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Relationship between Public and Private Investments in Indian Agriculture with Special Reference to Public Canals*

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I

INTRODUCTION

An important issue in investment literature has been whether governmental or public investments stimulate or discourage private investments. Whereas stimulation has commonly been described as 'crowding in' effect of public investment in macro theoretic parlance, the phenomenon of hindering private investments has quite aptly been characterised as 'crowding out' effect. Many empirical researches in India have tended to support the 'crowding in' hypothesis in so far as public investments in the agricultural sector are concerned. The 'crowding out' hypothesis has, on the other hand, been deemed to be more applicable to the industrial sector, particularly under conditions of full employment.

Admittedly, 'crowding in', unlike 'crowding out', is not a very communicative phrase. Indian agricultural economists, who found a positive relationship between public and private fixed capital formation in Indian agriculture at the macro level, have therefore preferred to use the term 'complementarity' instead. Thus 'complementarity' hypothesis and 'crowding in' hypothesis are synonymous, implying the same key idea, namely, public investments in the agricultural sector induce farmers to step up their private farm investments. Recently, Mishra and Ramesh Chand (1995) have questioned the validity of this complementarity hypothesis. This invites a critical review of the literature in this area, more specially that dealing with empirical assessment of the effect of canal irrigation on canal farmers' investments. Canal irrigation in India is practically wholly in the public sector domain, and it is a dominant source of public irrigation. Furthermore, canals account for the bulk of the total public fixed capital formation in Indian agriculture. In view of this, our investigation can provide a fairly reliable test of the aforesaid complementarity hypothesis. Fortunately, we can conduct our investigation with a fresh set of data which, unlike the national estimates of capital formation in agriculture, are survey based. This data base acquires significance because Mishra and Ramesh Chand's criticism of the complementarity hypothesis stems partly from their dissatisfaction with the aforesaid national estimates of capital formation.

A select review of literature pertaining to empirical relationship between public and private capital formation in Indian agriculture is presented in Section II. In the subsequent section the effects of public investments in canal irrigation works on farmers' own fixed farm investments are broadly delineated. Whether development of irrigation under public aegis discourages farmers' own investment in private means of irrigation is discussed in a dynamic framework. It necessitates a close look at the importance of public investments in canal irrigation vis-a-vis other agricultural projects in the recent period, as also at the major components of private fixed capital formation in agriculture in India. Empirical support to

* Based on ongoing research work in farm investments. Professors V.N. Pandit, K. Krishnamurthy, Gopal Kadekodi and S.K. Ray offered valuable comments on the draft version of this paper. In final editing Suren Navlakha and Maria Saleh, among others, were extremely helpful. While the author is very grateful to them, he alone is responsible for the views expressed here.

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our view is sought in plan documents and in Debt and Investment Survey Report for 1981-82 (RBI, 1988, 1989).

In the concluding section of the paper an attempt is made to analyse certain field survey data available for Punjab and Karnataka states in order to ascertain the impact of canal irrigation on private farm investments. The Punjab survey data were gathered by Bhalla and Chadha (1983); the Karnataka field data for Ghataprabha and Malaprabha canal commands were gathered by the Institute for Social and Economic Change (ISEC), where Venkata Reddy played a noteworthy role in field work, data analysis and report writing. The latter data set allows us to assess the impact of canal irrigation on dryland farmers' investment and savings behaviour.

II

REVIEW OF LITERATURE

The estimates of annual capital formation in India are prepared by the Central Statistical Organisation (CSO) and published in its document *National Accounts Statistics* (NAS). Using this data base, many economists have estimated the elasticity of private investments in Indian agricultural sector with respect to public investments. The estimational work has been generally attempted in multiple regression framework, whereby positive influence of other factors on private fixed farm investments has been duly eliminated. The elasticity turns out to be less than unity. This less than proportionate impact of public investments on private investments is understandable since fixed agricultural capital formation on private account far exceeds the corresponding capital formation on public account. Furthermore, the share of the former in total fixed capital formation has increased over time: from 67 per cent in 1968-69 to 77 per cent in 1991-92. As for the magnitude of the elasticity, it is found to be between 0.26 and 0.90. In earlier studies, it tended to be in the narrow range of 0.60-0.66. Chakravarty (1987) placed it at 0.62 for the period 1970-71 to 1982-83, whereas Shetty (1990) found it to be 0.66 for the period 1960-61 to 1986-87. Earlier, Krishnamurty (1985) estimated it at 0.60, and more recently Storm (1993) reported a value of 0.904 for the period 1962-86. Storm, however, confirms, in a personal communication, that there was a printing error, and that the correct value is 0.664.¹

The lower value of elasticity of 0.26 is from an ongoing study in macro modelling at the National Council of Applied Economic Research (NCAER).² It is noteworthy that this estimate is based on a long time-series for the period 1960-61 to 1989-90. Yet, it turns out to be lower than earlier estimates, possibly because of differences in model specification. NCAER's multiple regression equation (in double log form) is as follows:

$$\begin{aligned} \text{GFCF} = & 1.9333 + 0.2603 I_{g-1} + 0.3588 \text{CREDIT} + 0.2307 \text{ATT}_{-1} \\ & (0.74) \quad (2.04) \quad (2.89) \quad (0.42) \\ R^2 = & 0.86, n = 23 \end{aligned}$$

where GFCF is gross fixed capital formation in agriculture on household account;
 Ig is government investment in agriculture;
 CREDIT is institutional credit to agriculture;
 ATT is agricultural terms of trade;
 Figures in parentheses are t-values.

Mishra and Ramesh Chand (1995), however, find no positive relationship between public and private capital formation in agriculture. They fail to get it for two possible reasons. First, they do not explore the relationship in a multiple regression framework. Second, they restrict their assessment mainly to the period of the eighties during which public investments in agriculture declined markedly while private agricultural investments continued to rise, although extremely slowly than before.³

Let us look at the results emerging from another ongoing study by a joint Research Team of Institute of Economic Growth (IEG) and Delhi School of Economics (DSE) (1994). This Research Team, led by K. Krishnamurthy of IEG and V.N. Pandit of DSE, finds a relationship of almost one-to-one correspondence between the two categories of investments in Indian agriculture. That is to say, one rupee of additional investment in agriculture on public sector account is accompanied by almost one rupee of additional investment in agriculture on private account. Their estimated linear regression equation is given below.

$$I_p = -38.9253 + 0.9805 I_g + 0.2972 ATT_{t-1} + 0.0440 AGINCOME$$

(1.42) (2.57) (1.51) (3.18)

$$\bar{R}^2 = 0.67; \quad DW = 1.93; \quad AR(1) = (0.2918)$$

(1.13)

where I_p is private capital formation in agriculture at 1980-81 prices (Rs. billion);
 I_g is public capital formation in agriculture at 1980-81 prices (Rs. billion);
 ATT_{t-1} is agricultural terms of trade lagged by one year (the ratio of wholesale price index of agricultural items to the wholesale price index of all commodities, with base 1981-82 = 100);
 $AGINCOME$ is the average of real, 'permanent' income from the agricultural sector for three years (t , $t-1$ and $t-2$) at 1980-81 prices (Rs. billion);
(t-values are in parentheses).

In view of the existence of a relationship on a nearly one-to-one basis, one could say that the decline in public investments in agriculture by Rs. 720 crores between 1980-81 and 1991-92 would have, *ceteris paribus*, discouraged private farm investments by nearly Rs. 700 crores. Had public investments not declined, private farm investments during 1991-92 might have been around Rs. 4,600 crores instead of the actuals Rs. 3,906 crores. Thus reduction in public farm investments depressed private investments by nearly 15 per cent. No wonder, then, one notices a marked slowdown in the growth of private farm investments during the decade of the eighties as compared to the earlier two decades. According to Gulati and Bhide (1993), the annual growth rate of such investments declined from 8.1 per cent during the sixties and 4.2 per cent during the seventies to merely 0.3 per cent during the eighties.

To conclude this section, the magnitude of elasticity of private farm investments with regard to public investments in agriculture hinges on (a) specification of the multiple regression model and (b) time period of analysis. In the absence of a well formulated theory of private investment in agriculture of a developing economy, there is room still for elementary empirical enquiry into the magnitudes and directions of such investments under given conditions. One is struck by the weight of such empirical evidence as lending support to the thesis of complementarity between private and public investments in Indian agriculture.

III

PUBLIC CANALS AND THEIR INVESTMENT EFFECTS

A pertinent question is: how do public investments in agriculture stimulate farmers to step up their own investments in farm business? Part of the answer lies in the very composition of these two categories of investments. Unfortunately, such details are missing from the NAS publication, and we have to take recourse to the original sources of data from which the CSO compiles its estimates of capital formation in agriculture. Government budgets and plan documents are helpful in assessing the importance of public canal investments vis-a-vis other agricultural investments in total fixed capital formation in agriculture on public sector account. Debt and Investment Survey Reports of the Reserve Bank of India are likewise useful in getting a fairly detailed composition of Indian farmers' annual capital expenditure in general and the resultant fixed farm capital formation in particular.

Even so, it ought to be mentioned that it is not possible to firmly assess from aggregative statistics of plan and budget documents as to how much of plan outlays and budget capital expenditure figures shown under broad heads like 'irrigation' and 'agriculture' result in fixed capital formation. For that, one needs finer details of items under each broad head in the plan and budget documents. Going by aggregative plan statistics, actual public irrigation outlays during the Sixth and the Seventh Plan amounted to Rs. 101 billion and Rs. 152 billion respectively.⁴ These exceeded the corresponding outlays on 'agriculture' head reckoned respectively at Rs. 66 million and Rs. 128 billion. Nearly four-fifths of the public irrigation outlays are accounted for by major and medium irrigation works which are almost synonymous with public canals - the rest of the one-fifth is on minor irrigation works (public tubewells, tanks, etc.). Thus, public investments in canal irrigation development constitute a very substantial portion of total public investments in the agricultural sector.

The Reserve Bank of India (RBI) carries out a nationwide survey of households, better known as Debt and Investment Survey. This survey is done once in ten years, and the latest survey pertains to 1991-92. But reports for this year are not yet available, so that the following analysis of private farm investments is based on data for 1981-82. The first striking fact to take note of is that only a small fraction of Indian farmers' annual capital outlay results in fixed capital formation in agriculture. During 1981-82 hardly one-sixth of the cultivator households' capital expenditure was geared towards addition to fixed farm assets (excluding purchase of land). This fraction of capital outlay resulting in fixed capital formation in agriculture could be construed partially as a measure of Indian farmers' preference for acquisition of fixed farm assets over others such as land, livestock, residential housing, financial assets and assets of non-farm business (e.g., transport vehicles). This preference varies greatly across states and is found to be very highly and positively correlated with fixed farm capital per cultivator household ($r=0.97$) but negatively associated with normal rainfall ($r = -0.66$).⁵

Fixed investments in agriculture are distinguished by the following eight heads:

1. Reclamation of land,
2. Bunding and other land improvements,
3. Orchards and plantations,
4. Wells,
5. Other irrigation sources,

6. Agricultural implements, machinery and transport equipment, etc.,
7. Farm houses, barns and animal sheds, and
8. Other capital expenditure.

The magnitude of fixed capital formation in agriculture on private account was rather low at Rs. 138 per *rural* household during 1981-82. It was somewhat higher for *cultivator* households for whom it averaged Rs. 176, way above Rs. 14 per non-cultivator household (Rs. 51 per urban household and Rs. 124 per self-employed urban household). Concentrating on cultivator households who accounted for the bulk of the private household fixed capital formation in farm business (Rs. 12.7 billion out of a total of Rs. 14.5 billion in 1981-82), we find that investment (including expenditure on major repairs) in agricultural machinery, farm implements, and farm transport equipment (item 6 above) accounted for 47 per cent of total private fixed capital formation in agriculture during 1981-82. The share of this item was relatively high in the northern states of Punjab, Haryana and Uttar Pradesh (67-69 per cent), and very low in West Bengal and Assam (5 per cent). The relatively lower share of private means of irrigation (item 4 plus 5) of 26 per cent in total fixed farm capital formation is under-stated because the value of mechanical pumpsets so extensively used in private well irrigation, is included under agricultural machinery. Next in order of importance are investments in land improvements (items 1 and 2) with a share of 15 per cent, followed by farm buildings and structures (item 7), orchards and plantations, and other items of capital formation. Needless to say, these shares differ markedly from state to state, both in proportionate and absolute magnitudes per cultivator household/unit sown area.

Let us now explore which of these components of private fixed farm investments are likely to be adversely affected by the development of public irrigation service in general and public canals in particular. Obviously, the most likely item in this regard is private means of irrigation. Such substitutional effect can be quite pronounced in the early stages of a new canal project, especially in the upper reaches of the canal system (i.e., head-end areas of the main and branch canals, distributaries, 'minors' and terminal watercourses) where farmers are less likely to experience the notorious inadequacies of public canal system. The long history of Indian canals bears testimony to the decline in well irrigation within canal commands. However, this very history also shows that in the later stages of canal development the canal farmers evinced renewed interest in developing their own means of irrigation, especially wells. This later stage could come well after a generation of time has elapsed since the completion of a canal project. One classic case of this type is that of the great Ganga Canal of Western Uttar Pradesh, in which canal farmers reverted to investments in well irrigation in the last decade of the nineteenth century after having abandoned well irrigation during the early phase (30-35 years) of canal irrigation.⁶

Why do farmers invest in their own irrigation sources when they have access to public canals (or tanks or even tubewells)? Do their own means of irrigation serve the purpose of merely being a standby so as to cope with the uncertainties of canal supplies in quantity or timeliness? Risk avoidance through a supplementary source of irrigation is admittedly an important consideration. The risk is more serious in tail-end areas of canals where farmers suffer disproportionately more from uncertain and inadequate supplies of canal water. No wonder, the desire to invest in one's own well irrigation is stronger here than in the upper-end or middle areas of a large canal command.⁷ However, no less important is the objective of

expanding the scale of irrigated farming when certain restrictions are imposed by authorities on the use of canal water.⁸ Such restrictions may be felt in all reaches of a canal system, thereby raising the need for private sources of irrigation everywhere in a canal command.

The needs of farmers may be better realised through development of groundwater-based irrigation works like dugwells, tubewells, borewells and filter points. Groundwater recharge from seeped-in canal waters is known to radically transform the profitability of private investment in well irrigation, especially in low rainfall tracts where the groundwater table is naturally at great depth (e.g., in semi-arid alluvial north-western India) or is highly scarce (e.g., in the hard rock areas of western and southern India). Since seeped-in canal water can spill over to adjoining areas of a canal command, it can encourage also dryland farmers on the fringes of a canal command to invest more in well irrigation.⁹

We do not find any negative association between farmers' investment in irrigation structures and the extent of canal irrigation. For 17 states the average private investment in irrigation per cultivator household during 1981-82 bears a positive correlation with canal irrigation ratio. However, the coefficient of correlation is not high enough ($r = 0.27$) to be considered statistically significant. But this relationship needs to be probed further (a) with fresh data set because statewise estimates of private fixed capital formation in irrigation structures are deficient in one major respect, namely, these are exclusive of private investments in electric and oil-driven pumpsets, and (b) in a multivariate framework.

All items of private fixed farm investments other than irrigation structures are less likely to be affected adversely by public investments in canal irrigation. Serious damage to farm lands due to canal-related waterlogging or soil salinity can lower farmers' investments in agriculture. But this can take many years after the advent of canal irrigation. Likewise, non-availability of institutional credit for meeting greatly enhanced working capital needs of irrigated farming can compel farmers to divert investible resources to buying chemical fertilisers, high-yielding variety (HYV) seeds, etc., leading to a decline in their fixed farm investments in the initial years of canal irrigation. On the whole, canal benefited farmers are most likely to step up such outlays following the advent of irrigated farming, whether the source of irrigation is canal or other surface water or groundwater. This is for two reasons. On the supply side, canal irrigation enhances their savings, thereby improving their ability to self-finance both farm and non-farm investments. At the same time, financial institutions as well as moneylenders may find giving term loans to them a more viable proposition than under risky dryland farming. On the demand side, since profitability of farm investments is heightened as a result of switchover from rainfed to dryland farming, farmers' willingness to invest in farming improves radically, a necessary condition for investment to take place.

It is important to recognise that rise in farm incomes - and savings and farm investments thereof - in the wake of canal irrigation is not a one-shot affair, but a continuous process. It can take several years for farmers to realise the full yield potential of crops. The same is true of crop diversification, another substantial source of enhancing farm incomes. Thus provision of a given amount of canal irrigation in year 'T' can give rise to a time-series of private farm investments in subsequent years¹⁰ (T+1, T+2, T+3.....). Whether or not this series would have a rising trend cannot be asserted *a priori*. What is being argued here is that the magnitude in each time period would be higher than the corresponding hypothetical value possible under a no-canal scenario.

It is found that canal irrigation ratio bears a significantly positive correlation with total private fixed farm investments ($r = 0.65$) as well as with investments in agricultural machinery ($r = 0.74$). These correlations are based on estimates of fixed capital formation in agriculture per cultivator household for 17 states for the year 1981-82. These fairly high correlations could have partially resulted from the fact that financial institutions in India did relatively more lending in canal-irrigated tracts during 1981-82. This is suggested by the fact that canal irrigation ratio and institutional borrowing per cultivator household was well correlated ($r = 0.58$). Should we also reckon with farmers' inclination to undertake fixed farm capital formation with their own capital funds, the following noteworthy result is obtained:

$$\begin{aligned} \text{FF INVESTMENT} = & (-) 123.03 + 4.62 \text{ CANAL} + 0.35 \text{ CREDIT} \\ & \quad \quad \quad (-4.26) \quad (2.92) \quad \quad \quad (7.10) \\ & + 7.60 \text{ PREFERENCE}, \quad R^2 = 0.9603 \\ & \quad \quad \quad (5.30) \quad \quad \quad n = 17 \end{aligned}$$

where FF INVESTMENT stands for the average fixed capital formation in agriculture per cultivator (Rs.);
 CANAL stands for the net canal irrigated area as a per cent of net sown area (per cent);
 CREDIT stands for the average borrowings per cultivator from institutional sources (Rs.);
 PREFERENCE stands for the share of fixed capital formation in agriculture in total capital expenditure of a cultivator household (per cent);
 n stands for the number of states in the cross-sectional data for 1981-82;
 (t-values are shown in parentheses).

The estimated regression equation has a pretty high R^2 value and expected positive signs of three regression coefficients, not to mention their statistical significance. At mean values of the variables, the elasticity of fixed capital formation in agriculture on private account with respect to canal irrigation ratio, institutional credit and preference variable is 0.25, 0.60 and 0.69 respectively. While the elasticity in respect of public canals is very close to that of NCAER, there is a great difference in respect of that for institutional credit (0.60 as against NCAER's 0.36). This once again underscores the model specification differences giving rise to differences in the estimates of elasticity.

IV

ANALYSIS OF FIELD SURVEY RESULTS

The CSO does not prepare statewise estimates of fixed capital formation for any sector of the Indian economy. We have thus to evaluate the impact of development of public canal irrigation on private fixed capital formation in agriculture with the aid of sample survey data in respect of farm investments (and savings). Even there we cannot deduce fixed capital formation resulting from such investments on farmers' account. One has to contend also with the fact that such field-based studies, which focus on collecting farmers' investment expenditure during the survey period, are rather few in number. This constrains us in generalising from our findings. The results reported in what follows need to be viewed subject to these limitations.

Results for Punjab

G.S. Bhalla and G.K. Chadha carried out a state-wide survey of 1,663 cultivator households for the state of Punjab. The results are reported in Bhalla and Chadha (1983), the data being for the year 1974-75. Though the focus of their enquiry is on studying income and consumption effects of the new farm technology, they do briefly report data on farm investments by a sample of farmers during 1974-75. Such investments averaged Rs. 631 per cultivator household. Inter-spatial comparison reveals that the average was higher (Rs. 808) for south-western Punjab, a predominantly canal-irrigated region, than in central Punjab (Rs. 486) where private tubewell irrigation was the main source of irrigation, and in semi-hilly northern Punjab (Rs. 624) where both canals and tubewells are in use. The evidence shows that public investments in canal irrigation enhanced farmers' own farm investments. It may be clarified that though Bhalla and Chadha's measure of farm investment is exclusive of expenditure on land purchase, it includes livestock purchases during 1974-75. However, published statistics do not permit us to compare inter-spatial farm investment net of livestock component.

The above inter-regional comparison may be affected as much by region-specific factors as by sample cultivator-related factors over and above by canal irrigation. This is a difficulty of sorts in every with-and-without impact analysis. In the present case, the inter-spatial disparity in farm investments favours south-western farmers whose average operated land holding was comparatively higher, namely, 11.31 acres as compared to 8.74 acres for central Punjab farmers and 6.80 acres for northern Punjab farmers. Knowing as we do that farm investments can be an increasing function of farm size, the earlier inference that canal irrigation steps up farm investments remains no more fully intact when comparison is done on the basis of farm investments per unit area. Farm investment per acre averaged more for northern Punjab region (Rs. 92) than for south-western Punjab (Rs. 71) - the latter canal-irrigated region still did better than tubewell-irrigated central Punjab (Rs. 56). It is only if one is inclined to ignore region-specific differences between central and south-western Punjab cultivators that one can still accept the earlier inference of canal irrigation stepping up farmers' farm investments. It may be clarified that irrigation factor is not in favour of south-western region whose sample cultivators had an irrigation ratio somewhat lower than that of their counterparts from the central Punjab region - the third region of northern Punjab having the lowest irrigation ratio. More specifically, gross irrigated area as a per cent of net operated area of a land holding of sample cultivators averaged 166 for central Punjab, 137 per cent for south-western Punjab and 104 per cent for northern Punjab.

Results for Karnataka

The analysis is carried out in what follows with the help of two ISEC studies conducted by its Malaprabha and Ghataprabha Projects Unit under the leadership of B.K. Narayan. Though the sample of cultivator households in these surveys is not as large as in Bhalla and Chadha's study on Punjab, their work merits attention because of its following interesting features. First, the Ghataprabha canal command was first surveyed in 1975-76 and the *same* sample rural households (cultivators as well as non-cultivators) were resurveyed 11 years later. The results of both the benchmark survey and resurvey are reported in Reddy (1990).

This permits us to study the impact of public canals using both with-and-without and before-and-after approaches of project evaluation. Second, for 1975-76 the benchmark survey covers both Ghataprabha and Malaprabha projects. Third, instead of the usual selection of two tracts, one benefiting from the project and the other without such benefits and lying outside the project command, three tracts or zones were chosen for survey work. These zones, labelled as zone A, B and C in ISEC studies, are distinguished as follows: zones A and B are located within a canal command but zone C is an adjoining tract outside the canal command. While the selected villages from zone A had received canal irrigation by 1975-76, the selected villages from zone B were to benefit imminently from canal irrigation on the completion of the then ongoing Ghataprabha and Malaprabha projects - these had received canal waters by 1986-87. Thus during 1975-76 both zones B and C were essentially dryland regions, one within canal command and the other outside it.

The benchmark survey of 1975-76 shows a wide disparity in farm investment per cultivator household between the two non-canal benefited or dryland zones B and C (Rs. 149 in zone C and Rs. 776 in zone B). The much higher figure for zone B could be, *inter alia*, attributed to expectations factor at work. Since farmers here knew they would be receiving canal irrigation before long, this radically transformed the investment climate that promised good returns (in the shape of enhanced income and crop output) on farm investments. This desire to intensify investment in agriculture even under dryland conditions was very pronounced among large farmers (above 15 acres in this sample) who invested during 1974-75 unusually high amounts in agricultural machinery (Rs. 2,598 per cultivator as against Rs. 235 in zone C and Rs. 291 in zone A). But for the imminence of land receiving canal waters, farm investment in zone B during 1975-76 could possibly be no different from that in zone C. Since average farm investment in zone A was Rs. 850, one can reasonably conclude public investments in Ghataprabha-Malaprabha commands induced farmers in these commands to enhance their farm investments. Furthermore, these investments did not produce any adverse effect on investment in well irrigation in canal-irrigated zone A where an average farmer invested Rs. 177 in wells during 1975-76, quite above Rs. 64 invested in dryland zone C, and Rs. 19 in zone B.

The resurvey of Ghataprabha command during 1986-87 covered 496 households including 385 cultivator households. While canal irrigation had begun in zone B by 1986-87, the zone C was still a dryland zone though some non-canal irrigation had come into existence here. Total farm investment per cultivator household during 1986-87 in the two canal-irrigated zones was perceptibly more than in dryland zone: Rs. 10,493 in zone A, Rs. 12,489 in zone B and Rs. 9,676 in zone C. It is only when we assess farm investment per hectare of land holding of a cultivator household that we find the level of investment in two canal zones marginally exceeds by 4 to 5 per cent the corresponding level for dry zone.

Much more interesting is the finding that while farmers in two canal zones invested in well irrigation to some extent, their counterparts in dry zone reported no such investment at all for 1986-87. More specifically, 186 sample farmers in zone A and 169 sample farmers in zone B put 12 and 4 per cent of their capital expenditure of 1986-87 on construction of irrigation wells. The need for such investment was felt, *inter alia*, by canal farmers partly because of protective nature of Ghataprabha canal design and partly because of seasonal nature of canal running whereby annual crops like sugarcane and banana cannot be raised solely on canal water. The canal authorities do, however, allow farmers to raise these crops

by using their own means of irrigation during a year when canals are not scheduled to run. Thanks to private well irrigation, sample farmers in canal zone A were able to grow sugarcane on 16.7 per cent of their gross irrigated area of 1986-87. The same percentage was only 5.7 per cent in zone B and 8.2 per cent in zone C. Lesser cultivation of sugarcane in zone B than in zone A in 1986-87 could be attributed to canal farmers in zone B being in the very early stage of canal development.¹¹

V

THE UPSHOT

The foregoing evidence - both at the macro and micro levels - lends support to the proposition that public investments in canal irrigation in India stimulate private investments in agriculture, including investments in private means of irrigation. Since development of canal irrigation accounts for a major share of total public investments in Indian agriculture, the veracity of the proposition gives credence to the complementarity hypothesis according to which private fixed capital formation in Indian agriculture is generally positively induced by corresponding fixed capital formation on public account. In view of this, the recent attempt at invalidating the complementarity hypothesis by Mishra and Ramesh Chand cannot be endorsed.¹² The substantial decline in public fixed capital formation in agriculture since 1980-81 must be deemed as a major explanatory factor behind the marked slowdown in the rate of growth of private fixed capital formation in Indian agriculture during the 1980s as compared to 1970s and 1960s.

NOTES

1. Likewise, the correct elasticity of private agricultural investment with regard to agricultural terms of trade is 1.444, not 1.217 as mentioned erroneously in Storm's text. The correct values are quoted here from his equation number 4.41 on page 188.

2. This is mentioned in NCAER (1995), a summary version of which relating to agricultural sector was kindly made available to the author by S. Bhide.

3. According to the NAS data, gross agricultural capital formation on public account at 1980-81 prices plummeted from a value of Rs. 1,892 crores in 1980-81 to Rs. 1,162 crores in 1991-92 (Rs. 1,065 crores in 1992-93). In contrast to this 39 per cent reduction, there was a 31 per cent increase in gross agricultural capital formation on private account (from Rs. 2,972 crores in 1980-81 to Rs. 3,906 crores in 1991-92).

4. These statistics are cited from the World Bank (1995), Table 4.15(a), p. 147. Public outlays on irrigation cover minor, medium and major irrigation works, as also expenditure under Command Area Development Authority (CADA) head.

5. These as well as subsequent correlations are cited from Dhawan and Yadav (1995) to which interested readers may refer for more details on statewide data.

6. It may be noted here that this abandonment of well irrigation was not solely due to the comparative lower canal tariff vis-a-vis higher cost of well irrigation. It was a situation of more than mere substitution for economic reasons because excessive canal seepage rendered the older technology of *kutcha* or earthen dugwells dysfunctional owing to the caving-in phenomenon. Return to well irrigation was rendered possible with the help of *pucca* or masonry dugwells whose lined walls could withstand seepage of canal origin - extra capital costs of masonry work was mainly met through accumulated savings from enhanced farm incomes from canal irrigated farming. For more details, see Stone (1984).

7. It is mainly because of this factor that empirical results often belie the expectation of irrigated crop yields being lower in tail-end reaches of a canal command wherein conjunctive use of ground and surface water is better developed.

8. Among the various restrictions, one could be due to canal schedules being not conducive to the growing of certain remunerative crops which need watering either more frequently or in seasons of the year when canals are not kept in operation. Another restriction may be on the raising of heavily irrigated crops like sugarcane and paddy with canal waters. Finally, the concept of protective design behind a canal does not permit farmers to practice irrigated cropping on the whole of their farms.

9. Such encouragement to private investment in well irrigation could be reinforced by (a) demonstration effect of

benefits of irrigated farming on dryland farmers located on the fringes of a canal command and (b) opportunity to earn extra wage income by small dryland farmers by supplying their labour to canal farmers facing labour shortages due to substantial rise in demand for labour as a result of changeover from rainfed to irrigated farming.

10. In empirical work so far done, this lag effect is not fully captured by simply lagging by one year the public investment variable. Evidently, stock of public capital in fixed farm assets could be a more appropriate specification than merely introducing one or two more lags in the public investment variable. In the ongoing NCAER study referred to earlier, it is reported that Vasant Gandhi, who used government stock in agriculture while analysing determinants of private investment in agriculture during 1950-80, obtained a value of 0.42 in respect of private farm investment with regard to stock of government investments in agriculture.

11. Zone A of Ghataprabha command contains within its fold command area of an old canal, called Gokak canal, built in the closing decade of the nineteenth century. So, some farmers here could be deemed to be in mature stage of irrigated agriculture, and many with at least 11 years of experience with canal irrigated farming by 1986-87. These farmers had fairly long time to diversify their crop pattern by 1986-87, aided by own well irrigation. It is noteworthy that all the eight categories of sample farmers invested in wells during 1986-87 - even marginal farmers (upto one hectare) allocated nearly one-third of their total capital farm outlay on well irrigation.

12. Over time, the strength of complementary relation might have been reduced.

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