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RAPPORTEURS' REPORTS

Sub-theme 1: Science and Technology Policy

CONSOLIDATED REPORT ON SCIENCE AND TECHNOLOGY POLICY

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Under this broad heading, the following three topics are to be discussed:

(1) Science and Technology for Dryland Farming.
(2) Fertiliser Use.
(3) Irrigation and Water Management.

The purpose is to focus on the changes in these aspects of agricultural development strategy which will facilitate achievement of rapid growth with equity. On each of these themes, a lead paper setting out the major issues in a broad perspective has been commissioned from knowledgeable experts. In addition, individual researchers have contributed papers on particular aspects of each theme. There are altogether 58 such papers: For the most part, however, they are rather descriptive in nature, with occasional analysis of existing situation (or past developments). Relatively few focus sharply enough on the extent to which the strategies in respect of dry farming, fertiliser use or irrigation have succeeded or failed; the reasons for the successes or failures and the lessons to be drawn for the future. Our summary is therefore largely based on the lead papers drawing on the contributions of the others as and when appropriate.

SCIENCE AND TECHNOLOGY FOR DRY FARMING

The lead paper by N. S. Jodha sets out briefly but clearly the evolution of research on technology for dryland agriculture, its present status, the reasons for its slow spread and the key problems which need attention if a significant improvement in rainfed agriculture is to come about.

Traditional dry farming technology evolved over centuries was well adapted to cultivation under conditions of low demographic pressure and low fertility but is increasingly becoming non-viable in the face of rapid growth of population and commercialisation. The semi-subsistence character is seen to inhibit the switch over to more profitable crops for which there is a good demand while intensified demographic pressure has cut into grazing and other land for rearing livestock.

Research has focussed on (*a*) improving the environment of crop growth essentially through better conservation of soil and moisture; and (*b*) improving the genetic potential of specific crops grown under rainfed conditions. Jodha suggests that efforts at developing better soil and moisture conservation techniques have been considerably less successful (both in terms of territorial coverage and cost) than crop-oriented techniques. Apart from the question of appropriateness and cost, the resource-oriented technical improvement often cannot be implemented without group action on the part of the beneficiary farmers. Some elements of

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technique, *e.g.*, land preparation, call for a degree of precision which the farmers are not used to and may also be contingent on group action. In the case of crop specific techniques, the gains are sizeable but not dramatic and are besides liable to larger variability. This together with the relatively high cost of recommended technology packages is said to explain the rather tardy progress of dryland agriculture in India.

A reorientation of research strategy aimed at raising the efficiency of fertiliser use; maintaining the eating qualities of grain and greater attention to pest/disease resistance in plant breeding; switching the focus to cropping systems rather than on individual crops; and developing a wider range of options (covering non-foodgrain crops and livestock) adapted to different agro-ecological situations (which involves a considerable expansion of the research/extension network) are seen to be essential.

The complementarity between crop specific improvements and the agro-climate environment argues for developing economical techniques of soil and moisture conservation as well as institutional mechanisms whereby the techniques can in fact be applied and the use of land properly regulated.

Most of the 22 research papers presented here are descriptive giving facts regarding crop pattern, inputs and yields of agriculture in selected areas, or for selected farms in a particular region—that too not always strictly concerning rainfed agriculture. A few attempt to estimate optimum farm plans, *given* the technology and resource constraints in particular regions; but here again the focus is not strictly on dry farming. There are however some papers which discuss technical improvements for dryland agriculture, their economic viability and the factors impeding their spread. Y. V. R. Reddy and M. Sudha, and B. D. Bhole *et al.* present data to show that many of the techniques recommended by researchers give a positive net return over costs often of substantial magnitude. But none of them asks or examines why, if the techniques are as profitable as they indicate, they are not adopted more widely and faster than seems to be the case.

Since the technology of cultivation consists of a bundle of inputs and practices, it is useful to examine how far specific ingredients of recommended technology have been adopted by the farmers or how they differ as between farmers with different levels of productivity. This aspect has been considered in five papers (including specially G. Madhava Swamy; Alok Chattopadhyay; R. N. Pandey *et al.*; R. K. Singh *et al.*; and P. Rangaswamy). Though the treatment is uneven and not thorough enough, they show that the extent of adoption of individual components varies a great deal, as do the reasons for non-adoption. The latter include lack of knowledge, unsuitability of variety to local conditions, high cost of inputs, low returns and high risk. One would have liked to see more detailed analysis of this type for many more regions and crops.

While Jodha has posed the general issues quite clearly and sharply, it is necessary to ask ourselves whether dryland agriculture is in fact everywhere as stagnant or on the decline as it is generally assumed. The example of Gujarat immediately comes to mind as one predominantly dry region which has managed to sustain respectable—even high—overall growth in production and in per hectare yields. I am sure that if we look more closely at district level experience we can find other examples. A more detailed examination of the performance in terms of growth

and stability of the districts with little or no irrigation and explication of the main factors contributing to disparate performance and more especially rapid growth would be useful in reshaping the strategy for dryland agriculture on a more discriminating basis.

A related question is whether technical change is wholly a function of state-sponsored research and extension. Is it not possible that in response to growing demographic pressure on land, farmers even in dry regions may be, on their own, introducing changes to permit more intensive cultivation and/or higher productivity? Whether or not this kind of process exists and in what areas and with what intensity are questions which need probing.

A third line of approach would to be examine the factors responsible for considerable variations in technique and productivity between dryland farmers even within a small area, and try and sort out how far they are due to (*a*) environment; (*b*) inputs/practices on specific crops; and (*c*) cropping system as a whole. Could we not use detailed data from cost of cultivation and other similar surveys to assess what changes if any, are taking place?

Fourthly, there is need for deeper analysis of the available data from experimental farms, demonstration plots and farmers' fields in areas where research and extension work has been relatively intensive, to assess the costs and returns of recommendations as against farm level experience, the speed with which different elements of technique get diffused among farmers, and the reasons for selective adoption or non-adoption of techniques. Since both ICRISAT and AICRPDA have several years of experience in research and extension, it should be possible to get more concrete and finer insights on these questions.

FERTILISER USE

The individual research papers—of which there are 15—deal with one or other aspect of fertiliser use in particular regions or on specific crops. A number of papers focuss on the inter-regional variations (across States, and across regions/districts within a State) in fertiliser use and its growth; variations in the extent and intensity of fertiliser use across different categories of farmers; and estimating the productivity of fertilisers. Unfortunately, with a few exceptions, these papers do not offer much by way of deeper analysis or fresh insights than what is available in the literature.

By far the most interesting papers are those dealing with inter-farm variations and constraints on fertiliser use. But even they do not take us further than confirming the role of irrigation, rainfall, crop pattern, HYV use, distribution network and the like in explaining differences in fertiliser use; the existence of imbalances across crops, regions and nutrients; and the relatively minor role of prices. One would have liked to see more discussion on the relation between farmyard manure and chemical fertilisers; the importance of irrigation quality on fertiliser use; the reasons for the wide variation in the extent of diffusion and intensity of fertiliser use across crops and regions; the relation between yield response to fertiliser under farm conditions and its variability, on the one hand, and fertiliser use, on the other. One or two studies suggest that the returns to phosphatic and potassic fertilisers are quite high and yet they are seldom used on the recommended scale. Surpri-

singly, while some papers dealing with changes in fertiliser use consider the effect of fertiliser prices *per se*, none examines the role of fertiliser prices *relative* to crop prices.

Gunvant M. Desai's lead paper presents a broad perspective on the factors which have contributed to the past expansion in fertiliser use in India and the strategy needed to achieve projected rate of expansion in the future. He makes a number of important points:

(1) The unprecedented growth of chemical fertiliser use in the past two decades has come about partly by a progressive rise in the proportion of cropped area on which fertilisers are used and partly from a progressive rise in the quantum of fertiliser used per unit area.

(2) The use of fertiliser on irrigated land is by now nearly universal and the average dose is quite high. While fertiliser use has also spread on rainfed land, the extent of diffusion and the rates of application are far less than on irrigated lands and also less than the potential indicated by experiments. The propagation of fertilisers on rainfed land must receive high priority if the projected targets are to be realised.

(3) While the pricing of fertilisers relative to output is an important determinant of their use, it is by no means the most important. It would be wrong to view the maintenance of relatively low prices (even if it means continuing large subsidies) for fertilisers as the principal instrument for promoting demand. The subsidy is already imposing a severe burden on the budget. On the other hand, not enough attention is being given to reducing the cost of producing fertilisers and to the possibilities of raising the efficiency of fertiliser use by strengthening research (to evolve fertiliser recommendations better adapted to local conditions) and extension (to get the farmers to manage fertiliser application on the field more efficiently). The scope for improvement in both respects is considerable.

(4) Improvements in the agro-climatic environment (especially the spread of irrigation) and breeding more fertiliser responsive seed varieties would continue to be important, but the role of credit and distribution network for fertilisers should not be under-estimated. In fact, he sees the latter, along with research and extension, focussed on drylands as the key elements of policy to achieve the targeted growth in fertiliser comsumption whose necessity and desirability he seems to accept without much question. (After all if productivity can be raised substantially, the nutrients needed to produce a given output of agriculture will also be smaller!).

Desai has done well to focus on the crucial importance of non-price factors including the more efficient use of fertilisers. While we know a good deal about the importance of environmental factors (soil and moisture in particular) in determining fertiliser use, we need to go deeper into the pace and pattern of spread of fertiliser use in rainfed agriculture, and in particular into the reasons why some regions like Gujarat with low rainfall and irrigation have recorded such remarkable growth while others apparently similarly placed have not. Desai's explanation in terms of better credit and supply network seems plausible but one would like to see it more convincingly established by detailed analysis. Similarly, the factors behind the relative stagnation of fertiliser intensity in East India need closer

study. The dynamics of fertiliser usage in terms of rates of diffusion, and intensity of usage by crops and under different environmental conditions need to be understood a lot better than we do at present.

Desai rightly stresses the crucial importance of efficient fertiliser use. His argument that there exists a large scope for raising this efficiency finds strong corroboration from other studies. More than a decade back, Ashok Parikh showed that given the yield responses obtained under farmers' field trials, the targeted foodgrain production for the Fifth Plan could be achieved with a substantially smaller input of fertiliser than envisaged by the planners if the allocation of nutrients across regions and varieties were more diffused than the HYV strategy envisaged. There is some indication that the actual growth of foodgrain production is slower than what could be expected from the absorption of inputs (including fertilisers) even at the pre-HYV level of fertiliser response, implying that the productivity per unit of nutrient may be declining over time.

Granting that there is much scope for raising the efficiency of fertiliser use, it is still necessary to pin down more precisely and in concrete terms the extent and sources of inefficiency. Desai rightly stresses the need for a larger, better organised and more diffused research network to evolve fertiliser recommendations adapted to local conditions and to carry this knowledge to the farmers, along with organisational arrangements to provide the necessary credit and bring the input supply network within easier reach of farmers. But the relative importance of environmental and institutional constraints is far from uniform, and we know far too little about their role in different crops and regions before operational programmes can be revamped. A systematic and detailed analysis of differences in fertiliser responses between experimental, demonstration and field conditions and the reasons therefor is indicated. Also, perhaps the wealth of detail contained in the cost of cultivation surveys could give us a better insight into the dynamics of fertiliser diffusion and response in different conditions. It would be useful if the group session addresses itself to identifying the kinds of analysis which could give us a better understanding of fertiliser use on the basis of available data.

IRRIGATION AND WATER MANAGEMENT

The development of irrigation has had a central place in the strategy for development of India's agriculture: while a great deal has been accomplished—both in terms of quantitative expansion and qualitative improvement—many problems remain. Broadly speaking, these relate to (*a*) the under-utilisation of potential created; (*b*) inefficient utilisation of facilities; (*c*) the question of equity in the distribution of benefits; and (*d*) some fundamental long-term problems of planning irrigation.

Under-utilisation

B. D. Dhawan's lead paper as well as V. K. Sharma's paper make the important point that the current practice of measuring under-utilisation by comparing the area actually irrigated with the area potentially irrigable is seriously flawed and misleading: For there are major ambiguities in the concept of irrigation potential and the way it is measured. The assumptions regarding the total quantum and seasonal distribution of water supply in a system and the extent of losses in conveyance and application which underlie the system design may be—and often are—

quite at variance with reality. The area which can be irrigated is a function of the crop pattern and the general experience has been that the actual crop pattern turns out to be at substantial variance from what was assumed in the project design. Much of the under-utilisation therefore may be more apparent than real, reflecting the inadequate data and unrealistic assumptions used by designers partly because of strong political pressures on designers to extend the command over as large an area as possible. The lack of field channels and inadequate land preparation in the command may also contribute, but they are not always the main reason.

Efficiency of Utilisation

Some of the papers have focussed on the physical efficiency, *i.e.*, the proportion of water let out at the head of the system which effectively reaches the root zone of the crops, the difference representing system losses. These losses are a function of both physical conditions and the way a system is designed; measures to increase the technical efficiency often involve extra costs and there are alternative ways of achieving a given level of efficiency. And yet there is far too little discussion of these aspects in the choice of project design; in fact not much is known about the extent of losses and the relative importance of different factors affecting them.

Without a fuller knowledge of the physical efficiency of an irrigation system, evaluation of economically efficient use of its water supply is also rendered difficult. In principle, of course, techniques (represented by various types of optimisation models) are available whereby one could estimate the 'efficient' allocation of a given quantum of resources (including water) available for cultivating the command area, in the sense of securing maximum output (or net income). But when the bulk of the water supplied is lost—Dhawan mentions a figure of 70 per cent but no one knows for sure and the figure could well be even higher—small errors in estimated losses make a sizeable difference to the quantity of water available to plants and therefore the validity of the 'optimum allocation'. The solution also depends on the water-yield response functions, including the water-varieties-fertiliser interaction. A great deal of research on the latter has been done over the last 15 years under the All India Coordinated Programme for Research on Water Management but the data remain largely unanalysed. Given these deficiencies, one has to take the results of optimisation exercises of the type reported here with considerable caution. In any case, very few of the projects are designed on such systematic analyses of alternative designs and alternative patterns of water allocation. This is obviously a major lacuna which demands attention from both planners and researchers concerned with water resource development.

Even if a project were designed after such careful deliberation, there remains the question of how efficiently the optimal crop pattern and the quantum of water supplied for each crop in different segments of the command can be enforced in practice. That actual crop patterns differ significantly from planned patterns is a well documented fact. Some of the papers presented at this Conference (and especially Dhawan, Sharma and B. W. Ashturkar) make pointed reference to the tendency for the proportion of area actually devoted to water intensive crops like paddy and sugarcane to be much higher than postulated in the design. This incidentally is an important reason why the actual irrigated area is generally less than

the estimated potential of the system. Dhawan further argues that Indian systems being designed for extensive irrigation do not provide enough water to realise the full benefit of modern (*i.e.*, HYV-fertiliser) technology. This is perhaps an overstatement inasmuch as the fact that the actual irrigated area is below potential implies that actually irrigated area receives more water than assumed; and also because the problem is at least as much—if not more than—one of timelines and assurance as of the total quantum of water supply.

Ashturkar's paper raises an important question whether a water intensive crop pattern is necessarily more socially efficient (in terms of additional output per unit of water) than a pattern which gives greater importance to water-light (so-called irrigated-dry) crops. He suggests that the latter could give a larger increment to total output from a given amount of water available and that it could have the added merit of making the benefits available to a much larger number of farmers and hence desirable from the equity view-point. This is a major point whose validity and implications deserve fuller discussion at this Conference.

Even if the optimal design and water allocation could be worked out in advance, we need mechanisms and procedures for enforcing them on a continuing basis. In general, some form of rationing of both area sown to different crops and water supply are universal in canal irrigation systems. There is some differential pricing of water by crops but the primary emphasis is on physical rationing. It is also observed that pricing is in general ineffective in controlling the crop pattern—the head reachers invariably seem to get away with planting more than the permitted area of wet crops.

Rotational irrigation has been tried in several systems to ensure equitable distribution of supplies within a season, apparently with some success. But the problem is evidently far from satisfactorily resolved: There is an extensive literature on the subject which unfortunately is not reflected in the papers presented here perhaps because it deals with institutions. But one important lesson to be learnt is that institutional mechanisms and procedures for water control are a crucial determinant of the effectiveness of irrigation and economists must pay much more attention to them.

Equity in Water Distribution

Dhawan has rightly drawn attention to two different aspects of equity in access to irrigation: One has to do with differential access across space and the other across different classes of farmers within a particular area. The former is to some degree conditioned by technical factors—like *e.g.*, rainfall, nature and size of catchment, the location of storage sites, topography and geological formations—which are necessarily subject to large regional variations. Even where technical solutions to such constrants may be available, their implementation may run into problems of the scale of investment and economic returns, not to speak of political conflicts. But as of now, one has to accept the fact that the potential for irrigation development does vary a great deal across States and even within States. The speed with which these potentials are exploited is largely a function of the resources available to the States and the priority they attach to irrigation.

The question of inter-class inequality has again two aspects: One relates to the superior access of larger farmers to water within a given system, and the other

to the superior access of large farmers to certain categories of irrigation. In surface systems, especially newer canals, all available evidence—some of which is cited in the papers presented here—suggests geographical location to be an important determinant of access: the head reaches being invariably better off than those at the tail. But this does not by itself establish size-bias unless there is a systematic and significant tendency for the larger holdings to be concentrated in the head reaches of the distribution network. This seems highly improbable and, at any rate, needs to be established as a fact. The extent to which larger farmers *in general* are able to manipulate allocations in their favour also need to be established.

On the other hand, there is little doubt that there is a decisive bias in favour of larger farmers in the case of groundwater. And since groundwater irrigation has grown much faster than surface irrigation, the distribution of total irrigated area may well have shifted in favour of larger farmers (note that this is consistent with the persistence of an inverse relation between the irrigation ratio and size of holding). This is a matter which can be investigated on the basis of the National Sample Survey (NSS) land holding surveys—if only the detailed tabulations were readily available!

Several issues concerning planning and implementation of projects have also been raised, primarily by Dhawan. The first and most obvious relates to problems arising out of the poor quality of projects, pressures to start far too many projects and to over-extend commands; the deplorably low standards of scrutiny before the projects are cleared, and the leakages in the process of construction.

(2) Conjunctive use of groundwater with surface water is a good way of increasing the quality of water management, but there is perhaps room for more effective regulation of the extent and location of wells in a command, particularly with a view to achieve a more equitable access for different reaches. Lining of canals and distributaries to save on conveyance losses (especially seepage) is not always desirable; the relative merits of lining and of allowing seepage in unlined systems to be recycled by the farmers need to be examined in the light of specific conditions of different commands.

(3) Outside the canal command, there is a widespread feeling that unregulated development of wells has led—at least in some areas—to over-exploitation reflected in a progressive lowering of the water table. Corrective action to arrest, and if possible reverse, the process in areas where over-exploitation has already occurred, and regulation to prevent the situation from arising in other areas are clearly important issues.

(4) The other critical problem area relates to the siltation of reservoirs and degradation of soil in command areas through waterlogging and salinity. The problem is serious, if not alarming. But precisely because the consequences are felt over a relatively long period of time, they tend to be ignored until it is too late and far too costly to correct. The ingredients of the preventive and corrective actions are known but governments have been short-sighted and niggardly in providing the necessary resources to implement them. The seriousness of this set of problems and the fact that they, like much else to do with irrigation, require action on both the technical and the institutional fronts perhaps deserve greater emphasis than is apparent in Dhawan's paper.