the first dimension in our review), provided we discover significant differentials in levels of adoption and

performance of MVs between small and large farmers and between landowners and tenants respectively. It is to the review of empirical evidences on this aspect that we now turn.

Section 1

Adoption Pattern of MVs Among Farmers and Tenants:

A. Small Versus Large Farmers:[9]

Absence of time-series data on area under MVs, size-wise, has been indeed a handicap in tracing the trend in adoption pattern by small and large farmers in the country. Especially in regions where MVs are not adopted universally, collection of such data would be of immense utility. In the absence of such comprehensive official statistics, we are compelled to depend on "adoption studies" undertaken by various agencies and organizations.

Biases of crop, region and time-profile of the empirical evidences on green revolution in the country notwithstanding, fairly comprehensive surveys on the adoption pattern of MVs were undertaken by, (i) the Program Evaluation Organization (PEO) of the planning commission for the years 1967-68, 1968-69 and 1969-70, and (ii) by Agro-Economic Research Centers (AERCs) variously for the years 1966-67 to 1968-69. Findings based on a critical analysis of data collected in these surveys are readily available from two studies undertaken by Lockwood, Mukherjee and Shand (1971) and by Schluter and Mellor (1972) respectively.

The Lockwood et al., study, based on data in the 1967-70 PEO surveys covered five crops wheat, rice, maize, bajra and sorghum, and fairly large samples from the relevant states of India for individual crops. It found a strong positive linear relationship between the proportion of farmers adopting HYV and the farm size.[10] This relationship was true for each of the five crops and each of the three years studied. However, within this "highly generalized picture" (emphasis added) they discovered considerable

variation between states and often between districts within states. For instance in the Punjab, the use of high yielding seed did spread fairly evenly to farmers in all decline groups, and as the general level of participation increased over time (a span of three years in this specific study) the inter-decile difference in percentage of adopting farmers declined and in 1969-70 there was virtually 100 percent participation in all deciles.[11] Lack of reliable irrigation (particularly where reliability was a function of tubewell investment which was limited largely to the larger farms), poorly organized supplies of required inputs, etc., according to the authors, possibly prevented this situation being reached in other states like Haryana, Rajasthan and Bihar.

Schluter and Mellor drawing primarily on the published reports of the AERCs and PEO, found a positive relation between adoption and farm size in most areas. In 17 of the 20 areas studied by the AERCs, the relationship was statistically significant as it was in over half of 50 cases studied by the PEO. In no case was there a significant inverse relationship between adoption and size of farm. They noticed, however, considerable variability among regions and crops in the strength of the relation between farm size and adoption. An interesting and important observation that these researchers made in the course of their analysis was that although a high degree of irrigation availability was a necessary condition for adoption, it was not a sufficient condition either for adoption or for equalizing rates of adoption between farm size groups. For instance in East and West Godavari districts (of Andhra Pradesh) almost the entire acreage on all farm size groups was irrigated. But differential rates of adoption were observed between farm size groups, as well as high rates of nonadoption in all groups. The authors hypothesized that either high cost

of cultivation or uncertainty (both of these primarily working against small farmers) caused differential rates of adoption between farm size groups.

Studies done by Lockwood et al. and Schluter and Mellor do lend support to the hypothesis that it is the large farmers who take the lead in the adoption of MVs. But, they also implicitly suggest that with certain conditions being fulfilled, like availability of irrigation, credit and insurance against risk and uncertainty, small farmers would catch up fast with the large farmers in the adoption of MVs. Therefore, it is important to recognize that reasons for the initial lagging of small farmers in the adoption of MVs more importantly lie in their inadequate resource base, and in the nature of infrastructual and institutional arrangements surrounding them rather than in the new technology as such.

In contrast to the initial picture of adoption of MVs being largely a "large farmer phenomenon", the later picture emerging out of surveys/ field studies undertaken after a few years' experience with MVs is one of small farmers progressively catching up with the large farmers.

A joint follow-up study by the PEO and ANU (1976) of the HYV program in India, 1970-75 observed that if size of holding was a factor in the spread of HYV wheat in the selected districts, it might have been a constraint in the earlier years, but soon disappeared.

Mandal and Ghosh (1976) in their study based on a survey of 40 farm households from each of the two selected villages in the districts of Burdwan (west Bengal) and Shahabad (Bihar) and Sambalpur (Orissa) respectively, in the years 1972-73 and 1973-74, found that the participation was more or less equal among all sections of the farming community irrespective of Tenurial status and the size of holdings.

They attributed this dissemination to factors like "concentrated extension service, administrative efforts and other facilities of production" made possible under the IADP in these districts.

Mencher's (1974) field study in Chingleput district, Tamil Nadu at three points of time (in 1963, 1966-67 and 1970-71) showed that where new seeds were available small farmers had begun to adopt them even though no extension efforts were being made to reach them; with more assistance the adoption could have been considerably increased.

With regard to the spread of H-4 variety of cotton in Sabarkantha (Gujarat) district, Desai (1978) found that within a span of four years (1969-70 to 1972-73), there was a rapid adoption by increasing number of cultivators. Although the adoption began with cultivators having big farms, superior irrigation facilities, better educational background, etc., very soon -- once the profitability of growing H-4 was well demonstrated -- cultivators with smaller farms, not-so-good irrigation facilities and poor educational background also began cultivating H-4.

NCAER's (1978) fairly comprehensive study (a sample of 25,000 farmers spread over 17 Indian states) held in 1975-76 did not report any clear relationship between farm size and rice area in MV in 14 of 17 Indian states.

As a part of Global-2 Indian studies, surveys done in Muzaffarnagar (Uttar Pradesh) and Ferozpur (Punjab) revealed that over a span of 5 years (1967 to 1972), the adoption of HYV wheat became virtually universal.[12]

Above cited studies do bring forth the salient point of small farmers progressively catching up with the large farmers in the adoption of MVs within a relatively limited number of years, thereby refuting the hypothesis that green revolution has been essentially a large farmer

phenomenon; although in the initial phase it appeared to be so, it turned out to be a transitory phenomenon.

However, studies which report a progressive number of small farmers adopting MVs within a limited span of years thus catching up with large farmers do not present, with some exceptions, a systematic and in-depth analysis of circumstances/factors that made the process possible, although some broad statements and indications to that effect can be picked up. A detailed accounting and stock-checking of factors that contributed to this trend over different regions would have proved immensly beneficial for gaining a better perspective of the new technology and also for initiating appropriate policy measures.

Despite many evidences pointing out to the wide diffusion of MVs among producers over time, forcefully countering the view that it has been predominantly a large farmer phenomenon, it serves well to remind us that the diffusion process is neither assured nor automatic and depends a great deal on political, social and economic conditions under which MVs are introduced. A study by Parthasarathy and Prasad (1978) undertaken in 1972 in a canal irrigated rice village in West Godavari district (Andhra Pradesh) -- with no other crop in either the wet or dry season -- found a significant association between farm size and adoption of modern varieties, in both the wet and dry season, when cultivators were classified into groups that farm less than or more than 4 ha. "The big farmers led in using the new technology, were ahead of others in terms of rates of adoption and used a greater proportion of the package of inputs". Small farmers, according to the authors, were obviously placed in a disadvantageous position with regard to investable resources and imperfections in the input markets.

Supporting evidence to Parthasarathy and Prasad's finding that even after a few years of diffusion of MVs, small farmers may be still deprived of its benefits comes from Chinnappa's study (1977) of MVs of paddy in North Arcot district (Tamil Nadu) for the year 1973-74. In the survey area, possession of pumpsets emerged as the one factor leading to higher rate of adoption among all groups of cultivators: big and small. But the proportion of small cultivators who could afford pumpsets was much lower than that among the larger cultivators. Other constraints appeared to be the scarcity and high price of fertilizers and the nonavailability of credit, particularly to small cultivators.

The PEO and ANU Study (1976) observed indeed that the coverages of HYVs in wheat growing areas extended very fast and reached a saturation point in certain districts, often as short a time as five years. But the same study drew attention to the rather disturbing fact that in a few of the primarily wheat growing areas -- such as Hissar and Sonepat blocks in the progressive state of Haryana -- there was either still rather poor coverage or a shift away from HYVs to local improved varieties since 1971-72. The constraints for this situation prevailing were, among others, the lack of adequate or assured supply of water for irrigation, inadequate supplies of fertilizers, high prices of fertilizers and chemicals, lack of institutional credit especially for the small farmers who faced problems in all selected districts (except Ludhiana in Punjab and Muzaffarnagar in Uttar Pradesh). The farmers in the districts of Hissar (Haryana), Rohtak (Haryana), and Basti (Uttar Pradesh) had frequently to resort to private money lenders and big landlords with rates of interest varying from 18 to 40 percent. In some of the districts, viz Amritsar (Punjab), Gaya (Bihar) and Basti (Uttar Pradesh), a number of cooperative societies were defunct on account of accumulation of heavy overdues.

From the PEO and ANU Study (1976), we further gather that with respect to MVs of paddy, the picture was much more diffused and complex. Even after a decade of the operation of the HYV program, HYV area coverage exceeded 50 percent of the total paddy area in only 3 of 27 blocks selected. In another 3 blocks, it ranged from one-fourth to one-half. In the other 16 blocks, coverage was less than 25 percent. It was negligible in 5 blocks. The factors accounting for the low HYV paddy coverage were lack of assured irrigation, nonavailability of varieties of required duration to suit local and seasonal conditions, lack of institutional finance, etc.

The findings of the above cited studies helped highlight the fact that the adoption process of MVs among producers is by no means automatic (which seems to be suggested in the evaluations of over-zealous enthusiasts of green revolution). They also bring out among other things the relevance and importance of physical and institutional infrastructure to ensure universal diffusion of MVs among the producers.

The proportion of farmers in different size groups, adopting MVs, is only a partial indicator and any inferences drawn regarding its likely effect on income distribution among producers may be misleading. For a meaningful appraisal of income distribution effects of green revolution among producers, we have to take into account related parameters of adoption pattern of MVs viz: differences in the intensity of adoption (i.e. effective participation), and yield rates (preferably net income) obtained across farm size. It is to the examination of empirical evidences relating to these parameters of the adoption pattern across farm size that we now turn.

Farm Size and Effective Participation in New Technology:

The study by Lockwood et al. (1971) showed that there was a slight inverse association between farm size and proportion of HYV rice area. But in wheat areas, the same study found a positive relationship between the proportion of acreage under MVs and farm size. Supporting evidence to PEO studies' finding (with regard to MV wheat) may be found in IADP Aligarh study and AERC studies in Karnal and Amritsar. AERC studies in Kota, Bijapur, Faizabad and Saharanpur exhibited the reverse trend. The farm management study of Ferozpur suggested a positive relationship between farm size and proportion of wheat area under MV, although no such evidence was forthcoming in another farm management study (i.e. of Muzaffarnagar) (Vyas: 1975; p. 18).

Analysis by Schluter and Mellor (1972) referred to varying situations with regard to the relationship between the proportion of acreage under the MVs and farm size. In the case of rice, generally as farm size increased, the proportion of the crop's acreage put under the new varieties decreased. This was hypothesized by the authors to be mainly due to problems like labor shortage and labor supervision. In contrast, large farmers put a greater proportion of their wheat acreage under the new varieties than the small farmers. But in bajra growing areas, evidences of both direct and inverse relationships of the proportion of hybrid varieties with the farm size were observed. For maize and jowar crops, there was not a significant relationship between proportion of acreage under the new varieties and farm size.

Chowdhury (1970) pointed out in his study that in Birbhum district (West Bengal) nearly one-fourth of the cultivated area in the lower size group had been brought under the HYV crop (rice) but in the other

contiguous size groups the extent declined considerably. Likewise in Saran district (Bihar), the farmers in the lowest size group had put nearly one-third of the total cultivated area under hybrid maize. In the preceding size groups, the importance of hybrid maize declined consistently so that in the highest size group, the extent of hybrid crops was as low as 7 percent of the total cultivated area. On the basis of this evidence, Chowdhury concluded that the "effective participation" by small farms in the HYV program was no less satisfactory than that of the large farms.

Supporting evidence to Schluter and Mellor's finding that in the case of rice there existed an inverse relationship between farm size and proportion of acreage under MVs comes from Chinnappa's study (1977). Small cultivators (in the survey areas of North Arcot district) particularly those possessing 0.6 to 1.0 hectare had higher rates of adoption than cultivators with smaller acreages and those in the next higher size group (1 to 2 hectares).

It is obvious from the evidences cited above that we cannot draw any firm conclusion regarding the relationship between adoption levels of MVs and farm size. Evidences seem to be mixed in nature (possibly with the exception of those for MVs of rice), for a given crop across regions and for a given region across crops. Therefore, either of the claims that "effective participation" in the spread of MVs is clearly more among small farmers or among large farmers seems to be not "conclusive".

It may be noted, however, that in general, in studies dealing with adoption of MVs, effective participation in new technology by farms in different size groups is measured in terms of proportion of MVs' area to their respective farm size. But, if it is conceded that irrigation is the major determinant of adoption of MVs, then a more relevant index of

participation would be the proportion of MVs' area to irrigated area on farms of different size groups.[13] Making use of this criterion, Bhalla (1979) observed in his study, based on a fairly comprehensive NCAER household survey data for the three years 1968-69 through 1970-71, that 46 percent of the irrigated large farms and 34 percent of the irrigated small farms grew HYV varieties in 1968-69. But by 1970-71 both the small (62%) and large farmers (66%) were almost on equal ground. The crucial difference was, however, that within three years, the large farmers could increase their area under HYV the most: 63 percent compared to 13 percent for the small farmers. Thus, the effective participation of small farmers in HYV adoption, according to this evidence, did not keep pace with that of the larger farmer. Details for wheat and rice farmers showed similar trends in HYV adoption with respect to farm size as did the aggregate data on adoption. The lower resource base of the small farmer, lack of investable surplus, high cost of cultivation, etc. were presumably the constraints operating against the small farmers in progressively increasing their area under MVs, despite the fact of irrigation availability. (Interestingly enough, the study noted that different reasons were offered by small and large farmers for not using fertilizer in 1970-71. Lack of credit was mentioned as a major constraint by 48 percent of the small farmers and only 6 percent of the large farmers; and as contrast, 32 percent of small farmers and 84 percent of large farmers mentioned irrigation as a major limitation).

A point that forcefully emerges, either explicitly or implicitly from a survey of the adoption studies is that given the necessary support -- institutional, infrastructural, etc. small farmers do participate increasingly and effectively in the adoption of new technology. In such

a situation, new technology, being scale neutral, would help improving their income status. On the contrary, if supportive measures to remove the constraints: institutional, economic, political, etc., faced by small farmers are not forthcoming, they would not be able to reap the benefits from new technology, although it is technically neutral to scale. Therefore, it is to be recognized that it is the institutional, economic and political conditions under which the new technology is operating that discriminates against small farmers relative to large farmers rather than the new technology as such.

Farm Size and Productivity/Income of MVs:

Yield/income differentials of MVs between small and large farmers is another parameter in the adoption pattern that can either narrow down or widen the income disparities among producers. What does the empirical evidence look like on this parameter and what does it suggest? Rather than reproducing the large amount of field evidence available on yield/income of MVs by farm-size, we prefer to start with the summary findings based on such evidences on wheat and rice: the two major food crops in India, by Vyas (1975) and Herdt (1980) respectively.

Vyas, relying on evidences put forward by farm management surveys of Ferozpur (Punjab) in 1969-70 and Muzaffarnagar (Uttar Pradesh) in 1968-69 and several AERC studies concluded that the "weight of evidence" suggested a positive association of per hectare net income and the size of holding. However, Vyas did make a cautious and careful qualification that this was not a universal phenomenon and there were other studies which did not support this conclusion.

Herdt assembled data variously spread over the period 1970-78 on yields (and fertilizer use) obtained in studies of villages growing modern rice varieties. Because each study used its own division of size groups, Herdt, for the purposes of comparison consolidated all the observations into two groups: large and small, by averaging all observations below the middle size and all above the middle size. Of the 28 Indian locations for which data were available, in 17 the yields of large farmers exceeded those of small farmers (ranging from 0.1 t/ha. to 1 t/ha.), in 8 the yields of small farmers exceeded those of large farmers (ranging from 0.1 t/ha. to 0.4 t/ha.) and in 3 the yields of large and small farmers were equal. Thus, large farms outnumbered small farms in reporting higher yields of MVs on their farms. Fertilizer use likewise seemed to be somewhat higher on large farms, although the difference occasionally was in favor of the small farms. However, most of the studies from which Herdt assembled yield data contained no statistical tests.

Although sheer "numerical weight" of evidences offered by Vyas and Herdt in respect of yield of MVs of wheat and rice, prima facie seems to suggest a positive relationship between yield/income per unit of area and farm size, it should not be misconstrued to interpret or conclude that large farms are better suited (or better performing) to the cultivation of MVs than the small farms. For one thing these data do not contain statistical tests of significance and for another it is not clear whether they separate out the influence of a number of confounding factors on yield like differences in soil quality, irrigation, level of inputs used etc., across the farms. Differentials in yield/income per unit of area between large and small farms growing MVs, may at best be taken as reflections of the differentials in the levels of inputs used, which in

turn may be due to a host of peculiar economic, social, political and institutional factors. In an environment devoid of these limitations, or relatively less pronounced, one may perhaps visualize, new technology living up to its virtue of scale-neutrality. In fact Sidhu's (1974) econometric exercise for HYV wheat in the Punjab indicates that new technology has been approximately neutral with respect to scale, that it has not been strongly biased in either labor-saving or capital-saving direction and small and large farms have achieved approximately equal gains in efficiency. Unfortunately such rigorous and methodologically satisfying econometric exercises are not undertaken for other regions or crops in the country.

A preliminary comparison of yield rates/income per acre of MVs as such across the farms though helpful is obviously crude and has its own limitations in offering firm and integrated evidence about the relationship between farm size and productivity, and also in tracing the change in that relationship in the pregreen revolution and postgreen revolution period in Indian agriculture. It is often contended that in the postgreen revolution period the income disparities between large and small farmers have widened because the inverse relationship that generally obtained between farm size and productivity in the traditional technology in 50's and early 60's has weakened or even reversed itself in the late 60's and 70's, because of presumed advantages of the larger farms in access to and use of the new technologies.[14]

In support of this view, C. H. H. Rao (1975) assembled regression results from studies for three regions and a number of years and pointed out that the negative relationships between gross value of output per acre and farm size had weakened between the 50's and the 60's (see Table 1).

Table 1. Relationship Between the Gross Value of Output Per Acre and Farm Size

Year		Slope (b)	Coefficient of Correlation
		Muzaffarnagar (Uttar Pradesh)	
1955-56		-0.25*	-0.46
1956-57		-0.17*	-0.33
1966-67		-0.14*	-0.25
1967-68		-0.09*	-0.25
1968-69		-0.04*	-0.17
		Ferozepur (Punjab)	
1955-56		-0.06	-0.09
1956-57		-0.17*	-0.28
1967-68		-0.03	-0.05
1968-69		-0.03	-0.04
		West Godavari (Andhra Pradesh)	
1957-60			
	Output	-0.11***	-0.62
	Labor	-0.13**	-0.82
	Fertilizer	-0.05	-0.21
1969-70	Output	-0.02	0.15
	Labor	-0.16**	-0.86
	Fertilizer	0.10***	0.77

*Significant at 0.1% level; **Significant at 1% level; ***Significant at 5% level; the remaining coefficients are not significant at 5% level.

SOURCE: C. H. H. Rao, Technological Change and Distribution of Gains in Indian Agriculture (Delhi: Macmillan Co. of India Ltd., 1975, p. 143. Adapted from the following sources:

(1) The results pertaining to Muzaffarnagar and Ferozepur are taken from N. Bhattacharya and G. R. Saini, 'Farm Size and Productivity: A Fresh Look,' Economic and Political Weekly, Review of Agriculture, 24 June 1972.
(2) The results relating to West Godavari for the period 1957-60 are obtained by using the data contained in Directorate of Economics and Statistics, Ministry of Food and Agriculture. Studies in Economics of Farm Management, West Godavari.
(3) The results relating to West Godavari for the year 1969-70 are obtained on the basis of the data contained in Waheeduddin Khan and R. N. Tripathy, Intensive Agriculture and Modern Inputs: Prospects of Small Farmers - A Study in West Godavari District, National Institute of Community Development, Hyderabad, 1972, pp. 13, 64 and 76.

Being too limited in coverage and based mostly on group averages the results of these studies are, however, of limited utility, especially in obtaining a general picture at the all India level.

Fortunately Bhalla's study (1979) based on farm level data (1,772 farm households dispersed throughout India) collected by NCAER as a part of its "Additional Rural Income Survey" (ARIS) for the years 1968-69, 1969-70 and 1970-71 offers such a possibility. The principal findings of this study were as follows: (i) the hypothesized inverse relationship between farm size and output per farm area was confirmed empirically, for the years 1968-69 to 1970-71, when major changes due to green revolution were taking place.[15] This relationship was true even when the influence of land quality (as reflected by land price) was removed and also when the influence of irrigation was removed; (ii) the relationship held systematically at the level of the individual product sector, so that changing product-mix alone did not account for declining output per farm area.

Although Bhalla's study confirmed that the inverse relationship between farm size and productivity persisted even in green revolution period (1968 to 1971), it did, however, observe that the factor combinations shifted away from labor toward land and to a lesser degree capital as farm size increased. The elasticity of input use with respect to farm size (percent rise in input use per percentage rise in farmland area) was only 0.55 for labor, 0.74 for capital and 0.77 for seeds, fertilizers and insecticides. Also during the period of the green revolution (1968 to 1971) larger farms appeared to have increased both output per acre and the fractions of their farm area in MV (as mentioned earlier) more rapidly than the small farms. This relative change was

primarily facilitated, as contended by the author, by easier and cheaper access to credit for large farms than for small.

Above qualifications found in Bhalla's study (set within the major finding of an inverse relationship between farm size and productivity even in green revolution phase) do suggest the necessity and importance of ensuring a greater accessibility to inputs for small farmers (critically of credit to meet both the increasing operating expenditures and long term investments in controlled water supply facilities), if they were to retain their historical edvantage of higher yield per unit of area over large farms even in the context of new technology.

To sum up, broadly two views may be distinguished in literature with regard to the income distribution effects of green revolution among producers: (i) new technology has widened the income disparities among producers, since it is the large farmers who have adopted it to a far greater degree (because of capital-intensive nature of new technology and easy accessibility to inputs by large farmers) and therefore, the gains from green revolution have gone disproportionately to large farmers, (ii) new technology is fairly diffused among all the classes of farmers and new technology being scale-neutral, the gains from it are proportionately shared by them.

However, from the detailed review of empirical evidences at our disposal, the following integrated view seems to be fair and realistic.

Green revolution has not been predominantly "a large farmer phenomenon", although large farmers did take the initial lead, possibly due to their comparatively better resource position, access to information, accessibility to inputs, etc. But, small farmers did show a remarkable tendency to catch up with the large farmers within a short span of time.

However, the pace and effectiveness with which this was achieved across the regions (and crops) depended upon a set of supportive measures that was offered to them in the infrastructural, institutional, economic spheres, etc.[16] The latter qualification implied that the sheer virtue of new technology being scale-neutral, though important, was not sufficient to ensure that the gains would be partitioned proportionately among producers, unless it was accompanied by a fair degree of equity in the distribution of resources.

B. Tenancy and Adoption of MVs:

Whether or not tenancy acts as a handicap for introducing innovations in farming has been debated in literature by many scholars offering their own theoretical formulations. In a recent survey, Binswanger and Rosenzweig (1981), after thoroughly discussing these various theoretical propositions and studying empirical evidences come to the conclusion that tenancy need not and would not retard innovations in farming. Indian empirical evidences regarding the adoption of MVs by tenants seem to support this conclusion.

The investigation by Mandal and Ghosh (1976) of farm households in the districts of Burdwan (West Bengal), Shahabad (Bihar) and Sambalpur (Orissa) conducted during 1972-73 and 1974 revealed that the participation in HYV program was more or less equal among all sections of the farming community irrespective of tenurial status (and the size of holdings).

Mishra and Tyagi (1972) in their study of Kota district of Rajasthan found that the percentage of owners-cum-tenants was higher among the adopters than among the nonadopters.

Lockwood et al. study (1971) observed that no significant difference occurred as between the performance of the owners and tenants. If anything, it appeared that the tenant farms had used on an average more fertilizer per hectare than the owners. Mukherjee (1970) argued that the similarity in adoption pattern between owner and tenant farmers was because of the high potential that the MVs had for achieving substantial higher yields which could more than compensate for the onerous terms of tenancy.

Muthaiah (1971) in his analysis of AERC data for Thanjavur district (Tamil Nadu) for the years 1967-69, found that the tenants did not seem to lag much behind the owners either in the application of fertilizers or in productivity of HYV paddy.

However, Parthasarathy and and Babu (1970) pointed out that it was necessary to distinguish between "pure tenants" (cultivating only land taken on lease) and "owner-tenants" (owners who add to their cultivated area by leasing-in) for making a meaningful appraisal of tenancy vis-a-vis adoption of MVs. In fact Parthasarathy and Prasad in their study (1978) based on field investigation of a village in West Godavari (Andhra Pradesh), mentioned earlier, found that the allocation between tenure and adoption was significant at 5 percent level, indicating that owners had an edge over tenants. (Likewise, in the application of relatively new inputs, tenants revealed a lag and also used them in smaller quantities compared to large farmers). This evidence of a negative relationship between tenancy and adoption of MVs, shown by Parthasarathy and Prasad in their rather limited study, may be taken to be more apparent than real for two reasons. Firstly, in the Indian context, even the "pure tenants" do not constitute a homogeneous group to draw any meaningful generalizations.

(For instance Mukherjee (1970a) pointed out that in Punjab, 57.1 percent of the selected "pure-tenant-participants" in the HYV program had operational holdings of 5 acres or less, while the remaining had operational holdings ranging from 5 to 10 acres. In Tamil Nadu, on the other hand, 96 percent of the selected "pure-tenant-participants" had operational holdings of 5 acres or less, in many cases the figures being 1 to 2 acres). Secondly, as rightly argued by Binswanger and Rosenzweig in their above mentioned survey, it was perhaps the limiting factors (capital constraint etc.) applicable to small farmers that held good for tenants also (in the village studied by Parthasarathy and Prasad) in adopting MVS rather than the "tenancy" as such.

C. Green Revolution and Farm Income Inequality:

In support of the thesis that green revolution has (not) aggravated the income disparities among producers, some extended exercises have been made to study and compare the size distribution of farm income at two points of time: (i) pregreen revolution period and (ii) postgreen revolution period with a view to providing evidences to the role of new technology in accentuating or narrowing the income inequality between the two distributions. Studies made by Katar Singh (1973), Bardhan (1974), Junankar (1975), Saini (1976), and Raju (1976), may be mentioned as being important in this field of inquiry. While Bardhan, Junankar, and Saini have made use of farm-level farm management survey data for selected districts in Punjab and/or Uttar Pradesh, Maharasthra, West Bengal, Katar Singh and Raju have taken farm-level data from the Bench Mark and Assessment Survey of IADP districts of Aligarh (Uttar Pradesh) and West Godavari (Andhra Pradesh) respectively.

Among various measures available to quantify the difference in inequality between the two distributions, the most commonly used in these studies have been, either singly or severally, concentration ratio, standard deviation of the logarithms of incomes and coefficient of variation.[17]

The dispersion in data sources, sampling-design,[18] areas studied and time-reference, together with the conflicting findings emerging from these studies fails to provide a solid basis for drawing any firm conclusion with regard to the impact of new technology in accentuating or redressing the farm income inequality. For instance Bardhan's analysis of 4 districts: Ferozpur, Muzaffarnagar, Ahmadnagar and Hooghly revealed, one case each of clear increase and clear decrease in concentration ratio, with two ambiguous cases of changes in the Lorenz curve. Junankar's study of Ferozpur district revealed that there was a slight decrease in inequality of farm business income between 1968-69 and 1969-70. Saini found that in Uttar Pradesh there was some increase, though small -- in the inequality of farm income distribution, whereas the magnitude of growing inequalities was markedly high in Punjab. In contrast, Katar Singh's study concluded that the farm income inequality declined in Aligarh in the period 1963-64 to 1968-69. Likewise was the case with West Godavari district between 1967-68 and 1970-71 as revealed in Raju's analysis.

Moreover, the method adopted in the studies cited above has been to analyze data relating to "farms" rather than to "families" at two points of time (with the exception of Junankar's study). In situations where the two terms may not refer to identical entities, the analysis in terms of "families" is likely to provide findings which are both more relevant and more readily interpretable.[19] Besides these studies about the income

distribution effects of new technology among farm households are of limited value as they are based on analysis of farm business income data, which is not a comprehensive indicator of the income status of the farm households. In addition to farm business income, it is meaningful and important to take into account, as rightly noted by Junankar (1975), wages earned outside the family farm.

Section 2

Green Revolution and Landless Laborers:

The nature of income distribution effects of green revolution on (landless) laborers, through changes in their levels of employment, is essentially interlinked with the direction of labor-using (saving) bias in new technology. In order to examine the directional bias of new technology with respect to labor employment, it is essential that the employment effects of new seed-water-fertilizer-innovation be separated from those of the mechanical innovations.[20] This is obviously important not only for understanding what has been happening but also for future policy purposes, for, use of the growth-promoting innovations even though accompanied by some of the labor-saving technical changes may still be a basically distinct and independently viable process.[21] In point of fact much of the controversy and debate that surrounds the employment effects of green revolution arises from the failure to separate out the employment effects of green revolution from those of mechanical innovations.

Sidhu (1974a) by making use of farm-level cross section data of old and new varieties of wheat for the year 1967-68 from Ferozpur district of Punjab (150 farms spread over 15 villages) indicated a 25 percent shift in the labor demand function on farms growing HYVs of wheat.

Robert Herdt (1980) assembled labor use data on farms growing MVs and TVs of rice from a number of empirical studies undertaken in Asia (a majority of them referring to India) and noted that the labor use in the cultivation of MVs as compared to TVs was "considerably higher".

Chinnappa's (1977) study relating to MVs of rice in North Arcot reported that the increase in demand for hired labor from cultivation of

HYV paddy as compared to TV paddy was 22 percent and for nonfamily labor (attached + hired) was 28 percent. In absolute terms every acre that went over to HYVs from TVs of paddy generated an additional demand for 17.1 person days of all types of labor.

Short of quoting a large number of individual investigations that looked into employment effects of new technology we prefer at best to borrow the findings from Bartsch's systematic and careful study (1977), based on extensive literature on alternative technologies and techniques in Indian and other Asian countries' production systems of wheat and rice. Bartsch showed that the switchover from traditional to HYV technology resulted in higher labor input, (i) per unit of cropped area over a cropped season (essentially due to increased levels of inputs used and yield effects), (ii) per unit of cultivated area over a year (due to greater utilization of labor per unit of cropped area and/or higher cropping intensity), provided either the traditional techniques were retained or the shift in cultivation techniques was limited to intermediate techniques only. (Traditional techniques were defined as those that depended mainly on unassisted human or human and animal power, along with simple traditional implements, for most of the field operations. Intermediate techniques meant substituting improved implements and equipment for the traditional ones but retaining the same power sources).

It is clear, therefore, that the impact of new technology as such, on labor employment is not in the direction of labor-saving, but labor-using.

Apart from the prospects of increase in the volume of employment, due to green revolution, it is significant to note the changes, if any, in the composition of farm labor (in terms of unpaid family labor and hired labor).

Empirical investigations by Chawla et al. (1972), Garg et al. (1972), Singh et al. (1972), Rathore and Subramanyam (1972) and Chinnappa (1977), indicate, in the context of new technology, a greater increase in the use of hired labor than in the use of family labor.[22] The dominant reason for this trend is the requirement to complete agricultural operations in the context of new technology within a short period of time. This feature of increased employment of hired labor than of family labor is meaningful for "a swelling strength of landless laborers, in the sense of providing them with additional employment than otherwise would have been the case without green revolution".

Additional support to the finding that the effect of green revolution on labor employment (and hence their income status) has been favorable may be sought, through looking into the trend in real wages of agricultural laborers in the country in the pre and postgreen revolution period.[23]

There are mainly two sources of data: (i) Agricultural Wages in India (AWI), annually published by the Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, and (ii) National Sample Survey (NSS) data from Rural Labor Enquiries in 1950-51, 1956-57, 1963-64 and 1970-71, which have been utilized by researchers to study the trend in real wages of agricultural laborers. Differences in the concepts, coverage and methods of collection of agricultural wage data in these two sources together with differences in the time period chosen for studying the trends have led the researchers to come out with conflicting results. For important studies in this field of inquiry see Bardhan (1970, 1973), Gough (1971), Krishnaji (1971), Herdt and Baker (1972), Jose (1974) and Deepak Lal (1976). Deepak Lal's study is particularly relevant and useful for our purpose, for it reviews the

studies of other researchers, draws attention to their various limitations and chooses "relatively more reliable" NSS data source for its own analysis. According to Deepak Lal's study, real agricultural wages rose in India during the period 1956-57 to 1970-71. However, in the first part of this period, i.e. 1956-57 to 1964-65, real wages were constant or fell in 8 out of the 15 states of India; but in the following period: 1964-65 to 1970-71 (which can be termed as "green revolution" period) they rose sufficiently to offset the earlier decline. He concluded that the demand inducing effects of agricultural growth did have a positive effect on real wage rates.

The direct effect of output-increasing green revolution as such on agricultural employment (per unit of area) and hence wage rates has to be nothing but favorable has been made an emotional issue in literature by mixing it up with other questions like (i) whether or not the increased demand for agricultural labor has kept pace with the increase in supply of labor, (ii) whether or not the rise in real agricultural wages has been adequate to meet the increased cost of living of agricultural laborers, and to assure a fair share of the output growth in favor of the agricultural laborers, etc. While these related questions are extremely important from the point of view of appropriate policy measures, nevertheless, they seem to have clouded the vision in so far as the assessment of the direct effects of green revolution on employment and wages of agricultural laborers is concerned.

Section 3

Factor Shares and Green Revolution:

While discussing the changes that have occurred in the factor shares, with a switch over from TVs to MVs, critics often do not make it clear in literature whether they are using factor shares either with respect to "value of output" or with respect to "value added in output". It is important to retain this conceptual distinction while interpreting the changes in factor shares due to MVs, for the factor shares do vary in magnitude, if not in direction, depending on the concept of output used.

On the basis of data collected by various AER centers, PEO and individual researchers, Mellor (1976) demonstrated effectively that the incremental share of hired labor, in an increased gross production with switch to HYV was, in the majority of the cases (12 out of 17 cases), between 5 and 15 percent only. In other words the bulk of the share in the increased production due to MVs went to other inputs: principally land and capital. As a result the "absolute disparities" in income between laborers on the one hand and owners of land and capital on the other got considerably widened.

Supporting evidence to Mellor's findings may be seen in C. H. H. Rao's (1975) analysis of farm management survey data for Ferozpur as between the local variety and the HYVs of wheat and rice respectively for the period 1968-70. He observed the tendency for the labor's share in total output to decline with the switch to HYVs from local varieties. Although the absolute labor cost (including family labor at market rates) per acre was considerably higher for HYVs of wheat and paddy than for the corresponding local varieties, the increase in both gross and net output (net output

defined as factor income after deducting the material costs) with the switch over to HYV from local variety was much larger, resulting in a reduction in the relative share of labor. He showed further that, with the switch to HYV from local variety, there was a steep decline in the relative share of land also, but the "combined share" of rent, interest and profit income rose significantly. As a result land-owner farmers operating with hired labor gained absolutely as well as relatively, whereas landless laborers gained somewhat absolutely, but lost in relative terms.

The evidence for the relative share of hired labor in total output to decline with the switch to MVs from LVs may also be found in the study of Parthasarathy and Prasad (1971). Their study of cost pattern of hired labor in the cultivation of local and IR-8 paddy in the East and West Godavari districts of Andhra Pradesh for the year 1968-69, revealed that the absolute share of hired labor per acre was higher for HYV paddy compared to local paddy, but it's relative share in net or gross value of output of HYV was smaller owing to the greater yield per acre.

Analysis by Chinnappa and Silva (1977, p. 210), relating TVs and MVs of paddy in North Arcot district, showed that the total wages paid per unit of land for HYVs was about 33 percent higher than for TVs; this was mainly due to the increase in employment of hired labor for HYV harvesting and threshing. However, the 33 percent increase earned from HYV cultivation by agricultural laborers compared poorly with the increase of nearly 76 percent in net income earned by cultivators. In absolute terms, the difference in increased earnings was more striking. An average cultivator household having 1.5 hectare of land, and growing paddy on about 1 hectare of it could increase its net income from paddy by Rs. 928 -- if it switched

from TVs to HYVs. The average landless agricultural labor household, in the survey area, had an income of Rs. 836 and the increase in its income because of HYV cultivation would be Rs. 276: that is just 30 percent of the increase earned by the average cultivator household.

It can hardly be disputed that the empirical evidences conclusively show that the switch over from local to MVs widens the absolute income gap between owners of land and capital on the one hand and the landless laborers on the other. But it is important to appreciate that this has been essentially the result of an interaction between "augmentation effects" of new technology (that enables the efficient use of all factors of production including labor, thereby, bringing about a reduction in every input requirement per unit of output) and the nature of supply-elasticities of these factors of production.

Despite this observed tendency of absolute income gap widening between owners of land and capital on the one side and landless laborers on the other, with a switch to MVs from TVs, the crucial point that is often overlooked and which needs to be stressed is that MVs through prospects of an increased demand for labor per unit of area makes an improvement in the absolute income status of landless laborers a plausible proposition. It is quite reasonable to presume that in the absence of MVs and given the high elasticity of the supply of labor (due to population pressure and/or in-migration into green revolution areas) the income of landless laborers would have degenerated further. The question of how best to narrow the gap in the absolute income levels between land-and-capital-owners and landless laborers falls into the realm of fiscal measures, rural works, wage regulations, etc., by the government.

Section 4

Green Revolution and Regional Disparities:

Of various dimensions relating to the income distribution effects of green revolution, perhaps the least controversial is one of its impact on income differentials among regions. It is widely held view that differentials in physical and institutional infrastructure development among the regions reinforced by the product-resource-and location-specificity characteristics of MVs have benefited some regions more than the other in terms of increased productivity. Analyses carried out, on the basis of secondary data, by C. H. H. Rao (1975), Staub and Blase (1974), Krishnaji (1975) and Bhalla and Alagh (1979), lend support to these contentions.

C. H. H. Rao observed that the inter-state disparity in productivity per hectare of major food crops: rice, wheat, bajra and maize, experiencing technological change increased between 1964-65 and 1970-71 (although the variability in output of major crops did not increase due to the compensatory changes in area allocated to these crops). Likewise, inter-state variation in the per-capita output of foodgrains as a whole increased because crops like wheat and bajra, which experienced a breakthrough in output showed higher variability than other crops. These trends, according to Rao, were associated with increasing inter-state disparities in the supply of institutional credit per hectare and the percentage of net sown area irrigated.

Staub and Blase noted that 76 percent of the increase in wheat production in India which increased by 63 percent between 1965 and 1970 was restricted to two states only: Punjab and Uttar Pradesh. They pointed out further that the two states Punjab and Uttar Pradesh, and Tamil Nadu which experienced the most rapid rate of adoption of HYV wheat and rice respectively, and sustained the largest increases in farm production also had the largest portion of farmlands irrigated of the states reported.

Krishnaji's study revealed that the overall inequality -- as reflected in the coefficient of variation in inter-state differences in per capita production of foodgrains -- hardly changed between 1950-53 and 1960-63, but sharply increased between 1960-63 and 1970-73. This was entirely due to the rise in per capita production in wheat areas. The regional averages of per capita production for the nonwheat areas hardly changed during the sixties, remaining around 170 kg. per annum. By contrast, the per capita production in the wheat region increased from 216 kg. in 1960-63 to 329 kg. in 1970-73. Krishnaji noted that this was a highly aggregative, nevertheless suggestive picture of the regional variations which emerged on the scene, owing to the green revolution.

A study by Bhalla and Alagh, based on triennium average district-wise figures of area, and output for 19 major crops during 1962-65 and 1970-73 revealed that rapid agricultural growth was confined to 17 percent of the districts in India. Of the 282 districts, only 68 accounting for just 18.9 percent of area recorded a growth rate exceeding 4.5 percent, 102 districts had a growth rate between 1.5 and 4.5 percent, and 62 a rate between 0 and 1.5 percent. In addition there were as many as 70 districts accounting for 26.78 percent area that recorded negative growth rates. What is more significant is that high growth rates were significantly associated with high use of modern inputs.

Although there is no one to one correspondence between the growth in MVs area on the one hand and growth in the use of modern inputs on the other, it may be reasonable to presume a high correlation between them. If so we may infer that the relative performance of districts in agricultural growth was, among others, a function of growth in area and yield of MVs, i.e. green revolution.

Broadly speaking, it may be seen from Table 2 (although the crop references and years in columns 2 to 6 are not strictly comparable) that states which recorded comparatively large increases in foodgrain production, between 1967-70 and 1976-79, were the ones which in general had comparatively large proportions of their foodgrain area irrigated as well as sown with MVs. Also these states fared better in respect of fertilizer use and availability of credit. This aggregate picture at the state-level is indicative of the regional disparities that have emerged due to an interaction between growth in physical and institutional infrastructure on the one hand and growth in MVs on the other.

The study by Easter, Abel and Norton (1977) gives strong support to the impact of physical and institutional infrastructure on the adoption of MVs and new inputs, and thereby stresses its' importance for growth in agricultural output. Using production functions to measure the contribution to agricultural output of infrastructure and the quantity and quality of inputs, the study showed that in the wheat region (comprising 73 districts in the states of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh and Rajasthan), continued increases in the quantity and quality of irrigation, the introduction of new varieties were promising sources of output growth. For the eastern rice region (comprising 69 districts in Eastern Uttar Pradesh, Bihar, West Bengal, Orissa and Eastern Andhra Pradesh), increases in irrigation quality and new varieties were important sources of output growth.

Table 2. Production of Foodgrains, Area Under MVs, Irrigated Area, Fertilizer Use and Institutional Credit by State.

State	Percentage Increase in Foodgrain Production Between 1967-70 and 1976-79	Percentage of Foodgrain Area Sown with MVs 1975-76	Percentage of Foodgrain Area Irrigated 1975-76	Fertilizer Use Per Unit of Gross Cropped Area Kgs/ha 1977-78	Institutional Credit Rupees/ha 1977-78
1	2	3	4	5	6
Andhra Pradesh	25.3	30.2	40.4	40.3	162
Assam	15.2	16.5	32.6	1.8	6
Bihar	15.4	23.3	30.5	15.4	47
Gujarat	39.1	40.3	16.4	28.5	178
Haryana	46.5	36.2	47.2	34.7	234
Karnataka	25.4	21.9	16.5	24.1	164
Kerala	1.0	27.9	29.6	26.3	343
Madhya Pradesh	12.9	13.1	9.3	7.5	52
Maharasthra	44.4	19.9	9.9	18.3	175
Orissa	3.9	8.9	19.5	8.3	75
Punjab	67.7	66.8	78.6	72.4	273
Rajasthan	46.2	9.7	17.2	6.6	60
Tamil Nadu	68.9	41.2	54.3	59.0	341
Uttar Pradesh	26.4	33.3	38.8	36.9	124
West Bengal	18.9	23.6	25.5	21.6	110

SOURCES: Col. 2: Based on data from Estimates of Area and Production of Principal Crops in India, 1978-79, Ministry of Agriculture, Government of India (1980), Appendix A.

Cols. 3 to 5: Skakuntala Mehra (1981) Instability in Indian Agriculture in the Context of the New Technology, International Food Policy and Research Institute, Table 13, p. 29.

Col. 6: J. S. Sarma (1981), Growth and Equity: Policies and Implementation in Indian Agriculture, International Food Policy and Research Institute, Table 6, p. 31.

Conclusion

A review of empirical evidences on the adoption pattern of MVs in India suggests a wide diffusion of MVs among farmers, over time, irrespective of farm size and tenurial status. This unmistakably refutes the hypothesis that green revolution in the country has been predominantly a large farmer phenomenon and that the gains from it have gone disproportionately or solely to large farmers. But the pace of diffusion of MVs of a given crop among farmers, across the regions and over the years, has certainly revealed a tendency to be closely interlinked with the nature and level of their (regions) development in physical and institutional infrastructure. For instance we may recall the poor coverage of MVs in a few of the primarily wheat growing areas of Haryana in marked contrast to universal diffusion of MVs of wheat in Punjab. In areas where the relative access to product and factor markets has been unequal among the farmers, due to various economic, social and political factors (as was the case, for instance, with the village in Andhra Pradesh studied by Parthasarathy and Prasad), the gains from new technology have been disproportionately shared by the large farmers. But it is important to recognize that the regressive impact on income distribution in such areas, which is indeed real and serious, is not caused/accentuated by the new technology as such, but by the nonneutrality of their economic, social and political institutions. This "diagnostic perception" is crucial to judge the income distribution effects of new technology in its proper perspective and also to suggest appropriate policy measures to remedy the situation.

Being technically scale-neutral, the relevance and importance of new technology in improving the income-status of the small farmer need

not be over emphasized. "... the HYV technology has helped to lower the threshold of viability of small farms. On certain conditions being fulfilled, a two-acre farm has now hope of becoming viable with the new technology. This is not a small gain for a country whose agriculture will continue to be dominated, at least in a forseeable future, by the small farm economy".[24] It should be noted that new technology with its characteristics of high yield potential and scale-neutrality has offered a possibility to break the vicious circle in which small farmers are caught both with regard to "deficiency of investment" and "riskiness of investment". "... The (small farm) sector is considered unproductive and therefore, sufficient investment is not made in it. But it remains unproductive because sufficient investment is not made in it in spite of the fact that substantial productivity and profitability potentials exist and remain unexploited.... Riskiness of small farm investments is mainly due to yield instability. Yield instability in turn is mainly due to inadequate inputs of HY seeds, irrigation, water control, pest control and fertilizers and the absence of multiple cropping. Optimal investments in those inputs can stabilize yields. Again, therefore, we observe investment remaining inadequate because of its riskiness and riskiness remaining high because of inadequate investment. Only a big investment thrust with a matching technological, extension and delivery back up, can break the vicious circle".[25]

With regard to the "pure effect" of new technology (devoid of mechanical innovations) on labor employment and (hence on wage rates) empirical evidences in India do reveal a positive influence, although there may be differences about the quantum of additional employment generated, and the adequacy or otherwise of the increase in wage rates

to keep pace with the increase in cost of living, etc. Through prospects of an increased demand for labor, new technology has undoubtedly exerted a favorable impact on the absolute income status of the landless laborer, notwithstanding the fact that the owners of land and capital have relatively gained more than the laborers in the increased production due to MVs. (The latter result with MVs, which emerges essentially due to an interaction between "augmentation effects" of new technology -- requiring less of every input per unit of output -- and peculiar supply elasticities of factors of production: land, labor and capital, is often misconstrued to mean that there is labor-saving bias in new technology).

As regards the impact of new technology on regional income differences, empirical exercises by researchers have shown a widening effect. This result has been due to an interplay between, (i) differentials in levels of physical and infrastructural development of regions and (ii) product-location-specificity characteristics of new technology. However, in the long run, if MVs are broad based, if the differentials in development of physical and institutional infrastructure among the regions are narrowed and if the gains from new technology in the favored regions are shared by other regions (through appropriate government action), it is possible to visualize an altogether different scenario! Herein lies both an opportunity and a challenge.

Footnotes

[1]T. W. Schultz (1978), p. 6.

[2]See, among others, Wolf Ladejinsky (1969), Walter P. Falcon (1970), Francine R. Frankel (1971), Keith Griffin (1974), B. Sen (1974).

[3]Another dimension that is important but has gone untouched in this review is the distribution of gains of green revolution between producers and consumers, (i) partly because few Indian empirical studies exist and (ii) partly because the treatment of this aspect involves, among others, analysis of government policies on agricultural prices, procurement, distribution, etc., requiring a great deal of time and effort.

[4]Crop-wise the picture was as follows:

Crop	Percentage of Area Sown With HYVs in Total Area of the Crop
Rice	38.8
Wheat	72.1
Jowar	18.4
Bajra	23.6
Maize	20.5

SOURCE: Adapted from Shakuntala Mehra, Instability in Indian Agriculture in the Context of the New Technology. International Food Policy Research Institute, July 1981. Appendix 2, Table 19, p. 40.

In this context, skepticism of Farmer about the accuracy of Indian official statistics may, however, be noted: "Most seriously, Nanjamma Chinnappa's meticulous work on the North Arcot Survey ... indicates beyond any reasonable doubt that the official statistics for the adoption of HYVs in North Arcot district are grossly inflated, those for the areas under HYVs by a factor of at least 3". B. H. Farmer (ed.) Green Revolution? Westview Press, Denver, Colorado, 1977, p. 414.

[5]The terms "green revolution", "new seed-water-fertilizer-technology", "new technology" are used in the text interchangeably. Likewise is the case with modern varieties (MVs) and high yielding varieties (HYVs).

[6]For an interesting account of geographical bias, etc., in Indian empirical evidences see John Harris, in B. H. Farmer (ed.), op cit., ch. 4.

[7]See B. Dasgupta (1977), pp. 184-186.

[8]For a detailed discussion, see B. Dasgupta (1977), ch. 3.

[9]There are indeed definitional problems in identifying the farmers as being "large" or "small" and also problems in comparing them across the regions. However, these problems can be overlooked if we take the broad view for our purpose that by "small" we mean those who are on the lower side of the land ladder and by "large" we mean those who are on the upper side of the land ladder in a given region.

[10]Farmers in each village were ranked by size of operational holding and the list was divided into ten equal groups. The corresponding decile groups for all villages surveyed for the relevant crop in a state were aggregated.

[11]It is curious to note that many researchers who cite Lockwood et al. study in support of the hypothesis that green revolution has been mainly a large farmer phenomenon conveniently ignore these major qualifications.

[12]See B. Dasgupta (1977, p. 227).

[13]For the exposition of this point, see S. S. Bhalla (1979; note 24, p. 239).

[14]The following discussion on this issue has benefited from R. A. Berry and W. R. Cline (1979), ch. 4, pp. 106-116.

[15]Also study by Chattopadhyay and Rudra revealed that in selected districts in 7 out of 10 Indian states (data ranging from 1962 to 1973) output (of all crops) per acre was negatively associated with farm size. For two of three others (Punjab and West Bengal), the relationship was significantly negative in the mid-50's, went positive as HYVs began to spread and again went negative in the third of the (successive) recent years for which data were available.

SOURCE: Adapted from Michel Lipton (1978), "Inter-Farm, Inter-Regional and Farm-Nonfarm Income Distribution: The Impact of the New Cereal Varieties". World Development, Vol. 6, No. 3, p. 324.

[16]Vyas makes this point succinctly as follows: "... Depending upon the institutional factors and the irrigation base of each state, the new technology has spread in varying degree and content in many parts of the country. Thanks to a wide network of canals and a rapid multiplication of tubewells in recent years, very largely facilitated by the successful completion of consolidation of holdings, flow of more institutional finance and the government drive for rural electrification, the Punjab state adopted the new farm technology far more quickly and comprehensively than most other states of India.... The institutional handicaps are found to be relatively low in Punjab.... In other areas, especially small farms are highly restrained by these institutional handicaps to perform, unlike large farms...". V. S. Vyas in Foreward to G. K. Chadha (1979), Production Gains of New Agricultural Technology, Publication Bureau, Punjab University, Chandigarh.

[17]For a persuasive argument about the limitations of these measures, as regards their informativeness and ability in monitoring changes in land and income distribution, see M. L. Dantwala and V. M. Rao, "Inequality of Farm Income: A Comment". Economic and Political Weekly, May 18, 1974, pp. 801-803.

[18]"Some attempts have recently been made to present empirical evidence of the growing inequalities in farm incomes among different strata of farm households at two points of time.... However, insufficient appreciation of the difference in the sampling design of farm management surveys at the two points of time has rendered at least some of these analyses and results of doubtful validity...". G. R. Saini "Green Revolution and Disparities in Farm Incomes -- A Comment," Economic and Political Weekly, Nov. 3, 1976, pp. 1804-6.

[19]See Dantwala and Rao, op cit., p. 803.

[20]The need for maintaining this vital distinction is discussed in Hayami and Ruttan (1970).

[21]K. Bardhan (1977, p. 1063).

[22]On the basis of this finding, it is possible to argue that MVs will have a discriminating effect on small farmers (as compared to large farmers) because the cultivation of MVs by small farmers enhances their dependence on hired labor, causing significant additions to operating costs, which small farmers may not be able to foot in out of their own resources. This argument, adds an urgency to the mounting up of institutional finance for small farmers. It is important to note that higher net returns from HYVs even on small farms offset the additional costs that could be incurred by

them. In this context, the empirical finding by Chinnappa and Silva is worth recalling: "The increase in net income per unit of land from cultivation of HYVs was of the order of 76 percent.... Such increases in net incomes, even when the yield rates of HYVs were far below potential, when the recommended package of inputs was not being applied in full and when the market prices were lower than those for TVs suggests that substantial increases in incomes of cultivators are possible from the cultivation of HYVs. The scale-neutrality of HYVs will ensure similar increases in net incomes of all cultivators, big and small...". Chinnappa N. and W. P. T. Silva (1977, p. 207).

[23]However, to the extent the income status of a landless laborer depends not only on his wage rates, but also on the quantum of employment in a given year, and also to the extent increases in prices of wage goods consumed by the laborer are not accompanied by compensating increases in his wage rates (or are accompanied with a lag), enough caution needs to be exercised in interpreting the interrelationship between trends in wage rates and income status of landless laborers.

[24]M. L. Dantwala (1978), p. 1300

[25]Raj Krishna (1979), p.

References

1. Bardhan Kalpana (1977), "Rural Employment, Wages and Labor Markets in India: A Survey of Research - II," Economic and Political Weekly, July 2, 1062-1117.

2. Bardhan Pranab K. (1970), "'Green Revolution' and Agricultural Laborers," Economic and Political Weekly, Special No., July, 1239-1246.

   _____ (1973), "Variations in Agricultural Wages: A Note," Economic and Political Weekly, May 26, 947-950.

   _____ (1974), "Inequality of Farm Incomes: A Study of Four Districts," Economic and Political Weekly, Annual No., February, 301-307.

3. Bartsch, W. H. (1977), Employment and Technology Choice in Asian Agriculture, Praeger Publishers, New York-London.

4. Berry, R. A. and W. R. Cline (1979), Agrarian Structure and Productivity in Developing Countries, The Johns Hopkins University Press, Baltimore and London.

5. Bhalla, G. S. and Y. K. Alagh (1979), Performance of Indian Agriculture: A District-Wise Study, Sterling Publishers, New Delhi.

6. Bhalla, S. S. (1979), "Farm Size, Productivity and Technical Change in Indian Agriculture," Appendix A in R. A. Berry and W. R. Cline Agrarian Structure and Productivity in Developing Countries, The Johns Hopkins University Press, Baltimore and London.

7. Binswanger, H. P. and M. Rosenzweig (eds.), (1981), Contactual Arrangements, Employment and Wages in Rural Labor-Markets in Asia, (mimeographed).

8. Chawla, J. S., S. S. Gill and R. P. Singh (1972), "Green Revolution, Mechanization, and Rural Employment: A Case Study in District Amritsar," Indian Journal of Agricultural Economics, Vol. XXVII, No. 4, Oct.-Dec., 198-206.

9. Chinnappa Nanjamma (1977) in B. H. Farmer (ed.), Green Revolution?, Westview Press, Boulder, Colorado, ch. 8.

10. Chinnappa Nanjamma and W. P. T. Silva (1977) in B. H. Farmer (ed.), Greenview Revolution?, Westview Press, Boulder, Colorado, ch. 14.

11. Chowdhury, B. K. (1970), "Disparity in Income in Context of HYV," Economic and Political Weekly, Review of Agriculture, September, A90-A96.

12. Dantwala, M. L. (1978), "Future of Institutional Reform and Technological Change in Indian Agricultural Development," Economic and Political Weekly, Special No., August, 1299-1306.

13. Dasgupta Biplab (1977), Agrarian Change and the New Technology in India, Geneva.

14. Desai, G. M. (1978), Cultivators' Experience of High Yielding Varieties of Cotton: A Micro-Study in Gujarat, IIM, Ahmedabad (Monograph No. 77).

15. Easter, K. William, Martin E. Abel and George Norton (1977), "Regional Differences in Agricultural Productivity in Selected Areas of India," American Journal of Agricultural Economics, May, 257-265.

16. Falcon, Walter P. (1970), "The Green Revolution: Generations of Problems," American Journal of Agricultural Economics 52, December, 698-710.

17. Frankel, Francine R. (1971), India's Green Revolution: Economic Gains and Political Costs, Princeton University Press, Princeton, New Jersey.

18. Garg, J. S., Om Prakash and H. L. Srivastava (1972), "Impact of Modern Technology on Rural Unemployment," Indian Journal of Agricultural Economics, Vol. XXVII, No. 4, Oct-Dec., 206-210.

19. Gough, James W. (1971), "Agricultural Wages in Punjab and Haryana," Economic and Political Weekly, Review of Agriculture, March, A19-A20.

20. Griffin, Keith (1974). The Political Economy of Agrarian Change: An Essay on the Green Revolution, Harvard University Press, Cambridge, Massachusetts.

21. Hayami, Yujiro and V. W. Ruttan (1970), "Factor Prices and Technical Change in Agricultural Development: The U.S. and Japan, 1800-1900," Journal of Political Economy.

22. Herdt, Robert W. (1980), "Changing Asian Rice Technology: Impact, Distribution of Benefits and Constraints," (mimeographed).

23. Herdt, Robert W. and E. A. Baker (1972), "Agricultural Wages, Production and the High Yielding Varieties," Economic and Political Weekly, Review of Agriculture, March, A23-A30.

24. Jose, A. V. (1974), "Trends in Real Wage Rates of Agricultural Laborers," Economic and Political Weekly, Review of Agriculture, March 30, A25-A30.

25. Junankar, P. N. (1975), "Green Revolution and Inequality," Economic and Political Weekly, Review of Agriculture, March, A15-A18.

26. Krishna, Raj (1979), "Small Farmer Development," Economic and Political Weekly, May 26, 913-918.

27. Krishnaji, N. (1971), "Wages of Agricultural Labor," Economic and Political Weekly, Review of Agriculture, Sept., 25, A148-A151.

_____ (1975), "Inter-Regional Disparities in Per Capita Production and Productivity of Foodgrains: A Preliminary Note on Trends," Economic and Political Weekly, Special Number, August, 1377-1385.

28. Ladejinsky, Wolf (1969), "The Green Revolution in Punjab -- A Field Trip", Economic and Political Weekly, Review of Agriculture, June 28, A73-A82.

_____ (1969), "The Green Revolution in Bihar: The Kosi Area -- A Field Trip," Economic and Political Weekly, Review of Agriculture, September 27, A147-A162.

29. Lal Deepak (1976), "Agricultural Growth, Real Wages, and the Rural Poor in India," Economic and Political Weekly, Review of Agriculture, June, A47-A60.

30. Lockwood, Brian, P. E. Mukherjee and R. T. Shand (1971), The High Yielding Varieties Program in India - Part I, The Planning Commission of the Government of India and the Australian National University, Canberra.

31. Mandal, G. C. and M. G. Ghosh (1976), Economics of the Green Revolution: A Study in East India, New York: Asia Publishing House.

32. Mellor, John W. (1976), The New Economics of Growth, Cornell University Press, Ithaca and London, ch. 4.

33. Mencher, Joan P. (1974), "Conflicts and Contradictions in the Green Revolution: The Case of Tamil Nadu," Economic and Political Weekly, Nos. 6, 7 and 8, pp. 309-322.

34. Mishra, V. N. and D. S. Tyagi (1972), "An Economic Analysis of the High Yielding Varieties of Wheat: A Study of Kota District," Arthavikas, January, 118-130.

35. Mukherjee, P. K. (1970), "The HYV Program: Variables that Matter", Economic and Political Weekly, March 28, A15-A22.

_____ (1970a), "The HYV Program: Variables that Matter -- A Reply", Economic and Political Weekly, Dec. 5, p. 1980.

36. Muthaiah, C. (1971), "The Green Revolution: Participation by Small Versus Large Farmers," Indian Journal of Agricultural Economics, Jan-March, 53-66.

37. National Council of Applied Economic Research (1978), Fertilizer Demand Study: Interim Report, Vols. 2-6, New Delhi.

38. Parthasarathy, G. and D. H. Babu (1970), "HYV Program: Variables that Matter -- A Comment," Economic and Political Weekly, June 10, p. 986.

39. Parthasarathy, G. and D. S. Prasad (1971), "Season-Wise Progress of High Yielding Varieties in Andhra-Pradesh: Role of Economic Variables," Economic and Political Weekly, Review of Agriculture, Sept. A117-A122.

_____ (1978), "Response to the Impact of New Rice Technology by Farm Size and Tenure - Andhra Pradesh, India," in Interpretative Analysis of Selected Papers from Changes in Rice Farming in Selected Areas of Asia, IRRI.

40. Program Evaluation Organization, Planning Commission, Government of India and The Australian National University (1976), The High Yielding Varieties Program in India: 1970-75, Part II.

41. Raju, V. T. (1976), "Impact of New Agricultural Technology on Farm Income Distribution in West Godavari District, India," American Journal of Agricultural Economics 58:2, 346-350.

42. Rao, C. H. H. (1975), Technological Change and Distribution of Gains in Indian Agriculture, Macmillan Co. of India, New Delhi.

43. Rathore and Subramanyam (1972), "Farm Employment and the Green Revolution in Rajasthan," Indian Journal of Agricultural Economics, XXVII, No. 4, p. 233.

44. Saini, G. R. (1976), "Green Revolution and the Distribution of Farm Incomes," Economic and Political Weekly, Review of Agriculture, March, A17-A22.

45. Schluter, M. and J. W. Mellor (1972), "New Seed Varieties and the Small Farm," Economic and Political Weekly. March, A31-A38.

46. Schultz, T. W. (1978), "On Economics and Politics of Agriculture," in T. W. Schultz (ed.), Distortions of Agricultural Incentives, Indian University Press, Bloomington-London.

47. Sen Bandhudas (1976), The Green Revolution in India: A Perspective, New Delhi, Wiley Eastern.

48. Sidhu (1974), "Relative Efficiency in the Wheat Production in the Indian Punjab," The American Economic Review 64, September 742-51.

_____ (1974a), "Economics of Technical Change in Wheat Production in Indian Punjab", American Journal of Agricultural Economics 56, Vol. 2:217-226.

49. Singh Katar (1973), "The Impact of New Agricultural Technology on Farm Income Distribution in the Aligarh District of Uttar Pradesh," Indian Journal of Agricultural Economics 28, 2, 1-11.

50. Singh, R. I., R. Kanwar and Shri Ram (1972), "Impact of New Agricultural Technology and Mechanization," Indian Journal of Agricultural Economics, XXVII, No. 4, 210-214.

51. Staub, William J. and M. G. Blase (1974), "Induced Technological Change in Developing Agricultures: Implications for Income Distribution and Agricultural Development," The Journal of Developing Areas, July, 581-596.

52. Vyas, V. S. (1975), India's High Yielding Varieties Program in Wheat: 1966-67 to 1971-72, CIMMYT, Mexico.

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