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CONSULTING REPORT:

A SURVEY AND ANALYSIS OF EX-POST COST-BENEFIT STUDIES OF SAHELIAN IRRIGATION PROJECTS

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A SURVEY AND ANALYSIS OF EX-POST COST-BENEFIT STUDIES OF SAHELIAN IRRIGATION PROJECTS

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INTRODUCTION AND SUMMARY

The Sahelian droughts of the 1970's stimulated interest in irrigation projects in that region. Along with a flush of proposals for river basin development and increased investment in irrigation projects came a number of papers expressing reservations about various aspects of such developments (e.g., Brokensha, et al., 1977; Nelson and Tileston, 1977). One of the concerns was the generally poor record of irrigation projects in the Western Sahel. This paper is an attempt to draw together bits and pieces of ex-post "cost-benefit" studies done in the past five years. The term "cost-benefit" is used advisedly since social cost-benefit analysis has gained the status of a methodology in economics. Strictly speaking, its application would imply adherence to a well-defined theoretical framework as layed out in Sen, Marglin, and Dasgupta (1972) for example. In practice its application requires the exercise of considerable judgment in lieu of solid information. Therefore the lines between full cost-benefit analysis and partial analysis become blurred. Because there were but two studies which came close to a full ex-post cost-benefit analysis, this paper has made use of cost-benefit like data. Another limitation of this paper is its focus in irrigation as opposed to the much broader issue of river basin development.

Two excellent master's theses provide the most comprehensive ex-post cost-benefit studies of Sahelian irrigation projects. Coincidentally, both evaluate projects on the Senegal River and there is overlap which provides a

useful comparison of assumptions. In addition there are a number of studies describing particular projects such as papers from the West African Rice Development Authority (WARDA), a series of recurrent cost studies done by the Harvard Institute for International Development (HIID) for the Club du Sahel, and World Bank reports. Particularly useful is a series of works done by Purdue's USAID project on irrigated perimeters in the Sahel. The later study, under direction of William Morris, was unique because it enlisted the expertise of senior Francophone social scientists such as J. L. Boutellier, a consultant for Office du Misien Value of Fleuve Senegal (OMVS), and J. Y. Weigel of the Paris-based research institute OSTROM. Access to their work in English greatly facilitated the job of gleaning current knowledge about village level economies on the Senegal River.

Although there are considerable differences between different analyses, one fairly clear conclusion is that investment in large scale irrigation of rice falls far short of paying for itself in the Sahel. Another conclusion is that small scale irrigation of rice probably does pay for itself and then some. This is not to say that rice is the only irrigated crop, but it is the crop which most interests Sahelian governments, and it is the crop for which the most information is available.

A partial explanation for inefficiency of large scale projects lies in the attempt to use hierarchical control of production processes which are most efficiently operated under decentralized control.

By contrast, small scale irrigation projects (small perimeters) leave much more control in the nads of farmers -- including considerable choice in cropping mix and disposition of production. Individual farmer participation in small perimeters is definitely supplemental to their existing farming

operations. Interestingly, much more labor is used per hectare on these supplemental plots than the full-time plots of the large perimeters. It is argued, however, that the real labor cost of small perimeters is overstated relative to large perimeters because small perimeter farmers are left with productive alternatives for their off-peak labor. Larger perimeter farmers have been resettled and have fewer opportunities to use their off-peak labor constructively. Moreover, resettlement schemes are notoriously devoid of community which means collective goods are undersupplied. A conjecture is that smaller perimeters are likely to result in much more substantial downstream multipliers from incomes spent locally than are large perimeters which more closely resemble "enclave," or extractive type industries which have very small local multiplier effects.

Policy recommendations include avoidance of new large scale perimeters in favor of small scale perimeters; re-organization of existing large scale perimeters to allow farmers more control; redirection of government agencies away from their role in managing production and subsidizing inputs and toward a client-oriented R & D program aimed at particular constraints limiting farmer productivity -- e.g., research into alternative pumping technologies for small perimeters and supplemental irrigation. If government agencies limited themselves to the role of research and development services for farmers lack of farm-level cost-benefit data need not concern aid donors because the problem of assessing the profitability of new technologies could be transferred to farmers. Finally, there is one area where additional benefit-cost data are necessary: in the case of large scale, indivisible water diversion or impoundment facilities. Scudder and others have rightly cautioned that large dams on the Senegal and Niger Rivers may have catastrophic consequences for

thousands of farmers who depend upon flood recession agriculture. Proceeding with such projects without provision for these farmers should be unthinkable.

SOME COST-BENEFIT INFORMATION: LARGE SCALE IRRIGATION OF RICE

The two studies which most closely fit the ex-post cost-benefit analysis framework are applied to the same area, and in fact both cover the same project -- the Nianga Project -- yet they come with seemingly contradictory conclusions! Weiler (1979) concludes the Nianga Project is profitable while Diallo (1980) finds it to be grossly unprofitable in its major crop, rice. This does not indicate fault on the part of either analyst, rather it is partly explained by the difference in focus of the two studies and partly by the lack of hard data which forced both authors to exercise judgment of important consequence. Weiler was the only study cast in the formal mold of a cost-benefit analysis of a whole project. It was the only study which considered the without case, i.e., the agricultural production which was displaced by the Nianga Project. This means that it is not directly comparable with the bulk of the other studies, including Diallo's, which were heavily preoccupied with rice production. Nevertheless, it is possible to dig into Weiler's assumptions about costs and benefits of rice production in order to make a comparison with Diallo's results and results of others who have studied the profitability of rice production in Senegal, Gambia, and Mali.[1/]

Weiler finds the Nianga Project marginally profitable using both market prices and shadow prices. There are, however, crucial assumptions which can

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[1]Apart from its analytical content, Weiler's thesis is recommended for its description of the political and organizational realities of a large perimeter project. This description is mostly to be found in Chapter III.

tip the balance in the other direction. These stand out when compared with assumptions used by Diallo. Most notable are assumptions of rice yields (4.5 metric tons per hectare versus 3.1 metric tons per hectare for Diallo), an apparently low transport and milling cost for government marketed rice (versus rather severe assumptions by Diallo), a generous assumption on the life of pumps (7+ years versus a more realistic 5 years by Diallo), and an assumption that salaries of upper-level project staff are not costs of the project (versus Diallo's assumption that even cost of staff at general headquarters of the umbrella agency, SAED, should be attributed, pro rata, to the project).[2/] Another difference was that Weiler accounts for the fact (amply documented in studies cited below) that 32 percent of rice production at Nianga is consumed locally while Diallo assumes all rice is marketed through SAED and consumed in Dakar. This is significant in light of the high milling costs assumed by Diallo, and in light of the fact that Weiler treats rice consumed locally as an import substitute -- therefore adding a benefit of transport costs and foreign exchange saved.

Tyner and Manteufel (1980) take issue with Weiler's assumption on the grounds that absent locally produced rice, Senegalese farmers would not consume imported rice but rather locally produced millet. The facts on this issue are not clear, but there is evidence that Weiler's assumption is better than Manteufel and Tyner's (credit only SAED's official price of rice for locally consumed rice) or Diallo's. Village studies done by French social scientists have found (1) that on small perimeters local prices of rice are generally

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[2]Weiler has a point. In Senegal, jobs are guaranteed to all persons achieving a certain level of education. Therefore, in a sense, the salaries are fixed costs. On the other hand, one can note that this assumption implies a certain cynicism regarding the opportunity cost of SAED staff time.

above the price given by SAED (Fieloux, 1980), therefore only a small fraction of rice produced in smaller perimeters is sold to SAED and (2) that farmers on the Senegal River have access to substantial income streams repatriated by extended family members who have migrated to urban centers or abroad (Weigel, 1980). These income streams are estimated to be quite substantial -- $13 million for the Soninke ethnic group alone! -- and they have been used partly to purchase grain for consumption. It can be argued that even if purchased grain is millet, on some level those purchases increase the demand for rice. Apart from that consideration, there is the failure of all studies to credit rice consumption with the well known labor savings in preparation when compared with coarse grains. If local prices are used, this credit is claimed, but use of CIF plus transport or SAED's price doesn't capture it. Since women's labor is increasingly important in agricultural production (Fieloux, 1980), this saving is, in principle, monetized by local market prices.

Assumptions made about milling costs turn out to crucial. Diallo's source for milling costs was Tuluy (1978). In a related paper Tuluy (1979) develops a whole range of milling costs, including milling done by hand in the village, at a cost of CFA 5.3/kg. of milled rice, milling done by small machines in rural areas at a cost of CFA 7.08/kg. of milled rice, and milling done by large scale government mills at a cost of CFA 26/kg. of milled rice. This latter cost compares to the cost of imported milled rice which is about CFA 80 (CIF)! Tuluy is not explicit (in his WARDA report) about why the cost of processing in goverrment mills is so high. He does mention (1979, p. 17) that the plants run far below capacity, but if this is so, then the marginal

cost of processing rice at those mills should be quite low. At any rate, it is the CFA 26/kg. of milled rice that Diallo uses.

Diallo's assumed administrative cost attributable to production amounts to CFA 29/kg. of milled rice. It should not be surprising that Diallo finds rice produced at Nianga much more expensive than CFA 80/kg. imported rice. One can argue that Diallo's assumptions are too harsh, but even if one accepts Weiler's overly generous assumptions, Nianga rice production is not profitable. The most direct way to see this is to subtract out the revenue Weiler attributes to tomato production: after 1982, tomatoes are assumed to account for 70 percent of the gross value of production at Nianga on less than 17 percent of cultivated acreage! If the project were marginally profitable with tomatoes, then it is clear that it would be unprofitable without them! Clearly rice production on the Nianga perimeter is unprofitable. This is, of course, taking into consideration the sunk costs of building the perimeter. It cannot necessarily be concluded that considering only variable costs rice production is not profitable.

According to Diallo's cost/ha, the variable cost of producing a kilogram of milled rice (ignoring milling costs) would be CFA 145 using Diallo's assumed yield. However, if Diallo's administrative cost is dropped and if Weiler's assumed yield is used the cost would be CFA 82, which would be profitable if the rice were consumed locally and if hand milling were not counted as a cost. So it appears that rice production on the already existing perimeter may be profitable even though it would not pay to build a similar perimeter to grow rice.

Tuluy (1979) is yet another source of estimates of the cost of rice production at Nianga (and six other locations in Senegal as well). Excluding

investment costs, Tuluy finds that rice production for local consumption is profitable at Nianga, but only marginally so.

How does Nianga compare with other large perimeters? Diallo concludes that the Delta perimeter is more than 50 percent more expensive than Nianga in producing rice and costs at the Dagana perimeter are less than 75 percent of those at Nianga. Subracting only administrative cost and using a generous yield the cost of producing rice at Dagana is still 25 percent above the cost of imported rice (not considering milling or transport). Thus, the Dagana Project is strongly unprofitable when investment is counted.

When investment costs are subracted out the cost of producing a kilogram of milled rice at Dagana is CFA 56. Thus rice production at Dagana for consumption in Dakar might be profitable -- not counting the sunk costs. Tuluy also computes the cost for producing rice at the Delta perimeter and finds it the most unprofitable of all -- consistent with Diallo.

There is a strong case that large irrigated perimeters in Senegal are bad investments if their main crop is to be rice. Does this experience carry over to other countries? The only country for which comparable studies were found was Mali. Martens (1980) found that Mali's Office du Niger (ONM) rice production was not meeting recurrent (maintenance) expenses. Martens uses an unpublished USAID paper done by McIntire (1978) which employed crop budget/ linear programming techniques. Assumed yield for rice on the ONM Project was 2.3 metric tons/ha. Taking ONM figures for a satisfactory annual maintenance budget of $233 to $268/ha and the official price given for rice, Martens showed a gross return of only $230/ha cultivated in rice on the project.

Martens (1980) makes it clear that he believes the shortfall to be a result of irrational pricing policies followed by the Malian government, and that

the project could meet costs and then-some by rationalizing water and rice prices. The argument is plausible, but the dominant fact is that after 50 years of experience, the ONM is at best able to meet recurrent costs. It seems highly improbable that investment in large perimeters in Mali can be justified in terms of efficiency. Indeed, this seems to be the message of the World Bank's (1978) report which suggests funding of expenses to compensate for extensive deterioration of the ONM's physical capital due to inadequate maintenance over a number of years. The Bank strongly suggests that ONM's recurrent costs be put in order before any thought is given to expansion.

LARGE PERIMETERS AS RESETTLEMENT SCHEMES

Given the demographic patterns of West Africa, large perimeters invariably involve resettlement schemes. Therefore, one should look at the record of resettlement schemes as a standard for comparison and as a basis for predicting results. Results of resettlement schemes have been almost universally bad.

The records of resettlement projects in Senegal and Mali have counterparts elsewhere: during the 1950's the British attempted a large scale resettlement scheme in Nigeria (Baldwin, 1957). It took several years of operation before that project even reached the level of production of surrounding traditional farmers and the project folded after five years. Nor is the experience peculiar to West Africa or developing countries in general.

The record of resettlement in the U.S. is the subject of an article recently published by Marion Clawson in the journal, Agricultural History. The article consists of a brief introduction followed by the text of a report which Clawson had put together in January of 1943, over 35 years ago, but which he never released. The report gave results of a comprehensive study of American resettlement schemes instituted during the depression of the 1930's. Nine

projects of the Farm Security Administration were studied. The Farm Security Administration co-operated, believing that the projects would "provide a model for agricultural development of the irrigation project." (Clawson, p. 2.) But the "record on these projects was shockingly bad; far from being a model which should be imitated, they were examples of what should be avoided. At first FSA found excuses for the record, then in embarrassment tried to drop the study." In the summary the report concludes that the program failed to achieve incomes anticipated, settlers were unable to increase materially their capital and net worth, the projects failed to "achieve a high degree of stability among settlers in the sense that the settlers were able to or wish to remain on the project permanently or for long periods," and the "operations of the project have built up large amounts of frustrations on the part of settlers and appreciable social tensions among them." (Clawson, p. 77)

Similar patterns are reported by Scudder (1973) in a study of resettlement associated with displacement of populations by large dams. Private conversation with Scudder indicates that his current world-wide study of resettlement projects reinforces this message.

ORGANIZATIONAL PROBLEMS ENDEMIC TO LARGE PERIMETERS

If one considers the large perimeter/resettlement scheme from the perspective of information and incentives it represents potential inefficiency at every turn. First of all, agricultural production represents an archtype of a production process least amenable to control by a hierarchical organization. The tasks involved vary drastically day by day and from one place to another. Standard operating procedures lead to very suboptimal results. Contrary to popular images of highly profitable "corporation farms" employing dozens of

persons, the world's most productive agricultural sectors are dominated by small organizational structures -- to be sure, these may cover hundreds of thousands of hectares in the U.S., but the organization controlling the production remains small (Seckler, 1977; Sparling, 1980).

Irrigation of agriculture by surface water (as opposed to individual pumps), introduces a collective good problem on top of an industry which is extremely difficult to integrate horizontally. Operation and management of an irrigation network introduces potential for free-rider problems and conflict. Efficient operation therefore must depend upon existence or formation of a certain "social capital" composed of tradition, leadership, communication, and trust. Needless to say, such social capital is more likely to exist in stable communities than in resettlement towns.

Inability to form requisite social cpaital can lead to dependence upon higher authorities to provide needed collective goods or to enforce appropriate actions by farmers. But this dependence on outsiders has the effect of preventing the development of social capital if it is not there, and it can destroy the social capital if it were there in the first place.[3/]

Maas and Anderson (1978) have argued correctly that irrigation systems do not have to imply dependence on outside authority. They give multiple examples where farmers act collectively to assert their interests, both in terms of their physical environment and in terms of their political environment. It should be noted, however, that none of their examples involve

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[3]This theme is found in a number of places in the literature on public choice, e.g., James Buchanan (1975) and Michael Taylor (1976). One of the most persuasive examples is that given by Thomas Schelling (1960): Neighbors who rely on the services of an outsider to settle petty disputes are cutting off the possibility of compromise solutions and development of a co-operative relationship. Once the outside force is resorted to, the "game" is reduced to a zero-sum game so that future disputes cannot be resolved co-operatively.

resettlement schemes. Furthermore, in every case the collective action arose among farmers who were autonomous members of a stable community. It can be inferred that such collective action will not arise in the company town atmosphere of resettlement communities -- indeed, the term "company town" has come to be synonomous with gross underprovision of collective goods.

SMALL IRRIGATED PERIMETERS AS INCREMENTS TO A LARGER PLAN

The above argument points toward consideration of small irrigation perimeters as an alternative to large perimeters. Small perimeters can be established in conjunction with on-going agricultural production, thereby making use of the existing social capital to deliver necessary collective services.

In the context of West Africa the incremental nature of small perimeters also has implications for efficiency at the farm level. In many places farmers already practice river water related cropping -- that is, flood recession agriculture. In some places the farmers have independently found ways to partially control or augment flood waters (McIntire, 1978; Marzouk, 1980). Benefits of added control over water are therefore readily apparent to these farmers. Furthermore, familiarity with crops and the manipulation of water flows constitutes a fund of human capital usable for irrigation.

Efficiency of labor use is another virtue of incremental projects. As in most places, Sahelian agriculture is seasonal in its labor demands. But tropical Africa differs from many areas of the developing world in its high land to labor ratio. Nearly universally in the Sahel, labor is a dominant constraint in agricultural production. Diversification of cropping as well as mixed crop-livestock enterprises represent a strategy to spread out peak labor demands. Improved water control can add yet another degree of flexibility for

farmers who follow such a strategy of diversification. In short, there is an excellent efficiency case to be made for allowing farmers autonomy in selecting mixes of cropping enterprises which fit their resource endowments. Small perimeters seem to do just that (Freeson (1978) makes the same point in describing the success of the Matam small irrigation perimeters project). By contrast, resettlement projects extract settlers from niches where they had flexibility and impose upon them the inflexible requirements of a hierarchy. For this reason the labor cost of crops grown on resettlement schemes is probably understated while the like costs for crops grown in small perimeters is overstated.

If the above arguments are correct, then we may expect to find that small perimeters are more efficient than large perimeters. In fact, judging from studies discussed below, this seems to be the case.

If there is lack of agreement between studies regarding the profitability of irrigated rice in Senegal and Mali, there is agreement on the comparative profitability of large and small perimeters. Diallo finds the production costs of rice on the Matam project to be 23 percent to 64 percent below that of the three large perimeter projects he analyzes. Tuluy computes budgets for rice grown in the Matam project and two large scale perimeters on the Senegal River -- finding the Matam project to be at least 25 percent less expensive in producing rice. Tuluy also computes budgets for traditional rice production along the Casamance River in southern Senegal, and for traditional production with improved water control. This is found to be at least 12 percent lower in economic cost than the large perimeters. McIntire's unpublished report (1978) gives a similar analysis for Mali. His analysis shows the Office du Niger on a par with projects in Segou and Mopti which involve partial control of water, however, McIntire treats investment costs

in ONM as sunk -- therefore conceding the likely unprofitability of expansion of large perimeter production.

PROFITABILITY OF SMALL PERIMETER RICE PRODUCTION

Thus far evidence points to two conclusions: (1) large irrigation perimeters are unprofitable, at least for rice production; and (2) small scale irrigation perimeters are more profitable than large scale perimeters. It remains to be seen whether small scale perimeters are profitable. One indication of small perimeter profitability is the existence of small irrigated perimeters which have sprung up spontaneously or without subsidies. Several small village-level perimeters have sprung up spontaneously in Maruitania due to benign neglect of the Mauritanian government (Boutellier, 1980, p. 6). In Gambia, the MacCarthy Island Project was successfully developed with practically no subsidies (WARDA, 1976). Since the MacCarthy Island Irrigation Project was thriving on its own, we can fairly assume that the farmers found it privately profitable.

If small perimeter rice production is privately profitable there is reason to believe that social profitability is yet greater. Justification for this position is the probable existence of a significant positive multiplier effect for development of small scale perimeters. The theoretical issue of whether it is appropriate to count multiplier effects as more than regional income redistribution is side-stepped by claiming that there exist substantially underutilized resources in rural areas, and by pointing to recent arguments by Mellor (1976) that consumption linkages do matter for agricultural development.

In a recent article, Bell and Hazell (1980) used partial input-output analysis to study the downstream multiplier effects of an irrigation project in Malaysia. "Downstream" multipliers are the indirect effects of a project

felt by those who provide increased goods and services to farmers whose incomes have increased. To the extent that there exists "underutilized" capacity in the rural areas these effects can be counted as benefits of the project. The Malaysian irrigation project studied by Bell and Hazell was not a small perimeter, but was in fact a river basin development. The irrigation component did however resemble the small perimeters development of the Senegal River in the most essential respects: the farmers were already there growing rice but dependent on seasonal rainfall; irrigation permitted them to grow two crops per year and to utilize high yielding varieties. In the period of the study (1967-1974), incomes of 51,000 farm households doubled.

Bell and Hazell devised their semi-I/O model in order to examine the effects of this increase on the non-farm households of the region. With and without project analyses showed that incomes of non-farm rural sector families was more than 14 percent above what it would have been without the project whereas incomes for landowners as 66 percent to 71 percent above what it would have been while the percentage rise for landless laborers was 73 percent above what it would have been.

How applicable is this to Sahelian countries? Using household survey data from sub-Sahelian Sierra Leone, King and Byerlee (1978) studied the marginal propensity to consume rural versus urban produced commodity groups. Somewhat to their surprise they discovered that the income elasticity of rural non-food products was 1.40. This runs counter to a hypothesis of Hymer and Resnick (1969) that these goods would be inferior -- have negative income elasticity of demand. But the King-Byerlee result is consistent with the findings of Bell and Hazell. Moreover, the income elasticity of demand for locally produced goods and services will be higher the further the region

from major urban areas; transportation costs will make local products more competitive. Since Sahelian farmers are generally more remote from urban areas than are Sierra Leonean farmers, one may expect strong MPC's for local goods and services and that downstream regional multipliers will be quite significant in the rural Sahel.

By contrast, large perimeters/resettlement schemes remove farmers from their village economies without bringing along the rural non-farm workers who supply the rurally produced goods and services studied by King and Byerlee. The result is that farmer income is more likely to be spent for modern sector products. Moreover, since these projects always have a significant population of middle level staff who demand modern sector commodities, there will tend to be easier access to urban manufactured and imported goods. In short, the resettlement scheme has the multiplier characteristics of an extractive industry -- there is relatively little indirect effect on the surrounding region's economy.

INCOME REDISTRIBUTION EFFECTS

Introduction of irrigation technology into regions depending on rainfall or flood recession naturally raises questions about income distribution effects. As Boutellier (1980) reports, there are uncertainties about how class structure and land tenure in flood recession areas will affect the organization and performance of small perimeters. Availability of irrigation can be expected to increase the value of labor so that those classes who sell their labor are likely to benefit proportionately more. If water allocation in small perimeters is tied to families rather than to land, it is also clear that small holders and laborers will benefit proportionately more than those with use rights to larger areas of land. There is some evidence that the availablity of irrigation

water in the Soninke area has benefited to the lowest castes most in that they have assured rights to irrigated land now whereas before they were at the mercy of nobles for the use of flood recession land (Weigel, 1980).

In large perimeters allocation is under control of the organizing agency, and it is in principle easy to assure equitable allocation among participating farmers. Waldstein (1978) has a good discussion of the income redistribution effects among peoples neighboring large perimeters. He studied the Delta Project in Senegal in depth and surveyed literature on other projects. It is not possible to do complete justice to his discussion in a brief section, but he feels that income redistribution effects are mixed in the surrounding region, and probably worst for pastoralists who had previously depended upon river lands for dry season pasture.

Regional income distribution effects in either the large or in the small perimeter are bound to favor the rural over the urban sector. It is argued above, however, that the difference will be more marked for small perimeters than for large.

ECONOMIES OF SIZE IN INVESTMENT VS. DISECONOMIES OF SIZE IN RECURRENT COSTS

A plausible argument in favor or large scale perimeters is their theoretical economies of size in facilities. This advantage does not show up in comparisons of existing small and large perimeters (quite the contrary, small perimeters cost are only a fraction as much as large in an area comparison), but it must be noted that many of the large perimeters have not had a chance to go beyond the pilot project stage (most notably the Nianga Project). However, one must weigh against the theoretical economies of size in diversion and delivery facilities the theoretical diseconomies of perimeter size in recurrent costs. Recurrent costs are an acute problem for public projects of all kinds

in West Africa, so much so that the Harvard Institute of International Development recently co-ordinated a large study of this problem (Gray and Martens, 1980). The problem is not easy to unravel in practice, but the underlying phenomenon is well understood: overlapping jurisdictions and collective good externalities naturally lead to free-rider problems and heavy transactions/monitoring costs in controlling recurrent costs. One way to circumvent the problem is to vest ownership of the collective resources in individuals who then have incentives to maintain them at reasonable costs. A somewhat less efficient solution is to vest ownership in a small group of users. The trick is to have non-trivial shares in the collective good so that there are less significant tendencies to free ride, and so that it is easier to detect those who elect to free-ride. Small perimeters seem to fit this description quite well according to several reports (Fresson, 1978; Boutellier, 1980).

POLICY IMPLICATIONS

The clearest implications are that large perimeters are poor investments, small perimeters are privately profitable investmensts and socially even more profitable. But some qualifications need to be made. First of all, existing large perimeters involve large sunk costs, and do represent socially profitable means of production -- at least potentially. The problem of recurrent costs is a very sticky one for these perimeters -- being a problem of crossed jurisdictions and a chronic problem of information and incentive structure. Secondly, it is not aggregate size which is a problem so much as it is the size of increments. In other words, a large project which delivers water to a large number of small perimeters need not be plagued by the same administrative tangle as a smaller project which tries to deliver water to a single large perimeter and to control the use of the water within the perimeter. The case

of trying to deliver water to many small perimeters and to control the use of water within the perimeters presents an administrative nightmare, so hopefully agencies such as SAED would be discouraged from trying too hard. Besides, in smaller perimeters, smaller numbers of water users works in favor of farmers organizing themselves to counterbalance overzealous administrators. According to Weigel's account of the interaction of the Soninke and SAED in Bakel, the Soninke have been quite successful in wringing successive concessions out of SAED. Unfortunately, when entrepreneurial energies are directed toward political methods of capturing income streams there is likely to be a lapse of attention to details in the economic side. The moral seems to be that both subsidies and administrative controls should be kept at a minimum so that there is little potential for such political entrepreneuring.

Incrementalism is also indicated i.. the realm of technological change. Just as the project size is not necessarily bad, neither is mechanization. But just as the size of increments in irrigation matters a good deal, so does the size of increments of change in technology.

While a package of technological change has great theoretical appeal, it ignores the fact that surrounding any technology is a great deal of tacit knowledge of details which need to be accounted for if the technology is to function smoothly, but which are not specified (or even specifiable). These details are the type that lead to giant cost overruns on defense contracts, and they are well appreciated by anyone who has undertaken as mundane a task as remodeling a home. Therefore, incrementalism is a good rule of thumb for those seeking to introduce technological change into irrigated agriculture.

For some time there has been much made of the systems approach to agricultural research. It is significant that recent writing on the subject of farming

Systems Research has been moving toward the position of incrementalism. This tendency has been largely implicit, but comes through strongly and it carries considerable credibility because it stems from field experience.

In a recent critical survey of Farming Systems Research, three eminent West Africanist agricultural economists place a clear emphasis on the importance of farmers' knowledge (Gilbert, et al., 1981). A similar message is contained in a paper by three experts on South Asian irrigation (Clyma, et al., 1977). "Systems approach" in the context of this literature seems to mean a spirit of interdisciplinarity, but it stresses attacking one constraint or problem at a time. There is a healthy growth of humility amongst practitioners of farming systems research as they become increasingly aware of the great fund of tacit knowledge which resides in their clients, the farmers

This discussion is a bit general and needs to focus back on what it all means to USAID as it faces the problem of what to do about aid in Sahelian governments. It implies that USAID should pursue a joint policy of encouraging Sahelian governments to approach irrigation investment in the role of technical advisers only, and to build into these advisory roles the capacity to conduct constraints research. In other words, the engineers and agronomists who help farmers in establishing their own irrigation perimeters should be a conduit for information concerning farmer problems. USAID should encourage and support efforts of governments to do research and development work on such small problems as adapting small pumps to the farmers' needs, or designing structures which can be easily used to divert water from one field to another, or to consider the special drainage problems of specific perimeters, or to develop guidelines farmers can use in determining water requirements of a given crop, or to identify suitable irrigated fodder crops. In other words, research should be motivated by real farmer problems.

A final note should be made of the importance of existing, traditional methods of irrigated agriculture, particularly flood recession agriculture as practiced on both the Senegal River and the Niger River. This paper has made much of the potential for augmenting this type of irrigation, as is being done in the small perimeters of Senegal. So far these perimeters encompass a few thousand hectares, out of 50,000 to 120,000 hectares (Boutellier, 1980) generally believed to be irrigated by flood recession. The area irrigated by this method in Mali's interior delta alone is thought to be in excess of 100,000 hectares (Brokensha, et al., 1977). Brokensha, et al., have expressed a well founded concern that plans to build large dams upstream of these flood recession irrigators threatens their existence. If the dams go in without sufficient lead time for the farmers to adopt augmental irrigation methods, the Sahelian countries stand to harm thousands of people and possibly to induce their migration away from precisely the areas where their human capital and labor is needed to develop small perimeters.

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