Vol XXXV
No. 3

JULY-
SEPTEMBER
1980

ISSN 0019-5014

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

RESEARCH NOTES

THE LONG RUN IMPACT OF THE GREEN REVOLUTION ON THE DISTRIBUTION OF RURAL INCOMES IN INDIA*

I

The agricultural sector and its problems have always dominated the Indian economic scene. The nation's approach to agricultural development has been characterized by a commitment to the twin goals of maximum increase in agricultural production coupled with its equitable distribution.[1] For instance, the obvious economic advantages of concentrating scarce resources in irrigated areas, where they would be expected to bring the greatest increase in production, were recognized in the selection of first community projects in 1952. The community projects were initially allocated only to the districts with assured water from rainfall or irrigation facilities. Almost immediately, however, serious social objection was raised to the practice of picking out the best and the most favourable regions for intensive development. Within a year the principle of selective and intensive development was abandoned. The Planning Commission announced a programme for rapid all-India coverage under the National Extension Service and Community Development Programme with special attention to backward and less favoured regions.[2]

This conflict between maximization of output and equitable distribution of rural incomes both across various regions and different strata of rural population has become more acute since the mid-1960's advent of the so-called 'Green Revolution' in the Indian sub-continent. The term 'Green Revolution' has been used to describe the introduction of the high-yielding seed varieties (HYVs) coupled with the increases in the use of chemical fertilizers. Hybridization techniques for maize and millets were initiated in India as early as 1960. Hybrid seeds began to be widely adopted by 1963. In wheat a beginning of great importance was made in 1963-64 by trying out Mexican dwarf varieties on a selected basis. Improved paddy varieties such as Taichung Native-1 were introduced in 1965. The propagation of various high-yielding varieties seeds (the High-Yielding Varieties Programme or HYVP) was taken up as a full-fledged programme from May 1966 onwards. The HYVP has thus far covered five crops, namely, wheat, paddy

*An earlier version of this paper was presented at the 1978 Annual Meeting of the Southern Economic Association held in Washington, D. C. The author would like to thank Shri Kishor Saxena for his valuable assistance.

1. For example, the Third Five-Year Plan stated that "economic activity must be so organized that the tests of production and growth and those of equitable distribution are equally met." Third Five-Year Plan, Planning Commission, Government of India, New Delhi, 1961, p. 9. The Fourth and the Fifth Five-Year Plans have also reiterated this very sentiment.

2. Francine R. Frankel: India's Green Revolution: Economic Gains and Political Costs, Princeton University Press, Princeton, 1971, pp. 3-11.

(rice), bajra (bulrush or spiked millet), jowar (great millet), and maize (corn). The improvement in wheat yields has been the most impressive. In the case of some dwarf varieties of Mexican wheat, a yield of five to six tons has been recorded in farmers' fields as against a normal yield of two tons in irrigated areas. Similar improvements in yields have taken place for bajra, jowar, and maize.[3]

Despite these impressive improvements in yields, the debate on the potential impact of the Green Revolution on Indian agriculture continues unabated. Two types of questions have been raised in this context. The first relates to the overall impact of the green revolution on agricultural production in general and food production in particular. The optimists point to the yield improvements with the new seeds and maintain that substantial increase in agricultural production will materialise as the farmers adopt the high-yielding seeds and learn the appropriate input combinations and water management skills. The pessimists, on the other hand, emphasize the restriction of the new tehnology to irrigated land and question the possibility of the green revolution ever living up to its expectations.[4] They also allude to several second generation problems associated with the green revolution. For example, it is claimed that the use of high-yielding seeds along with great quantities of chemical fertilizers may affect soil productivity adversely so that ever increasing amounts of fertilizers will have to be applied to keep yields at a high level.

Another oft-mentioned, and perhaps the most important, second generation problem of the HYVP relates to the effects of the new technology on the distribution of incomes between large and small farms, between owner cultivators and tenants, and between the dry and the irrigated areas of the country. The informed views on the effect of the green revolution on the distribution of rural incomes range across a wide spectrum. At one end of the spectrum is the claim that the green revolution would undoubtedly increase the inequality in the distribution of rural incomes. The logic of this argument is that the adoption patterns of new technology would be different between small peasants and farmers with large holdings. It is argued that the new technology itself is scale neutral (*i.e.*, it is equally beneficial irrespective of the size of the holding), but the public institutions charged with its propagation are likely to favour the large farms.[5] In contrast to this, Sen has arrived at the conclusion that the early fears of the green revolution accentuating income differences have been largely unwarranted.[6] Noting

3. In the *kharif* of 1968, the average yields for hybrid bajra, jowar, and maize were 0.87, 1.06 and 2.05 tons per hectare. The corresponding yields with local varieties were 0.38, 0.54 and 1.01 tons per hectare. Report on the Evaluation of the High Yielding Varieties Programme, Kharif, 1968, Programme Evaluation Organisation, Planning Commission, Government of India, June 1969, p. 97.

4. Bandhudas Sen: The Green Revolution in India: A Perspective, John Wiley & Sons, New York, 1974.

5. A leading exponent of this view is Keith Griffin: The Political Economy of Agrarian Change, Macmillan Press Ltd., London, 1974, p. 69.

6. Sen: *op. cit.*

that the spread of the new technology limited to irrigated lands, Sen has examined the holding distribution of irrigated land in India. From the data in the various Rounds of the National Sample Surveys, he finds that the distribution of irrigated land is not too uneven. Hence his conclusion that the green revolution is not likely to increase the income inequality between the small and large farmers.

In view of these conflicting claims in the literature, it is tempting to appeal to empiricism to settle the issue. Unfortunately, the available evidence is often unreliable, contradictory, and suitable to make few generalizations. Therefore, it is necessary to resort to economic theory. At the theoretical level, the effect of the green revolution on income distribution can be investigated using either a static or a dynamic framework. In the former, the distribution of assets is held constant; in the latter, the pattern of ownership of assets is allowed to vary. In other words, the static model gives us short-term effects whereas the dynamic framework indicates the long run impact of the green revolution on income distribution. In a developing country such as India, land obviously is the most important asset. But land is not homogeneous. Its quality, which crucially depends upon the availability of irrigation water is, therefore, an important dimension to bear in mind.

A great deal of work in the area of seed-fertilizer revolution and its impact on the distribution of incomes has taken place in the confines of the static model. The distribution of land is assumed not to change with the spread of the new technology. Consequently, most analysts have looked at the differences in the adoption patterns of new technology, the differential effects of yield uncertainty with hybrid seeds on the use of complementary inputs such as fertilizers, and the inequities in the distribution of irrigated land between the small and the large farmers.[7]

Anyone who is interested in the long run effects of agricultural change on the distribution of rural incomes, however, can not be satisfied to work within the confines of a static model. In the long run, the green revolution will undoubtedly bring about substantial changes in the pattern of land ownership. The objective of this paper is to examine, in particular, the possible long range effect of the green revolution on the ownership of irrigated land. Clearly, irrigated land is not a constant over time but can be augmented by investment outlays. If for any reason, large farmers are in a position to increase their holdings of irrigated land, emergence of inequality in the distribution of rural income is an inevitable long run outcome. It can be argued that the large farmers will be in an advantageous position to increase their share of the irrigated land for two reasons: first, due to their higher savings potential; and second, due to the possibility of the average and marginal costs of irrigation declining with an increase in the size of the holding.

The latter of these propositions is investigated in section II of the paper

7. See in particular, Keith Griffin: *op. cit.*; Clive Bell, "The Acquisition of Agricultural Technology: Its Determinants and Effects", *Journal of Development Studies*, Vol. 9, No. 1, October 1972, pp. 123-160.

using cost data on 60 dug-wells from the Karjat taluka of Ahmednagar district in Maharashtra, India. The construction costs of wells are related to their capacity to provide irrigation water, the latter being measured in terms of the wells' surface areas of percolation. The estimated total, average and marginal cost equations are analysed to show that the total construction costs of wells increase at a declining rate as the size of the well rises. The implications of these results are considered in section III. This final section also includes a brief discussion of alternative policy measures that can be pursued to negate the adverse effects on the distribution of rural incomes.

II

To bring out the limitations of the static analyses of effects of the green revolution on income distribution, this section begins with a critical appraisal of Sen's empirical approach.[8] Noting that the spread of new technology is at present limited to irrigated land, Sen has examined the holding distribution of irrigated land using the 1959-60 and 1960-61 National Sample Surveys. His basic premise is that the inherited pattern of distribution of irrigated land is not biased against the small farmers. Hence his conclusion that the green revolution is unlikely to accentuate income differences between the small and large farmers. Some supplementary data on the adoption pattern of new technology and the use of fertilizers are presented by Sen to substantiate his contention that little differences in the spread of the green revolution by the size distribution of holdings exist. He has further argued that since the green revolution is not limited only to the large farms, tractorization and the subsequent displacement of labour is not an eminent danger.

The above argument argument by Sen can be challenged on several grounds. To study the distribution of irrigated land, he relies on aggregative data at the all-India level which could have a possible aggregation bias. Pooling irrigated areas with lower average farm size and unirrigated areas with higher average farm size and then studying the relationship between size and irrigation is likely to give a distorted picture.[9]

A second deficiency of Sen's analysis relates to his exclusive emphasis on the size distribution of irrigated land as if the latter were a homogeneous entity. Specifically, within the group of irrigated land holdings, intensity of irrigation can differ from farm to farm. Those farms that use irrigation water intensively can be

8. Sen: *op. cit.*

9. G. Parthasarathy has made this point in reviewing Sen's book, *Indian Journal of Agricultural Economics*, Vol. XXX, No. 1, January-March 1975, pp. 92-94. In this review, he refers to a regional study that presents data separately for *deltas* and *uplands* of West Godavari district in Andhra Pradesh. In the deltas where every farm, both big and small, is completely irrigated, the skewness in the distribution of land ownership is much greater. In contrast, in the uplands small farms account for a lower percentage of irrigated land than big farms but the irrigated land ownership pattern is much less skewed. Pooling, therefore, results in under-estimating the degree of inequality in the ownership of irrigated land.

expected to gain more from the green revolution. Since irrigation intensities depend upon the average and marginal costs of obtaining water, it is of interest to examine the differences in the costs of irrigation for farmers in various holding brackets. In the specific context of well irrigation, four sources of water are available to the farmers: State tubewells, private tubewells (electric), Persian wheel and *charsa*. For the district of Aligarh in Uttar Pradesh, the costs per one thousand cubic metres of water from different sources are estimated as follows:

State tubewells	Rs. 33	per	one	thousand	cubic	metres;	
Private tubewells (Electric)	Rs. 22	”	”	”	”	”	
Persian wheel and	Rs. 75	”	”	”	”	”	
Charsa	Rs. 120	”	”	”.	”	”	

Source: T. V. Moorti, "A Comparative Study of Well Irrigation in District Aligarh, India", Occasional Paper No. 29, Department of Agricultural Economics, Cornell University, Ithaca New York, 1971.

For the same district, it is estimated that the small and medium farmers depend upon State tubewells, Persian wheel and *charsa* sources of water to a much greater extent than do the larger farmers. This is brought out in Table I.

TABLE I—SOURCES OF WATER FOR THE FARMERS IN DISTRICT ALIGARH, UTTAR PRADESH

Area (hectares)	Farm type	Average farm size (hectares)	Number of farmers using different sources of water (percentages in parentheses)				
			State tube-wells	Private tube-wells	Persian wheel	*Charsa*	Total number of farms
0.72—3.0	Small	2.28	20 (32)	16 (25)	21 (33)	6 (10)	63
3.3—7.8	Medium	5.17	16 (26)	18 (29)	20 (32)	8 (13)	62
8.4—17.4	Large	11.53	0 (0)	16 (100)	0 (0)	0 (0)	16

Source: T. V. Moorti and John W. Mellor, "Cropping Patterns, Yields and Incomes under Different Sources of Irrigation (with special reference to IADP District Aligarh, U.P.)", *Indian Journal of Agricultural Economics*, Vol. XXVII, No. 4, October-December 1972, p. 118.

Thus, only 25 to 30 per cent of the small and medium sized farmers obtain irrigation water from privately owned electric tubewells. In contrast 100 per cent of large farmers own and operate such wells. These differences in the sources of irrigation for small, medium, and large farmers necessarily reflect themselves in the differences in the costs of obtaining water. Using Table I in conjunction with the costs per one thousand cubic metres of water from different sources, the weighted average costs per one thousand cubic metres for small, medium and large farms are estimated at Rs. 52, Rs. 55 and Rs. 22 respectively. Since large farms obtain water cheaper than the small and medium farms, the former can be expected to use greater quantity of irrigation water, thereby benefiting more from the spread of new technology.

A final and perhaps the most important shortcoming of Sen's thesis lies in the static nature of his analysis. He does not consider the possibility of the green revolution providing differential incentives to the large versus small farmers to invest in irrigation facilities. If we attribute scale neutrality property to the green revolution, the differences in the rates of return on irrigation investments can be determined from the differences in the costs of constructing and operating irrigation facilities. Are there any cost advantages for the large farmers? The remainder of the section investigates this question in the context of dug-well irrigation.

The costs of well irrigation can be grouped under three main heads: *viz.*, costs of construction, operating costs and depreciation. Of these, the last two can be assumed to vary proportionately with the amount of water withdrawn. The hypothesis of cost advantages for large farmers, therefore, hinges upon the relationship between construction costs of wells and their capacity to provide irrigation water. In soft earth region, the construction costs include digging costs and the costs of lining. In hard rock areas, only digging costs are involved. The capacity of a well to provide water depends upon its water storage limit and the rate of percolation. To see this, consider Figure 1 where L gives the depth to water

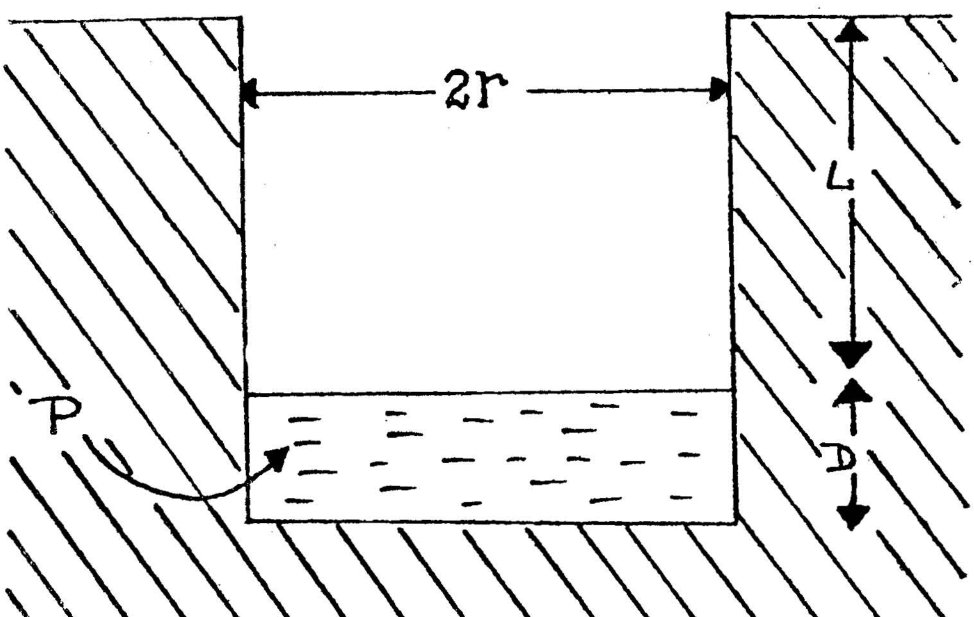

Figure 1—Well Characteristics

table (*i.e.*, distance from surface to the water level), 2r its diameter, D the depth of water and P the percolation rate. First, consider the simple case in which the percolation effects during the crop season are ignored. Given the depth of water D when the well is full, the total volume of available water will be given by the well's storage capacity $S = \pi r^2 D$. Now consider a more general case when percolation effects during the crop season are taken into account. For the sake of simplicity, assume that the irrigation water is needed for four months at a constant rate and that the percolation rate as well as the level of the water table in the area remains constant. With these assumptions, the maximum water that can be withdrawn from the well (at the end of four months, the well would be dry) is given by the following expression:

$$GS = \pi.r^2.D + [(2\pi.r.D + \pi r^2).P].T \qquad \text{...... (A)}$$

where $\pi.r^2.D = S =$ storage capacity of the well when full,

$(2\pi.r.D + \pi.r^2) = SA =$ the surface area to which the percolation rate (P) is to be applied,

and T = the relevant time interval. (Since P is generally specified as metres per hour, T = 2880 assuming a crop season of 120 days).

GS in equation (A) gives the actual capacity of a well to provide irrigation water over a four month period.[10] Of the various determinants of this capacity, the diameter of the well (2r) and the depth of the water (D) are within the control of the farmer. On the other hand, the percolation rate (P) is a random variable and the farmer only knows, at best, its expected value. Given the expected value of (P), the maximum *ex ante* capacity of a well to provide irrigation water would be directly related to SA, the surface area to which the expected (P) would apply. A farmer with a large holding, would construct a well with larger SA than a farmer with small size of the holding. Therefore, the basic relationship between the market costs of constructing a well and its *exante* capacity to provide water (given by SA) needs to be examined to test whether the large farmers enjoy declining average and marginal costs of water from wells.

The data suitable for studying the above relationship are provided in the detailed survey of 60 wells undertaken in 1969-70 by the AFPRO groundwater team in the Karjat taluka of Ahmednagar district in Maharashtra. These well characteristic data are reported by Deepak Lal in his book.[11] In this monograph, Lal has also provided information on the market costs of the 60 wells. To explore the relation between costs and size of the well, the following quadratic total cost function is specified:

$$TC = A_0 + A_1 SA + A_2 SA^2 + A_3 L + A_4 E + U \qquad \text{......(B)}$$

where TC = total market cost of a well,

SA = the surface area = $(2\pi.r.D + \pi.r^2)$,

10. This would also be the long run well capacity to provide water if in the remaining eight months (during which no water is withdrawn from the well) the percolation effect refills the well to its maximum storage capacity.

11. Deepak Lal: Wells and Welfare: An Exploratory Cost-Benefit Study of the Economics of Small-scale Irrigation in Maharashtra, Development Center of the Organisation for Economic Co-operation and Development, Paris, 1972.

SA^2 = surface area squared,
L = depth of the well to water table,
E = geological soil structure (values of E are between 0 and 1 with 0 for hard rock and 1 for soft earth),
and
U = the random error term. Estimating this cost function by the method of ordinary least squares, the following equation is obtained:

$$TC = -5422.72 + 24.86\ SA - 0.036\ (SA)^2 + 1460.50\ L + 2931.10E \quad ....(C)$$
$$(-2.61) \quad (1.90) \quad (-1.15) \quad (13.78) \quad (2.52)$$

$R^2 = 0.8148.$

In (C) above, the t-values are reported in parentheses below the coefficients. Since $\frac{\partial TC}{\partial SA} > 0$ and $\frac{\partial^2 TC}{\partial SA^2} < 0$, total construction costs of wells are found to increase at a declining rate as SA increases.[12] This implies that both the average and marginal costs of well irrigation are declining functions of the *ex ante* capacity of wells to provide water.

III

The cost equations reported in section II show that the construction costs of wells increase with the size of the well but at a declining rate. This would lead large farmers (requiring large wells) to incur smaller average and marginal costs for obtaining irrigation water. Given the scale neutrality of the green revolution, the lower costs of the large farmers would yield them higher rates of return on their investments in well irrigation. This can be expected to provide extra incentive to large farmers to irrigate their holdings and thereby increase their share in the ever-increasing irrigated land holdings in the country which eventually will accentuate income inequalities in the rural areas.

In order to counteract this adverse long run trend, the Government can adopt deliberate policy measure so as to neutralise the cost advantage of large farmers. For instance, small farmers may be granted soft-term or interest free loans to construct irrigation facilities. Alternatively, groups of small farmers may be provided with adequate incentives to construct large wells so that they overcome their individual cost disadvantage.

SUHAS L. KETKAR*

12. The estimation of a double logarithmic function yielded the following:

$$\ln(TC) = 6.06 + 0.25\ \ln(SA) + 1.005\ \ln(L) + 0.16\ \ln(E)$$
$$(16.66) \quad (3.68) \quad (17.89) \quad (2.67)$$

$R^2 = 0.8731$. The elasticity of TC with respect to SA is again substantially less than one confirming that the increase in construction costs is proportionately less than that in the expected capacity of the well to provide water.

*Assistant Professor of Economics, College of Business Administration, Department of Economics and Finance, Tennessee Technological University, Cookeville, Tennessee, U.S.A.