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A Thesis

Submitted to the Faculty

of

Purdue University

by

Edward M. Weiler

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

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ABSTRACT

Weiler, Edward M., M.S., Purdue University, May 1979. Social Cost-Benefit Analysis of the Nianga Pilot Project, Senegal. Major Professor: Dr. Wallace E. Tyner.

In response to the most recent Sahelian drought, various international donor agencies have been solicited to increase substantially the necessary capital for the development of irrigated agriculture. Within this Sahelian Zone, the OMVS Region (comprising the countries of Senegal, Mali, and Mauritania) has commanded a great deal of international attention, with the primary concern focusing on the development of tertiary irrigation (i.e., full water control) in the Senegal River Valley.

The major problem facing such donors, however, is the heretofore lack of sound economic analysis on the existing tertiary projects in the Region. In order to fill this gap, an ex post analysis of the Nianga Pilot Project in Senegal was undertaken. In operation since mid-1975, the Pilot Project consists of approximately 600 hectares of irrigated parcels arranged into 35 collective farms. At some point in the future, provided the funding is available, the Pilot Project will be extended into the surrounding development area (approximately 10,000 hectares) known as Grand Nianga.

Social cost-benefit analysis from an ex post perspective was used to derive three measures of project worth; and subsequently,

sensitivity analysis was used to examine the effects of various yields, prices, etc. on the foregoing results. In addition to the formal cost-benefit analysis, considerable attention was given to a descriptive but nonetheless rigorous review of the evaluation of the Nianga Project from its conceptualization through the present operational phase. Finally, a comparison was made between the ex ante feasibility study and the present ex post analysis.

The results of the cost-benefit analysis show that the Nianga Pilot Project,as currently designed, is modestly profitable from a social standpoint when a discount rate of 10 percent is used, but decidedly unprofitable from a financial perspective at any rate of discount rate deemed appropriate for Senegal. The recent rise in world commodity prices has increased the social profitability of projects such as Nianga to the extent that the "conventional wisdom" that tertiary irrigation is highly unprofitable needs to be reconsidered.

Furthermore, it was found that the decision makers of OMVS/FAO failed to reformulate the Project's design, despite the unfavorable findings of the ex ante feasibility study. Indeed, had various recommended cost-cutting proposals been implemented, the profitability of the Pilot Project would have been significantly enhanced. Based on the foregoing, it was concluded that tertiary irrigation, though not as currently designed and operated at Nianga, is potentially an economically viable enterprise in the Senegal Valley.

CHAPTER I

INTRODUCTION

The Problem

The legacy of the most recent Sahelian drought (1967-1974) has been the determination of many international funding agencies to "do something" to prevent a recurrence of the widespread famine and economic disruption that devastated most of the Sahelian region during that period. A considerable amount of this attention has been focused on the Senegal River Valley--or as it is more commonly known in the international development milieu--the OMVS Region.[1/] Not surprisingly, water control in general, and irrigated agriculture in particular, are seen as key components in solving the food problem. In a May 1976 report, OMVS concluded that:

> ....The solution of the Sahelian problem should be sought in a middle or long-term program for water control to meet the needs of human beings, plants, and animals. Such control should be secured in part through the stocking of large reserves of water near river basins; such an arrangement would make water available at will for distribution as and when required...As regards agricultural development in the Basin, the main option is irrigated farming....[2/]

1/ OMVS (Organization Pour La Mise En Valeur Du Fleuve Senegal): A Consortium consisting of the nations of Senegal, Mauritania, and Mali, which has as its goal the economic development of the Senegal River Basin.

2/ OMVS, <u>The OMVS Programme: Presentation, Methods, and Means of Implementation</u>, (Dakar: OMVS, 1976), pp. 13, 32.

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It would be incorrect, however, to conclude that interest in promoting irrigated agriculture in the OMVS Region, and in Senegal in particular, is of recent vintage. In a monograph of SAED,[3] Minelphe Diallo pointed out the efforts of Baron Roger in the early 19th Century under the French Colonial Government to develop irrigated agriculture in the area of Senegal which has come to be known as Richard Toll.[4] Within the present era, MAS[5] was created in 1938 to coordinate research and development of irrigation throughout the Senegal Basin. In 1939 work was begun on an irrigation project at Guede, and by 1943 1,000 hectares were ready for cultivation.[6] In 1946, a pilot perimeter of 120 hectares was begun at Richard Toll. By 1957 this had been expanded to cover 6,000 hectares; and by 1973, the year that construction began on the Nianga Perimeter, some 21,000 hectares had been developed.[7],[8] Moreover, as will be discussed later, plans for an irrigation project on the site of the present

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3/ SAED (Societe Pour l'Amenagement Et l'Exploitation Des Terres Du Delta): A semi-autonomous agency with the Senegalese government charged with the development of irrigated agriculture in that country's portion of the Senegal River Basin.

4/ Minelphe Diallo, "Une Societe Regionale: La SAED," Republique du Senegal, December, 1975 (mimeographed).

5/ MAS (Mission Pour l'Amenagement Du Senegal): An organization created by the French Colonial Government in 1938. The former is now defunct.

6/ Diallo, p. 74.

7/ OMVS. Perimetres d'Irrigation Sur la Rive Gauche du Fleuve Senegal (Dakar: OMVS, 1977), p. 6.

8/ This is not to say, however, that 21,000 hectares were actually under cultivation in this year. At the same time new areas were being developed for irrigation, other earlier developed areas were being abandoned for a variety of reasons.

Nianga Perimeter were laid as early as 1951.

From the foregoing, it would seem that sufficient operating experience would have been gained so as to give international funding agencies a clear idea of what would and would not work vis-a-vis irrigation in the Senegal Valley. However, as Bergmann has so aptly pointed out, while it is generally accepted that economic studies should be done prior to the inception of an irrigation project, post-evaluation analysis has been generally neglected by all financing bodies.[9/] This is certainly the case for the development that has occurred in the Senegal Basin. A review of the literature at the OMVS Documentation Center (St. Louis, Senegal) has turned up only two post-evaluation economic studies worthy of the name.[10/]

While on the face of it, two such studies, as noted above, might appear to be satisfactory for guiding potential donors in making funding decisions, it should be pointed out that there has been a rethinking of the technical givens of irrigation in the Basin since the late 1960's. The succession of failures in the early projects, which relied upon flooding by the Senegal River for irrigation water, and upon natural rainfall for crop-sprouting, made it clear to all that a different scheme was essential.[11/] As early as 1969, a decision was made by SAED that henceforth all perimeters would be converted to a

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9/ Helmuth Bergmann and Jean-Marc Boussard, Guide to the Economic Evaluation of Irrigation Projects (Paris: OECD, 1976), p. 12.

10/ The reader is referred to: R. D. Hirsch, Etude Economique du Casier de Richard Toll, 1972, and R. Rodts, Etude Economique du Casier Rizicole de Guede, September 1970.

11/ OMVS, The OMVS Programme..., p. 28.

system known as "tertiary development" (amenagement tertiaire).[12/] Briefly, this system necessitates peripheral diking and pumping for external control of water, as well as strict levelling of the interior paddy land, cut into small parcels by many low dikes, for internal control.

In effect, the funding agencies were practically back at point zero. It was clear that the old gravity-fed, rainfall-dependent system was not workable on technical grounds. But would the newer, more intensive (and hence more expensive) system of tertiary development be feasible on economic grounds? At that point, the only evidence was the feasibility studies for new perimeters yet to be built. It is a matter of history, of course, that the Perimeter of Dagana (Sectors A and B, for a total of approximately 2,700 hectares) and the Pilot Perimeter of Nianga (approximately 650 hectares) were in fact built using the system of tertiary development. As of this writing, negotiations are underway between the Government of Senegal and the Federal Republic of Germany for a project leading to the development of about 1,500 additional hectares of irrigated land (Sector C) at Nianga.

To date, no post-evaluation economic studies have been carried out on the SAED experience with tertiary development.[13/] The question

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12/ SAED, Presentation Succincte de la Societe d'Amendagement et d'Exploitation des Terres du Delta en Republique du Senegal, (St. Louis, Senegal: SAED, 1976).

13/ The author is not unaware of the informative doctoral thesis on the Perimeter of Dagana by Ba. (Alioune Ba, "Amenagement Hydroagricole et Etude Socio-Economique de la Cuvette de Dagana," Unpublished Ph.D. dissertation, Department of Geography, University of Dakar, 1976.) However, it should be pointed out that this work is largely descriptive rather than analytic in nature.

of how to proceed with further development must be answered without the benefit of evaluating the operating experience gained with the tertiary formula. Therefore, funding agencies are again faced with the prospect of approving projects solely on the basis of *ex ante* feasibility studies. If hindsight is better than foresight, then it should be exploited whenever possible.

Research Objectives

The major objective of this thesis is to fill the gap in our knowledge of large-scale tertiary irrigation projects in Senegal. This research will take an *ex post* perspective in evaluating the SAED experience with tertiary irrigation development on the Nianga Pilot Perimeter. To accomplish this overall objective, the task is divided into the following six subobjectives:

1. To review briefly the methodology of social cost-benefit analysis; and concomitantly, to develop a set of national parameters (i.e., weights, shadow prices, etc.) applicable to Senegal (Chapter II).
2. To describe briefly the geographic and socio-economic milieu of the Nianga Pilot Perimeter (Chapter III).
3. To describe in detail the development of the Nianga Project from the feasibility stage through the operational phase (Chapter IV).
4. To compare the findings in (3) above with the predictions of the *ex ante* feasibility study (Chapter IV).

5. To measure with the techniques identified in (1) above the economic viability of the Project from the standpoint of social and financial profitability (Chapter V).
6. To compare the methodology of the *ex ante* feasibility study with that used in (5) above (Chapter VI).

Although *ex post* analysis of irrigation project investments can be highly useful, it is not without its limitations. Each area has certain unique qualities regarding soil, climatological, and meterological characteristics, and other factors as well. The farmers involved in the project might come from a diversity of ethnic groups each with unique characteristics. Also, external events such as shocks from world markets, funding constraints, or technical uncertainty may impinge in such a way as to endow each development effort with its unique history.

From the foregoing, one could draw at least three implications for the research of irrigation development:

(1) Since all projects are unique, there is nothing to be gained by post-evaluation analysis.

(2) Since all projects are different, one can gain knowledge *post hoc* only by studying all such projects in a given region simultaneously.

(3) Since each project is composed of several elements which are unique to it, any post-evaluation must carefully show how these unique factors contributed to the final resulting project.

The first of the above implications contains enough truth to give it an initial appeal. Yet, in the final analysis it must be rejected on the grounds that all science (in the broad sense of the term) proceeds by an unravelling of the complexity of the real world so as to permit some degree of generalization. The second must be rejected on the practical grounds that the limited means at the disposal of this author do not permit such an enormous undertaking. It is then the third implication which is relevant for the fulfillment of the objectives mentioned above.

Methodology

In the OECD guidelines to the evaluation of irrigation projects[14/] a methodology for *ex post* economic evaluation of irrigation projects is set forth. Three principle stages for descriptive analysis are identified: construction or implementation stage; adaptation; and full production. A checklist of considerations upon which comparisons may be drawn between the predictions made in the feasibility study and what actually occurred is presented for each of the three stages. To the extent possible, this framework will be adopted here for the fulfillment of the descriptive research objectives.

For the measurement of social and economic profitability, the techniques of social cost-benefit analysis will be used. While the theoretical guideposts in this analysis will be Sen, Marglin and Dasgupta's *Guidelines for Project Evaluation*[15/] (hereafter referred to

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[14/] Bergmann and Boussard, pp. 76-83.

[15/] Amartya Sen, Stephen Marglin, and Partha Dasgupta, *Guidelines for Project Evaluation* (New York: United Nations, 1972).

as SMD), other sources relevant to social cost-benefit analysis will also be used. Finally, in those cases where data limitations prohibit use of the SMD formulations in their original form, appropriate modification of the latter will be made. In addition, sensitivity analysis will be used to test key parameters and assumptions made in the cost-benefit analysis.

The original raison d'etre of social cost-benefit analysis evolved from the fact that the profitability of a given development project depends upon the viewpoint from which it is analyzed. Thus from an accounting (financial) standpoint a project might be highly profitable, while from the viewpoint of society as a whole it might be equally unprofitable, or vice versa. With the application of the techniques of cost-benefit to the sphere of development projects in underdeveloped economies characterized by relatively imperfect markets, the need arose to develop a set of national parameters which would permit the analyst to determine the real costs of a project to society. This latter aspect will command a great deal of attention in the theoretical chapter (Chapter II) of this thesis.

Contribution of This Research

As noted above, funding agencies are faced with the prospect of approving additional projects in the Senegal River Valley in the absence of any knowledge of the economic viability of existing projects which have been built under the concept of tertiary development. While it is recognized that the results of the analysis of one project cannot be fully generalized even to technically identical projects, it would appear that post-evaluation analysis nevertheless aids in the pre-evaluation process by providing a "means of critical comparison."[16/] Hopefully this thesis will aid in filling the present void in *ex post* analyses of tertiary irrigation projects.

Study Organization

Chapter II exposes the theoretical elements of cost-benefit analysis necessary for the fulfillment of the stated objectives of this thesis. In a general vein, a brief review of landmark works from the literature is presented; in addition, an explication of the key concepts of the "with/without logic" and "financial vs. economic analysis" is made. On a more technical level, the role of national objectives and national parameters in project analysis is discussed. Also in the technical vein, the measurement of costs and benefits is presented both theoretically and empirically. Finally, a brief theoretical discussion of the implications of risk and uncertainty for project analysis is provided.

Largely non-analytical in nature, Chapter III describes the milieu of the Nianga Project, providing a general overview of the demographic, climatic, meterological, and socio-economic characteristics of the area. While Chapter IV, in highlighting the historical development of the Project, continues in the same mode, it nevertheless critically evaluates the performance of the Project in all of its developmental stages.

[16/] Bergmann and Boussard, p. 76.

CHAPTER II

THE THEORY OF COST-BENEFIT ANALYSIS

Historical Overview of the Development of the Cost-Benefit Methodology

In their widely known survey of the literature, Prest and Turvey[1/] credit the beginning of cost-benefit analysis to the work of Dupuit, who in 1844 conducted a feasibility study for the construction of canals in France. From here, the authors jump to twentieth-century America to the Rivers and Harbors Act of 1902 in their sequencing of the development of cost-benefit methodology. This act required the Army Corps of Engineers to draft a statement of special benefits derived from a given project such that user-charges could be levied.

The next landmark legislation was the New Deal-generated Flood Control Act of 1936, which authorized Federal participation in flood control projects, provided that benefits exceeded costs.[2/] In 1950, an inter-agency committee was set up to codify a generally agreed-upon set of principles on which projects were to be evaluated. The end-product was the "Green Book," which was used as the standard for evaluating all projects in the United States, until it was

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[1/] A. R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey," Economic Journal, LXXV (December 1965), p. 683.

[2/] Ibid., p. 684.

superceded in 1970 by the Principles and Standards, as drafted by the United States Water Resources Council.3/,4/

From the foregoing, one might conclude that social cost-benefit analysis (SCB) was the exclusive domain of its American practitioners. However, in a recent article Pingle shows that throughout the nineteenth century extensive use was made of SCB techniques by British civil servants in India. In Pingle's words:

> There is no doubt that British officials in India were influenced by the contemporary thinking in Europe, because within ten years of Dupuit's work Arthur Cotton (1854) made use of all these three approaches [Reference is made here to methods worked out by a committee of the Government of Bengal (1927), by J. B. Say (1821) and by Dupuit.] to work out the costs and benefits of investment in transportation.5/

As to whether or not the main impetus to the development of SCB did indeed emanate from British civil servants in India, as Pingle contends, is only of historical importance. Whatever the case, one could safely conclude that the methodology benefited from fertile soils in both America and Europe, and in the latter's former colonies as well. What is clear, however, is that the post-war period of colonial independence and the subsequent rise of bilateral and multilateral aid projects to lesser developed countries (LDC's), characterized

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3/ Arthur S. Westneat and Wallace E. Tyner, Social Cost Benefit: A Theoretical Review, A Report Prepared by the Purdue West Africa Project (West Lafayette, Indiana: Purdue University, 1978), p. 86.

4/ United States Water Resource Council, Principles for Planning Water and Land Resources and Standards for Planning Water and Land Resources (Washington, D.C.: July 1970).

5/ Gautum Pingle, "The Early Development of Cost-Benefit Models," Journal of Agricultural Economics, XXIX (January 1978), p. 66.

by relatively imperfect capital and labor markets, underscored the need for consistent guidelines for the evaluation of development projects. Two of the most comprehensive works to appear in this period were the UNIDO Guidelines[6/] and the Little-Mirrlees Manual,[7/] which was superceded by an updated version in 1974.[8/]

While a great deal of debate has ensued concerning the differences between these two approaches, it should be noted that the similarities outweigh the differences. Nowhere is this point made more forcefully than by LM themselves:

> ....There is no doubt that the two works adopt basically the same approach to project evaluation. Both treatments single out the values of foreign exchange, savings, and unskilled labor as crucial sources of a distorted price mechanism. Both go on to calculate accounting prices which will correct these distortions, and both carry out these corrections in an essentially similar manner. Both advocate DCF [Discounted Cash Flow] analysis and the use of PSV's [Present Social Value]. The treatment of externalities is very much the same. Finally, both works advocate making explicit allowance for inequality.[9/]

There are nevertheless several differences. While a thorough discussion of all such differences is beyond the scope of this thesis,

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6/ SMD.

7/ I. M. D. Little and J. A. Mirrlees, Manual of Industrial Project Analysis for Developing Countries (Paris: OECD Development Center, 1968).

8/ I. M. D. Little and J. A. Mirrlees, Project Appraisal and Planning for Developing Countries (New York: Basic Books, Inc., 1974). Cited hereafter as LM.

9/ Ibid., p. 362.

some of the more important differences concern:

1. Numeraire: While LM uses uncommitted resources valued in foreign exchange as its numeraire, SMD uses aggregate consumption valued in domestic prices.

2. Prices: Typically, LM convert prices to border (world) prices, while SMD uses domestic prices adjusted for market distortions.

3. Planning: LM emphasizes a "top-down" planning procedure, whereby accounting prices are derived by a central planning unit at the top echelons of government and are subsequently imposed on subordinate levels for project purposes. By contrast, SMD advocate a "bottom-up" approach, whereby accounting prices are treated as unknowns and are left to emerge from individual project decisions.

In contradistinction to the LM and SMD approaches, which have already been shown to be quite similar, is a methodology associated with such names as Charles Prou, Marc Chervel, T. Courel, and D. Perreau, known as the "Effects Method."[10/] Widely used by French economists in Francophone Africa, its most distinguishing feature is the express omission of shadow pricing of primary factors. Its proponents eschew shadow pricing on the grounds that these prices present such formidable conceptual and empirical difficulties for the analyst and decision maker alike, that we are better off to avoid them entirely. Whatever the merits of this method, it is certainly true, as Balassa has observed, that the Effects Method has been little noticed by the protagonists of the LM-SMD debate.[11/]

10/ Cf. Charles Prou and Marc Chervel, Establissement des Programmes en Economie Sous-Developpee, Tome 3, l'Etude des Grappes des Projets (Paris: Dunod, 1970).

11/ Bela Balassa, The 'Effects Method' of Project Evaluation, World Bank Staff Working Paper No. 231. (Washington, D.C.: IBRD, March 1976), p. 1.

development at some level occurs with or without a project. Since it is only net benefits that are of interest in SCB, the unambiguous isolation of the latter is essential to the analysis.

Application to the Nianga Perimeter

How might the logic be applied to an analysis of the Nianga Perimeter? The key element in formulating the without case is the determination of whether or not significant change could be expected in yields and in crop patterns in the environs of the Nianga Project. From one standpoint, this is already a moot subject, in that the latter is already in place. Yet within the with/without framework, it is completely logical even in an ex post study to compare what is (with) against our best estimates of what would have developed (without) in absence of the project. These considerations will guide the formulation of the without case to be discussed in Chapter V.

Financial vs. Economic Analysis

While both financial and economic analysis are technically subsumed by SCB, in practice the latter is often identified in the literature as being synonymous with economic analysis. Conceptually, the only difference between financial and economic analysis is the point of view from which the analysis is made. The distinction between social and private analysis is not useful here, for as Gittinger has observed, we may use financial analysis to evaluate public sector investments.[13/] The crucial distinction, rather, is profitability

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13/ Ibid., p. 5.

for society perceived as a whole versus profitability for an individual economic entity, be it private or state-owned.

For a variety of reasons, all of which will be considered later, the relevant measures of cost and benefits for an individual enterprise are often inappropriate when applied to society. For now it will suffice merely to note that a given project might be highly profitable from a commercial (i.e., financial) standpoint, but unprofitable from the social (i.e., economic) perspective, or vice-versa.

This framework is crucial for the analysis to be carried out in the present study. First, a financial analysis will be done in order to evaluate the profitability of the Nianga Project qua enterprise. Second, an economic analysis will be done to evaluate the worth of the Project to society as a whole--i.e., to the nation of Senegal.

National Objectives

Essential to the evaluation of a given project is a clear notion concerning national objectives. Failure to specify clearly the latter can result in considerable confusion. A classic example is discussed by Arthur Maass where he shows that the controversy in the literature which has revolved around the accounting of secondary benefits is directly due to a lack of clearly specified objectives. To wit:

> ....it is interesting to examine the arguments over so-called secondary benefits and how they should be included, if at all in project analyses. There is no such thing as a secondary benefit. A secondary benefit, as the phrase has been used in the benefit-cost literature, is in

deficit, excluding private capital flows and/or "balancing" transactions which are used to bring about ex post facto balance. A still more crude measure is the trade gap.[18/]

But is increased production in response to a payments deficit a legitimate national objective? LM answer in the negative:

> ....It is often argued that countries must develop production of this or that, on long-run balance of payments grounds. We are not here concerned with that at all. Any good criterion for project selection will take proper account of the fact that a country cannot run a balance of payments deficit indefinitely.[19/]

What might then be sufficient causes for positing self-reliance as an independent objective? Here LM reply: "..the risk that imports in general may have to fall sharply."[20/] Countries which suffer from extreme fluctuations in prices of their exports are particularly vulnerable. The decrease in available foreign exchange following a rapid decline in export prices could leave the best of development plans, often highly dependent upon imported goods, in a complete shambles.

Merit Wants

Merit wants are those goods which are determined by the political process to have value greater than that which can be measured by market prices. In this sense, then, employment and self-reliance are special cases of the merit wants objective. Other commonly

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18/ Ibid.

19/ LM, p. 63.

20/ Ibid.

cited merit wants are education and health care.

National Parameters

In conformity with the SMD approach, two types of national parameters are posited here--the first being a set of weights that are politically determined; the second, a set of shadow prices which are calculated from economic data. It should be noted, however, that the use of national parameters of the first type--i.e., value parameters--is not universally accepted. Thus Mishan protests that:

> "...there can be no place in an economic criterion, and more specifically a cost-benefit criterion, for the use of so-called 'national parameters' to supplement market data, or more broadly speaking, subjective valuation--at least insofar as such parameters are not offered as estimates of people's valuations but are derived instead directly, or indirectly from political mechanisms."21/

In light of what has been said above concerning national objectives, it can be said that Mishan, while partially correct, has actually missed the point. There is indeed no place in efficiency analysis for subjective or politically determined valuations. But as was clearly shown above, there are other national objectives in addition to efficiency. Moreover, it is incorrect to posit an identity between the efficiency criterion and cost-benefit analysis. While the latter did in fact have as its beginnings a methodology for measuring efficiency costs and benefits, SCB *qua* methodology is at most a measuring device, and as such, there is no reason that it must

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21/ E. J. Mishan, *Cost-Benefit Analysis* (New York: Praeger Publishers, 1976), p. 414.

remain exclusively tied to efficiency analysis. The issue then is not should but can the SCB methodology be adapted to incorporate objectives other than efficiency? If one accepts the validity of the SMD approach, then the answer is very definitely that it can.

Value Parameters

As alluded to above, value parameters are a set of weights that are subjectively determined by the political process. The rationale for this set of weights is that it allows the analyst to combine various national objectives in a way that benefits and costs can be measured by a common numeraire--that numeraire being aggregate consumption in the SMD approach. When it is stated that these weights are politically determined, it is not meant that they result from a national plebiscite, a ministerial voice, or indeed necessarily from any such direct process. Rather, it is meant that the weights are inferred from project decisions past and present, tax structures, national plans, etc. The derivation of two such weights will be described below.

Regional redistribution

Suppose the government has determined that one of its objectives is to redistribute income from the more affluent to the poorer regions. How might the analyst infer the relative weights to be attached to the increased aggregate consumption accruing to the respective regions from a given project? Two such exercises will be pursued here--one for ideal conditions, another for a real situation, using data from Senegal.

In order to see how the regional distribution weight might be inferred from the national plan, the reader is referred to Figure 1.[22/]

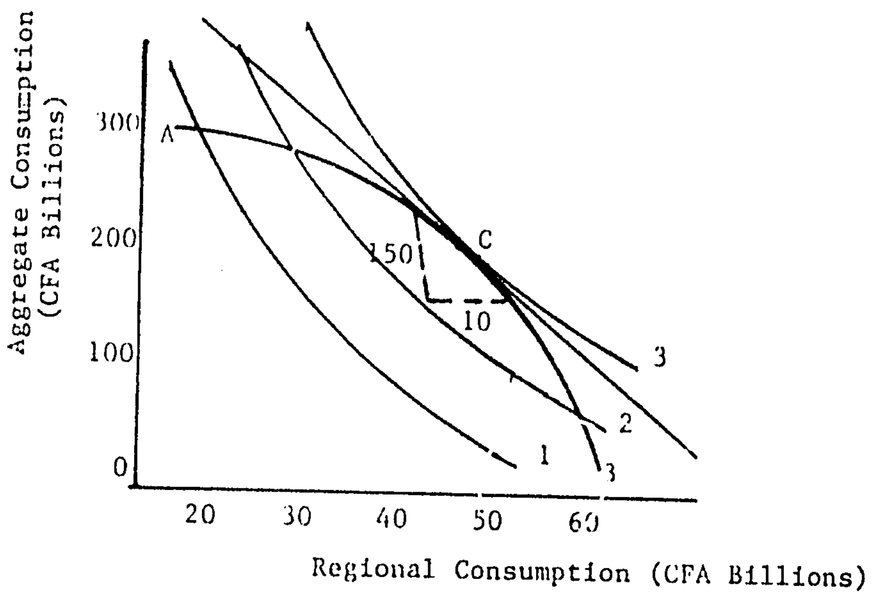

Figure 1. Determination of Regional Distribution Weights.

We begin with the curve AB, which is the feasibility frontier. This curve represents all the production alternatives for the economy as a whole which are technically feasible, and thus each point on AB corresponds to a different national plan. The next step is for the analyst to elicit from the policymakers a set of equal welfare curves (designated by Arabic numerals in Figure 1), each of which shows the trade-offs they are willing to make between aggregate and regional consumption. It is readily seen that the optimal welfare point is C, where the highest equal welfare curve (curve 3) is tangent to the feasibility frontier. The weight to be attached to regional

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22/ Adapted from SMD, p. 124.

consumption then is equal to the slope of curve 3 where it passes through point C.

While all of the foregoing is straightforward enough conceptually, it would be nearly impossible to carry out empirically. In the first place, it is highly unlikely that one could ever derive a curve which would show all of the technically feasible national plans. Secondly, the process of forcing policy makers to formulate the tradeoffs between regional and aggregate consumption for various levels of output would be an exceedingly expensive task in time and money.

A realistic case: Senegal

For a real situation, the analyst must often resort to short-cut methods. For example, the Senegalese government has followed a policy of granting favored tax status to investments which generate new employment. In order to qualify for special status (entreprise prioritaire) the industry must invest at least over 40 million CFA over a 3-year period and create a minimum of 40 permanent jobs. However, if the industry locates anywhere in Senegal outside the Region du Cap Vert (the region in which the capital city of Dakar is located), the minimum qualifications for preferential tax treatment fall to an investment of 20 million CFA and the creation of only 20 permanent jobs.[23/] From the foregoing, then, one might infer a regional distribution weight of 2.

23/ Survey of African Economies, Vol. III (Washington, D.C.: IMF, 1970), p. 548.

Social rate of time preference (SRTP)

The Social Rate of Time Preference is a rate of interest which expresses society's intertemporal choice with respect to consumption. The rationale for discussing future costs and benefits is based primarily on two assumptions: (1) that per capita consumption will increase over time; and (2) that the marginal utility of consumption diminishes with each increment of the latter.[24/] Thus future consumption is seen as being less valuable than present consumption, and the parameter which expresses the rate at which society's valuation of future consumption falls over time is SRTP.

Care should be taken not to confuse the notion of SRTP with that of social discount rate. While the former is strictly a consumption rate of interest, the latter is a generic term, and as such, it comprehends a variety of different types of interest rates that might be used for discounting the value of future benefits and costs.

One of the more salient features of SMD's approach is that SRTP inherently reflects society's value judgments, and as such, cannot be calculated from economic data. Their case against such calculation rests on the contention that neither private savings behavior nor the productivity of capital (MP_K) in the economy are reliable guides to intertemporal valuation. The former is discredited on philosophical grounds, wherein life is seen as being too brief and control over one's lifetime-consumption too limited (at least for the typical worker/peasant) to permit rational intertemporal choice, as well as on economic grounds, whereby the existence of externalities

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24/ SMD, pp. 164-5.

exercise a disincentive for the individual to save. While a given individual might be inclined to save more if he knew that others would do likewise, he will actually tend to save less out of fear that others, in the absence of coercion, will be unwilling to make an equal sacrifice. MP_K is seen as being equally unsuitable as a proxy for SRTP, on the grounds that its use (implicitly) assumes an optimal savings rate throughout the economy--an untenable assumption in the case of underdeveloped countries.[25/]

Treating SRTP as an unknown

If SRTP is indeed a value judgment, then the most logical procedure would be to infer the latter from the growth targets as found in the national plan. Given that one cannot attribute optimality to such plans, as SMD have shown,[26/] the remaining alternative is to treat SRTP as an unknown. Thus, the evaluator, using the technique of sensitivity analysis is to seek the "switching value" of the project--i.e., that discount rate which renders the net present value equal to zero. Or in other words, where efficiency is the objective, SRTP becomes synonymous with the project's internal rate of return.[27/]

But what is the link between rates of return from <u>individual</u> projects and a <u>social</u> rate of discount? It should be recalled from an earlier part of this chapter that the SMD approach is largely a "bottom-up" planning procedure, whereby project decisions in their

[25/] <u>Ibid</u>., pp. 157-64.

[26/] <u>Ibid</u>., pp. 26-33.

[27/] The IRR is defined as that rate of return which renders net present value equal to zero.

ensemble coalesce over time to form a coherent set of national parameters. Indeed the procedure recommended by SMD is only seen as a transitory one, wherein it is meant only as a way of confronting policymakers with the implications of their decisions. Eventually, this very process will allow (or so it is hoped by SMD) the policymakers to clearly specify their value judgments prior to the formulation of projects.

Ironically enough, LM, despite their emphasis on "top-down" planning, are equally indirect in their approach toward estimation of a social discount rate (ARI in their parlance). To wit:

> ...The right ARI is the one that passes just the right volume of projects: to estimate it, one needs some idea of investible resources and how well they can be used.28/

Evaluation of the "unknown" procedure

Essentially two criticisms will be made of SMD's methodology, whereby SRTP is treated as an unknown, and subsequently equated to the project's internal rate of return. The first criticism, of a mechanical nature, is that the IRR is, for a variety of reasons, seriously flawed as a measure of project worth.29/

The second criticism, largely an empirical problem, is that in order for the procedure to work as envisaged by SMD (or LM, for that matter), the analyst could not simply evaluate one project. Instead

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28/ LM, p. 291.

29/ The nature of these flaws will be discussed later in this chapter under the rubric of "investment criteria."

he would have to be involved from the earliest stages in the planning process for all projects and potential projects. While this is perhaps conceptually feasible, there is little correspondence with the present-day reality of the planning process. Moreover, in the case of an ex post analysis, such as this thesis, the comparison of all projects and potential projects is, of course, a physical impossibility. Almost equally impossible to reconstruct are the discarded alternatives for existing projects.

Calculated Parameters

Social discount rate

As will be recalled, SRTP has been dealt with above under the rubric of "value parameters." The rationale for classifying the former as such is self-evident--viz., the advocates of SRTP plainly state that it represents a value judgment. On the other hand, both the social opportunity cost and the government cost of borrowing approaches to estimating the social discount rate are directly estimated from observable data, and for this reason are classified as "calculated parameters."

Government cost of borrowing

Of the two discount rates which are considered as calculated parameters, this one is by far the most straightforward, both conceptually and empirically. It is simply the government's cost of borrowing funds in the open market. Empirically it is measured as the weighted average of yields on long-term (10-15 years) government bonds. Since the government is assumed to be a risk-free enterprise, this rate is seen as being one that is net of risk. Although this method is applied to the evaluation of all water projects in the United States, it has little currency in the arena of underdeveloped economies. The major advantage of the approach is its simplicity, while its major drawback is that the low interest rate which it implies tends to favor projects which are capital-intensive and of long duration.

Opportunity cost of capital

In its purest form, the opportunity cost of capital approach is beguilingly simple--namely, that the appropriate rate of discount to be used for public investment is the marginal productivity of capital in the private sector. Perhaps the clearest statement of this approach has been made by Baumol:

> ....If it is true that in real terms what the government takes from the private sector is input resources, then to determine the relevant rate of discount one need not inquire beyond the rate of return currently being earned by users of such inputs.30/

From the foregoing one might infer that the only thing the analyst need do in order to obtain the relevant discount rate is to measure directly the marginal rates of return on private investment. However, as Prest and Turvey have pointed out, such a measure would be appropriate only to the extent that, "...the costs being evaluated consisted exclusively of displaced private investment."31/ In view of this

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30/ William J. Baumol, "On the Social Rate of Discount," AER, LVIII (September 1968), p. 792.

31/ Prest and Turvey, p. 699.

problem, Krutilla and Eckstein[32] assumed that the alternative to public expenditure would be a tax cut, and subsequently attempted to determine how such a cut would affect various groups. Based on their hypothesis of how the various groups would utilize their increased revenues, Krutilla and Eckstein then estimated an interest rate which was a weighted average of return. This too was not without its problems, as Prest and Turvey comment further:

> ....Quite apart from the logical and statistical problems associated with the techniques assigning tax cuts to the different income groups, etc., as Eckstein himself has noted, this approach deals with only two out of many relevant alternatives (e.g., more public investment might be met instead by less public consumption).[33]

Harberger offers an alternative method of estimating the opportunity cost of capital wherein the discount rate is obtained by tracing through the effects of additional government borrowing on various classes of savers and investors. Thus his version of opportunity cost is "...a weighted average of the marginal rates of time preference of the various categories of savers, and the rates of marginal productivity of capital in the various sectors."[34] The critical drawback with this method, however, is the assumption that all public expenditure is financed by government borrowing.

32/ J. V. Krutilla and Otto Eckstein, Multiple Purpose River Development (Baltimore: Johns Hopkins Press, 1958).

33/ Prest and Turvey, p. 699.

34/ Arnold C. Harberger, Project Evaluation (Chicago: University of Chicago Press, 1972), p. 126.

A general criticism which can be leveled against the various opportunity cost of capital approaches is not that they are wrong, but that they are incomplete. In each of the foregoing examples, a crucial but restrictve assumption was made as to the funding of the project. The problem, however, is that projects are funded by various means, and hence displacement typically occurs in many sectors. This is not meant, however, as a blanket condemnation of the opportunity cost of capital approach to discounting. Nevertheless, in the final analysis, the research effort necessary to determine accurately the displacement of investment in the various sectors of the economy as a result of the Nianga Project would be far beyond the scope of this thesis.

Toward a social discount rate:
an eclectic approach

Based on the foregoing review of the three major approaches to discounting, it can be fairly said that none is entirely satisfactory from either a theoretical or empirical standpoint. Therefore, the approach used in the present study will be an eclectic one which will attempt to incorporate the desirable features of all those reviewed above. How will such an approach be implemented? First, the discount rate will in a sense be treated as an unknown, as was done by SMD. Secondly, with some deference to the validity of both the opportunity cost of capital and the government cost of borrowing approaches, the range of the unknown values will be bounded on the high side by estimates of the marginal productivity of private capital, and on the low side by the rate at which the Senegalese government must pay for capital funds. Using sensitivity analysis, the net worth of the project also will be calculated for various interest rates falling within the two boundary points.

The assumption that the social discount rate falls between the government cost of borrowing and the marginal productivity of private capital does seem justified theoretically. With respect to the upper boundary, it should be noted that the marginal rate of return on private capital is one which is gross of taxes, and in addition, it includes a risk premium. Conversely, the rate at which the government obtains capital is of course net of tax and is for all practical purposes free of risk; and as a consequence, the government cost of borrowing is a sound candidate for the lower boundary.

We do not claim the approach taken here is superior to all others. In its defense, however, let is be simply noted that the issue of an appropriate discount rate has been a thorn in the side of SCB practitioners since its inception. Moreover, there appears to be no entirely satisfactory resolution to the problem within the foreseeable future.

Shadow prices

> ....The name 'shadow price' is perhaps unfortunate. It suggests to many, even to some economists, that an analysis based on them is remote from reality, and therefore academic and highbrow, and so is to be distrusted...From now on we shall use the term 'accounting prices.'35/

Whether they go by the name "shadow prices" or "accounting prices", as LM would have it, the idea is the same. Shadow pricing is a technique whereby observed prices are corrected so as to reflect

35/ LM, p. 36.

the true social costs of inputs and the true social values of outputs in the face of distorted markets. With respect to the connotations engendered by the term "shadow price," the real danger is not that they will be seen as being unreal, as LM seem to think, but rather that economists, policymakers, and the public at large might tend to reify these prices. Let it be clearly understood at the outset that shadow prices have no real existence. They are nothing more than theoretical constructs, and as such, have no existence outside of the analytical framework in which they are derived.

To the extent possible, the shadow prices derived below are based on the SMD framework. Even in those instances where modifications will be made to the original SMD formulation, the numeraire will remain aggregate consumption.

Shadow price of investment

Rationale. As defined by SMD, the shadow price of investment (P^{inv}) is, "...the present value of the additional consumption that a unit of investment would generate."[36] P^{inv} is a function of three things: (1) the social discount rate (i); (2) the marginal productivity of capital (q); and (3) the propensity to save or reinvest (s). In the event that this propensity differs across groups of income recipients, there will be a multiplicity of P^{inv}'s. For the sake of simplicity, SMD limits (conceptually) the number of such groups to three--capitalists, workers/peasants, and government, and the number of P^{inv}'s to two, on the assumption that workers/peasants save nothing

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36/ SMD, p. 150.

<u>Derivation of P^{inv}</u>. The derivation leading to the shadow price of investment in Equation (4) below is taken directly from SMD. The first element for consideration is the annual return from a dollar of investment, shown in Equation (1):

$$\text{Annual Return} = (1-s)q + P^{inv}sq \qquad (1)$$

where:

(1-s) is the direct contribution to consumption

sq is the direct contribution to investment

The present value of these returns is equal to the shadow price of investment, as shown in Equation (2):

$$P^{inv} = \sum_{t=1}^{\infty} \frac{(1-s)q + P^{inv}\ sq}{(1+i)^t} \qquad (2)$$

Since $\sum_{t=1}^{\infty} \frac{1}{(1+i)^t} = \frac{1}{i}$, Equation (2) can be rewritten as Equation (3) if we are discounting to infinity:

$$P^{inv} = \frac{(1-s)\ q + P^{inv}q}{i} \qquad (3)$$

Solving for P^{inv}, one obtains Equation (4):

$$P^{inv} = \frac{(1-s)q}{i-sq} \qquad (4)$$

The formula in Equation (4) above embodies two assumptions: (1) both s and q remain constant over time; and (2) all capital expenditures come out of displaced investment in the private sector. The first assumption is made purely for the sake of simplicity. Moreover, according to SMD, Equation 4 remains a reasonably good approximation to P^{inv} so long as the time horizon over which i exceeds sq is large.[37/] This latter option is not, however, unanimously held by economists. Thus, Blitzer[38/] contends that the assumption of constant values for i, s, and q leads to a systematic overestimation of P^{inv}, given that the natural state of affairs is for q to decline and s increase as the national economy develops. As a remedy, he advocates the use of economy-wide general equilibrium models which are capable of analyzing the interrelated supply functions which determine q's time path. In the final analysis, this is no solution at all (as Blitzer admits), in that, "...such models are costly to construct, require rather complete and sophisticated data, and are available for only a few countries."[39/] Thus for the purposes of this thesis, SMD's first assumption will be accepted as valid.

The second assumption that all public investment occurs at the expense of private investment is unrealistic; and, in fact, it was used by SMD only for heuristic purposes. The usual assumption is that in any economic system, public investment results in the displacement of some fraction (perhaps zero) of investment and consumption.[40/] To accommodate this latter assumption, SMD modified P^{inv} (as derived in Equation (4) above) in the manner shown in Equations (5) through (8) below.[41/]

37/ Ibid., p. 180.

38/ Charles R. Blitzer, On the Social Rate of Discount and Price of Capital in Cost-Benefit Analysis, Economic Staff Working Paper No. 144 (Washington, D.C.: IBRD, February 1977), p. 20.

39/ Ibid., p. 22.

40/ Larry A. Sjaastad and Daniel L. Wisecarver, "The Social Cost of Public Finance," Journal of Political Economy, LXXXV (June 1977), p. 516.

41/ SMD, p. 81.

Assume that $a^{inv} = s$ (5)

where

a^{inv} = the proportion of project capital costs that result in displaced private investment.

Assume further that total activity foregone is equal to 1 franc per franc of capital outlay such that

$$a^{con} = 1 - a^{inv} \quad (6)$$

where

a^{con} = the proportion of project capital costs that result in displaced consumption.

Then, $a^{inv}P^{inv} + a^{con}$ 42/ $= s\ P^{inv} + (1-s)$ (7)

By substituting P^{inv} from Equation (4) 43/ one obtains the "corrected" P^{inv}--i.e. the corrected opportunity cost for 1 franc of nominal cost.

$$s\ P^{inv} + (1-s) = \frac{(1-s)i}{i-sq} \quad (8)$$

Empirical application of P^{inv}. Underlying our consideration of the shadow price of investment up to this point has been the assumption that incremental benefits from the project are consumed as they become available. Ultimately, however, SMD relax this assumption; and hence the "corrected" P^{inv} of Equation (8) must be applied to both the cost and the benefit streams (or, which amounts to the same

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42/ It should be recalled that since consumption is the numeraire, there is no need to multiply a^{con} by P^{inv}.

43/ That is: $s\ P^{inv} + (1-s) = \frac{s(1-s)q}{i-sq} + (1-s) = \frac{(1-s)i}{i-sq}$.

thing, to the net benefits stream).[44/] Whereas the effect of shadow pricing the investment costs only is to "penalize" (i.e., decrease project worth), the effect of shadow pricing the resulting benefits is to "reward" the project for having produced incremental income which in turn can be reinvested.

The most critical assumption with respect to the project worth which is obtained is that concerning the value of a^{inv}. The most stringent assumption which can be made, of course, is that $a^{inv} = 1$, because this assumption implies that all the project investment displaces other investment. The effect of assuming that some of the project's costs will come out of consumption (i.e., $a^{inv} < 1$), as was done in Equation (8), is to increase the project's present value.[45/] And finally, as was seen above, the effect of shadow pricing benefits is to increase present value still more. Thus on a continuum of project worth, the latter situation results in the highest present value, while the assumption that $a^{inv} = 1$ results in the lowest present value. Since project worth is potentially extremely sensitive to these underlying assumptions, alternative results reflecting these polar cases will be presented with the empirical findings of the ex post cost-benefit analysis in Chapter V.

44/ SMD, p. 185.

45/ Not only have SMD made the assumption that $a^{inv} < 1$, but they have also made the particular assumption that $a^{inv} = s$. While this latter assumption has been roundly criticized (e.g., Sjaastad and Wisecarver, p. 524), and indeed its only rationale would seem to be that of expository and/or empirical convenience, it should be pointed out that the critical feature here is the extent to which a^{inv} differs from 1, rather than its relationship to s.

approach this model, the social opportunity cost of labor--i.e., the output foregone as a result of transferring a worker from one sector to another (rural to urban, private to public, etc.)--would equal his wage rate in the sector of his current employment. On the other hand, in the case of underdeveloped countries, which are typified by widespread unemployment or underemployment (i.e., labor-surplus economies), the economy might lose nothing, save the disutility of additional individual effort, in terms of foregone output as the result of the creation of an additional job.

Over the years, largely as a result of a too-literal interpretation of the concept of a labor-surplus economy, there has ensued a considerable amount of controversy as to whether or not $MP_L = 0$ in the traditional agricultural sector. SMD have correctly dismissed this controversy as being simply irrelevant. Alternatively, they maintain that:

> ....the definition of surplus labor in terms of unemployment or zero marginal productivity is rightly to be understood as a simplification of the kind that is made in all theorizing, and not as a literal description of the economies that the theory attempts to describe.
>
> ....
>
> The essence of surplus labor lies in the gap between the market wage in the organized, capitalistic sector of the economy and the social value of the marginal product of labor in the rest of the economy, and not in the value of the marginal product *per se*.[47/]

[47/] *Ibid.*, p. 202.

Finally, it should be noted that the concept of surplus labor is applicable primarily (but not exclusively) to unskilled or non-specialized labor.

Explication of SMD's shadow wage (W*). The complete SMD shadow wage rate consists of three parts: (1) the direct opportunity cost, Z; (2) indidrect costs, or savings effects; and (3) redistributional benefits and costs. The first approximation of W* is thus Z, more of which will be said below; and it is for this parameter that empirical estimations of the shadow wage are most commonly used.

The second part measures the indirect costs borne by the public sector as a result of the reallocation of resources toward consumption, such reallocation resulting from increased employment of those who, as seen before, are assumed to save nothing. The derivation of this part requires an estimate of the marginal propensity of capitalists to save, the wage rate of unskilled labor in the modern sector, and a special form of P^{inv} for a labor surplus economy, the latter which in turn requires an estimate of the marginal labor: capital ratio. Of significance here is the fact that even when Z might equal zero, W* would nevertheless be greater than zero, given the existence of these indirect costs.

Finally, the third part of W* incorporates the elements of (1) and (2) above, and in addition, attaches a weight, or more precisely a redistributional premium to the added employment. Whereas the function of (2) was to "penalize" the project due to the indirect social costs of additional consumption, the purpose of (3) is to "reward" the project for the resulting increase of income to certain less-favored societal groups. It should be noted that (3) is applicable only in those instances where redistribution has been explicitly cited as an objective of the project.

Given the sophisticated data requirements for parts (2) and (3) above, no attempt will be made to incorporate them into the shadow wage rate (SWR) to be derived directly below. Moreover, even were such data available, (3) would be inapplicable to the purpose at hand, in that redistribution will not be included (see Chapter V) as an objective for our analysis of the Nianga Project.

Derivation of SWR, explicitly incorporating migration. As indicated above, the only component of W* which will be considered here is Z, the direct opportunity cost. Thus, in the discussion which follows, the latter will be used interchangeably with SWR.

How might one measure Z? Conceptually, it is the social value of the production foregone in the traditional sector as a result of creating a new job in the modern industrialized sector. In the absence of a detailed study, it might be approximated by the wages of landless laborers in the traditional sector.[48] According to SMD, however, such an approximation might overestimate the marginal productivity (and hence the opportunity cost), given the existence of certain "non-economic factors" which result in a reservation wage in the traditional sector which may be greater than the marginal productivity. Provided that at least the direction of the bias is clear, however, they suggest that this wage in the traditional sector may nevertheless serve as a reasonable approximation of Z.[49]

48/ Ibid., p. 204.

49/ Ibid.

While no quarrel is taken here with the above specification of Z as a general approach, it should be pointed out that in those areas where rural-urban migration represents a viable alternative to agricultural work, this formulation might tend to underestimate Z. What is needed then is a formula for Z, cast in probabilistic terms, which incorporates the possibility of migration, such as Equation (9) below.

$$Z = (P_1 Wa) + (P_2 Wi) + [1 - (P_1 + P_2) \cdot Wo] \qquad (9)$$

where:

P_1 = probability of employment in the traditional agricultural sector,

P_2 = V/U = probability of employment in the modern sector,[50/]

V = the number of employment vacancies for unskilled labor in the modern sector,

U = the number of unemployed in the modern sector,

Wi = wages for unskilled labor in the modern sector,

Wa = wages of hired labor in the traditional agricultural sector,

Wo = zero wages = 0

While a factor for transfer costs is often included in the formulation of Z when migration is considered, it has been expressly omitted here. Mishan, for example, states that the opportunity cost of a worker's labor is equal to his (zero) marginal product in agriculture

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[50/] This formulation is adapted from: Deepak Lal, "Disutility of Effort, Migration and the Shadow Wage Rate," Oxford Economic Papers, XXV (December 1973), p. 117.

plus a sum to compensate his preference for the rural sector plus the costs of his movement, both physical and psychic.[51]

There are at least two reasons for not including such transfer costs here. With respect to physical costs, it should be pointed out that interregional transportation in West Africa is relatively inexpensive. But more importantly, the decision to migrate is presumably based upon a calculation of future income over a time horizon of several years, or perhaps a lifetime. Therefore, the cost of bush-taxi (*taxi brousse*) fare would likely be a negligible sum in the potential migrant's calculations.

With respect to the supposed preference for the rural area, as well as the "psychic costs" of moving, there is reason to believe that both of these have been overstated, and indeed, they might even be negative. Some indirect evidence on this matter is given by Yap in his recent review of migration literature, where he notes that in certain rural-urban migration studies, the destination (income) elasticities were much larger than the origin elasticities. In Yap's words:

> ....it will require much more than a 10% increase in rural incomes to cancel the stimulus of a 10% increase in urban incomes. Given the higher cost of living in cities, these results suggest that the pull of urban incomes is quite strong.[52]

51/ Mishan, p. 72.

52/ Lorene Y. L. Yap, "The Attraction of Cities: A Review of the Migration Literature," *Journal of Development Economies*, IV (September 1977), p. 248.

(2) At relatively low levels of material living standards, the government may value an increase in material goods higher than an increment in leisure, and then may want to raise national output beyond that inferred from private preference.[55]

What is at issue here is essentially the substitution of the government's values for those of the individual. While the above propositions are unabashedly political, they are no more so than many of the other concepts used to evaluate social costs and benefits. In the case of P^{inv}, for example, the very rationale for such a national parameter is society's (i.e., the government's) judgment that saving is sub-optimal, and thus saving is valued higher than an equal nominal amount of present consumption. While numerous other examples could be cited, the point should by now be perfectly clear. In SCB analysis, even when the latter is restricted to efficiency analysis, it is impossible to divorce political decisions from economics.

Shadow exchange rate (SER)

Rationale. Foreign exchange is often a concern for devleopment projects in at least two ways. On the one hand, many of the project's inputs (especially capital goods) may have to be imported, while on the other, some or all of the output may be exported. Therefore, within the SCB framework, the flows of foreign exchange must be identified and appropriately valued.

55/ Ibid.

That some shadow rate should be applied to the valuation of foreign exchange rests on the premise that the currency of many underdeveloped countries is overvalued, or conversely, that foreign exchange is undervalued vis-a-vis the domestic currency. But why is this so? In order to answer this question, it will be necessary to digress a bit on the balance of payments (BP). Generally speaking, a "favorable" BP (i.e., absence of chronic deficits) is particularly desired by developing countries, in that the continued availability of foreign exchange permits the importation of goods which are a spur to further development, and hence increased aggregate consumption. One of the most commonly used attempts at improving the BP is by recourse to tariffs and/or import quotas, the imposition of which permits an equilibrium payments situation at a lower exchange rate (i.e., fewer units of domestic currency per unit of foreign exchange) than would be the case under free trade.[56/]

That an equilibrium BP is maintained at an artificially low exchange rate means that the domestic currency is overvalued, relative to foreign exchange. Thus the result of the attempt to improve the BP through the erection of trade barriers is an overvalued domestic currency, and hence the need for a shadow exchange rate in project evaluation. If it is then assumed that foreign exchange is valued for the ultimate increase in aggregate consumption it promotes, and not as an end in itself (i.e., as a merit good), then the shadow exchange rate is by definition, "...the contribution a unit of foreign

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56/ Bela Balassa and Associates, The Structure of Protection in Developing Countries (Baltimore: The Johns Hopkins Press, 1971), p. 7.

exchange makes to aggregate consumption."[57/]

SMD's shadow price of foreign exchange P^F. SMD's shadow price of foreign exchange as shown in Equation 10,[58/] is simply the ratio between the weighted sum of imports at domestic prices to the same weighted average at world prices. The spread between P^D and P^{cif} is due to the existence of tariffs or the tariff equivalents of quotas.

$$P^F = \frac{\sum_{i=1}^{n} f_i P_i^D}{P_i^{cif}} \qquad (10)$$

with $f_1 + \ldots f_i + \ldots f_n = 1$

Equation (10) involves three assumptions. First, it is assumed that the existing tariff structure will remain intact for the life of the project. Second, imported goods are seen to be distributed by the market mechanism, not rationing, and thus the prices $P_i^D \ldots P_n^D$ are market-clearing prices based on consumer willingness to pay. The third, and certainly the most controversial assumption, is that the increments to supplies, measured by the rations $\frac{f_1}{P^{cif}} \ldots \frac{f_n}{P^{cif}}$, are indeed net additions, not replacements for commodities already being produced in the local economy.[59/] This condition is seen to hold except in the case of capital goods, and it is this latter point on which the controversy turns.

57/ SMD, p. 152.

58/ Ibid., p. 216.

59/ SMD call this type of replacement, "reverse import substitution." Ibid., p. 218.

In a footnote, LM state the following, "For some reasons which we do not understand, and believe to be mistaken, the Guidelines (i.e., SMD) suggests that capital goods should be left out of the calculations."60/ The rationale provided by SMD for this exclusion follows from their basic viewpoint that the relevant constraint on the rate of investment in developing countries is not foreign exchange availability, but rather a number of political and institituional factors which frustrate the government's efforts to force additional saving. While there would appear to be a kernel of truth in this proposition, SMD have surely pushed this reasoning too far in the instance where they state: "It is not increases in foreign exchange that of themselves make greater capital formation possible, but the increases in domestic income, which are normally highly correlated with increases in exports as well as imports."61/ But as the OPEC experience has shown, increases in foreign exchange earnings can and do have substantial impacts on capital formation.

Be that as it may, P^F will not be used as the measure of SER in this thesis, the reason being empirical, however, rather than theoretical in nature. The available data simply does not permit a reasonably accurate determination of the appropriate weights (f_i's) to be used. Therefore, a slightly different approach, presented directly below, will be used in deriving the SER for this study.

60/ LM, p. 361 (footnote).

61/ SMD, p. 219.

Derivation of the Shadow Exchange Rate (SER). The model used here for the SER is taken from a recent World Bank Staff Working Paper by Colin Bruce.[62] The starting point in the derivation is α, which is commonly known as the Standard Conversion Factor (SCF), the role of which is to convert the domestic price of a good to its border (world) price. Algebraically, it takes the form as shown in Equation (11).

$$\alpha = \frac{\Sigma \varepsilon X_i + \Sigma_n M_i}{\Sigma \varepsilon X_i (1-t_x) + \Sigma n\, M_i (1+t_m)} \qquad (11)$$

where:

ε = elasticity of exports,

n = elasticity of imports,

X_i = value of exports of i number of goods,

M_i = value of imports of i number of goods,

t_x = ad valorem tax rates on exports (negative for subsidies),

t_m = ad valorem tax rates on imports.

The above equation gives the ratio of the weighted average of world prices to domestic prices of imports and exports by estimating the weighted average of the rates of protection, the weights being the respective elasticities.[63] In agreement with the thinking of

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62/ Colin Bruce, Social Cost-Benefit Analysis: A Guide for Country and Project Economists to the Derivation and Application of Economic and Social Accounting Prices, World Bank Staff Working Paper No. 239 (Washington, D.C.: IBRD, 1976), pp. 9-12, passim.

63/ Ibid., p. 11.

SMD, Bruce assumes here that the existing trade restrictions are likely to remain

Unfortunately, estimates of import and export elasticities are often either unavailable or unreliable.[64/] However, as Bruce has pointed out, Equation (11) implicitly assumes that a marginal increase in foreign exchange resulting from a project brings about an adjustment in the exchange rate and it is for this reason that price elasticities were used to weight imports and exports. But in the case where the government uses marginal increases in foreign exchange earnings to increase investment, there need be no change in the exchange rate. Therefore, if one drops this implicit assumption, then Equation (11) can be rewritten as Equation (12)

$$\alpha = \frac{M + X}{M(1+t_m) + X(1-t_x)} \tag{12}$$

Given the lack of sufficient data vis-a-vis tariff <u>rates</u> for Senegal, it will not be possible to use Equation (12) as written. Instead of tariff rates, the absolute values of tariffs will be used here, as shown in Equation (13):

$$\alpha = \frac{(M+X)}{(M+T_m) + (X-T_x)} \tag{13}$$

[64/] In fact Bela Balassa has made tentative estimates of such elasticities for Senegal. However, these estimates are first-best arc elasticities representing the response to elimination of all trade restrictions, and as such, they are incompatible with the "no change" assumption made by Bruce and SMD vis-a-vis trade restrictions. [Bela Balassa, "Methodology of the Western Africa Study," Origin unknown, February 1976 (mimeographed).]

Now as LM have noted,[65] the shadow exchange rate is simply the inverse of α; and therefore, in order to obtain SER here, one need only invert the right hand side of Equation (13). By now it should be amply clear that the SER derived here is essentially the same as Sen, Marglin, and Dasgupta's P^F – viz., the ratio of domestic prices to world prices, measured in domestic currency.

Indeed there are only two differences between the two measures. First, as can be seen in Equation (13), there is no weighting for individual commodities as is the case for P^F. Second, implicit in Equation (13) is the inclusion of capital goods into the formulation of α (and hence its inverse, SER), in direct opposition to SMD. Which is theoretically correct? To date no clear-cut answer has emerged from the literature. Fortunately, for the empirical task at hand, it would make little difference which approach was used, given that most capital goods, regardless of origin, are in Senegal either subject to very low tariff rates, or are totally exempt. In addition, there is a general exoneration of most tariffs on imports from the Common Market, the provenance of the greatest bulk of such goods in Senegal.[66]

Measurements of Benefits and Costs

This section will be for the most part a brief summarization of the theory underlying the SMD approach to the measurement of benefits and costs, with particular emphasis on those aspects germane to

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65/ LM, p. 361.

66/ IBRD, Senegal: Tradition, Diversification et Developpement Economique, Rapport Economique de la Banque Mondiale (Washington, D.C.: IBRD 1974), pp. 193-226, passim.

objectives are other than aggregate consumption.

Before attempting to measure the benefits of a project, however, the analyst must determine precisely the nature of the net output, the latter term being defined as, "...the goods and services made available to the economy that would not have been available in the absence of the project."[67/] There are two possibilities here. If the project adds to the total supply of good X in the economy, then this additional amount of the good is the relevant output to be measured. On the other hand, if the added supply of X substitutes for an alternative supply of the latter, then the relevant output is not the additional amount of X, but rather the inputs released from the alternative source of supply. In the former case, the appropriate measure of a benefit is the WTP for the net output itself, while in the latter it is the WTP for the inputs released or saved by the project.

Once the nature of the net output is identified, it becomes necessary to find an appropriate measure of WTP for each of the cases outlined above. Toward this end, SMD have identified three categories of output--consumer goods, producer goods, and foreign exchange--each of which will be taken up directly.

Benefits from consumer goods

The best first approximation to the measurement of a consumer-good benefit (e.g., wheat) is its selling price on the market. However, in order that this market price may truly reflect WTP, three conditions must hold:

67/ SMD, p. 41.

(1) the commodity in question is available in any quantity to any customer willing to pay the market price;

(2) no customer has monopsony power (i.e., no consumer can influence the price of goods he purchases);

(3) the addition of the total supply of the commodity brought about by the project is not large enough to alter the market price.[68]

In the event that any one of these conditions is violated, the market price will tend to understate WTP. For example, if there is rationing according to a quota system, some consumers will be frustrated in their efforts to obtain as much of the good as they want. Moreover, SMD caution against assuming that the black market rate is a good proxy for WTP, in that the former is, "...a function of the limited demand and supply that finds its way into illegal transactions."[69] The only recourse for the analyst in the face of rationing then is a rigorous analysis of the demand curve for the good in question.

Where an increase in supply due to the project's output is large enough to cause a fall in the market price (i.e., condition 3 is violated), neither the old nor the new market price reflects WTP. Instead, WTP is the area under the demand curve between the old and new supply levels as shown in Figure 2. This area (ABCD) is the sum of new price times the increment in supply, plus the change

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68/ Ibid., p. 42.

69/ Ibid.

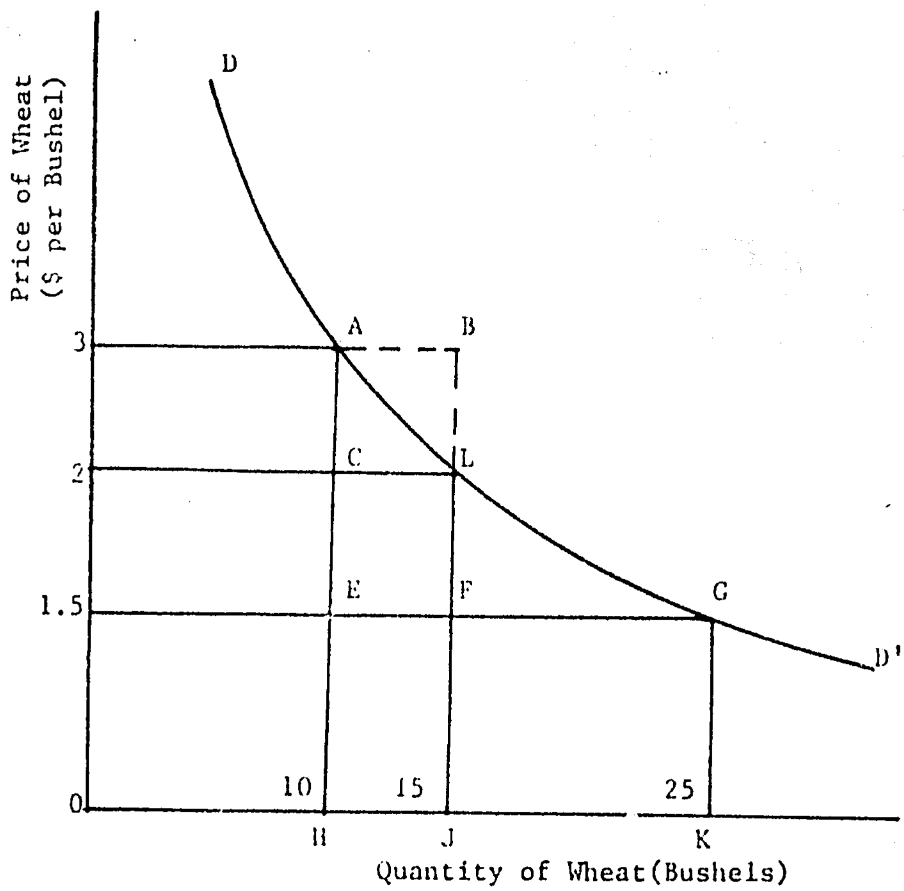

Figure 2. Willingness to Pay for a Commodity.

in consumers' surplus, induced by the added supply.

A much more serious difficulty arises where the output is not purchased at all in the market. Unfortunately, such examples are not hard to find. Medical services, educational and vocational training programs, housing, etc., are all cases where the price paid by the user rarely reflects WTP, and in many instances is zero. For valuing medical services one might speculate how much consumers would pay; or in the case of free or subsidized housing, rental rates on comparable structures would be a reasonable proxy. In the case of educational programs, the best that can be done is simply to note the existence of benefits, albeit unquantifiable ones, given our present state of knowledge vis-a-vis measurement.

Benefits from producer goods

A producer good is an input for the manufacture of another good, rather than one which is consumed directly. The fact that, (say) steel is a producer good changes nothing in principle in the WTP framework, and thus the value of an increment in steel output is the ultimate consumers' WTP for all of the consumption deriving from steel (e.g., automobiles).[70/] In economic parlance, this is called derived demand. Again, a reasonable first approximation would be the market price; but in this instance it will be the price the producers of goods which use steel as inputs pay for the raw product. However, for this market price to reflect the producers' WTP, all of the three conditions mentioned above in the discussion of benefits from consumer goods must hold. In addition, a fourth condition requires that the purchasers of intermediate goods (steel, in this case) do not exercise monopoly power in the market in which they sell their final product.

What can be done when one of these four conditions is violated, which is likely to be the case, especially in under developed economies? SMD[71/] suggest that the analyst might still estimate the producers'

70/ *Ibid.*, p. 46.

71/ *Ibid.*

WTP by calculating a residual after all inputs other than steel will have been subtracted.

Benefits in earning foreign exchange

Not infrequently it happens that the ultimate effect of a project is not a direct increase in the supply of goods to the economy, but rather a net increase in the availability of foreign exchange, such increase owing either to increased exports or reduced imports as a result of import substitution. With respect to the latter, SMD state that the net effect is a release of foreign exchange equal in value to the foreign exchange cost of previous exports "...provided these goods actually can be expected to replace previous imports, rather than augment total supplies."[72/]

This argument can be seen best by reference to Figure 3 below. Suppose that the annual supply of steel in a country is 1,000 tons, one half of which is imported. While the c.i.f. import price is only $250 per ton, the government has placed a protective tariff of $50 per ton on imported steel; and as a consequence, all steel is sold at $300 per ton.

Subsequently, a new domestic plant is developed with a capacity of 200 tons which, when added to total supply, causes the price to fall to $280 per ton. In this case, the appropriate measure of the benefits would be according to the principle of WTP, the area ACHG, under the demand curve, or as discussed previously, the new price times the additional supply plus the change in consumers'

72/ Ibid., p. 47.

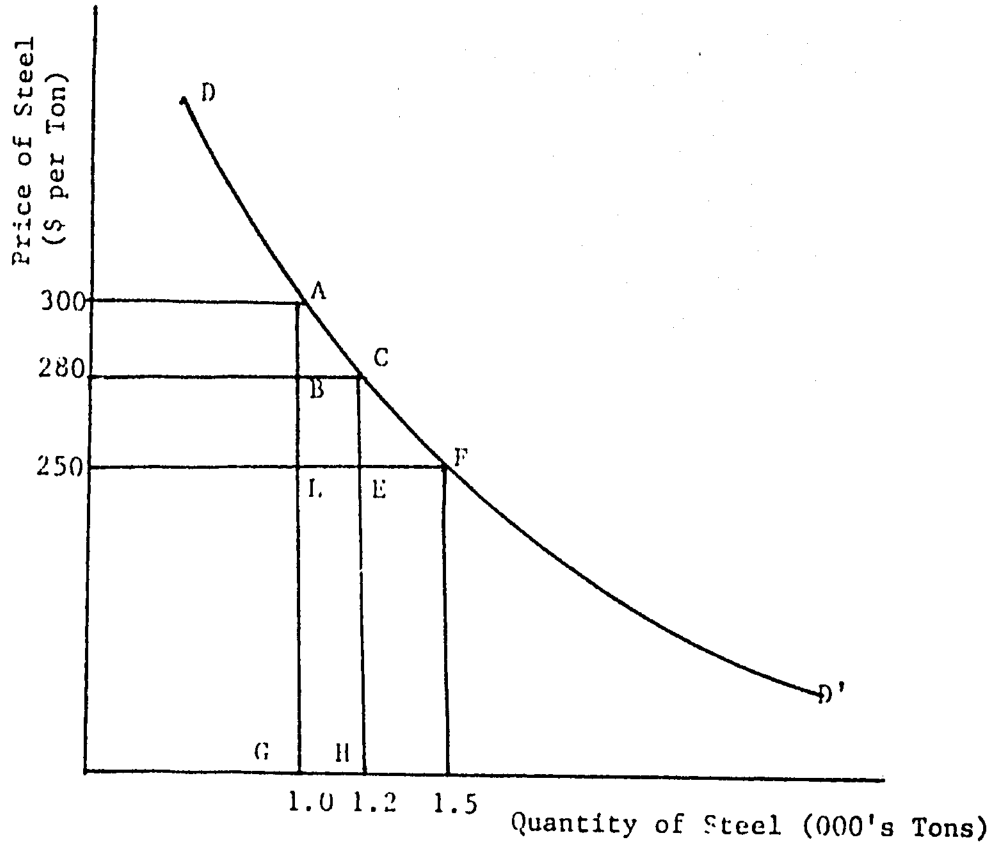

Figure 3. Willingness to pay and foreign exchange.

surplus (the latter being measured by ABC). If on the other hand, the effect of the project was to substitute for previous imports, such that total supply remained constant at 1,000 tons (and hence price at $300 per ton), then the appropriate measure of project benefits would be the amount of foreign exchange saved--i.e., $250 times 200 tons (LEGH).

There are others (most notably LM) who would argue that LEGH is the appropriate measure of benefits regardless of the project's effect on supply. This follows from a basic conviction that SCB should assume optimality with respect to the government's trade policy. SMD counter that it is well and good to talk about optimal trade policy, but somewhat beside the point. The issue is rather <u>can</u> or <u>will</u> the government follow an optimal trade policy? If the answer is negative, SMD recommends that the analysis procede on the assumption that existing distortions will remain intact.

Once it has been determined that the net output of the project is indeed foreign exchange, there remains the question of valuation. Just as with consumer and producer good benefits, the analyst must estimate the WTP (in domestic currency denominations) of the foreign exchange saved or earned by the project; and the market price is the appropriate first approximation of WTP. But in the face of trade distortions, the free market exchange rate will tend to understate the domestic WTP for a unit of foreign exchange. To remedy the situation, the analyst must convert at official exchange rates all foreign currency values into their domestic equivalents, and subsequently multiply the obtained values by SER.

Direct Costs

Direct costs for SCB accounting purposes consist of net inputs to the project. In keeping with the notion of opportunity costs, these net inputs are defined as, "...the goods and services withdrawn from the economy that would not have been withdrawn in the absence appropriate method for valuing each of these categories follows directly below.

Producer goods

Where total supply is reduced

SMD[74] have us imagine a project involving the construction of a concrete-filled dam, for which one of the most important inputs is, obviously, cement. If total supply of cement is reduced as a result of the project, then the analyst must attempt to measure WTP for the cement that no longer is available. Moreover, market prices will accurately reflect producer WTP, provided the same four conditions noted previously (in the discussion of producer-good benefits) still hold. Should the amount of cement be large relative to the size of the industry, such that the price changes as a result of the project (i.e., condition 3 is violated), then producer WTP is understated by the original (lower) market price and overstated by the final (higher) market price.

Where total supply is increased

If, however, in response to incremental demand resulting from the project, the total supply of cement to the economy is increased (due perhaps to economies of scale in the cement industry), it is not WTP, but rather the cost of the additional inputs used to boost cement production that becomes the appropriate measure of cost.

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[74] Ibid., pp. 54-6.

Labor costs

> ....To identify the relevant net input to a project that corresponds to the hiring of any given man, one must as usual ask the question: What does the rest of the economy ultimately lose when this man joins the project? To begin with, what productive resources--human or material--decline in availability as a result of the input of labor to a project.[77]

In answer to their own questions, SMD state that the immediate effect of hiring a man's services on a project is to deprive the rest of the economy of these services. So as to be able to identify clearly the net labor input to the project, it is necessary to divide it into skilled and unskilled components, with the latter being defined as the most fundamental kind of labor a man could provide, requiring neither education nor training.

In determining the consumer WTP tor unskilled labor services, the market wage is universally rejected as a proxy, on the grounds that typically such rates in underdeveloped economies are highly distorted. The conventional remedy is the application of a shadow wage rate for unskilled labor ranging from zero to the market rate. For reasons mentioned previously in the section dealing with SWR, however, it is most unlikely that the latter is ever literally zero. On the other hand, for skilled labor, the usual assumption made is that the market wage reasonably reflects the opportunity cost of this category of labor.

77/ Ibid., p. 59.

Land costs

Unlike other factors of production for which value may be measured at either the supply or demand margins, land may be valued only at the latter, given that as a project input it is nearly always in constant supply. Thus, the appropriate measure of land cost is usually the ultimate consumer WTP for the aggregate consumption made possible by its use. However, if the land needed for a project has no potential alternative use, its value for SCB purposes is zero, regardless of the sum actually paid for it by the project. On the other hand, if it does have an alternative use, but for some reason (e.g., institutional constraints) the market price does not adequately reflect WTP, then its cost may be approximated by the net benefits foregone in the highest alternative use.

Indirect Benefits and Costs

One of the most confusing aspects of SCB is the notion of "indirect benefits and costs."[78/] Moreover, it is often difficult to determine whether differences among economists are theoretical or only terminological in nature. Thus, as was pointed out previously in this chapter, many of the so-called secondary benefits (e.g., income distribution) are more properly classified as direct benefits once the relevant objectives have been clearly specified.

Unfortunately, the concept of secondary benefits, as found in the literature, is very broad, and thus one will also find subsumed

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78/ For the discussion which follows "indirect benefits and costs" should be understood to be synonymous with "secondary benefits and costs."

under this rubric the notion of stemming effects, induced benefits, and so forth. The latter refer to those instances where the output of a project gives rise to increased activity in other related industries. Prest and Turvey, making the argument that since perfect markets are capable of capturing these effects, "...we need worry about secondary benefits (or for that matter, costs) only to the extent that market prices fail to reflect marginal social costs and benefits."79/

Gittinger, as if in reply to Prest and Turvey, states: "The problem is, of course, that such perfectly adjusted market structures only rarely exist, at least in developing countries."80/ And so they do not. However, as shown by SMD in the passage cited below, this dispute vanishes once the terminology is clearly defined:

> ....It must be admitted that, to an extent, the distinction between 'direct' and 'indirect' benefits is arbitrary. For example, suppose that the output of a project is not directly consumed, but is purchased for use in further processing. Moreover, suppose that there are monopoly or monopsony elements in the further processing. We have seen that the immediate purchaser of the project output then does not capture the full consumption benefit of that output when he resells it after processing. It was argued previously that in such a situation, to measure the full value of the output benefits the immediate purchasers' willingness to pay must be supplemented by the excess on the subsequent purchasers' willingness to pay over and above their actual payments. It is largely a matter of convenience to incorporate such an output within direct benefits...81/

79/ Prest and Turvey, p. 690.

80/ Gittinger, p. 26.

81/ SMD, p. 64.

Then there is the matter of what are called transfers, which are also often included under the rubric of secondaries. The former refer to transfer or distributional payments which flow among the various groups of society. Since a more detailed discussion of transfers is to follow later in this chapter, it will suffice for now to note only the inadmissability of such payments as benefits or costs, inasmuch as the aggregate consumption objective is concerned only with incremental output arising from a given project investment.

If not any of the foregoing, then what does SMD consider fit for inclusion in their concept of indirect benefits and costs? Essentially, there are two broad categories: (1) externalities, or more specifically, technical externalities, and environmental spillover effects; and (2) savings and investment effects, wherein the net benefits brought about by a project give rise to changes in consumption and investment due to the existence of social groups with varying propensities to save and consume.

Indirect benefits and costs due to externalities

While a review of the recent literature on externalities will reveal that great strides have been made in recent years on the theoretical front, the truth of the matter is that our state of knowledge is such that, in practice, little more can be done in an SCB study than simply identify the existence of externalities and speculate as to the direction of their cumulative effects. This should not, however, be construed as a plea for the nostrum that SMD have referred to as "the principle of insufficient reason," whereby an assumption is made that the sum of positive and negative effects is zero. Such an approach, they maintain, is unacceptable:

> ....Instead of rationalizing away present ignorance, it is far better, in our view, to acknowledge that external effects may well be important even though we may not be able to quantify them.82/

Having emphasized the importance for an unequivocal statement by the analyst of the presence of externalities, SMD nevertheless exclude certain broad categories of the latter from the analytical process. Specifically, such comprehensive and vague effects as "the creation of an enterprising spirit among the population" are not seen fit for inclusion, the rationale being that the government has already made the decision to bring about industrial and commercial development. Moreover, the role of SCB analysis is to evaluate competing projects, not such fundamental decisions as whether or not to develop in the first place. Conversely, external disbenefits (i.e., costs) such as the loss of traditional values would then also be excluded.

What effects then are appropriate for inclusion in the SCB analysis? There are essentially three types:

1) Reduced Cost of Production Effects: Suppose a large project necessitates the construction of access roads which are available for use free of charge to users not related to the project. The reduced transport costs may very well be translated into reduced production costs for a variety of enterprises. However,

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82/ SMD, p. 67.

none of these additional benefits will be captured by the project.

2) Training Effects: In the instance where a project provides training or education to its personnel, there will be external benefits to the economy at large if/when the trained worker (who is presumably more productive as a result of his training) takes a job outside of the project. Here again the project will be unable to capture the benefits.

3) Environmental Spillover Effects: The most typical example is the pollution of air or water by an industrial project. The costs of such pollution, in the absence of any negotiations between the project and the injured parties, and/or in the absence of legislated compensation, will be borne by those outside the project.

Indirect benefits and costs due to changes in savings and investment

An individual who benefits from a project may respond to his improved financial situation by increasing his savings; and conversely, an individual who incurs costs as the result of a project may respond by reducing savings rather than consumption. Any such changes in savings translate themselves into changes in investment, which in turn have consequences fo[illegible]re aggregate consum[illegible]tion.[83]

To the extent that a project increases current investment, it provides indirect future consumption benefits. If on, the other hand, the effect of the project is to redistribute resources from those classes with high savings rates to those who save little, or nothing, current consumption is favored over investment, and thus the project provides indirect costs to society. The parameter used to measure these indirect costs or benefits is the shadow price of investment

83/ Ibid.

(P^{inv}), as defined previously in this chapter.

Transfers

Often as the result of a project certain cash flows arise that can be classified neither as benefits nor as costs, but are merely transfers from one sector of the economy to another. SMD provide a good example of such payments in their case study of the fictive Managua Water Project. The latter is a land settlement scheme whereby the government expropriated (with compensation)large tracts of land from wealthy landowners, developed it for small-scale irrigated farming, and made the resulting farm land available to the local peasantry on a purchase or rental basis. At the same time, the government created an authority which provided irrigation water to the farmers on a fee basis.

From the above description, it can be seen that the Managua Project has given rise to several transfer payments. First there is a payment from the government to former landowners as compensation for the expropriated land. Second, there are three separate payments --irrigation fees, rental fees on land and farm equipment, and interest payments on loans--from the newly installed farmers to the water authority. Since none of these flows corresponds directly to the direct use of resources, they represent neither a cost nor a benefit to society as a whole--i.e., for the purposes of economic analysis. On the other hand, from the viewpoint of the farmer and/or the water authority--i.e., for the purposes of financial analysis--these charges and receipts are very real indeed, and thus must be counted as benefits or costs in the usual fashion.

Suppose now, that in addition, the government levies a tax against the water authority, and at the same time sells agricultural inputs to the farmers at subsidized prices. Here again, for the purposes of economic analysis, the tax and subsidies should be treated as transfers, and hence netted out of the calculation. On the other hand, for the purposes of financial analysis, the tax would represent a cost to the authority and a benefit to the government, while the subsidies would represent a benefit to the farmers and a cost to the government.

Of a more subtle nature is a transfer in the form of an economic rent. Mishan[84/] provides an example of this where he discusses the rise in rents paid by restaurants, gas stations, etc., due to increased site values as the result of a highway construction project. In the absence of economic growth it is improper to include this increased value as a benefit, since rents will have fallen by an equal amount elsewhere as a result of shifting demand. Thus the change in asset valuation is merely a transfer from entrepreneurs off the highway to their better situated comrades.

But what happens if economic growth occurs? In that instance, according to Mishan:

> ....the flow of some additional benefits exceed the corresponding flow of losses. What one has to guard against is counting the same benefit or loss twice; once as a flow, and again, later as a change in asset valuation derived of the flow.[85/]

84/ Mishan, p. 78.

85/ *Ibid.*

Thus in either case, with or without economic growth, the economic rent is not to be included for the purposes of economic analysis. As before for other transfers, however, any such changes in asset valuation would be properly included in the financial analysis.

Investment Criteria

The three major investment criteria for project selection used in SCB analysis are Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR), each of which are defined below in Equations (14), (15), and (16), respectively.

$$NPV = \sum_{t=0}^{t=n} \frac{B^*_t}{(1+i)^t} \tag{14}$$

where:

B^*_t = net benefits in time t

i = social discount rate

$$BCR = \frac{\sum_{t=0}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{t=n} \frac{C_t}{(1+i)^t}} \tag{15}$$

where:

B_t = benefits in time t

C_t = costs in time t

$$IRR = \sum_{t=0}^{t=n} \frac{B^*_t}{(1+\lambda)^t} \qquad (16)$$

where

λ = that rate of discount which renders NPV equal to zero.

Unfortunately, none of these measures is without its drawbacks. NPV is an absolute, not a relative measure, and hence it is biased toward large projects.[86] Moreover, NPV is extremely sensitive to the discount rate used.[87] The major limitation of BCR is that its use in the face of a budget constraint may result in the selec tion of a set of projects which is sub-optimal.[88]

The IRR is beset with two major difficulties. The first is that IRR, in being quadratic, gives rise to more than one solution. The necessary (but not sufficient) condition for more than one solution is that not all costs be incurred in an initial investment period.[89] Second, an implicit assumption in the IRR formulation is that all benefits from the project are reinvested at the same rate of interest as the IRR itself, an assumption which more times than not is unfounded.[90]

Given the inherent weaknesses in all three of these measures, it would be unwise for the analyst to recommend the selection of a project based on any one of them alone. Consequently, it is advisable

86/ Gittinger, p. 71.

87/ Mishan, pp. 177-9.

88/ Ibid., pp. 193-4.

89/ Ibid.

90/ Ibid., p. 227.

to use all three in order to evaluate project worth--the procedure which will be followed here for the evaluation of the Nianga Project.

Project Evaluation Under Risk

Up to this point, the SCB methodology has tended to assume a riskless environment--i.e., the values of inputs, outputs, prices, etc., are known with a probability of one. Such an assumption is obviously invalid in the face of real world conditions. The earliest and most simplistic method economists have used to remedy this situation is that of sensitivity analysis, whereby one or all parameters are varied singly or in combination by a certain percentage. An alternative version of sensitivity analysis seeks to determine by how much a given variable (or variables) must be charged in order to reduce net benefits to zero. A major weakness of either version, however, is that such a procedure does not account adequately for interrelationships among variables.

A slightly more sophisticated analysis results from use of expected values (EV), whereby the analyst, based on educated guesses, determines all of the possible values a given variable might take on. Each of these values is then assigned the probability of its occurrence, such that the probabilities sum to one. The result is a probability distribution for each variable, and from this distribution, the mean--i.e., the EV--is selected as the value to be used in the SCB analysis.

Use of the EV is not without its difficulties, however. As Squire and van der Tak[91/] have noted, use of EV implies that the government

[91/] Squire and van der Tak, p. 46.

(assuming here the case of a public project) is indifferent to risk. This assumption causes no problem, according to these authors, where the risk is pooled across the entire population. While this reasoning holds up fairly well for the case of an individual project, it tends to break down for agricultural projects where there could be individual losers--e.g., farmers, cooperatives, etc. An additional problem with the use of EV is that no insight into the variation around the mean values selected for the SCB accounting is provided. Thus in the final analysis, EV is incapable of exposing the riskiness of a project.

Of a still greater degree of sophistication is a variety of techniques known as risk analysis, one such technique (and perhaps the most widely used) being that of Monte Carlo simulation. This technique requires specification of probability distributions for each variable as well as the covariances among variables. Whereas a probability distribution was constructed for each variable with the EV technique, in Monte Carlo simulation, output distributions are derived for different possible values that each input variable might take on. Given these probability distributions, specific values are randomly selected and combined so as to arrive at an estimate of NPV. This process is repeated many times so that a probability distribution of NPV and other outputs is produced. The major difficulty here, however, is in obtaining reliable parameters for the input probability distributions.

While risk analysis is eminently preferable to the cruder method of sensitivity analysis, use of the former presupposes the availability of substantial quantities of data with which the analyst may estimate the various probabilities. Given the deficiencies in available data for the Nianga Project, recourse will be made in this thesis to sensibility analysis only for the evaluation of risk.

CHAPTER III

DESCRIPTION OF THE NIANGA AREA

Before undertaking an analysis of a given project, one should have a general understanding of the physical and human geography of the area. It is toward this end that Chapter III is directed. Thus, included is a brief description of the physical environment, with a special emphasis on the hydrology of the Senegal River, as well as an overview of the socio-economic characteristics of the local population and its institutions.

Location

The area in and around the Nianga Perimeter is situated in one of the northernmost points of Senegal, approximately 180 kilometers east of the coastal city of St. Louis (see Figure 4). Roughly speaking, the project area itself is bounded on the north by the Doue (a fork of the Senegal River), on the east by the Bretelle de Podor,[1/] on the south by the Route Nationale (N2), and on the west by a leg of the exterior dike which runs from the village of Ndiayene along N2 to the village of Niandane on the Doue (see Figure 5).

1/ Bretelle is a French word, which in this context translates as "transversal route." More colloquially, one might simply translate Bretelle de Podor as "the Podor Road."

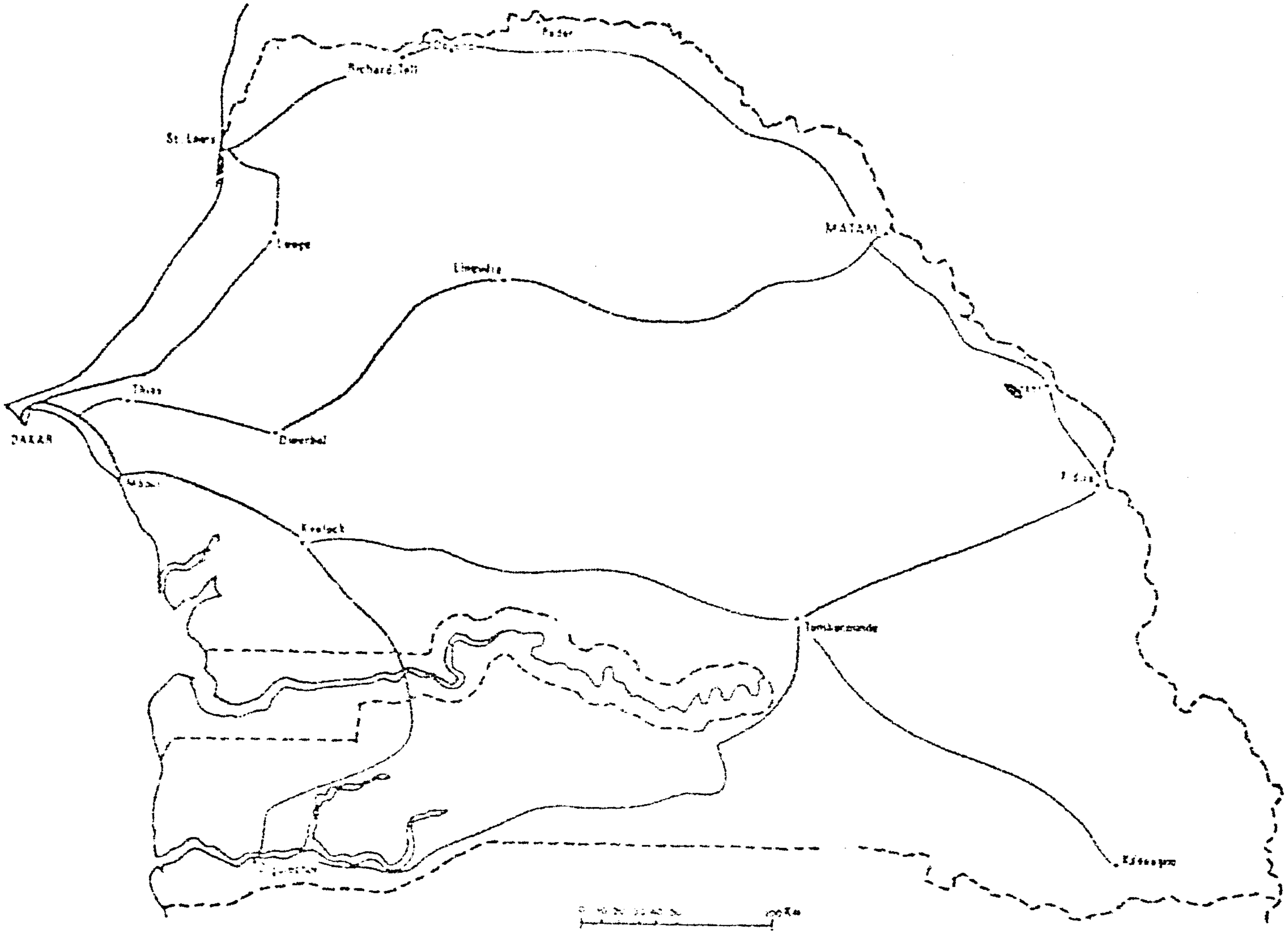

Figure 4. Map of Senegal.

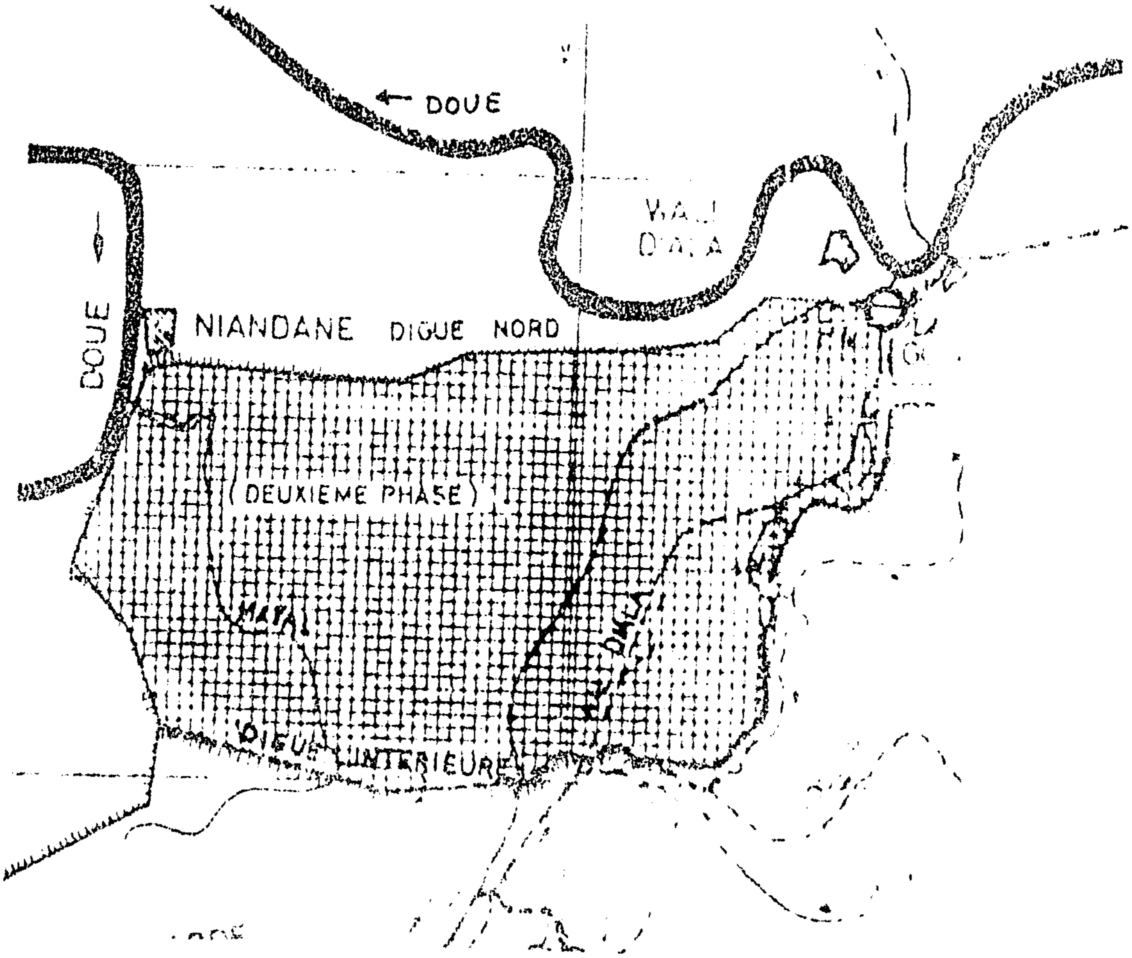

Figure 5. Map of the Pilot Project Area.

Source: HYDROPLAN, 1972-75, p. 4.

In terms of political jurisdiction,[2/] the Project is situated in the:

- Region du Fleuve (capital: St. Louis)
- Departement de Podor (prefecture: Town of Podor)
- Arrondissement de Thylle-Boubacar (seat: Village of Thylle-Boubacar).

It should be noted, however, that the northeastern tip of the project is located in the Arrondissement de Ndioum, of which the seat, the Village of Ndioum, is located approximately 40 kilometers to the east.

In terms of accessibility by modern transportation routes, the project area is connected to N2 (a paved, two-lane highway) by a laterite road eight kilometers in length which runs atop the western leg of the exterior dike. As noted by HYDROPLAN[3/] (a West German consulting firm), accessibility prior to construction of the dikes and the accompanying roads was severely limited during the rainy season. Before the development of the Project, the area was cut by a network of small, meandering streams (walls), more of which will be said later, as well as a network of small trails (sentiers).

In addition, there were two "principal" transversal roads, neither of which were passable by auto during the rainy season, connecting N2 with the Town of Podor. The first, known as the Piste[4/]

[2/] Roughly speaking, the entities underlined below have, respectively, as their American counterparts the jurisdictional units of state, county, and township.

[3/] HYDROPLAN, Amenagement Hydroagricole du Perimetre de Nianga/Senegal: Rapport Final sur l'Execution des Travaux, 1973-75 (Herdecke, Federal Republic of Germany: HYDROPLAN, January, 1976), pp. 2-3.

[4/] Piste: A French word meaning, in general, a dirt road.

de Podor, bifurcated what is now the Project Area, and as such, ran from the Village of Thieole, situated on N2, to the Village of Guia on the Doue, where it connected with the ferry which carries passengers and vehicles across the river on their way to Podor. The second piste (which has recently undergone considerable construction and is now designated as the Bretelle de Podor) connected N2 from a point 17 kilometers to the east of Thieole with the same ferry at Guia.

Natural Conditions

Topography

The Piani e Progetti Study (hereafter referred to as P&P) gives a nearly pastoral description of the topography which is worthwhile repeating here:

> ....At the end of its mountainous journey the Senegal River flows into the plain which constitute the Moyenne Vallee, from where it continues with only a gradual fall toward the ocean, following a meandering course through alluvial deposits from the Quaternaire. Superimposed on these deposits are stable dunes, which are the legacy of the region's arid past.[5]

The presence of these dunes gives the area a "choppy" relief. In contrast to these high spots are a series of depressions, the lowest of which remain permanent swamps, expanding during the rainy season as a result of the flood, and contracting with the progression of the dry season.

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[5] Piani e Progetti, Etude des Possibilites d'Amenagement du Perimetre de Nianga Dans la Vallee du Fleuve Senegal, A Report Prepared by Piani e Progetti (Rome: Bureau d'Etudes Piani e Progetti, March 1968), p. 11. [This author's translation].

Based on a review of the literature, it would appear that there is only rough agreement among the experts concerning the altitude of the Project Area. P&P[6/] cite a range from 1.60 meters (cote IGN)[7/] for the lowest depression to 15.0 meters for the tops of the highest dunes. SOGREAH (a Grenoble, France-based consulting firm) in a more recent study cited a range from 3 to 6 meters.[8/] And finally, HYDROPLAN specified a similar range--from 2.5 to 6 meters.[9/]

Climate

Rainfall

There are two major features which characterize the rainfall patterns in the Nianga Area. One is the unevenness of distribution within the year, whereby the bulk of precipitation falls during a rainy season lasting only three months--July, August, and September (see Table 1). The second is the interannual variation. This is best illustrated by the fact that, although mean annual rainfall for the period 1920-1957 was 320.7 mm., the range was from 98.0 to 803.4.[10/]

It is this interannual fluctuation of precipitation which has been largely responsible for the periodic famines in the region, which

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6/ P & P, p. 16.

7/ "Cote IGN" refers to the measurement of altitude established by the Institut Geographique National, based in Paris.

8/ SOGREAH, Etude Hydroagricole du Bassin du Fleuve Senegal: Schema de Principe Detaille-Casier Pilote de Nianga-R11310-A-Memoire, A Report Prepared by SOGREAH (Grenoble, France: SOGREAH, December 1972), p. 4.

9/ HYDROPLAN, p. 3.

10/ SOGREAH, Annex 2, p. 3.

TABLE 1

RAINFALL DATA[a/]

Month	Podor Station: Mean 1920-57 (mm.)	Podor Station 1975/76: mm.	Podor Station 1975/76: No. of Days of Rain	Guede Station[b/]: Mean 1970-76 (mm.)	Guede Station 1975/76: mm.	Guede Station 1975/76: No. of Days of Rain
July	59.9	52.6	3	46.4	Missing	Missing
Aug.	127.5	75.5	10	92.8	97.9	2
Sept.	84.1	36.0	5	21.9	43.5	6
Oct.	22.1	13.6	1	6.9	9.7	3
Nov.	2.6	--	-	0.5	--	-
Dec.	0.8	0.5	2	--	--	-
Jan.	1.4	1.3	2	--	2.4	1
Feb.	1.5	7.3	2	1.8	5.3	2
Mar.	0.8	7.1	2	--	11.7	3
Apr.	0.1	--	-	--	--	-
May	3.0	--	-	--	--	-
June	16.9	9.6	2	6.7	19.9	2
Total Annual	320.7	169.6	28	177.7		

a/ Table reproduced from: SAED Rapport de Campagne Contre-Saison 1975-1976, September 1976, p. 1.

b/ The irrigated rice project at Guede is located approximately 25 kilometers east of the Nianga Project. Therefore, rainfall data at this station can be used as a proxy for the Podor Area--i.e., the Nianga Project Area.

in turn have made all the more urgent the cries for intervention to alter the agricultural environment. This variation in rainfall has devastating effects because millet (petit mil or souna, as it is known locally), one of the major dryland food crops, cannot produce at less than 250 mm. of rainfall.[11/] Moreoever, as will be discussed in more detail in Chapter V below, this variability had proven to be one of the major stumbling blocks in previous attempts (amenagement primaire et secondaire) at irrigated rice culture, which were dependent upon the rains for sprouting of the rice.

Finally, it should be noted that the average annual rainfall for the period 1970-76 (177.7 mm.) was significantly less than for the period 1920-57 (320.7 mm.). While the long range significance of this phenomenon is open for debate,[12/] the short run effect, as noted in Chapter I of this thesis, has been the mobilization of resources by donor agencies to provide irrigated agriculture as an alternative means of livelihood for the drought's victims.

Seasons

As can be seen in Table 2, there is important seasonal variation in temperature during the calendar year. Variation in temperature and rainfall combine to yield the five annual seasons which are the following:

[11/] M. Gaudy, Manuel de l'Agriculture Tropicole--Afrique Tropicale et Equatorial (Paris: La Maison Rustique, 1965), p. 140.

[12/] For example, the 1976 OMVS Report (OMVS, Presentation, Methods, and Means..., p. 10) states the following, "The notion of cyclic drought is a controversial one, but some exports agree on the following features: (1) a short drought cycle every seven years; and (2) a long drought cycle, every 30 years."

TABLE 2

AVERAGE MONTHLY TEMPERATURES (CELCIUS)[a/]

Month	Podor Station: Mean 1920-57	Podor Station 1975/76: Max.	Min.	Mean	Guede Station: Mean 1970-76	Guede Station 1975/76: Max.	Min.	Mean
July	30.8	38.6	24.2	31.4	30.2	37.2	24.7	30.9
Aug.	29.7	35.5	24.5	30.0	29.8	33.9	24.3	29.1
Sept.	29.9	35.7	24.5	30.1	30.2	34.1	23.9	29.0
Oct.	30.4	39.5	23.6	31.5	30.1	38.7	22.7	30.7
Nov.	23.4	32.8	17.8	25.3	25.8	33.4	15.4	24.4
Dec.	23.5	33.7	16.9	25.3	22.6	32.5	14.1	23.3
Jan.	22.8	28.7	15.0	21.8	21.4	27.4	12.4	19.9
Feb.	24.3	31.2	16.5	23.8	22.4	29.7	14.6	22.1
March	27.6	34.2	19.1	26.6	25.4	33.3	17.8	22.5
April	29.9	38.6	22.6	30.6	27.9	37.8	22.5	30.1
May	32.2	38.8	21.2	30.2	30.8	38.7	21.6	32.1
June	30.8	41.4	23.8	32.6	30.2	40.0	24.2	30.9
Average	28.4	35.7	20.8	20.8	27.4	37.4	19.8	27.0

[a/] Table reproduced from: SAED, Rapport de Campagne de Contre Saison, 1975-76, p. 2.

(1) N'DOUNGOU: from mid-July to mid-October; rainy aand moderately hot.

(2) KAOULE: from mid-October to mid-November; dry and moderately hot.

(3) DABOUNDE: from mid-November to approximately March 1st; dry and cool.

(4) TIEDOU: the months of March and April; dry and moderately hot.

(5) DEMINARE: the months of May and June; dry and very hot.[13/]

[13/] SAED-SATEC, Programme d'Extension des Perimetres d'Irrigation Villageois Dans les Departements de Podor et Matam, A Report Prepared by SATEC (Paris: SATEC, 1976), p. 11.

Wind

According to SOGREAH,[14/] data is available on wind and wind velocity for only the years 1951-57. Based on this data it was found that:

(1) There is no wind direction which predominates.

(2) The hot, dry wind from the east (harmattan) is relatively rare; but when it does blow, the temperature rises significantly and substantial quantities of dust are carried with it.

(3) Maximum wind velocity is 55 km. per hour--a velocity sufficient to cause substantial soil erosion in an area such as Nianga where there is limited vegetal cover.

(4) In certain zones which become extremely hot (surchaufe) during the day, whirlwinds form, which are highly erosive.

Evapotranspiration

Here again, the available data is limited--from 1950-57.[15/] The annual potential evapotranspiration (P.E.T.), calculated according to the TURC Formula, is 1904 mm. It should be noted that for every month of the year, except August for which there is an equilibrium, the P.E.T. exceeds rainfall. (See Table 3). Thus agriculture in the area is highly dependent upon supplementary supplies of water.

[14/] SOGREAH, Annex 2, p. 5.

[15/] SOGREAH, Annex 2, p. 5.

TABLE 3

AVERAGE MONTHLY P.E.T. AND RAINFALL (mm.)[a,b]

Month	P.E.T.	Rainfall
Jan.	146	1.4
Feb.	164	1.5
March	192	0.8
April	222	0.1
May	211	3.0
June	167	16.9
July	142	59.9
Aug.	132	127.5
Sept.	134	84.1
Oct.	142	22.1
Nov.	123	2.6
Dec.	129	0.8
Total	1,904	320.7

[a] Source of P.E.T. data: SOGREAH, Annexe 2, p. 6.

[b] TURC formula for P.E.T.:

$$\underset{\text{mm/month}}{\text{P.E.T.}} = (\text{lg} + 50) \cdot 40 \frac{1}{t+15} \left(1 + \frac{50-\text{HR}}{70}\right)$$

with lg: mean value of total solar radiation (calories/cm^2/day)

$$\text{lg} = \text{IgA} \left(a + b \frac{h}{H}\right)$$

IgA = energy of the solar radiation that would reach the soil in absence of the atmosphere

a = 0.29 cos ψ in tropical regions
b = 0.52 cos ψ in tropical regions
ψ = latitude
h = number of hours of sunlight per day
H = astronomic length of day in hours
t = $\bar{t}$ 12h = average temperature at 12 noon
HR = daily mean humidity

Hydrology

The annual flooding of the Senegal River

The traditional lifeline of the inhabitants of the Nianga Area, as well as for all indigenous peoples in the Senegal River Valley, has been the annual flooding of the river, which has made possible a flood-recession agriculture based mainly on sorghum. As was noted above, evapotranspiration greatly exceeds the annual rainfall; and this deficit must be filled by moisture which comes directly or indirectly from the floodwater of the Senegal River. Thus of vital concern to all is the height of the flood, the date of its arrival, and the date of its recession--this latter date signaling the beginning of the planting season for sorghum.

The Senegal River, approximately 1,750 kilometers in length, is the result of the confluence of the Bokoyi in Mali and the Bafing in the Fouta Djallon Region of Guinee--the latter being a relatively moist area, with an average annual rainfall of 2,000 mm. (see Figure 6). On its journey through Senegal to the Atlantic Ocean, however, the Senegal flows through progressively more arid regions. At Bakel, for example, the average rainfall is only 700 mm., while at Podor, as noted previously, it is a meager 320 mm.

The most outstanding feature of the flood is its variability in terms of magnitude and dates of arrivals and recession. At Podor the flood generally begins in June, but does not become significant until the end of July, while its maximum is generally attained in early October. However, the maximum may occur as early as September

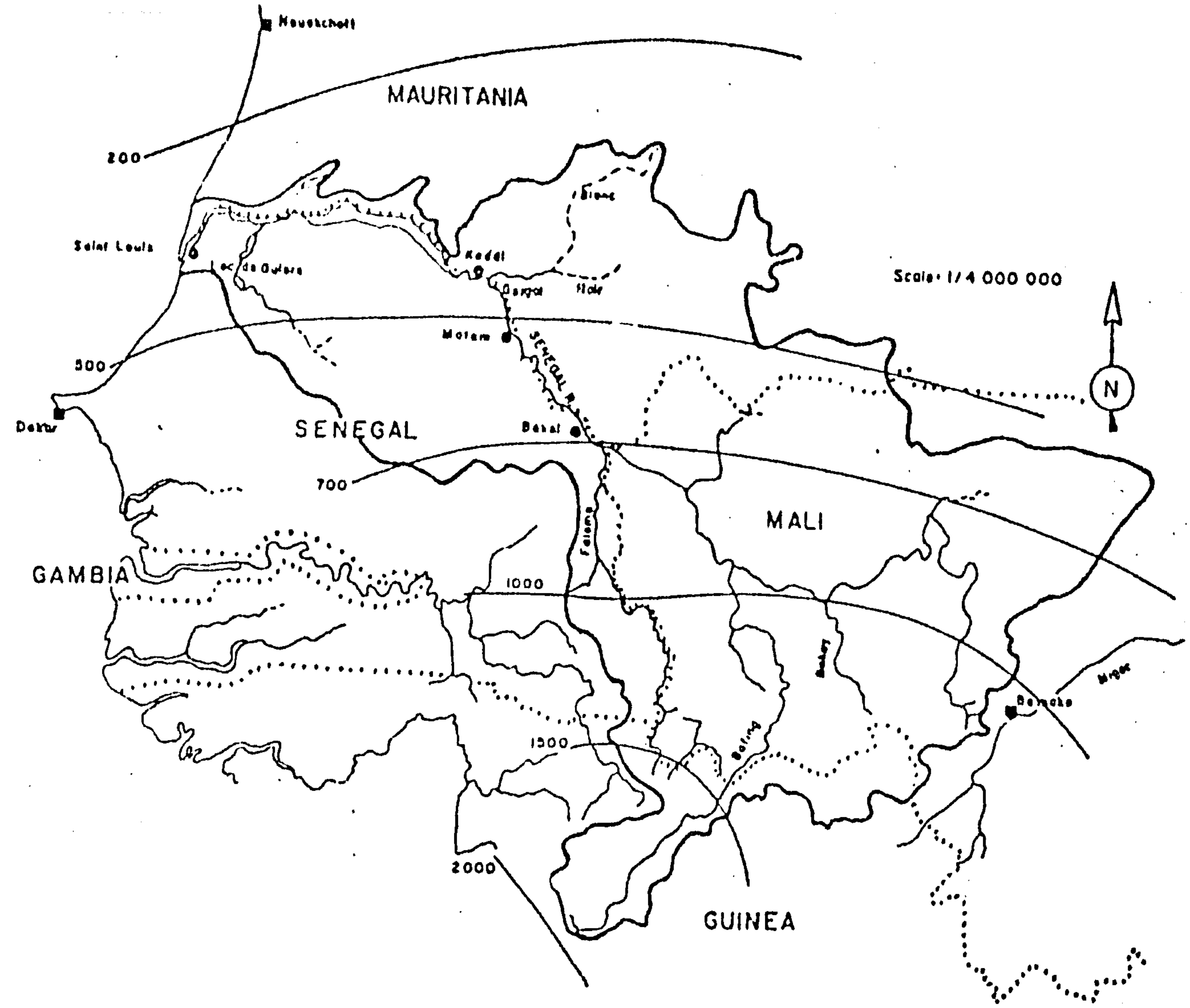

Figure 6. Map of the Senegal River Basin.

Source: J. Paul Riley, "Senegal River Basin Planning," Invited Paper for the AID-Sponsored Symposium, Towards a National U.S. Policy on River Basin Development in the Sahel (Washington, D.C., April 1976).

15 and as late as November 16. The maximum height varies from 3.5 to 6.8 meters (IGN).[16/] At Guede, which is located on the Doue (in contrast to Podor, which is situated on the main branch of the Senegal River), the flood arrives at roughly the same time. The maximum flood there may vary from 5.1 to 7.1 meters IGN.[17/] While the above figures are unimportant in of themselves, they nevtheless point out the fact that the flood-recession agriculture as traditionally practiced in the valley is subject to extreme uncertainty.

Another feature of the River equally important for its agricultural implications is the level of flow during the dry season (<u>debit d'etiage</u>). Whereas the flow at Bakel exceeds 1,000 m^3 per second at the time of peak flooding in even the driest of years (the range is from 1,400 to 10,000 m^3/s),[18/] it drops to less than 10 m^3/s by May[19/]--the last month before the rains. Downstream from Bakel, the flow at this time becomes negligible.

From this limited water supply devolved two important implications for the development of irrigated agriculture at Nianga and in most of the Senegal Valley. First, due to the low level of fresh

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16/ <u>Etude Pedologique du Perimetre de Nianga</u>, A Report Prepared by IRAT (Dakar: IRAT, 1968), p. 20.

17/ According to P & P (p. 19), the zeropoint on the hydrometric scale is -.44 and -.63 meters (IGN) for Podor and Guede, respectively.

18/ OMVS, <u>Hydrologie du Fleuve Senegal de Bakel a St. Louis de 1965 a 1975</u> (Dakar: OMVS, 1976).

19/ SOGREAH, Memoire, p. 2-4.

water flowing out of the river during the dry season there is a considerable backflow of salt water from the Atlantic Ocean. Some fairly precise estimates are available on the magnitude of this backflow. For example, with an outflow of 50, 100, and 300 m^3/s at Bakel, the backflow of sea water is 120, 100, and 35 kilometers, respectively, from St. Louis.[20] Double-cropping of rice at Dagana, an irrigated perimeter only 60 kilometers downstream from Nianga is out of the question due to the presence of this salt water in the latter part of the dry season.

The second implication for irrigated agriculture is the necessity for pumping if a supply of water is to be assured throughout the year. Taken together, these two implications are the partial basis of OMVS's justification for the construction of two dams on the Senegal River. One, to be built at Diama in the Delta Region near St. Louis, would block the backflow of salt water, while the other, to be constructed far upstream on the Bafing at Manantali in Mali, would regularize the River, such that an average flow of 300 m^3/s at Bakel would be guaranteed on a year-round basis. It should be noted, however, that construction at the Manantali Dam will not alleviate the need for pumping. According to SOGREAH,[21] even if the flow at Bakel is regularized at 300 m^3/s, the water line will be only two meters above the level at which it flows during the dry season.

20/ SOGREAH, Memoire, pp. 2-5.

21/ *Ibid.*

The walis

Prior to development of the Project, the area was traversed by numerous meandering streams, known locally as walis, which were fed by floodwater from the Doue. Subsequently, as the flood receeded, they yielded the water back to the Doue from whence it had come. Most of the walis retained some water throughout the year. In addition to providing drinking water for humans and livestock alike, they served as a transportation network, especially during the flood.

Ground water

In neither the BCEOM Study[22/] nor in P & P is there any mention of ground water. SOGREAH[23/] notes only in passing that other studies performed by FAO within the framework of its project, "REG-61,"[24/] have shown the ground water resources to be of feeble quantity and of poor quality (i.e., saline) in the Nianga-Fodor Area, and thus of little interest for irrigation purposes.[25/]

Pedology

Just as the flood patterns of the Senegal River have been the object of a considerable amount of study, so have the pedological

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22/ Bureau Central d'Etude Outre Mer, Etude Hydroagricole du Perimetre de Nianga, A Report Prepared by BCEOM for MAS (Dakar: MAS, January 1967), p. 3.

23/ SOGREAH, Memoire, p. 2-6.

24/ "REG-61": This is FAO's numerical designation of the large "umbrella" study known as Etude Hydroagricole du Basin du Fleuve Senegal.

25/ SOGREAH, Memoire, p. 2-6.

characteristics of the Valley received a great deal of attention. What follows, however, is only a brief overview of the factors necessary for a general understanding of the soil types and of their implications for both traditional and irrigated agriculture; and therefore, no attempt will be made at an exhaustive review of the literature.

The vernacular classification

The most fruitful starting point lies with an understanding of the indigenous classification scheme. It should be noted that this system is much broader and hence less precise than those commonly used by soil scientists. This should not, however, be construed as a criticism. The fact of the matter is that the traditional classification is a multi-dimensional system which orders soils in a way which is meaningful to the farmer.

As noted previously, the annual flood is the most salient element of the traditional agricultural milieu; thus it is not surprising that the underlying concept in the traditional classification scheme has the flood as its point of reference. The presentation in Table 4 is adopted from Boutillier *et al.*[26/]

Each of the major soil types shown in Table 4 is associated with a particular kind of agriculture, more of which will be said later in the description of traditional agricultural practices. For completeness, however, one refinement should be added to the vernacular classification, *viz.*, the terms *diaty* and *dir*. Both of these

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26/ J. L. Boucillier, *et al.*, *La Moyenne Vallee du Senegal* (Paris: Presse Universitaire Francaise, 1962).

TABLE 4

TRADITIONAL CLASSIFICATION OF SOIL TYPES[a]

Soil Type	Distinguishing Features
1. Oualo	- In general, land which is annually flooded
1(a) Fonde	- Land which is only occasionally flooded; generally sandy with less than 25% clay content.
1(b) Hollalde	- Low lying land which is regularly flooded; high clay content (25%). Highly valued by farmers.
1(b)(1) High 1(b)(2) Medium 1(b)(3) Low	- These subtypes have a tendency to flood in increasing order (e.g., "high" refers to height of flood above the river bed).
1(c) Falo	- Rich dark soils containing much silt; they are found on the river banks. Highly valued by farmers.
2. Dieri	- Land which is never flooded, but is nevertheless arable due to rainfall. These soils are found in an elongated zone on both banks of the Senegal River; bounded on the north by the Sahara Desert in Mauritania and on the south by the arid Ferlo Region in Senegal. In general this is sandy soil.
2(a) Seno	- Sandy soil; beige in color; considered fertile land.
2(b) Niaroual	- Sandy, but mixed with clay; black in color; finer texture than Seno.
2(c) Seno Baledjo	- Is a soil type intermediate between the two sub-types above.

[a] Source: Boutillier, et al., pp. 63-4.

refer to dieri soils, the former indicating land that had been under cultivation in the previous year, the latter referring to either fallow or virgin land that is being brought under cultivation.

Soil characteristics

The following general observations may be made concerning the soils in the Nianga area:

- Fertility (presence of N-P-K): All oualo soils are poor in nitrogen due to reduction conditions caused by submersion. Most soils are poor in phosphorus but rich in potassium.[27]

- Presence of organic matter: All soils are low in organic matter.

- Stability: Soil structure is very unstable; consequently there is a risk that surface clays might sink to form a sub-surface hardpan following deep plowing.

- Salinity and alkilinity: Both of these are "problem factors" for agriculture in Nianga.[28]

General aptitude of soils for irrigated agricluture in the Senegal Valley

In the period 1969-73, SEDAGRI[29] undertook a pedological survey throughout the Valley; this study determined that a total of 600,000 hectares are available for irrigated agriculture, of which 380,000 hectares are found on Senegalese territory.[30] A subsequent study

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27/ Ton That Trinh, L'Experimentation du Riz Avec Maitrise de l' Eau Dans la Vallee du Fleuve Senegal Dans la Cadre du Projet RAF 73/060, A Report Prepared for OMVS (Dakar: OMVS, 1976), passim.

28/ SOGREAH, Annex 3, passim.

29/ SEDAGRI: a private consulting firm jointly owned by Senegalese and American interests.

30/ OMVS, Perimetres d'Irrigation..., p. 15.

funded by the United Nations[31/] used these results to classify the Basin into a system of unites naturelles d'equipement (UNE)--agricultural units, ranging from one to 10,000 hectares, which were recommended to be developed autonomously, each in accordance with its specific pedological characteristics. The Nianga Project Area is composed of UNE-NG3 and part of NG4.[32/] According to Beyrard, these two units would necessitate the diking of roughly 22,000 hectares, for a yield of approximately 15,000 hectares of irrigable land.

Socio-Economic Conditions

The People

Population

> We are presently ignorant of the precise demographic situation of the Region du Fleuve, and for that matter, all of Senegal. The only available demographic sources are the 1970 recensement administratif, which by definition covers only taxpayers, and two sample surveys made in 1960/61 and 1970/71. This gap will be filled with publication of the results of the general census carried out in April 1976.[33/]

The foregoing summarization of our state of demographic knowledge of Senegal remains valid, for as of this writing, the results from the 1976 Census have not yet been made available to the general public. Thus for the purposes of this research, recourse will be

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31/ Norbert Beyrard, Programme Integre Pour le Developpement du Bassin du Senegal, A Report Prepared by Norbert Beyrard (Paris: Norbert Beyrard, 1974).

32/ OMVS, Perimetre d'Irrigation...., p. 23.

33/ SAED, Programme d'Action a Court et Moyen Terme: Rapport de Fin de la Premiere Phase, Vol. III, Analyse et Diagnostic sur les Conditions Humaines et Economiques de la Region, A Report Prepared by SCET-INTERNATIONAL (St. Louis, Senegal: SAED, 1977), p. 3.

made to the sample survey of 1970/71, as presented by SCET-INTERNATIONAL, as well as a localized survey made in the Nianga Area.

As can be seen in Table 5 below, the Department of Podor, which includes the Nianga Area has a total population of only 94,300 persons. Its population density (7.3) is relatively low compared with Senegal as a whole (16.9).

TABLE 5.--Population and Population Density by Arrondissement in the Department of Podor, 1970.

	Area (km.^{2})	Population (000's)	Density (pop./km.^{2})
Town of Podor		5.0	
Arrond. of Cascas	3,098	32.9	10.6
Arrond. of Ndioum	3,901	24.4	6.3
Arrond. of Salde	2,743	17.5	6.5
Arrond. of Thylle Boubacar	3,205	14.5	4.5
Dept. of Podor	12,947	94.3	7.3
Region du Fleuve	44,127	366.6	8.3
Total Senegal	196,722	3,328.9	16.9

At the village level, various demographic studies have been carried out in the Fleuve Region. One of the most exhaustive such studies was conducted by Lericollais in 1973 under the aegis of ORSTOM-SENEGAL, the results of which were not obtainable by this author. From November 1974 to February 1975, SAED surveyed the villages that were slated for participation in the Nianga Project. The results from this study are shown below in Table 6.34/ However, inasmuch as the purpose of the SAED study was to determine the allocation of cultivation rights on the Perimeter, there was a tendency on the part of the villager to over-report.35/ Unfortunately there are no available estimates of the degree of such over-reporting.

TABLE 6.--Total and Active Population of the Villages Concerned by the Nianga Pilot Project.

Arrond.	Village	Active Population	Total Population
Thylle Boubacar	Pendao	568	1,182
	Ndiayene	134	210
	Vodabe I	940	1,715
	Vodabe II	874	1,583
	Niandane	953	1,837
	Nguendar	976	1,515
	Thieole	68	134
	Figo	102	195
	Savonabe	884	1,348
	Diamel	189	181
	Kiraye	290	476
Ndioum	Guia	758	1,676
	Koditte	100	210
	Ouromady	126	258
	Ndiawara	267	581
	Diambo Diaube	81	137
	Diambo Soubalo	96	212
	Sinthiou Diambo	33	66
	Decole	454	842
Total		7,893	14,358

34/ Aboulakry Niang, Resultats Enquetes Socio-Economiques Dans les Villages Concernes Par le Projet du Perimetre de Nianga, A Report Prepared by the Cellule d'Evaluation of BEP (St. Louis, Senegal: SAED, August 1975).

35/ Papa Syr Diagne, Impact de l'Amenagement Hydro-Agricole du Nianga Sur le Village de Guia, A Report Prepared for IDEP (Dakar: IDEP, July 1977), p. 10.

As can be seen in Table 6, the total population to have been affected by the Project was estimated at slightly over 14,000 persons, and of those, only roughly 8,000 were of the age to be actively engaged in agriculture (active population). The former number comprises 38 percent of the combined populations of the arrondissements of Ndioum and Thylle Boubacar, and 15 percent of the population of the Department of Podor.

Ethnicity

The four major ethnic groups found in the environs of Nianga are in descending order of numerical importance: Toucouleur, Peul, Maure, and Wolof. As seen in Figure 7, this area represents the western front of the Toucouleur enclave in the Fleuve Region. It should be kept in mind, however, that such a map represents nothing more than a rough guide to the ethnic distributions of the population. While it might appear from Figure 7 that the various ethnic groups reside in strictly segregated blocks, this is not the case.

A classic example of such mixing, as noted above, is the Village of Ndiayene, located on the southwestern tip of the Perimeter, and characterized by Niang as "cosmopolitan" due to its ethnic diversity. Found there are significant numbers of Toucouleurs, Wolofs, and a sub-grouping of the Peul known as the Vodabe.

Another point which should be noted in passing is that the village in which a given family resides is not necessarily its "official residence"-- i.e., for tax collection purposes. Many families leave their native villages due to demographic pressures, clan

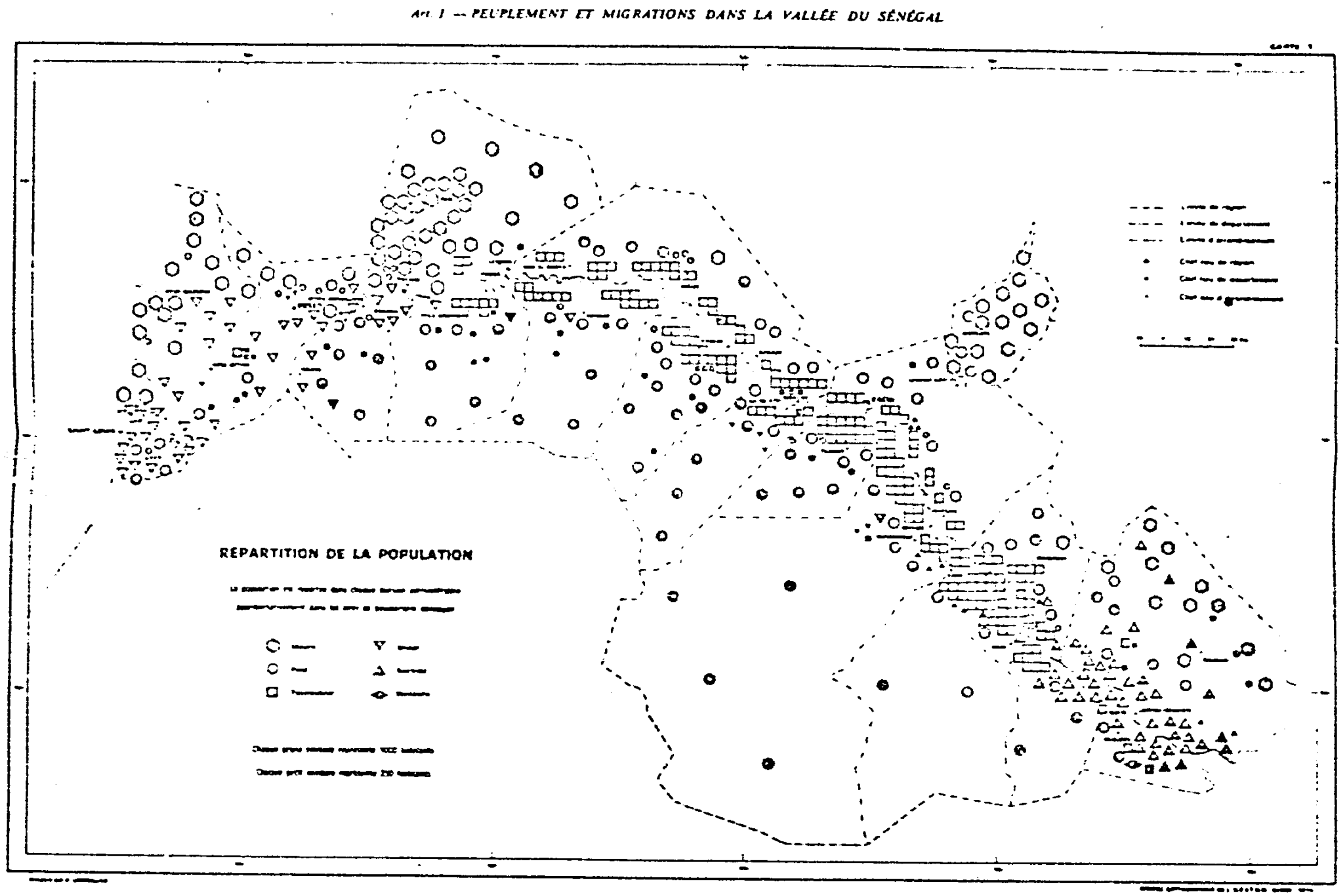

Figure 7. Ethnic Map of the Region du Fleuve.

Source: Andre Lericollais, "Peuplement et Migrations Dans la Vallee du Senegal," Cahiers d'ORSTOM, Vol. XII, No. 2 (Paris: ORSTOM, 1975), p. 131.

disputes, or other reasons, and install themselves in neighboring villages. At the same time, they often continue to consider themselves residents of their native village.

Caste

Boutillier has noted that despite the presence of a caste society in the Fleuve Region, the degree of specialization is not nearly as advanced as in other caste societies (e.g., India), where the number of such sub-castes runs into the hundreds. By contrast, in the Senegal Valley there are less than a dozen. Moreover, neither livestock raising nor agriculture are caste activities, and thus are practiced to some degree by all groups.[36/]

The delineation of the Toucouleur caste system, in descending order of social prestige is as follows:

(1) Torobes: the noble caste composed of scholars and propogators of Islam;

(2) Dimo: free men, but socially inferior to the Torobes; includes three sub-castes--fishermen, former warriors, and courtisans;

(3) Artisans: consists of six distinct artisan groups, including musicians and story tellers;

(4) Mathioudo: captives who live today in varying degrees of economic and social independence form their former feudal (Torobes) masters.[37/]

36/ Boutillier, et al., p. 56.

37/ Ibid., p. 54.

Family Structure

While the existence of the extended family in Africa is common knowledge, few in the Western world are familiar with the economic aspects of this system. Nor would there appear to be agreement on basic issues among the experts who have studied the traditional family structure in the Senegal Valley. For example, while Diop[38] states that the foyre is equivalent to the Western notion of household, Minevielle claims the contrary; and moreover, that, "....the notion of household in the European sense of the term is nonexistent in the Toucouleur mileu."[39] Or to cite another example, while Minevielle[40] claims the food consumption unit is the foyre, Boutillier et al. state that it is the galle, the extended family compound.[41] There is nevertheless sufficient agreement to allow for at least a general understanding of the matter. What follows is largely a summarization of Diop's[42] description of the Toucouleur family structure.

38/ Abdoulaye Bara Diop, Societe Toucouleur et Migration (Dakar: Institut Francais d'Afrique Noire, 1965), p. 21.

39/ J. P. Minevielle, Migrations et Economies Villageoises Dans la Vallee du Senegal (Dakar: ORSTOM, 1976), p. 54. [This author's translation].

40/ Ibid.

41/ Boutillier, et al., p. 55.

42/ Diop, pp. 20-23.

The linage (lenyol) represents the family grouping in the largest sense of the term. It includes all of the descendents (living and dead) from a common ancestor. The lenyol is patrilineal, and thus all members of the latter bear the same family name (yettode). The primary economic function of the lenyol is to allocate the use of the commonly owned agricultural lands to the various family members, the latter who rarely ever own land outright, but rather enjoy the right of usufruct.

The next lower level in the family hierarchy is the galle, the extended family as it is commonly understood in the Western world. While the lenyol might be split into many segments and widely dispersed geographically, the galle is a branch of the family that lives together in the same compound.

At the bottom of the family structure is the foyre, a unit which (notwithstanding the controversy alluded to above), corresponds roughly with that of the nuclear family. It is the foyre which is generally conceded to be the economic decision-making unit relevant to micro-economic research of agriculture.[43/] Indeed the foyre does exercise a significant degree of economic independence. The head of the foyre farms his own parcels (whether he owns them outright or they belong to the galle), maintains his own graneries, and manages his own budget. On the other hand, there is at the same time a significant degree of interdependence among the various foyre which constitute

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[43/] USAID, Development of Irrigated Agriculture at Matam, Senegal, A Report Prepared by the Bechtel Overseas Corporation (Dakar: USAID, 1976), pp. 4-13.

the galle. Thus the head of the former owes a certain obeisance to the head of the latter. Moreover, there is often a significant degree of shared labor, both in the fields and in the kitchens.

Land Tenure

The traditional system

At the risk of oversimplification, only a brief overview will be given of what is a highly complex subject. Before consideration of the details, however, a brief caveat with respect to the term traditional is in order. In Boutillier's words:

> With respect to this subject, it is important to note that the custom which prevails today has existed in its present form for only a relatively short time. It is often thought that the traditional system is one which is perfectly defined, and that it has been respectfully transmitted from generation to generation since time immemorial. In fact, at least for lands in the Senegal Valley, customs and allocations have been continually disrupted throughout its history....[and] it was not until the period between 1880 and 1910 that the tenure system in the Valley became more or less stabilized.[44]

The present traditional tenure system is characterized by a juxtaposition of large feudal-type holdings with small family-owned plots. The existence of the former is due to the fact that over the centuries the Valley has been dominated first by one then another powerful minority, each of which translated its political power into land ownership. Adding to this process was the colonial penetration

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[44] Boutillier, et al., p. 129 [This author's translation].

of the French, which in large part was effected by the attribution of large tracts of land to collaborationist local chiefs.

A second and very different source of complexity in the tenure system is inherent in the land itself. Whereas the dieri, which is both relatively plentiful and less fertile (since it is never flooded), is not highly regarded, the silt-rich oualo is highly prized. Moreover, in the oualo, the water supply is more or less guaranteed,[45/] while in the dieri the farmer is dependent upon the highly erratic rains. Predictably enough then, the customs dealing with tenure in the oualo are numerous and complex. By contrast, the tenure rules concerning the dieri are relatively casual. In effect, the latter is treated as a free good, in that no rent is collected for its use. Not so for the oualo. Over time a complex system of rents and/or tithes has developed. In addition, sharecropping has also been widely practiced.

The law of 1964

The passage of the Loi 64-46 du Juin 1964 Relative au Domaine Nationale was touted by the Government as a return to Black African authenticity. Thus in a discourse to the nation, President Senghor stated the following:

> ....it's a question of rejecting Roman Law and returning to Black African Law, of rejecting the bourgeois conception of property for the socialist conception which is that of traditional Black Africa.[46/]

[45/] However, for any given oualo parcel, water supply is dependent upon the level of the flood.

[46/] President Senghor, "Discours a la Nation," Dakar-Matin, May 2, 1964 in Alioune DIA, Contribution a l'Etude de l'Evolution du Regime Foncier Rural Dans la Region du Fleuve, A Report Prepared for MAS (Dakar: MAS, 1967), p. 50.

More concretely, the law eliminated the payments made to landholders under th traditional system. This was not, however, as revolutionary as appearances would have it, for as early as 1961 a study of the tenure system in the Fleuve Region showed that such payments had already largely fallen into desuetude. Of greater consequence for future economic development was the provision that henceforth only the State could acquire legal title to lands belonging to the Domaine Nationale. In short, it was a nationalization of all lands for which a title had not been filed prior to 1964, while all lands so registered remained in private hands.[47]

The Domaine Nationale consists of four types of zones: (1) zones urbaines; (2) zones classes; (3) zones de terroirs; and (4) zones pionniers. The first includes the urbanized areas, while the second comprises such areas as national forests, protected wildlife areas, etc. It is the latter two types which are of greatest interest here. The zones de terroirs are, in general, any lands which are regularly exploited for rural habitation, agriculture, or the raising of livestock. Local political control is assumed by a Conseil Rural, which is made up of one or more locally based civil servants (who represent the State) on the one hand, and representatives from the local villages and farmers' cooperatives, on the other.[48]

The zones pionniers are uninhabited areas which at the same time have been targeted by the State for eventual development. Such

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47/ Ibid., p. 55.

48/ MAS, Etude Economique et Financiere des Projets de Demet et Nianga: Application de la Loi Sur le Domaine National et du Mode de Gestion du Perimetre, A Report Prepared by MAS (Dakar: MAS, January 1967), p. 2.

development must procede according to a well-defined national plan. A state-designated agency (SAED in the case of the Nianga Perimeter) is charged with this development. The land thus improved for modern agriculture is then attributed to officially recognized farmers' cooperatives on a contractual basis, and the cooperatives in turn organize their members so as to cultivate the land. At the same time, the cooperatives are contractually bound to market all of the harvest, except for a small portion retained for home consumption by individual members, to the aforementioned agency.

It would appear, however, there is considerable flexibility in the criteria as stated above, and that indeed the designation of zone type may be a function of expediency, more than of "objective" characteristics of the land itself. Thus in the MAS Study,[49] which appeared in January 1967, Nianga was designated a zone de terroir. Yet in Dia's study, which appeared the same year, it is stated that Nianga was to be developed as a zone pionnier. The rationale for this status, according to Dia[50] was the heavy capital investment (which only the national government would be capable of marshalling) necessary for the ultimate development of Nianga as a rice-producing area for the Senegalese nation. Thus it would appear that the decision to develop Nianga as a zone pionnier (and hence via large-scale irrigation) rather than a zone de terroir (which implies greater local control) was primarily a political decision, and not one based on technical considerations.

49/ Ibid.

50/ Dia, p. 99.

The Local Economy

Not surprisingly, the local ecology has largely determined the traditional economy; but as Boutillier et al. have pointed out, each of the principal ethnic groups that one finds in the Valley has interpreted these ecological givens in its own fashion.[51/] The Toucouleurs place the greatest importance on agriculture and fishing, while at the same time practicing livestock raising on a limited scale. By contrast, the Maures, and above all the Peuls, have made livestock their primary activity, with agriculture a strong second. For these two groups, fishing is of negligble importance.

As can be seen in Table 7, it is far from uncommon for a given individual to exercise more than one profession. While most individuals exercise both their primary and secondary professions within the basic sector--i.e., farming, livestock, fishing--there is nevertheless a significant minority who combine one of the basic activities with commerce or artisinal work. In the remaining portion of this chapter a brief overview will be given of the various sectors which constitute the local economy. In that migration is an important source of family revenue, it too will be considered within this overview.

Agriculture

As a quantitative description of pre-project agricultural practices will be presented in Chapter V for the purposes of

[51/] Boutillier et al., p. 59.

TABLE 7.--Principle and secondary economic activities[a] for males, age 14 and over.[b]

Secondary Activity	Farming	Livestock	Fishing	Total
Total	51,180	6,910	2,840	60,930
- without secondary act.	38,830	950	1,330	41,110
- with secondary activity	12,350	5,950	2,410	19,820
- Farming	--	4,990	2,350	7,190
- Livestock	2,900	--	40	2,940
- Fishing	5,310	100	--	5,410
- Artisenat	1,850	--	20	1,870
- Commerce	700	--	--	700
- Services	920	860	--	980
- Other	670	--	--	730

[a] Based on a sample size of 61,000.

[b] Adapted from Boutillier, et al., p. 60.

delineating the "Without Case" for the SCB analysis, only a general, more qualitative approach will be taken at present. Perhaps the most unique feature of traditional agriculture as practiced in the Senegal Valley, which sets it apart from dryland farming systems in the Sahelian Zone, is that it is in fact a dual system, whereby the farmer is engaged in agriculture in both the rainy and the dry seasons. That this is possible is due, of course, to the annual flooding of the Senegal River.

Not all families, however, farm both in the *dieri* and in the *oualo*. There are three factors which intervene here: (1) availability of *oualo* land; (2) availability of labor; and (3) distance.

As noted previously, land is not a constraint with respect to the dieri. Such is not the case for the oualo. Unless the peasant enjoys usufruct on oualo parcels, he may be unable to obtain oualo land in a given year. Moreover, even if he retains such rights, the level of the flood in a given year might be so low as to preclude cultivation of his oualo parcels.

For a given family, labor may be a constraint. Even under "normal" conditions--i.e., average rainfall, average flood level--there is typically a bottleneck in the thirty-day period from mid-October to mid-November. This bottleneck is due to the overlapping of the harvest of dieri crops with the planting of oualo crops.[52] Labor may also be a constraint as a result of migration to the cities by those of prime age for agricultural work.

Finally, there is the factor of distance. Some villages in the dieri are as much as 20 kilometers away from any available oualo lands. The converse is true for some villages located on or near the river bank in the oualo. This is not to say, however, that distance is absolutely limiting. Many farmers maintain residences in villages both in the dieri and in the oualo. Thus by a sort of seasonal migration, they are able to maintain this dual farming system.

Crops and agricultural technology

The primary crop grown in the dieri is a small-grain millet (Pennisteum), known locally as souna. It is grown simply or in combination with cowpeas (Vigna sinensis), and/or a type of squash

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[52] Diop, p. 37.

known locally as beref (Citrullus vulgaris). All three of these crops are well suited for the dieri in that they are remarkably drought-resistant.

In the low-lying oualo lands (cuvettes) are grown several varieties of sorghum. Two of the more popular varieties are known as sambasouki and mairam saoudatou. In the falo are grown corn, sweet potatoes, and various vegetables. During those years when the fonde soils are flooded, they too will be planted in sorghum.

Whatever the crop, it is used largely for home consumption or for barter for fish or milk. Thus the agriculture, as traditionally practiced, was and remains essentially one of subsistence. Moreover, due to erratic rainfall and periodic plagues of insects, the area is often stricken by famine and must resort to imported cereals.

Diop, writing in 1965, described the agriculture of Fouta Toro[53/] as follows:

> ....The agricultural techniques are archaic; they have evolved very little over many centuries. The only instruments used are the daba and a pointed stick.[54/]

While this is essentially correct, he might have also included use of the machete, and the gopu, a long-handled hoe used primarily for weeding in the dieri. More recently, the use of small carts drawn by donkey or horse has become fairly widespread. Although the use of animal traction for sowing and weeding has been reported

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53/ This is the Toucouleur name for the area in the Senegal Valley dominated by the latter.

54/ Ibid., p. 37 [This author's translation].

elsewhere in Fouta Touro,such is not the case in the environs of Podor-Nianga.

Livestock

Virtually every family compound owns at least a few chickens, sheep, and/or goats. Nor is it uncommon for the compound to maintain a few head of cattle.[55/] This marginal activity is applicable mainly to the Toucouleur, while as noted above it is the Maures and above all the Peuls who are the large-scale herders.

While it is generally true that the Peuls leave their villages during the dry season in search of pasture (the transhumance), it is incorrect to think that such movement has the same regularity as the proverbial geese going south for the winter. Thus Santoir has noted that the Peuls from Galodjina (located west of the Podor-Nianga area) did not depart at all on the transhumance during relatively wet years.[56/]

Fishing

Although, as was seen above, many individuals who engage in agriculture also have fishing as a secondary activity, the greatest percentage of the catch is handled by the Subalbe, a sub-group of the Dimo caste. While reliable estimates of fishermen's annual

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55/ Reliable herd counts are difficult to obtain in Senegal due to the existence of a livestock tax. Obviously it is in the interest of the herder to understate his inventory. The current tax rate is 400CFA per head for cattle, horses, and donkeys, while it is 200CFA for sheep and goats, payable once *per annum*.

56/ Christian J. Santoir, *Les Societes Pastorales du Senegal Face a la Secheresse* (Dakar: ORSTOM, August 1976), p. 11.

revenues are difficult to obtain, it would appear that the latter is significantly higher than for the typical farmer. Estimates run as high as 350,000 CFA for a good fisherman in a good year (i.e., a high flood).[57/]

Due to a lack of refrigeration, a significant portion of the catch is preserved by drying. However, fresh fish are usually to be had on a daily basis (at least during the flood period in both Niandane and Guia--two villages which lie along the banks of the Doue). Virtually all of the catch is consumed locally. At the same time, fish caught in the ocean at St. Louis are shipped in by auto to be sold by local vendors.

Artisinal activities

Due to a complete lack of industrialization in the area, the artisanat represents by itself the entirety of the secondary sector. Traditionally, the important crafts, each exercised by a specific caste, have been the following: (1) metal work--jewelers and blacksmiths; (2) wood crafting; (3) leather and upholstery work; and (4) cotton weaving. Diop[58/] has predicted that with the modernization of the national economy, these crafts will ultimately disappear. While to a certain extent this has already come to pass (e.g., the ubiquitous plastic shoes), this is not universally the case. For example, with the increased use of animal traction, there will be a greatly increased demand for the products of the blacksmith.

57/ USAID, pp. 4-5.

58/ Diop, p. 41.

Commerce

In La Moyenne Vallee du Senegal, Boutillier et al. paints a rather dismal picture of the state of commerce in the Valley as a whole as it existed in the late 1950's. The dearth of activity in the tertiary sector was seen as being caused by two factors: (1) the stagnation of the economy throughout the Valley; and (2) the remaining importance of barter in the economy, accounting for nearly 30 percent of local exchanges. Characterizing the commercial trade as marginal, they state that:

> ....only in exceptional cases will the annual volume of a given merchant exceed one million CFA--at most, a few sacks of rice, a few blocks of sugar, a few cases of tobacco, a few kilograms of tea, and a few barrels of kerosene.[59]

This picture has changed little in the intervening years, despite the opening of the area to year-round automobile traffic as a result of the paving of Route Nationale N2 as far as Matam, some 250 kilometers to the east of Podor. The only thing even remotely akin to modern retail outlets in the area are the SONADIS[60] stores in the towns of Podor and Nianga.

Migration

Due to its "round robin" nature, whereby a given individual migrates several times between his home in the traditional sector

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59/ Boutillier, et al., p. 141 [This author's translation].

60/ SONADIS: an acronym for Societe Nationale Pour l'Approvisionement et Distribution Senegalaise, a semi-public general wholesaler and retailer.

and regular employment in the modern sector, migration has long been considered as being an essential feature of the economy in Africa.[61/] Perhaps the most conspicuous evidence of migration and its effect on consumption levels in the Senegal Valley can be seen in the housing. Thus, Minevielle, in reference to the village of Boinadji in the Department of Matam, describes it in the following manner:

> ....At first view, the two quartiers of Boinadji appear as typical of villages where migration is an important factor, such villages being characterized by the near omnipresence of houses with exterior coatings of stucco or cement, long porches, and tin roofs....this type of housing can be considered in areas along the River as an accurate index of the return flow of money resulting from migration....[62/]

If the foregoing is indeed an accurate index, as Minevielle claims, then one might conclude on the basis of appearances that the Department of Podor has reaped considerably smaller benefits from the migration of its inhabitants than has its eastern neighbor, the Department of Matam. In contrast to the prosperous image invoked in Minevielle's description of Boinadji, the housing in the Podor-Nianga Area is constructed with the traditional material--viz., mud and thatch.

[61/] Marvin P. Miracle and Sara S. Berry, "Migrant Labour and Economic Development," Oxford Economic Papers, XXII (March 1970), passim.

[62/] Minevielle, p. 27. [This author's translation].

Be that as it may, some limited evidence has emerged from preliminary findings of the Purdue West Africa Study as to the importance of migration in Nianga.[63/] Of 20 family heads interviewed, 14 had migrated at least once. The range of duration was from four months to 10 years, for an average of approximately three years. In every instance the motive was for employment, which in nearly every case was for a job requiring little or no skills.

Summary

The Nianga Area is characterized by a semi-arid climate, subject to wide interannual fluctuations in rainfall. This in turn makes the traditional (subsistence) agriculture sector highly dependent upon the annual flooding of the Senegal River. The importance of the flood for agriculture is reflected in the complex set of land tenure rules that have evolved over time regarding the use of the lands thus flooded. Although agriculture is the leading economic activity, it is closely seconded by livestock raising. While fishing is also important, it is a more specialized activity than the former two. Having thus examined the pre-project milieu, we are now ready to consider the Nianga Pilot Project in some detail in Chapter IV which follows.

[63/] Reference here is to a current research effort by Purdue University in four Sahelian countries in Africa: Senegal, Mali, Upper Volta, and Niger. A brief description of the survey conducted on the Nianga Perimeter in Senegal is found in Annex G.

CHAPTER IV

DESCRIPTION OF THE NIANGA PROJECT

Description of the Project

The Nianga Pilot Perimeter (hereafter referred to as the Pilot Project) consists of the following six components for a total of 631.63 hectares of net irrigable land:

(1) 35 collective peasant farms;

(2) a seed multiplication farm;

(3) an experimental farm;

(4) the B.I.T.[1/] vocational training unit;

(5) the Cite SAED, consisting of 17 houses for SAED personnel, a guest house, office buildings, warehouses, and a garage;

(6) a small-scale feed lot for fattening sheep near the village of Pendao.[2/]

The Nianga Pilot Project is only a portion of Grand Nianga, which is comprised of the total area (approximately 14,000 hectares) enclosed by a peripheral dike. In addition to the Pilot Project, it includes five sectors which will ultimately yield roughly

[1/] B.I.T. is the French acronym for the International Labor Organization.

[2/] SAED, Amenagement Hydroagricole du Perimetre de Nianga: Compte Rendu No. 3, A Report Prepared by IFAGRARIA (Perimetre de Nianga, Senegal: SAED, September 1977), p. 2.

12,000[3/,4/] hectares of irrigable land. As of this writing none of these sectors has been developed, although bilateral negotiations are currently underway between the Governments of Senegal and West Germany for the development of Sector C (approximately 1,400 hectares).

To the extent that the Pilot Project benefits from the exterior dike, it is an integral part of Grand Nianga. Nevertheless, the former is an operationally autonomous unit and thus an appropriate object of study in its own right.

Project Boundaries

The precise boundaries of the Pilot Project are as follows (see Figure 5): the northern leg of the exterior dike which roughly parallels the Doue; (2) the Wali Diali which forms the eastern border; (3) the interior dike on the south; and (4) the western leg of the exterior dike which runs from the Village of Niandane in the northwestern corner of the Pilot Project to the Village of Ndiayene, where it meets the Route National N2.

Sources of Funding

The major source of funding for the Pilot Project was the Fonds Europeen de Developpement (FED) which approved a nonreimbursable grant of 1.671 billion CFA to the Government of Senegal (GOS). This

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3/ SOGREAH, Schema General d'Amenagement et Etude du Prefactbilite: Perimetre de Nianga, R11414A (Grenoble, France: SOGREAH, October 1973), memoire, p. 6.

4/ Unfortunately, there is not complete agreement in this latter figure. Thus HYDROPLAN (HYDROPLAN, p. 68) indicates that only 10,500 hectares will be irrigable in Grand Nianga.

amount was to cover construction costs, purchases of equipment, and the bulk of initial operating costs for the first four and a half years of the Project. The FED grant was applied to the costs of the seed multiplication and experimental units, as well as the land developed for commercial farms.[5/] GOS for its part agreed to pay the salaries of Senegalese civil servants hired by the Project. While the actual amount of cost is not available in published reports, it has been estimated by this author to be approximately 4.2 million CFA per annum.[6/]

The B.I.T. vocational unit was jointly financed by the United Nations Development Program and GOS,[7/] with the former paying for farm machinery, assorted training-related equipment, and expatriate personnel. GOS was required to pay the salaries of all Senegalese personnel (instructors, laborers, maintenance personnel), infrastructure development costs (construction of offices and classrooms and dormitories for the accommodation of 56 trainees),[8/] and to provide the annual operating funds.[9/] Unfortunately, no data is available concerning the magnitude of these costs.

5/ Convention de Financement Entre la Communaute Economique Europeene et la Republique du Senegal: Convention No. 1071/SE (Brussels: FED, March 1972), passim.

6/ Based on salary scales of the Fonction Publique in use in 1977.

7/ Specifically, the Secretariat d'Etat a la Promotion Humaine.

8/ Due to a chronic lack of funds, this part of the program has suffered considerable delay. As of this writing, less than one half of the proposed infrastructure has been completed.

9/ Luciano Montesi, "Le Centre National de Formation Pour les Cultures Irriguees de Nianga: Une Jeune Experience Concluante Dans le Sahel," Date unknown (mimeographed).

The sheep feedlot at Pendao is not, officially speaking, a part of the Pilot Project, in that it was foreseen neither by any of the feasibility studies, nor by the FED grant. It was an "add-on" made at the suggestion of an expatriate technical expert employed by SAED/Nianga, and thus it is mentioned here only for completeness.

The Role of SAED

The foregoing discussion vis-a-vis the financing of the Project, while essentially correct, is somewhat oversimplified. Although the FED did indeed finance the bulk of the costs, it did so in part through the intermediation of SAED. The latter was created in 1965 as a semi-autonomous agency within the Ministere du Developpement Rural et de l'Hydraulique, and as such, was given the authority to solicit funds from international sources (development agencies and/or foreign governments) to promote agricultural development on all Senegalese territory in the Senegal Valley. At the same time, SAED receives partial funding from GOS.

As stipulated in the Convention de Financement,[10/] the management of the Project was to be conferred to a public agency, following an initial operating period, the administration of which was to be assured by an outside consultant.[11/] SAED's control of the Nianga Project dates from 1974, at which time it replaced Genie Rural

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10/ Convention de Financement, p. 7.

11/ This function was performed by IFAGRARIA, a Rome-based consulting firm, under contract No. 1164 with the FED.

(another Senegalese governmental agency) as overseer of the Project.[12]

In addition to Nianga, SAED manages several other perimeters in the Valley funded by various international agencies and foreign governments. In order to coordinate all of the various activities in the Valley, SAED created a central administration (headquartered in St. Louis) and various other operational units, such as rice processing mills and a heavy equipment division (DAM), which provide services for the respective perimeters.[13] For the purpose of this research, the term SAED/St. Louis will designate this central administrative unit, while SAED/Nianga will refer to the administrative office housed on the Nianga Perimeter. Although SAED/Nianga enjoys a certain degree of autonomy, the authority for the purchase of equipment and agricultural inputs, as well as the determination of crop mixes on the Perimeter rests with SAED/St. Louis. Given the complexity of the SAED administrative structure itself, it is extremely difficult for an analyst from outside the agency to ascertain the flow of project funds.

Project Objectives

The stated objectives of a given project are in most instances more specific than the national objectives imposed by SMD (cf. Chapter II of this thesis) for social cost-benefit analysis. Thus the analyst must decide into which category (or categories) of

12/ HYDROPLAN, p

13/ Both the rice mill and the heavy equipment division are located near St. Louis in the village of Ross-Bethio. The equipment division, known as DAM, is used both for construction and maintenance purposes on SAED's many perimeters.

national objectives the more specific project objectives properly belong--a task which will be left for Chapter V. For now it will suffice to identify GOS's objectives for the Nianga Project. s stated by SOGREAH, they are the following:

(1) intensification of cereal production, especially rice, with an aim toward import substitution;

(2) introduction of forage crops for use as animal food;

(3) introduction and promotion of diversified farming;

(4) increase the material well-being of the peasantry.[14/]

Again, according to SOGREAH,[15/] the objectives of OMVS are essentially the same as those listed above. FAO, which played a major role in shaping the Pilot Project, had a much broader objective, that being the economic development of the Senegal Valley via intensive (i.e. double cropping) irrigated agriculture.[16/] Toward that end, FAO contracted with SOGREAH[17/] for a feasibility study of three pilot perimeters of 1,000 hectares each (Nianga, Boghe, Matam) and four large perimeters (Grand Nianga, Boghe, Matam, Salde), each ranging from 5,000 to 15,000 hectares.

From the foregoing, it is clear that the project currently under study (i.e., the Pilot Project) was not viewed (at least by FAO)

14/ SOGREAH, R11414-A, Memoire, p. 2.

15/ Ibid.

16/ Ibid., p. 1.

17/ Contract No. SF/AFR. REG. 61-12 AG1 (April 11, 1972).

as an end in itself but rather as a means toward fulfillment of GOS's objectives as stated above. This realization, however, in no way diminishes the relevance of an ex post economic evaluation of the Pilot Project. Obviously the role of such a project should be to develop irrigation strategies that are economically as well as technically sound.

Brief History of the Project Design Process: The Study Phase

The Early Proposals

Proposals for the development of the Nianga area date (at least) as far back as 1951. In that year a proposal was submitted to the French Colonial Government by the Union Hydroelectrique Africaine (UHEA) for the development of Nianga as an integral part of a larger scheme known as "Projet d'Amenagement de la Vallee du Senegal." A similar development program was again proposed by UHEA in 1964 as part of a different project known as "Canal Doue-Taouey."[18]

A technical study of the development of Nianga within the canal proposal (cited above) was undertaken by BCEOM in 1965 for the purpose of controlled submersion (amenagement secondaire).[19] Thus, neither pumping nor leveling (planage) was under consideration.

18/ MAS, p. 3.

19/ BCEOM.

Instead, BCEOM foresaw four large subperimeters arranged in step-like fashion, with each step falling by approximately 70 centimeters. In short, the Nianga Perimeter was to be modeled after the vast Office du Niger in Mali.[20/]

However, given the uncertainties vis-a-vis water availability inherent in this technology, only single cropping of rice--i.e., during the rainy season--was recommended. While the rice was to be transplanted by hand, all other operations were to be mechanized. In addition, a small rice hulling mill was proposed for installation at Nianga-Dieri. The boundaries of the BCEOM Project were similar to those of the present Grand Nianga, except that the western border, being roughly coterminous with the Piste de Podor, was situated five kilometers east of the western exterior dike ultimately constructed some eight years later. Thus the BCEOM Project envisioned the diking of 11,000 hectares which would have yielded 5,000 hectares of rice parcels.

MAS, dissatisfied with the BCEOM Study, claimed on the basis of its own research that the project boundaries as proposed would entail the diking of 12,000 hectares and would yield 7,000 hectares of paddy land. Moreover, the alleged water control difficulties could be remedied by strategically placing motor pumps in the various basins (cuvettes); and finally, the expected rice yield would be 2.0 tons, not 1.5 tons per hectare as foreseen by BCEOM.[21/]

20/ HYDROPLAN, p. 6.

21/ MAS, p. 17.

On the basis of its own study, MAS requested financing from the FED in May 1967. The latter's response, however, was to request additional research, and thus GOS let a contract in January 1968 with Piani e Progetti toward this end.[22] While more complete than the earlier BCEOM Study, the economic analysis of the former was equally lacking in rigor. No attempt was made at a discounted cash flow analysis. The measure of profitability used instead was the coefficient of capital--the ratio between capital expenditure and annual net revenue. This coefficient was found to be 6.7 percent for the Nianga Project as then proposed.[23] In its technical conception the P & P Project was essentially the same as its predecessors--i.e., a system whereby the flood is regulated through diking, yet full water control is not attained.

The INSTRUPA Study[24]

In 1969 under FED financing, GOS contracted with INSTRUPA, a West German engineering firm, for an implementation study of the Nianga Project. In August of the same year, INSTRUPA, benefitting from more detailed maps than had been available at the time of the BCEOM Study, presented a preliminary report in which it was pointed out that the latter's gravity-fed system was unworkable, given the "choppy" nature of the terrain. Moreover, it was shown that for a

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22/ P & P, p. 1.

23/ Ibid., p. 116.

24/ The author was unable to obtain a copy of the INSTRUPA Study, and therefore, only indirect reference can be made to it. The description presented here borrows heavily from HYDROPLAN (HYDROPLAN, 1973-75, pp. 6-8).

relatively small increase in capital expenditure (approximately a 9 percent increase over the original cost of 268,814,000 CFA at 1970 prices), the western boundary of the Project could be displaced from the Piste de Podor to a ridge five kilometers further west, running from Niandane to Ndiayene (see Figure 5). This additional expenditure was justified by the fact that it would bring 3,000 more hectares under rice cultivation.

Despite various changes from the previous BCEOM design, INSTRUPA's proposal essentially relied on the flood for irrigation, with pumping to be used only in those instances when there would be too much or too little water on the land. Only a single crop of rice, planted during the rainy season was foreseen, given that its germination would be dependent upon the rains. No levelling was proposed; instead, the irrigated area was to be terraced by small dikes placed at 50 centimeter contour intervals. Use was to be made of the four principal _walis_ for both irrigation and drainage canals. The initial stage concerned only approximately 2,000 hectares, with the remaining 8,000 hectares to be developed in two successive stages.

By 1971 the Study was submitted to GOS and the FED. That it was generally acceptable to the FED can be surmised from the fact that the essential proposals of the _INSTRUPA Study_ found their way into the _Convention de Financement_.

It would seem, however, that one point having enormous implications for the economic viability of the Nianga Project was not even considered by INSTRUPA. At the same time the latter was preparing its study for submission to the FED, Juton was questioning the conventional wisdom that it was best to proceed first with a large peripheral dike, and subsequently develop sub-perimeters within the diked area. To wit:

> ....If the development of the interior sub-perimeters is to be phased at a relatively slow pace, then it is not at all evident that the same method as used in the Senegal Delta (i.e., peripheral diking of large areas) is applicable to the situation here, given that this method results in the immobilization of significant sums of capital in the early years of the project. Where the relief is suitable, which is certainly the case of Nianga where many topographical lines of 5 and 6 meters (IGN) can be easily distinguished, a phased diking is possible, whereby a single sub-perimeter...is delineated at a given time, and the remainder of the proposed development area is left open for traditional flood recession agriculture.[25]

Despite the above objections of Juton (a well-known expert on the hydrology of the River), INSTRUPA asserted that by diking first, provision could be made for eventual development, at the same time avoiding the additional costs of a new exterior dike.[26]

The SOGREAH Study

Under the aegis of FAO's Etude Hydroagricole du Bassin du Fleuve Senegal, SOGREAH conducted at least five studies, of which the most relevant for the purposes of this research is the feasibility study, which contains the *ex ante* cost-benefit analysis of the Pilot Project.[27]

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[25] M. Juton, Etude Hydroagricole du Bassin du Fleuve Senegal: Antenne Route de Podor, A Report Prepared for OMVS (Dakar: OMVS, December 1969), p. 6.

[26] INSTRUPA, Amenagement Hydroagricole du Perimetre Nianga/Senegal/Avenant No. 1 au Dossier Definitif: Deplacement de la Digue Perimetrale Ouest (Bad-Homburg, Federal Republic of Germany: INSTRUPA, date unknown), p. 3.

[27] Reference is made here to SOGREAH, R11310-A. Unless specified otherwise, the term SOGREAH Study shall refer to this report.

Inasmuch as a comparison between the latter and the _ex post_ analysis carried out in this thesis will be taken up in Chapter VI, it is only the technical aspects of the Pilot Project, as proposed by SOGREAH, which are presently of interest.

Genesis of the Pilot Project

At the time that the _INSTRUPA Study_ was nearing completion (i.e., mid-1972) SOGREAH began its study of the various pilot perimeters proposed by FAO/OMVS, including that of Nianga. Whereas the project at Nianga envisioned by INSTRUPA and the FED was simply the development of 2,000 hectares (with possibility for later extensions) of single-crop rice production, the Pilot Project proposed by FAO/OMVS involved a testing ground of some 950 hectares for tertiary irrigation--i.e., full water control. Thus for the purposes of project design, SOGREAH was instructed by FAO to take as given the completion of the dams at Manantali and Diama, which were (and still are) seen as necessary for providing sufficient quantities of water for irrigation on a year-round basis.

Despite the experimental nature of the Pilot Project, however, the implicit assumption in the SOGREAH Study was that subsequent development of Grand Nianga would occur on a timely basis. Thus a small rice hulling mill (capacity: 2 tons of paddy per hour) and storage silos were envisioned for the Pilot Project after the seventh year, with further expansion to occur as the various sectors of Grand Nianga came into production.

Variante 2

SOGREAH proposed a variety of solutions (within the technical framework prescribed by FAO/OMVS) for the development of the Pilot Project from which FAO/OMVS chose the least costly, known as Variante 2. The latter foresaw a hierarchical network of irrigation canals with control from upstream, totaling approximately 19 kilometers in length, most of which were to be earthen except for a few critical spots. Drainage was to be handled by a hierarchy identical to that used for irrigation, with the Wali Mayal and Wali Diala (see Figure 5) being adapted for use as primary drains. Given the slope of the terrain, it was necessary to place the pumping station, which was to serve for both irrigation and drainage purposes, in the north-east corner of the Pilot Project, near the village of Wali Diali. The pumping capacity of this station, 250 l/s, was to be provided by three pumps, each powered by 150 horsepower engines.

Mailles hydrauliques

On the demand of FAO, the land was to be subdivided into irrigation and drainage units of approximately 15 hectares each, called mailles hydrauliques (or mailles for short). Such a conception placed an additional constraint on the overall design of the system, in that a well-determined flow of water had to be maintained down to this level. Each maille was to be irrigated and drained independently by a series of quaternary canals. This requirement in turn necessitated the placement of approximately 570 sluice gates for admission of water into the mailles, as well as some 2,000 devices for water control in the individual parcels ultimately carved out of each maille.

Parcel development

Again in accordance with the directives of FAO, the development of the rice parcels was to be patterned after the Perimetre de M'Pourrie in Mauritania. Thus the irrigation quaternaries were to be placed at 150-meter intervals, with drainage canals placed half-way between, yielding individual parcels of approximately 0.5 hectares on the average. In principle, the land was to be made horizontal, with a tolerance of ± 5 centimeters.

Parcels destined for crops other than rice consisted of bands from 10 to 20 meters in width, with no levelling required where the natural slope of the land was less than 2 percent. Irrigation was to be effected with the use of plastic siphons, 50 millimeters in diameter, with a flow capacity of 1 ℓ/s.

Pedology of the Pilot Perimeter

An important factor in the choice of Nianga as a pilot area was the fact that most of the principal soils found in the Senegal Valley are also found there. Essentially there are four classes of soils in the Pilot Perimeter:

(1) undeveloped soils, found in the natural levees and in the bluffs along the banks of the larger walis;

(2) vertisols, occupying primarily the slackwater portions of the flood plain;

(3) hydromorphic soils, found in the intermediate zones between the high parts of the natural levee and the slackwater portions of the floodplain;

(4) sodic soils, located primarily at the bottom of the natural levees, and in the crevasses created by the floodwater cutting through the latter.

The first category above corresponds to the vernacular classification of fonde soils, where vertisols correspond to hollalde, and hydromorphic soils to faux hollalde. The sodic soils, unsuited for irrigation because of their high salt content, have no counterpart in this vernacular classification.[28]

Recommended crop patterns

The choice of crops and their rotation over time was subject to many constraints. The first and most binding was the distribution of soil types. Second, for a variety of agronomic reasons (animal and vegetal parisitism, volunteer growth, soil exhaustion, etc.) it was imperative to avoid cultivation of the same crop year after year on a given parcel.[29] And finally, there were two constraints of a non-technical nature imposed from the "outside": (1) a production goal of 3,600 tons of paddy per year set by the FED;[30] and (2) a requirement by FAO/OMVS that at least 200 hectares be devoted to forage crops to be used for feeding livestock. Consequently, SOGREAH recommended the double-cropping of rice on all soils deemed suitable for this crop. Forage crops were to be rotated on rice soils, such that at any given time, 90 percent of this land (590 hectares) would be in rice production and the remainder

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[28] It should be pointed out that only the oualo soils (i.e. only those soils in the flood plain),are under consideration here.

[29] SOGREAH, R11310-A, Annex 5,pp. 2-4.

[30] Convention de Financement, p. 5.

devoted to other crops, such as corn, wheat, cowpeas, etc.[31] The cropping pattern thus recommended is shown in Table 8 below.

The need for mechanization

The combined effect of the constraints imposed by the FED and FAO/OMVS (as discussed above) and the capital-intensive nature of tertiary development, necessitated the use of double cropping.[32] Recourse to the latter was seen, however, as leading inevitably to the mechanization of virtually all farm operations:

> ....The time constraint imposes a work schedule that the peasant with traditional techniques and equipment, even if aided by animal traction, would not be able to meet for any area greater than subsistence level. In other words, for all soil preparation, as well as for certain seeding and harvesting operations, mechanization is unavoidable, despite the negative psychological consequences the latter might engender vis-a-vis the peasants' sense of belonging to the Project.[33]

Despite the alleged inevitability of mechanization, SOGREAH nevertheless went to considerable lengths to devise a system less dependent upon such heavy mechanization.[34] Indeed, the conversion to a less mechanized production system (either animal traction or two-wheel tractors) was seen as a badly needed reduction in investment and operating costs, given the lack of profitability projected

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31/ SOGREAH, Projet en Vue d'Appel d'Offres/Casier Pilote de Nianga, R11375-A (Grenoble, France: SOGREAH, April 1973), Note Reservee a l'Administration, p. 6.

32/ SOGREAH, R11310-A, Annexe A., pp. 2-4.

33/ Ibid. [This author's translation].

34/ Ibid., Chapter VI.

TABLE 8

RECOMMENDED CROPPING PATTERN (SOGREAH)[a]

Rotation	Total Area (ha)	Crop	Percent	Area (ha.) during: Rainy Season	Dry Season
Rice-Forage	547[b] Hollalde and Faux Hollalde Soils	Rice	90	492	
		Rice	90		492
		Sorghum (Forage)	10	55	
		Sorghum (Forage)	10		55
Poly-culture	345[b] Fonde Soils	Sorghum (Grain)	30	103.5	
		Corn	30	103.5	
		Wheat	40		138
		Truck Garden	10		34.5
		Cow Peas (Grain)	10		34.5
		Cow Peas (Forage)	40	138	
		Cow Peas (Forage)	40		138

[a] Source: SOGREAH, R11310-A, p. 3-2.

[b] Does not include area for seed multiplication or experimental farms.

for the FAO/OMVS scheme.[35/] However, in that this conversion might have delayed the beginning of the Pilot Project, any consideration of the question was recommended for postponement until the development of Grand Nianga.[36/]

The exterior dike

Using its mathematical model of the annual flood to foresee the effect of additional projects on the water level, SOGREAH made its recommendations for the height of the exterior dike against the 100-year flood. This recommendation exceeded by one meter that made in the previous INSTRUPA Study, but since the Service de Travaux Publiques had already constructed the Bretelle de Podor (which serves at the same time as the eastern exterior dike for Grand Nianga), and in view of certain deficiencies in SOGREAH's model,[37/],[38/] GOS retained the height originally prescribed by INSTRUPA. At the same time, however, GOS agreed to SOGREAH's recommendation that the top of the dike be widened from 5 to 7.5 meters so as to permit at some later date the necessary increase in height.

35/ This aspect of the Pilot Project will be discussed further in Chapter VI of this thesis.

36/ SOGREAH, R11310-A, memoire, p. 6-15.

37/ HYDROPLAN, p. 10.

38/ SOGREAH, however, does not admit to any deficiencies in its model. Accordingly, its justification for GOS's retention of the original height of the dike was the necessity to stay within the budget allocation stipulated by the FED (SOGREAH, R11310-A, memoire, p. 5).

Construction Phase

There is, of course, no neat separation between the construction phase and its precursor, the study phase. For as noted by HYDROPLAN,[39] the contractor (Franzetti) began work on the exterior dike before SOGREAH had completed its solicitation for bids. Nor, as will be seen later, is there a definitive break between the construction and adaption phase. Be that as it may, the former, in the case of Nianga, may be delineated as the period 1973-75, beginning with construction of the exterior dike (January 1973), and ending in mid-1975 when partial cultivation of the Pilot Project began.

Technical Changes

As discussed above under the study phase, the Nianga Project, approximately 20 years in gestation, underwent substantial technical changes, partly as a result of increasing know-how, and partly as a result of the succession of institutions involved in promoting irrigated agriculture in the Valley. The changes which occurred during the actual construction phase, however, were of a fundamentally different nature, in that they were largely pragmatic responses to unforeseen difficulties which arose during construction.

Moreover, the superimposition of the SOGREAH Project (i.e., the Pilot Project) upon the INSTRUPA Project caused many difficulties. For example, the technical terms of the former did not correspond with the terms of the contract which had been let with Franzetti Thus it was necessary for HYDROPLAN, who held a contract with the

[39] HYDROPLAN, p. 11.

FED for verification of the construction work, to undertake an additional study to reconcile the differences.[40/]

Exterior dike

As a result of the SOGREAH Project, the proposed path of the exterior dike was somewhat altered. Franzetti agreed to any changes, but on the condition that he be reimbursed for any cubage (earth to be moved) in excess of 25 percent of the original terms of the contract. Genie Rural, fully aware that such excesses would result, subsequently stipulated that the width at the top be reduced from 7.5 to 6.5 meters--a width which may be inadequate to protect Grand Nianga from major floods.

Interior dike

As originally foreseen, the interior dike was to extend only from the western leg of the exterior dike eastward to the Wali Diali (see Figure 5); but as an added safety measure, it was decided to extend this dike by 3.2 kilometers from the Wali Diali up toward Guia. However, in order to achieve this end, and at the same time hold the line on costs, the width of the top of the interior dike was reduced from 6 to 4 meters on the extended portion.[41/]

Canals

To permit the use of steam shovels for digging the canals, it was agreed that the latter could be wider than the three meters

40/ HYDROPLAN, p. 11.

41/ Ibid.

originally designed. Moreover, this change permitted the cut to be effectively used as fill for the nearby secondary dikes.

Roads

Many of the primary roads (4 m. in width and capped by a 5-cm. layer of laterite) were downgraded to secondary roads (3m. in width and no laterite cap), at a considerable savings. Paradoxically, this cost-cutting move actually resulted in greater total accessibility, in that tracked vehicles (tractors, graders, etc.) are prohibited from traveling on primary roads, but are subject to no such restrictions on secondary roads.

Parcel development

SAED decided to perform the deep-plowing (defoncage), the leveling of parcels (planage), and the placement of pipes and small dikes (affinage) itself, rather than have Franzetti perform this work as had been stipulated in the contract.[42] This change resulted in no savings, as the FED was still required to finance the operation; and as will be seen below, it actually resulted in significant delays and additional costs.

An alternative technique, contour leveling (amenagement en courbe de niveau), which might have reduced both time and cost was suggested by HYDROPLAN. According to the latter, contour leveling would have cost only about 68,000 CFA per hectare, compared with 200,000 CFA

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[42] This work was done by the DAM.

per hectare for the procedure actually used--i.e., the formation of flat rectangular parcels. The major factor in this cost differential is the reduced quantities of earth that need be moved when leveling is done on the contour. An added advantage here is that with less earth to be moved, there is less chance of removing the all-important layers of organic material in the soil. The major drawback to this technique is that it results in smaller parcels, and thus makes mechanized cultivation more difficult. Perhaps it is for this reason that, "...this type of development was not agreed to by the interested (unnamed) parties."[43/]

Timeliness of Construction Work

Diking

In January 1973, Franzetti began construction of the exterior dike, with a targeted completion date of June 6 of the same year. The work proceeded much slower than expected, however, due mainly to two factors: (1) Franzetti had overestimated the operating efficiency of his earth-moving equipment; and (2) the sub-contractor (Societe des Transports Africains) provided only about one half the work stipulated in the contract. HYDROPLAN, in its role of supervisor of the construction granted a delay until September 9--a deadline which Franzetti was able to meet.[44/]

[43/] HYDROPLAN. Amenagement Hydroagricole du Perimetre de Nianga/Senegal: Rapport Final Sur l'Execution des Travaux, Supplement 1975-76 (Herdecke: Federal Republic of Germany: HYDROPLAN, June 1976), p.1.

[44/] HYDROPLAN, 1973-75, p. 16.

Pumping station

Installation of the pumping station was delayed largely due to the failure of the European suppliers of the pump and associated equipment to meet their delivery deadline. This delay eliminated any possibility of planting a crop in 1974, as had been foreseen by HYDROPLAN. As a practical matter, no irrigated agriculture would have been possible anyhow, given that no parcels had as yet been leveled.[45/]

Brush clearing

Given the available data, it is impossible to determine either the beginning or ending date of this operation. However, it is clear that the brush clearing was delayed owing to a lack of cooperation from the Direction des Eaux et Forets.[46/] Despite the efforts of first Genie Rural and later SAED to goad Eaux et Forets into using the wood thus cleared for charcoal production (an increasingly scarce resource in Senegal), no action was taken, and the wood was by necessity wastefully burnt on the terrain.[47/]

Development of the mailles and parcels

Here again the available information does not permit a precise evaluation. Franzetti constructed the quaternary irrigation and

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45/ *Ibid.*, p. 25.

46/ This is a governmental agency charged with (among other things) management of national forest lands.

47/ HYDROPLAN, 1973-75, p. 38.

drainage canals, as well as the secondary dikes. This operation posed difficulties, in that it was not possible to use the soil cut from the drains as fill for the adjacent dikes as had been foreseen. Consequently, Franzetti had to travel further for soil of suitable quality than had been stipulated in the contract--i.e., greater than 500 meters. While this problem did not result in a cost overrun, it is unclear as to whether or not the contracted time limit was exceeded.[48]

The development of the parcels within the mailles was carried out by SAED/DAM as noted previously. Completion of the deep plowing (defoncage) was delayed due to the extreme hardness of the clay soils. Moreover, much of the equipment purchased by the FED for SAED was inadequate for the task.[49]

While initially it had been expected that SAED/DAM would more or less maintain the same pace as Franzetti, the former fell far behind. In order to expedite the work, the FED wrote an additional contract with HYDROPLAN, which in effect made this firm responsible for the development of the parcels. Although HYDROPLAN had foreseen the completion of 5 hectares per day, this goal was often not attained, due to equipment breakdowns and lack of spare parts. Moreover, before the job was completed, SAED began to withdraw its personnel for work elsewhere. By June 1976, the end of HYDROPLAN's contract, all the parcels had been leveled at least once; but there

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48/ Ibid., p. 57.

49/ SAED, Rapport de Campagne, Hivernage 1975, A Report Prepared by IFAGRARIA (St. Louis, Senegal: SAED, March 1976), p. 7.

remained 245 hectares to be reworked, out of a total of 632 hectares ultimately developed.50/

Adherence to Cost Estimates

A glance at Table 9 reveals that projected and executed costs matched almost to the last franc. This is no coincidence. Strenuous efforts were made by SOGREAH and HYDROPLAN to stay within the limits of the FED's budget allocation.51/ However, Table 9 does not tell the whole story. When allowances were made for inflation, the total amount actually paid out came to nearly 1.4 billion CFA.52/

More fundamental than increases due to inflation, however, was the per hectare cost of development. While the FED had envisioned a project of nearly 2,000 hectares,53/ the Pilot Project which ultimately emerged included only 860 hectares54/ of gross irrigable land (including secondary dikes, canals, roads, etc.), yet cost the same as the original 2,000 hectare project.

The increased cost of construction noted above devolved directly from the decision to implement tertiary irrigation, as conceived by

50/ HYDROPLAN, 1975-76, p. 7.

51/ Ibid., p. 28.

52/ Total project investments costs (including consulting fees for HYDROPLAN) were 1,092,972,076 CFA at June 1972 prices. Due to alloances for inflation in the contracts, the amount actually paid out was 1,369,393,941 CFA. Any differences between the figures here and those in Table 9 are due to the effects of rounding.

53/ Convention de Financement, p. 5.

54/ HYDROPLAN, 1973-75, p. 69.

TABLE 9

PROJECTED VS. EXECUTED CONSTRUCTION COSTS

Item	Cost (000's CFA): 1972 Prices	
	Planned by FED for 2,000 ha.[a]	As Executed for 860 ha.[b]
Diking	275,000	232,097
Construction of Canals, Secondary Dikes, etc.	177,000	402,992
Pump Station and Masonry Work Inlets	340,000	109,848
Land Preparation	140,000	121,399
Buildings	155,270	150,656
Laboratory Expenses	5,000	Included Elsewhere Above
Consultant fees during execution of construction	Not applicable	75,979
Total	1,092,270	1,092,971

[a] Source: FED, Convention de Financement, p. 11.

[b] Source: HYDROPLAN, 1976, p. 30.

FAO/OMVS. In its feasibility study SOGREAH commented at some length on the costliness of this scheme. Essentially, the relatively high cost can be attributed to three factors: (1) the exaggerated length of quaternary canals necessitated by the 75 meter-long parcels; (2) the necessity for making parcels rectangular and completely flat; and (3) the large number of concrete structures used for permitting entry and exit of water for the individual parcels.[55]

To explore fully the various economies that might have been realized by various engineering alternatives would be far beyond the scope of this research. What is clear, however, is that tertiary development with double-cropping entailed a significantly greater capital cost than the system originally envisaged by the FED. At the same time, it would appear that there is a wide range of engineering options from which project designers can choose; and therefore, one should not blindly generalize from the Nianga case to all future efforts at tertiary development.

Adaptation Phase

Given that Nianga's role is that of a testing ground, one might logically expect a lengthy adaptation phase, as various technical alternatives are field tested. Nevertheless, SOGREAH foresaw a relatively short adaptation period--only three years following the installation of the farmers on the land. However, in that this installation was to proceed as the parcels became available, complete adaptation (i.e., full production) was not envisioned until

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[55] SOGREAH, R11310-A, Annex 6, p. 42.

after the seventh year of the project.[56/] Whether or not all of the technical problems can be resolved within this time framework remains to be seen. In the remainder of this chapter is a general discussion of the operating experience of the Pilot Project to date; and as such, it largely reads as a litany of the problems that had to be resolved, or in some cases, still await final solutions.

Inventory of Irrigable Land

As discussed above, the final preparation of the parcels lagged considerably behind projected timetables. By the beginning of the 1975 rainy season, only 50 hectares had been fully completed, while another 74 were in various degrees of completion. SAED, anxious not to frustrate the eagerness of the participating farmers, decided to begin cultivation, despite the lack of adequately prepared parcels. By the dry season of 1977/78 (beginning in October 1977), however, all potentially irrigable land had been readied for cultivation,[57/] for a total of 631.53[58/] hectares. The breakdown by project component is shown in Table 10.

[56/] Ibid., Memoire, p. 5-7.

[57/] This is only partially accurate, in that certain "fringe areas" of the pilot perimeter might at some later date be irrigable. Moreover, as has been done in the past, certain parcels which prove problematic for irrigation purpose might ultimately be abandoned.

[58/] SAED, Rapport de Campagne Hivernage 1977, A Report Prepared for SAED by IFAGRARIA (St. Louis, Senegal: SAED, April 1978), p. 1.

TABLE 10

INVENTORY OF IRRIGABLE LAND BY PROJECT COMPONENT[a]

Project Component	Hectares
Peasant farming	590.90
B.I.T. training unit	18.00
Seed mult. farm	13.55
Experimental farm	9.18
Total	631.63

[a] Source: SAED, Rapport de Campagne Hivernage 1977.

Table 11 shows the land area brought under cultivation by agricultural campaign from the rainy season of 1975 through the dry season of 1977/78. Presumably the amount by which the total of irrigable land in this table exceeds that in Table 10 (i.e., 6.14 hectares) is the result of an error in the data which was used to compile Table 11. Such an error is easily imaginable, given that the data was collected retrospectively for all of the parcels (approximately 660) in the Pilot Perimeter.

Table 12 shows the ratio between the total potential irrigable land and the area that was actually cultivated during the same time period shown in Table 11. Contrary to normal expectations, the actual:potential ratio decreases rather than increases through time. One should not, however, think of this ratio as a participation rate,

TABLE 11.--Seasonal increment in land brought under initial cultivation, by project component.[a]

Project Component	Increment of Land Brought Under Initial Cultivation by Agr. Season (Ha.)						
	R.S.[b] 75	D.S.[c] 75/76	R.S. 76	D.S. 76/77	R.S. 77	D.S. 77/78	Total
(1) Peasant Farms	124.36	68.32	263.07	51.08	64.68	25.56	597.07
(2) Experimental Farm	-	-	2.44	6.74	-	-	9.18
(3) Seed Mult. Farm	-	-	13.52	-	-	-	13.52
(4) B.I.T. Training Unit[d]	5.20	5.50	4.55	2.75	-	-	18.00
(5) Total	129.56	73.82	283.58	60.57	64.68	25.56	637.77
(6) Cumulative Total	129.56	203.38	486.99	547.56	612.24	637.77	

[a] Source: "Fiche Signaletique Par Maille," (Perimetre de Nianga, Senegal: SAED/Nianga), 1977. (typewritten).

[b] R. S. = Rainy Season

[c] D. S. = Dry Season

[d] The number of hectares brought under cultivation was not clear from the "Fiche Signaletiqu The numbers shown here are based on inferences made from a variety of sources. Only the total figure (18.00 ha.) is known with certainty.

TABLE 12

ACTUAL VS. POTENTIAL CULTIVATION BY AGRICULTURAL SEASON[a]

Land Use	Hectares Cultivated by Season					
	R.S. 75	D.S. 75/76	R.S. 76	D.S. 76/77	R.S. 77	D.S. 77/78
(1) Peasant farming	113.44	185.04	456.69	386.02	424.61	408.2
(2) Seed mult. & experimenting	1.48	23.11	18.02	16.15	17.09	18.03
(3) Total (actual)	114.92	208.15	474.71	402.17	441.70	426.23
(4) Total (potential)[b]	124.36	197.88	482.44	544.81	612.24	619.77
(5) Actual/Potential (%)	92.4	100+[c]	98.4	73.8	72.1	68.7

[a] Source: Semi-annual reports (Rapport de Campagne) prepared by IFAGRARIA for SAED, for rainy season 1975 through dry season 1977/78.

[b] This figure derived from Line (6) in Table 9 less hectarage for B.I.T.

[c] A statistical anomaly owing to disparities in the two data sources used to calculate this table. It should be noted that the "Fiche Signaletique," on which Line (4) is based, was completed in 1977,--i.e., retrospectively. Thus memory lapses and/or faulty records probably account for this aberration.

the latter implying a decision-making process wherein the individual farmer decides whether or not to adopt irrigated agriculture. At Nianga, it is SAED which makes such decisions. Thus the low cultivation rate in the dry season of 1976/77 was due mainly to a decision by SAED to re-work many of the parcels which had presented difficulties vis-a-vis water control. Likewise, the low rate in the rainy season of 1977 reflects a decision by SAED in that year to let numerous parcels fallow in order that the rice harvest (September-December) would not seriously impede the planting of tomatoes (which occurs during the same period) for the subsequent dry season of 1977/78. And finally as a rememdy for salinity problems, various parcels so affected were left fallow but flooded, so as to drive the saline groundwater (nappe phreatique) to deep levels.[59/]

But what of the remaining area within the Pilot Project? As noted previously, of the 1,150 hectares found within the Pilot Project, only 860 were ultimately equipped for irrigation. When the fraction .83,[60/] the relationship between gross[61/] and net irrigable area, is multiplied by 860 hectares, the result is roughly 714 hectares of net irrigable land. Yet as was seen in Table 10, there are in fact only 632 net irrigable hectares. Even when account is taken

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[59/] Based on interviews with SAED/Nianga officials, October 1977.

[60/] HYDROPLAN, 1973-75, p. 69.

[61/] Gross irrigable area includes the irrigated parcels, plus canals, dikes, roads, etc.

of the abandoned parcels (roughly 25 hectares),[62/] the quarries (sterile zones where soil was removed and used for construction purposes--about 8 hectares),[63/] and the land taken for Cite SAED (an estimated 5 hectares), there remain 44 "excess" hectares.

Unfortunately, a thorough reading of the available documentation yields no solution to the contradictory figures. Given this ambiguity, the per hectare cost of development, a common measure of project costs in the development literature, should be interpreted with extreme caution in the case of Nianga.

Attribution of Irrigated Land

Legal framework

It should be recalled from Chapter III that GOS decided to develop Nianga as a zone pionnier. The practical implications of the decision for the Pilot Project were that the land would be collectively farmed, and that the collective groups of farmers would work on the land on a contractual basis.

The groupement de producteur (GP)

The GP consists of a group of farmers who voluntarily organize themselves into a collective unit for the purpose of cultivating irrigated land on a SAED perimeter. Each GP is headed by a freely elected president who represents the members' interests vis-a-vis

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62/ Based on unpublished data at the SAED/Nianga Office.

63/ This author's estimate.

SAED. In general, though not always, the members of a given GP have mutual affinities based on ethnicity, village, and in many cases, family. At Nianga, only males may be inscribed as members; and although there are numerous exceptions, the typical GP member is married with children.

Despite the fact that a given GP remains on the same land, a contract is signed between SAED and the GP at the start of each agricultural campaign. Briefly, this contract requires that the GP will: (1) farm the land collectively; (2) maintain the quaternary canals and the intra-maille dikes attributed to it; (3) market all of its production (except for a small deduction for home consumption) through SAED: and (4) pay for all agricultural inputs immediately following harvest of the crop in question. Moreover, any remaining debt from a given campaign will be carried forward to the next one; and lack of good faith efforts at debt repayment may result in retraction of land use rights by SAED.[64/]

Land:man ratio

So as to preclude disputes over water use, SAED assigned the mailles as integral units. A total of 57 mailles were allocated to 35 GP's. The area of these mailles ranges from 2.79 to 23.82 hectares, with a mean of 10.37. The size of the GP varies from 9 to 39 members, with a mean size of 21.[65/]

64/ Contrat de Culture, the contract written between SAED and the respective GP's.

65/ "Attribution Definitive des Mailles Hydrauliques: Nouvelles Superficies Par Groupement et Par Village," (Perimetre de Nianga, Senegal: SAED/Nianga, 1977). (Mimeographed).

Dividing the total area farmed by the peasants (590.90 hectares) by the number of GP's (35) yields a mean of 16.88 hectares. And when the latter average figure is divided by the average number of members of GP (21), the result is the land:man ratio--or .80 hectares. This latter figure, which has been commonly used to characterize the farming system at Nianga,[66/] is highly misleading. Besides the more obvious fact that the variances of both the underlying distribution are quite large, this ratio is also unstable for a variety of reasons (sickness, temporary migrations for social or business reasons, disputes, etc.), the number of officially inscribed members for a given GP often overstates the actual membership. While SAED/Nianga is aware of this situation, it has no authority to regulate the rosters of the GP's. Thus, use of the land:man ratio for analytical purposes should be made with extreme caution.

Use of Animal Traction

By early 1975 draft animals and equipment were available for experimentation with animal traction. However, the initial experience was largely negative, due to the extreme hardness of the heavy clay soils.[67/] The FED in its first authorization of operating subsidies for the Pilot Project, allocated 3.6 million CFA for the purchase of additional equipment for use with draft animals. A

66/ cf. Diagne, p. 6.

67/ Interview with SAED/Nianga officials, October 1977.

series of ill-conce[illegible]periments were to be carried out on individually-owned plots of 3 hectares each--ill-conceived in that it had been clear from the start that all peasant farming was to be done collectively.[68/] Be that as it may, the latter experiments were never carried out, the additional equipment was never bought, and the oxen purchased in 1975 were sold in late 1977 for slaughter. No future experimentation with animal traction is planned.

Crop Patterns[69/]

A comparison between Tables 8 and 13 reveals a substantial difference between the recommended and the actual crop patterns practiced on the Pilot Perimeter. As first one then another crop proved unsuited for cultivation,[70/] the crop system was reduced to two possibilities--rice only in the rainy season and rice with tomatoes in the dry season--despite the agronomic difficulties that such a system engenders.

While greenbeans, a qualified success from an agronomic standpoint, might have been a feasible crop, the heavy-handed manner in which it was forced upon the farmers make continued cultivation

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[68/] "Devis No. 1," FED internal working document. (In the files of the FED office in Dakar).

[69/] This section, as well as the following one dealing with yields, draws extensively from the semi-annual reports prepared by IFAGRARÍA for SAED.

[70/] To date, a variety of corn suitably adapted to growing conditions in the Fleuve Region has not been developed. Peppers were an agronomic success, but suffered from marketing difficulties.

TABLE 13.--Crop pattern by agricultural season on the Pilot Project (peasant farms only).[a]

Crop	Agricultural Season					
	R.S. 75 (ha.)	D.S.75/76 (ha.)	R.S. 76 (ha.)	D.S.76/77 (ha.)	R.S. 77 (ha.)	CS 77/78 (ha.)
Rice	39.2	105.7	456.7	203.4	422.1	263.3
Tomatoes	-	53.5	-	152.4	-	144.9
Corn	74.1	-	-	-	-	
Peppers	-	25.8	-	-	-	
Green Beans	-	-	-	38.3	-	
Seasonal Total	113.3	185.0	456.7	394.1	422.1	408.2

Source: SAED/IFAGRARIA, Rapport de Campagne, various years.

problematic. Indeed SAED/Nianga[71/] was notified of the decision to produce green beans only after the dry season campaign (1976/77) had already begun; and as a consequence, either the beans were planted on soils ill-suited for the crop (faux hollalde), or on parcels that had been been prepared for tomato production and thus required modification. Moreover, the peasants had neither the interest nor the technical know-how for the cultivation of beans.

To be sure, various other alternative crops (wheat, melons, etc.) were tested on the experimental farm and at the B.I.T. Center, but none have proven economically viable. Thus for the foreseeable future, the Pilot Project will by force of circumstances be tied to the present crop pattern--i.e., double-cropping of rice and one annual crop of tomatoes.

Yields

Rice

Although it is perhaps too early to tell, it would appear that the full production yield of rice at Nianga is around 4,500 kg/ha (see Table 14). Due to unusual circumstances, neither of the first two agricultural campaigns were indicative of Nianga's agronomic

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[71/] In general, SAED/St. Louis determines the crop mix for a given agricultural campaign. This does not, of course, preclude a certain amount of input from the respective SAED perimeters. At the same time, SAED/St. Louis is subject to commands, of which the order to produce beans is an example, emanating from the Ministere du Developpement Rural et de'l Hydraulique. In this decision-making process, there is no channel for constructive input by the peasants--they can only veto decisions by refusing to work.

TABLE 14.--Yields by agricultural season for rice and tomatoes (peasant farms only).[a]

Crop	Agricultural Season R.S. 75 (kg/ha)	D.S. 75/76 (kg/ha)	R.S. 76 (kg/ha)	D.S. 76/77 (kg/ha)	R.S. 77 (kg/ha)	D.S. 77/78 (kg/ha)
Rice	1,758	1,909	4,760	4,880	4,454	not available
Tomatoes	-	21,514	-	11,515	-	14,724

[a] Source: SAED/IFAGRARIA, Rapport de Campagne, various years.

potential for irrigated rice. In the rainy season of 1975, 18 hectares were completely destroyed by rats, while during the dry season of 1975/76, several hectares were destroyed by birds. However, in the latter case, several parcels which had been measured prior to the attacks yielded on the average around 4,000 kg/ha. On the other hand, such plagues, while not annual occurences are not uncommon in the Fleuve Region; and therefore, any projection of yields must take these phenomena into account.

The data for rice in Table 14 above is taken from a (random) yield-plot survey carried out each campaign by SAED/St. Louis on all its perimeters in the Valley. Despite the various criticisms leveled against this survey,[72] it is the conviction of this author that the latter is reasonably sound, both in theory and in practice --a judgment shared by an agronomist for the FAO with considerable research experience in the Senegal Valley.[73] There is, however, one factor which biases the results upward--viz., that abandoned parcels which yield nothing are not included in the pool from which the random selection is made for purposes of the SAED survey. For example, during the rainy season of 1977 eight abandoned parcels were excluded.[74] However, in that the combined area of the parcels

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[72] S. Fresson, La Participation Paysanne Sur les Perimetres Villageois d'Irrigation Par Pompage de la Zone de Matam au Senegal, A Report Prepared by the Center for Development (Paris: OECD, April 1978).

[73] Interview with Mr. Mario Lucido, October 1977.

[74] Specifically, Parcels E and F in Maille 13M3; Parcel G' in Maille 12M2; Parcel E in Maille 13M18; Parcels B, D, and E in Maille 131M2; and a portion of Parcel A (1.22 ha.) in Maille 13M2.

was 9.07 hectares, or only 2 percent--of the total area under rice cultivation in that season--it would appear that the degree of bias, while significant, does not disqualify the survey results.

Tomatoes

Operating experience is too limited to determine the full production yield of tomatoes (see Table 14). Indeed there is no satisfactory explanation for the dramatic plunge in yield from 1975/76 to 1976/77. It was suggested in the Rapport de Campagne that the lack of timely transport services from field to cannery had resulted in severe weight losses during the latter season. Yet Lucido estimated such losses to be in the neighborhood of only 5 percent.[75/]

Indeed there is general uncertainty surrounding the tomato yield at Nianga. In a yield-plot survey, the yields varied from 10 to 60 tons/ha., while in a survey based on delivered weight at the cannery the range was only from 6 to 16 tons/ha.[76/]

Disposition of Production

Rice

As discussed previously, the GP's are contractually bound to market all agricultural production, save some unspecified amount for home consumption, through SAED. Intitially, SAED purchases paddy

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75/ M. Lucido, "Enquete Sur le Developpement et al Production de la Tomate en Culture Echelonnee Dans le Perimetre de Nianga," (June 1977), p. 24. (Mimeographed).

76/ Ibid., p. 23.

from the GP at 40 CFA/kg.; and provided the paddy meets certain quality standards--i.e., the absence of excessive foreign matter--an additional 1.5 CFA/kg. is remitted to the GP. Finally, SAED pays a premium of 0.39 CFA/kg. to the heads of the respective GP's for every kilogram of rice commercialized in excess of that quantity necessary for the reimbursement of agricultural inputs used by the GP's.[77]

Indeed this question of debt repayment has been a major point of contention between SAED and the GP's since the Project's inception. In principle, the GP's are contractually bound to reimburse SAED for all inputs immediately after the harvest, and thus no allowance is made for home consumption until all debts have been paid. In practice, however, there are clandestine movements of paddy by night from field to village, and thus during peak harvest time, paddy can be bought locally for as little as approximately 37 CFA/kg.

To date, SAED/Nianga's reaction has consisted mainly of exhortations, for in truth, it has neither the inclination nor the capability to force the peasants to market all of their products through official channels. As can be seen in Table 15, however, this "jawboning" effort has not been particularly successful, in that the proportion of paddy which bypasses SAED is typically 30 to 40 percent of total production. It is unknown how much grain is genuinely consumed by

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[77] Included in the FED's "Devis No. 1" was provision for incentive payments (prime de rendement) to supervisory staff of the SAED/Nianga extension service for increasing production. Such payments were never made; and moreover, the funds thus allocated were shifted into a "miscellaneous funds" category (frais divers de gestion), the latter requiring no justification to the FED.

the farmers themselves, and how much moves through the black market.

Tomatoes

The tomatoes grown at Nianga are for industrial use. As such they are shipped to SOCAS, a cannery located near St. Louis, where they are transformed into tomato paste.

SAED pays the GP 15 CFA/kg. at the farm gate. Since the only measure of yield is what passes through the SOCAS cannery, it is even more difficult here than in the case of rice to evaluate the percentage of production marketed outside of official channels. However, an in-house study by SAED/Nianga during the dry season of 1975/76 revealed that roughly 35 percent of the total production went through the black market, while 8 percent was used for home consumption. Black market prices were as high as 25 CFA/kg.[78]

It would be wrong, however, to conclude from the limited evidence above that one-third of Nianga's tomato crop will automaticall be sold on the black market. Indeed, given the primitive transporta tion network in the immediate vicinity of the Pilot Project, the local demand for tomatoes is limited. In this vein, it should be noted that for the campaign cited in the study above, only some 50 hectares of tomatoes had been cultivated. Unfortunately, there is no data available on black market activities in the following dry season campaign (during which hectarage was tripled), but in the opinion of SAED/Nianga officials, there was not a proportionate increase in unofficial sales.

78/ SAED, Rapport de Campagne, Contre-Saison, 1975/76, A Report Prepared by IFAGRARIA for SAED, (St. Louis, Senegal: SAED, April 1976), p. 40.

TABLE 15

DISPOSITION OF RICE PRODUCTION BY AGRICULTURAL SEASON[a]

Disposition of paddy	Agricultural Season				
	R.S. 75	D.S. 75/76	R.S. 76	D.S. 76/77	R.S. 77
Estimated production (kg)	69,235	201,834	2,146,446	908,607[b]	1,879,811
Debt repayment (kg)	25,400	132,667	587,360	570,147	445,138
Commercialization (kg)	22,502	3,062	687,953	243,196	643,864[d]
Home consumption and black market + sales (kg)[c]	21,333	66,105	871,133	95,264	790,809
Home consumption and black market as % of total production	31	33	41	11	42

[a] Source: adapted from SAED/IFAGRARIA's Rapport de Campagne, various years.

[b] Excludes the following GP's: Guia 5, Nguendar, Thieole, and Niandane II, for a total of 17.17 ha.

[c] Home consumption + black market sales = Est. Production - (Debt repayment + commercialization).

[d] Commercialization is slightly understated here due to the fact that not quite all of the rice had been threshed at the time of this report.

Inputs and Services Provided by SAED

Irrigation water

While it was foreseen by the FED[79] that the price of irrigation water to the farmers would be based on actual costs, SAED charges a flat fee by crop type on all of its tertiary perimeters in the Valley, regardless of the costs. The current rates are 25,000 and 35,000 CFA/ha. for rice and tomatoes, respectively. However, owing to the fact that actual water consumption on individual parcels is unknown, SAED could not charge on a use-basis even if it were so inclined. Toward this end, an in-house study by SAED/St. Louis recommended the installation of flumes at the head of selected parcels, so that precise water use at the parcel level could be measured.[80]

The utility of such devices is open to question, however, when it is recognized that strict control of water is often not maintained even at the level of the maille.[81] While SAED employs two irrigation specialists whose main function is control of the water flow, there has never been satisfactory control over the irrigation network.[82] Moreover, the farmers themselves exacerbate the problem

79/ "Devis No. 1".

80/ SAED, Cout Irrigation de Nianga, Hivernage 75/76, A Report Prepared by the BEP/Agro-Economie Division (St.Louis, Senegal: SAED, July 1976).

81/ It should be recalled that the Pilot Perimeter, as constructed, was equipped with flumes only down to the level of the maille.

82/ HYDROPLAN, 1976, p. 26.

by smashing the padlocks on the major sluice gates and opening them at will.83/

Agricultural inputs

SAED provides all necessary agricultural inputs to the peasants. All seeds, herbicides and insecticides are sold at full price, while fertilizer receives a substantial subsidy.84/

Initially it had been foreseen that production on the seed multiplication farm would make Nianga self-sufficient in rice seed. However, a procedure for seed treatment and certification was never established at Nianga; and consequently, the paddy from the seed multiplication farm is sent to SAED's mill in Ross-Bethio for treatment.

A charge frequently leveled against SAED has been an overreliance upon chemical pesticides, insecticides, etc. While this may be true of other SAED perimeters, it appears not to be the case at Nianga. Thus as shown in Table 16, the costs of such products, as a percentage of total inputs, has declined over time; and in the dry season campaign for rice, they have not been used at all.

Machinery services

Just for irrigation water, SAED charges a flat per hectare fee for machinery services which is uniform for all its tertiary perimeters in the Valley. Whatever the rationale for this pricing

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83/ Interview with SAED/Nianga officials, November 1977.

84/ The subsidy is funded by ONCAD, the national grain marketing organization.

TABLE 16.--Breakdown of the cost of factors of production (in percentage terms) for rice and tomatoes by agricultural season.[a]

Input	RS 75	DS 75/76		RS 76	DS 76/77		RS 77	CS 77/78	
	Rice(%)	Rice(%)	Tom(%)	Rice(%)	Rice(%)	Tom.(%)	Rice(%)	Rice(%)	Tom.(%)
Seed	8.88	13.39	3.41	12.30	15.01	3.79	14.45	12.76	2.98
Fertilizer	6.71	19.92	16.58	11.75	19.36	13.25	18.24	23.08	21.98
Insec., Herb., Pesticides	20.81	-	12.07	21.09	-	3.97	2.86	-	4.39
Irrigation	31.51	42.11	35.80	36.73	45.98	42.81	45.19	46.65	47.11
Machinery Services[b]	32.09	24.58	32.14	18.14	19.65	21.78	18.07	17.51	21.53
Hand tools	-	-	-	-	-	14.40	1.18	-	2.01
Total	100	100	100	100	100	100	100	100	100

[a] Source: SAED/IFAGRARIA, Rapports de Campagne, various years.

[b] Excludes threshing.

policy, it results in charges for machinery services at Nianga which have little relationship to their actual costs (see Table 17).[85/]

TABLE 17.--Charges for Machinery Services: Actual vs. Hypothetical Charges Based on Cost.[a]

Service	Actual Charge (CFA/ha)	Estimated Cost (CFA/ha)
Fertilizer spreading	2,500	690
Rice sowing	3,500	1,280
Deep plowing	9,800	8,000
Offset plowing	3,900	5,000

[a] Source: SAED, Cout des Facons Culturales, p. 8.

Declining use of mechanization

During the first few campaigns at Nianga nearly all farming operations were done mechanically. Since then, there has been a trend toward less mechanization, such that both fertilizer spreading and rice sowing are now done completely by hand. Land preparation, however, continues to be done with tractors, primarily due to the hardness of the hollalde soils.

85/ SAED, Cout des Facons Culturales de Nianga, Hivernage 1976, A Report Prepared by the BEP/Agro-Economic Division, (St. Louis, Senegal: SAED, date unknown), p. 8.

Threshing

Threshing has and continues to be an operation performed on a "catch-as-catch-can" basis. Thus one might simultaneously observe some peasants threshing grain with nothing more than a stick, others by small threshers (Borga machines), and still others with a self-propelled combine (Massey-Ferguson 510). The Borga threshers, subject to frequent breakdowns, have never functioned satisfactorily. As of the end of 1977, there were seven[86/] such machines at Nianga, five of which were in various degrees of disassembly.

The Massey Ferguson 510 is provided by SAED/DAM. Acquired in 1968, this machine is practically worn out. Currently, it remains stationary and is used for threshing only. Nevertheless, frequent and lengthy breakdowns are a daily occurence.

Once again the pricing structure is a flat fee--10,000 CFA/ha., whether the Borga or the Massey Ferguson (in stationary position) is used, despite the fact that the latter requires considerably less human effort. But it is the fact of pricing on a per hectare rather than a per hour basis that results in the leisurely pace of the peasants during the threshing operation.

Maintenance of the Pilot Perimeter

SAED is contractually bound with the GP's to maintain the dikes and canals down to the level of the *mailles*. But which division of SAED? SAED/St. Louis has charged DAM with this maintenance role --a situation which places SAED/Nianga in a helpless situation as

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86/ Three were on loan from other SAED perimeters.

it watches the continued degradation of the irrigation network. In late 1977, when the latter requested[87/] extensive repairs on the exterior dikes, the drains, and the bulk of the access roads, DAM was (for whatever reason) only able to scrape a few access roads near Niandane and reinforce one canal.[88/]

Aside from rapid erosion of the dikes, another problem which threatens to become a chronic drain on maintenance funds is the silting of the canal leading from the Doue to the pumping station. As early as late 1977, only 2½ years after the beginning of operations at Nianga, DAM was forced to contract with a private firm (SOSETER) to dredge this canal. More ominously, none of the intervening years were characterized by heavy flooding; hence, it can be expected that the canal will require additional dredging over the Project's useful life.

Extension services

For extension purposes the Pilot Project is broken into two zones, each presided over by a zone captain. Under each of these captains are four extension workers, whose role is to give technical advice and to coordinate the execution of the various agricultural operations between the SAED/Nianga tractor pool and the farmer. Each extension worker is responsible for four to five GP's.

87/ SAED, Amenagement Hydroagricole du Perimetre de Nianga: Compte Rendu No. 4, A Report Prepared by IFAGRARIA (St. Louis, Senegal: SAED, December 1977), p. 2.

88/ SAED, Rapport de Fin de Campagne; Nianga 1977-78, A Report Prepared by the DAM (Ross Bethio, Senegal: SAED, date unknown), p. 1.

Other Services

Risk sharing

In those instances where the GP's have incurred extensive debts through no willful negligence on their part, SAED has tended to annul them. For example, during the green bean fiasco of 1976-77, the greatest part of the losses were absorbed by SAED. Or in other instances, the debt is rolled over until the following season, with no charges added.

Thus, in effect, SAED to a limited extent provides a service in the form of risk sharing. This pardoning of debt is not done automatically, however; and in fact the decision to do so rests not with SAED, but with the Minister of Rural Development and Hydrology himself. Thus the peasants are shielded from total calamity by a type of noblesse oblige policy, but are still subject to most of the normal risks inherent in any agricultural undertaking.

Vocational training

It is the role of the B.I.T. center to provide instruction in: (1) the techniques of irrigated agriculture; (2) various wood and metal crafts; and (3) basic literacy. Officially designated as Le Centre Nationale de Formation Pour les Cultures Irriguees de Nianga, the BIT center is in a sense larger than the Pilot Project, in that its catchment area includes most of the Senegal River Valley. Indeed it is well that outside recruitment is practiced, for during the dry season campaign of 1977/78, no one from within the Pilot Project Area was willing to participate in the program.

In the fictional world of accounting ledgers, the Center is more or less separate from the Pilot Project. However, on an operational level, the two units are inextricably combined. Use of farm equipment and personnel is traded back and forth on an as-needed basis. While SAED allows the BIT Center to use the irrigated land rent free, it does (at least in principle, though not always in practice) charge for the irrigation water and agricultural inputs consumed by the latter.

Summary

This chapter has provided an overview of the development of what ultimately emerged as the Nianga Pilot Project from the earliest stages of conceptualization through the initial operating years up to the present. Emphasis was placed upon its changes in technical conception which occurred as the result of the changing cast of institutions involved with the development of irrigated agriculture in the Senegal Valley. From the descriptive we pass now to the analytical mode in Chapter V, wherein the theoretical framework laid out in Chapter II will be given empirical application to the Nianga Pilot Perimeter.

CHAPTER V

EX POST SOCIAL COST-BENEFIT ANALYSIS

While the purpose of the previous chapter was in part to evaluate in a broad, non-formalistic manner the development and initial operation of the Pilot Project, the role of Chapter V will be to determine the Project's worth within the theoretical confines of SCB. Toward this end, it will be necessary to derive national parameters (cf Chapter II) appropriate for Senegal and to estimate as rigorously as possible the net benefits for both the With and Without Cases. Finally, the results of this analysis will be expressed in terms of the three conventional criteria of project worth--benefit-cost ratio, net present value, and internal rate of return.

The Without Case

As was pointed out in Chapter II, SCB does not view the project from a before-after perspective; rather it forces the analyst to give his best estimates of what conditions would have been in the area in absence of the project. It is to this task that we now turn. In the analysis which follows, only agriculture is of concern, the assumption being that the dimensions of the Pilot Project (590 hectares under cultivation by 740 peasant farmers) are not of sufficient scale to alter significantly either livestock raising or fishing in the area. It should be noted in passing, however, that this assumption would not necessarily hold for a similar analysis of the impact of Grand Nianga--the latter comprising some 15,000 hectares.

Area Withdrawn From Traditional Cultivation

There are logically three reasons for which areas might be lost to production of traditional crops as a result of the Pilot Project: (1) the actual land on which the irrigation project is constructed is no longer available for traditional agriculture; (2) the land lying within the diked area, but not within the Pilot Project, is no longer flooded; and (3) farmers who take up irrigated agriculture abandon their traditional farms. Each of these possibilities will be dealt with in the discussion that follows.

The only available datum[1/] concerning the area under cultivation within the boundaries of the Pilot Project prior to its development, approximately 200 hectares, is little more than a crude estimate.[2/] While this figure can be neither verified nor refuted, it would appear that it is at least of the correct order of magnitude. Elsewhere it was learned that of the 15,000 hectares enclosed by the exterior dike, only approximately 2,000 hectares (13 percent) had been

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1/ Unfortunately, the maps (scale: 1/200,000) prepared by Juton and Mutsaars [M. Juton and M. Mutsaars, Inventaire des Superficies Cultivees en Decrue, Annee Agricole 1970-71, A Report Prepared by FAO (Dakar: OMVS, June 1971] are illustrations and not actual reductions of the original aerial photo maps. On the advice of these authors, it would be inadmissible to attempt a planimetric measurement from the 1/200,000 maps. (p. 4.)

2/ SOGREAH, R11310-A, Memoire, p. 5-7.

regularly under cultivation.[3/] If it is assumed that this same ratio is applicable to the Pilot Perimeter--such an assumption being entirely reasonable given the similarities in topography (and hence flooding) between the two areas, then the resulting estimate of the pre-project cultivated area is 150 hectares. For the purposes of this research, SOGREAH's estimate of 200 hectares will be used.

One might logically object, of course, that all of these 2,000 hectares withdrawn from production should be charged against the Pilot Project, on the grounds that the exterior diking necessary for Grand Nianga is equally essential for the former. This objection is, however, unfounded for two reasons. First, due to the provision by SAED/Nianga, whereby the sluice gate in the southwestern corner of Grand Nianga is opened at flood time, not all of the cultivable land in the latter has in fact been withdrawn from production as a result of the exterior dike.[4/] Second, and more importantly for the purposes of the SCB analysis to be carried out here, all investments which serve both for Grand Nianga and the Pilot Project will be charged against the latter on a pro rata basis. Given this method of treating investment

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[3/] Ministere du Developpement Rural, Etude des Possibilites de Resorption des Importations de Riz Par Augmentation de la Production Nationale, A Report Prepared by the Direction des Services Agricoles (Dakar: Ministere du Developpement Rural, April 1972).

[4/] HYDROPLAN, 1976, p. 6. In order to exploit the land within Grand Nianga to its fullest, provision had been made for an artificial flood up to a level of 4.5 m. IGN. However, as of 1976, three years after the closing of the dike, this level had not been attained; and for this reason, HYDROPLAN recommended that an additional inlet be constructed in the exterior dike--a recommendation which was never acted upon. In the final analysis, the cultivation of oualo land within Grand Nianga has been greatly reduced, but not completely eliminated.

costs, it would then be inconsistent to charge such reductions in Grand Nianga as a cost to the Pilot Project.

Finally, some consideration must be given to land outside of the diked area cultivated by farmers who now practice irrigated agriculture in the Pilot Project. Since oualo lands are highly prized, as evidenced by the existence of a complex set of land rights, rental fees and sharecropping arrangements (cf. Chapter III), it is assumed here that either farm families will reallocate their resources in such a way as to maintain cultivation of their oualo parcels, or that the latter will be farmed by someone else. In any event, it is assumed that no oualo land outside of the diked area is abandoned as a result of the Pilot Project. At the same time, since dieri land is treated as a free good (cf. Chapter III), it is further assumed that all dieri land is abandoned by those farmers taking up irrigated agriculture on the Pilot Project.[5/,6/]

How much dieri land was thus abandoned? In the absence of any data on the matter, recourse will be made to extrapolation from the best available estimates of the "typical" traditional farm. The latter has been estimated to consist of 3.77 hectares, of which 1.49 in dieri and 2.28 in oualo.[7/] Of the 740 GP members on the Pilot Project, only

[5/] It should be noted in passing that by definition no dieri land is found within either the Pilot Project nor Grand Nianga.

[6/] Both of these assumptions regarding the disposition of dieri and oualo lands were made by the authors of the Bechtel Study (USAID, p. G-2) in their evaluation of the nearby Matam Irrigation Project. While there is good reason to accept this position, it should be stressed, however, that this is a hypothesis which has not as yet been empirically demonstrated.

[7/] Boutillier, et al., p. 70.

an estimated 644 (87 percent)[8/] are family heads, and thus represent a family farm prior to the Project. Therefore, the total estimated dieri land withdrawn from cultivation was approximately 960 hectares (644 x 1.49).

Projections of Area Under Traditional Cultivation

Dieri

Given the erratic nature of the rainfall, it appears highly unlikely that any increase in the area under dry-land cultivation would have occurred in absence of the Project.

Oualo

Despite its relatively higher value in production (cf. Chapter III), it is also highly unlikely that any increased cultivation would have occurred on oualo land either. Indeed the available data has shown no increase in areas cultivated over the 23 year period from 1946 to 1969 (see Table 18), despite modest increases in the population over the same period.[9/]

What factors might explain the extreme interannual fluctuation in cultivated oualo lands? Regression analysis has shown that the maximum

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8/ Estimated by this author from preliminary data from the WAP Survey at Nianga.

9/ Thus Lericollais [Andre Lericollais, "Peuplement et Migrations Dans la Vallee du Senegal," Cahiers d'ORSTOM, Vol. XII, No. 2 (Paris: ORSTOM, 1975, p. 131] reports an increase in population of 30,371 (31 percent) and 10,126 (11 percent) in the Departments of Matam and Podor, respectively, between 1951 and 1972.

TABLE 18.--Estimated area of oualo under cultivation (various years) 1946-69, Zone Aval.[a/],[b/]

Year	46	47	50	51	52	53	54	55	56	57	61	63	64	65	66	67	68	69
Area (000's ha)	39.9	42.0	47.1	36.1	34.1	33.1	50.9	40.1	51.6	54.3	35.8	38.8	48.5	58.0	36.5	51.1	24.4	25.3

a/ Source: Juton, Vallee du Fleuve Senegal...., Annex.

b/ Zone Aval: Refers to a portion of the Senegal Valley, approximately 250 kilometers in length, from Orefonde to Richard Toll.

height of the flood accounted for only 58 percent of this variation (R^2 = .58). While various hypotheses have been advanced by both Juton[10/] and Boutillier et al.[11/] in an attempt to explain the remaining variation, it will suffice for present purposes to note simply that all land flooded in a given year is not automatically cultivated--a fact which suggests the lack of population pressures (although other hypotheses--e.g., land tenure constraints--are equally viable).

Potential for Alternative Irrigated Schemes

For completeness, it is necessary to consider the possibility that alternative types of irrigation might have been developed in absence of the Project. In fact, a flood-fed perimeter (amenagement secondaire) of 200 hectares located near the village of Nianga-Dieri was built under the auspices of the O.A.V.[12/] in 1964. Until 1966, most of the work was done by tractors, and the peasants were paid as laborers for maintaining the dikes. In 1967 the peasants assumed total control of the perimeter; and from this time on, most of the work was done by hand. Despite the apparent interest among the farmers,

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10/ While Juton [Juton, Vallee du Fleuve Senegal: Les Cultures de Decrue et L'Hypotheses de 300 m^3/s, A Report Prepared by FAO (Dakar: OMVS, August 1970), p. 12] made much of the importance of the height of the flood over a 30-day period, regression analysis showed the latter to be so highly correlated (r = +.98) with the simple maximum flood height, that the former was found to yield little additional information.

11/ Boutillier et al., pp. 100-106.

12/ Organisme Autonome de la Vallee: a semi-autonomous development agency created by the Senegalese Government in 1961 for the promotion of irrigated agriculture in the Middle Valley. The O.A.V. is now defunct.

the effort was doomed to failure. First it was plagued in the mid-1960's by high floods which ruptured the dikes, and subsequently by low floods which were insufficient to germinate the rice crop.[13] By the time construction had begun on the Pilot Project, the OAV/Nianga Perimeter had been completely abandoned.

Is it possible that still some other irrigation scheme might have been developed in absence of the Pilot Project? Perhaps. Indeed since 1976 SAED has promoted a series of small village-based perimeters (approximately 25 hectares each) in the Departments of Podor and Matam. To project the successful development of this type of irrigated agriculture, however, would take us squarely into the realm of speculation. Moreover, if the present research effort is to be anything more than ex post speculation, then the without case must be premised on the givens as they appeared in 1972 when the decision to finance the Pilot Project was made. On the heels of the OAV failure, it quite probably appeared that no irrigated alternative short of full water control (amenagement tertiaire) would be technically feasible.

Yields

Data on yields in the traditional sector are, unfortunately, extremely limited and of dubious accuracy. Presented in Table 19 are the yields habitually used in the literature dealing with agriculture in the Senegal Valley.

13/ Paul Seyral, Realisations Agricoles Actuelles Dans la Vallee du Fleuve Senegal, A Report Prepared for FAO (St. Louis, Senegal: OERS, April 1969), passim.

TABLE 19.--Yields of principal crops in the traditional sector.[a]

Crop	Yield (kg/ha)
Sorghum (oualo)	400
Millet (dieri)	350
Maize	650
Cowpeas	150
Beref (grain)	300

a/ Sources: SAED, Programme d'Action a'Court et a Moyen Terme..., Volume II, p. 10.
Memento de l'Agronome (Paris: Ministere de la Cooperation, 1974), p. 76.

It is posited here that no change in the yields shown in Table 19 would have occurred. This is not to suggest, however, that potentially yields cannot be increased. Indeed experiments carried out by IRAT at Kaedi (Mauritania) have shown that with nothing more than timely planting and weeding, sorghum (oualo) yields could be doubled; and with the application of nitrogen, yields could be increased to as high as 1,850 kg/ha.[14] However, given that the recommended weeding prior to planting would conflict with the sowing of the dieri crops, and given the rising costs of fertilizer, it was concluded by the IRAT researchers that no improvements in sorghum yields were likely in the traditional milieu.[15],[16]

14/ OMVS, Bilan Sommaire et Perspectives de Programmation, A Report Prepared for the Projet de Recherche Agronomique (Dakar: OMVS, March 1976), p. 15.

15/ Ibid., p. 15.

16/ Rapport Synthetique General Sur l'Acquise de la Recherche Agronomique et des Possibilites d'Extrapolation en Milieu Rural, Vol. I, A Report Prepared by IRAT (Dakar: IRAT, April 1969).

With respect to maize, experience at Nianga has shown that to date, no high-yielding varieties have been sufficiently adapted to the climatic conditions of the area (cf. Chapter IV). With respect to the improvement of the yields of millet, cowpeas, and beref grown on dieri land, IRAT has concluded that the rainfall is too erratic to justify the added expense of yield-augmenting inputs.

Prices of Agricultural Outputs

In conformity with the willingness to pay framework for the valuation of costs and benefits, as developed by SMD (cf. Chapter II), an attempt has been made to estimate the free market prices for the major traditional crops. (See Table 20).[17/] While these prices represent rather crude estimates based on limited data, they are nevertheless better measures of WTP than the artificially depressed producer prices guaranteed by ONCAD.[18/]

For the purposes of determining costs and benefits in this thesis, 1975 will be used as the base year. In general then, costs and benefits will be given in 1975 prices[19/] (unless otherwise specified),

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17/ The derivation of these estimates is presneted in Annex A.

18/ That the government guaranteed price is lower than the market price is true only in average sense throughout the year. Thus at harvest time, this guaranteed price may be equal to higher than the market price.

19/ The choice of 1975 as the base year is purely one of convenience, given the available data.

TABLE 20.--Estimated market prices of principal crops in the traditional sector (1975).[a]

Crop	Est. Market Price (CFA/kilo)
Sorghum	50
Millet	50
Maize	45
Cowpeas	60
Beref	50

[a] Source: Annex A.

the assumption being that all prices will rise proportionately, and thus not change their relative values. When all prices are held constant at the level of a given year--1975 in this case--they are in effect deflated by a price index.[21]

Costs of Agricultural Inputs

Fixed Costs

As was discussed in Chapter III, agriculture as traditionally practiced in the Podor-Nianga Area involves virtually no capital inputs--with the possible exception of purchased hand tools, which in any case represent negligible amounts when amortized over several years. Thus the only potential fixed cost is that of land rent for oualo parcels. However, since rent is a payment to a fixed factor, it represents nothing more than a transfer of income, and as such is excluded from

[21] Gittinger, p. 37.

the SCB economic accounting framework.

On the other hand, land rent should at least conceptually be included in the financial analysis. However, there would appear to be good reason for excluding such payments for our purposes here. In the first place, for a given farmer, even one who is a property owner, the amount of land rented and the per unit fee paid depends upon the level of the annual flood. Thus an estimation of the average rental payment would require cross-section observations through time--i.e., for a variety of farmers for a variety of flood levels. Not surprisingly, such detailed data is not available. Second, there is reason to believe that, in general, the farmers who are presently growing crops in the Pilot Project were not previous renters. Among the 30 farmers of the Purdue West Africa Project sample, who taken together cultivated 70 oualo parcels, only two such parcels were rented. Finally, even before passage of the Law of 1964 which outlawed the renting and sharecropping of agricultural land in the Domaine Nationale (cf. Chapter III), many of the various payments to the traditional landlords were no longer made.[22/] For all of these reasons, rental payments, which may still exist in some cases, will be excluded from the present SCB analysis.

Variable Costs

The use of fertilizer and pesticides being virtually non-existent in traditional agriculture in the Podor-Nianga Area, the only variable

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22/ Boutillier, et al., p. 129.

costs are seeds and family labor. Hired labor is used only rarely.[23/] Table 21 provides the estimated quantities of seeds used (on a per hectare basis) for the principle crops. In the absence of data on quantities actually used, recourse has been made to norms for West Africa as found in the literature. For the purposes of the SCB calculations, the imputed value of the seeds will be the market prices for comestible grains, on the assumption that no improved or treated seed is used.[24/]

TABLE 21.--Quantities (per hectare) of seed used for principal crops in the traditional sector (pure stand).[a/]

Crop	Quantity (kg/ha)
Sorghum	6
Millet	6
Maize	20
Cowpeas	15
Beref	1[b/]

a/ Sources: Momento de l'Agronome, passim.

Gaudy, passim.

b/ Assumed quantity.

23/ *Ibid.*, p. 68.

24/ This is not to say that farmers do not use selected seeds. Indeed, it has been shown (*Ibid.*, p. 323) that a significant portion of sorghum seed is purchased (from other farmers, presumably) rather than held over from the previous harvest. There is no evidence, however, that the price paid exceeds the market prices shown in Table 20 above.

In order to estimate the value of family labor in the traditional sector, it was necessary to characterize the "typical" farm. As noted previously, the average farm was found to consist of 1.49 hectares of *dieri* and 2.28 hectares of *oualo*. Further, the average farm family has 6[25/] members, 3 of which are active agricultural workers.[26/] Next it is assumed that the marginal product of the agricultural worker on the typical farm is equal to the value of his annual (subsistence) consumption requirements. The latter has been estimated to be approximately 13,750 CFA per year.[27/]

Gross Value of Production

The practice of intercropping in the traditional sector considerably complicates the task of calculating the value of agricultural production. Given the lack of production data, the analyst can only make assumptions as to the resulting effects on yields of the various crops thus cultivated. The approach followed here has been to formulate a low, intermediate, and high estimate of the gross value of production for the typical farm, the differences turning on the various assumptions made vis-a-vis the effects of intercropping. The low estimate assumes no intercropping--i.e., pure stands of sorghum and millet on the *oualo* and *dieri* lands, respectively. The intermediate

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25/ *Ibid.*, p. 68. Rounded up from 5.7.

26/ There is considerable disagreement in the literature as to the size of the average farm family. Worse, there is equal disagreement on a conceptual definition of the farm family--a situation to which allusion was made in Chapter III. The rationale for choosing the present figures rests on the fact that the sample size in the study conducted by Boutillier *et al*. was substantially larger than any of the other studies in the literature with which this author is familiar.

27/ See Annex B for the derivation of this estimate.

estimate assumes reductions ranging from 25 to 75 percent (such reductions due to decreased planting density for a given crop), while the high estimate assumes no reduction.

To arrive at the aggregate gross value of production for the Without Case, the gross value for the typical farm must be multiplied by 644--the estimated number of farm families on the Pilot Project. The results of this calculation are shown in Table 22. For the initial SCB calculation (to be carried out later in this Chapter), only the intermediate estimate will be used. Subsequently, however, sensitivity analysis will be used to determine the effects of the alternative estimates on net worth of the Pilot Project.

TABLE 22.--Alternative estimates of the annual gross value of agricultural production (Without Case).[a/]

Estimate	Gross Value for Typical Farm (CFA)	Aggregate Gross Value (000's CFA)
Low	71,675	46,158.7
Intermediate	76,473	49,248.6
High	132,377	85,250.8

a/ Source: Annex B.

Net Value of Production

We now have all of the necessary elements for calculating the annual net value of agricultural production for the Without Case. The results of this calculation are shown in Table 23 for both the typical farm and the aggregation of 644 family farms. In principle, this measure of net benefits for the Without Case should ultimately be subtracted from its counterpart in the With Case,and subsequently discounted to yield the NPV resulting from the Pilot Project. However, since it has been assumed that only dieri crops are withdrawn from production as a result of the Project (cf. p.171), and given that the latter account for approximately 34 percent of the total value of production in the traditional sector, only 7.25 million CFA will be subtracted here from the With Case benefits.

TABLE 23.---Annual net value of agricultural production (Without Case).[a]

	Value for Typical Farm (CFA)	Aggregate Value (000's CFA)
Gross Value of Production (intermediate estimate)	76,473	49,248.6
-Less seed cost (intermediate estimate)	1,977	1,273.2
-Less family labor	41,232	26,553.4
Net Value of Production	33,264	21,422.0

a/ Source: Annex B and C.

The With Case

Whereas the task of the analyst in the Without Case is to determine what would have occurred in absence of the Project, the With Case consists of an analysis of what will occur given the existence of the Project. While it might at first blush appear that an ex post analysis for the With Case involves little more than a simple recounting of history, it should be kept in mind that accurate predictions of future prices of inputs and outputs do not come any easier with the passage of time. Moreover, the ex post practitioner is beseiged by a host of niggling details which constitute the typical pattern of fits and starts of an incipient project, while his ex ante counterpart was free to proceed in legitimate ignorance. Nevertheless, an attempt will be made here, even at the risk of oversimplification, to place the myriad details of Nianga's operating experience into proper perspective, such that the underlying question of social profitability is not obscured.

SCB Objectives

It was noted previously (cf. Chapter IV) that the two most commonly cited objectives for the development of irrigated agriculture at Nianga were the increased production of cereal grains (chiefly rice) as substitutes for imports and the improvement of the material well-being of the peasants in the Fleuve Region. With reference then to the classification presented by SMD (cf. Chapter II), one might say that the corresponding SCB objectives are increased aggregate consumption and regional distribution of income, respectively. It is argued here, however, that the major emphasis was on import substitution,[28/] and that any increase in farmers' income was seen as a by-product of the push for increased domestic rice production. Once the rice is valued at the shadow price of foreign exchange, the benefits fit within the aggregate consumption objective. For this reason, then, the appropriate SCB objective for the *ex post* analysis is that of increased aggregate consumption.

Project Life

In the SOGREAH Study, the project life chosen for discounting purposes was 30 years. This interval would seem to be a reasonable

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28/ This preoccupation comes through in a previously cited study by the Ministere du Developpement Rural et de l'Hydraulique, reveal-ingly titled, *Etude des Possibilites de Resorption des Importations de Riz Par Augmentation de La Production Nationale*.

estimate of the economic life of the irrigation network, and therefore, this same time span will be used for the ex post analysis. Whether or not the project life is exactly 30 years is of little importance. For as Gittinger has pointed out:

> ....At the kinds of discount rates we are talking about, and the kinds of opportunity costs for capital we think exist in developing countries, any return to an investment beyond about twenty-five years probably will make no difference in your ranking of alternative projects.[29/]

Specification of Project Benefits

With reference to the project components identified at the beginning of Chapter IV, one might identify the benefits of the Pilot Project as follows:

(1) agricultural production;

(2) production of rice seed;

(3) increased knowledge of the agronomy of irrigated agriculture in the Fleuve Region;

(4) improved technical skills of both the farmers who participate in the Pilot Project and those who receive training from the B.I.T. Center;

(5) shelter provided by the 17 houses at Cite SAED.

However, for the purposes of the ex post analysis, only the first of the benefits above will enter into the SCB calculation. The production of rice seed is eliminated from consideration on the

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29/ Gittinger, p. 87.

simplifying assumption that the benefits equal the costs.[30] In that benefits derived from research and training are difficult to calculate on the one hand, and less than completely captured by the Pilot Project on the other, items (3) and (4) above are more appropriately classified as external effects; and as such they will be given special consideration later in this chapter. Finally, the benefits from the housing in Cite SAED are netted out of the calculation, on the assumption that the imputed rental value (benefits) is equal to the sum of amortization and maintenance (costs). Such an assumption is necessary since no market for comparable housing exists in the immediate environs of the Pilot Project. Thus the only benefit included in the *ex post* SCB calculations will be increased agricultural production.

Agricultural Production in the Pilot Project

In Chapter IV the operating experience of the Pilot Project from an agronomic standpoint was covered at some length. Our present task then is to build upon this discussion so as to permit a

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[30] Typically, SAED/Nianga produces about 16 hectares of rice per agricultural campaign on the seed multiplication farm. This seed rice is grown by SAED/Nianga itself and subsequently shipped off to SAED's mills at Ross-Bethio for processing. Seed rice is in turn purchased by SAED/Nianga from Ross-Bethio at 70 CFA/kg. The rice produced on the multiplication farm is more costly to produce than that grown on the peasants' farms due to increased dosages of urea, pesticides (Basudine 10C, primarily), herbicides (STAM F-34, Ordram), and the use of salaried labor. Moreover, care is taken to eliminate any heteroclite varieties. Unfortunately, there is insufficient information available to determine precisely either the costs or the benefits of this production, and hence the assumption is made that they are equal.

reasonable estimate of production throughout the life of the project. Such projections are especially problematic in the case of Nianga, given that even the probable crop mix has not yet been identified. In view of the agronomic consequences of continuous cropping (i.e., no rotation), especially for tomatoes, it is virtually certain that in the future other crops will be grown in rotation with rice and tomatoes. To specify such crops here, however, would be nothing more than speculation; and thus for the purpose of the ex post analysis, the benefits will be calculated as if the crop mix and rotation pattern in use during the years 1977/78 were to hold throughout the Project's lifetime. Thus in the production forecast which follows, none of the minor crops which were tried and subsequently abandoned will be considered. However, their estimated value will be included in the SCB accounting framework for the appropriate years.

Rice

In Chapter IV the full production yield was seen to be 4500 kg/ha. At the same time, it was noted that the rice crop is subject to attack by predators, primarily birds, and occasionally rats. Trinh has repoted that in the past birds have destroyed as much as 85 percent of the rice crop in various locations in the Senegal Valley. Attack by rats, while less frequent, can be equally devastating. Although there is evidence to suggest that the rat plagues are correlated with the periodic droughts,[31/] too little is known about

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31/ Trinh, pp. 61-5.

the frequency and the intensity of the attacks by either rats or birds to permit the construction of a probabilistic "damage" function. Therefore, the sensitivity of the benefits to changes in rice yields will be carried out in the classical manner (e.g., assume a 20 percent increase/decrease in the yield).

With respect to areas planted, it was shown in Chapter IV that the use rate of the irrigable land, while nearly 100 percent during the first few agricultural campaigns when the absolute hectarage was small, had decreased to less than 70 percent by the dry season of 1977/78. Presumably this trend will not continue indefinitely. On the contrary, an assumption is made for the _ex post_ analysis that this rate will reverse itself and stabilize at 75 percent. This assumed rate and the resulting hectarage under cultivation is shown in Table 24. In that this assumption potentially has significant implications for the economic viability of the Project, the sensitivity of

TABLE 24.--Projected land use rate and areas cultivated by agricultural season and by crop.[a]

Agricultural Campaign	Use Rate (%)	Area (ha.)
Dry Season	75	443
-Tomatoes	25	150
-Rice	50	293
Rainy Season (Rice only)	75	443

a/ Source: Calculated from data in Chapter IV, _passim_.

the net benefits to the use rate will be tested, with 75 percent constituting the intermediate, and 100 percent the high estimate. In that a rate less than 65 percent is highly unlikely, the latter will constitute the low estimate.

Tomatoes

The full production yield for tomatoes at Nianga remains an open question (cf. Chapter IV). To date the yields obtained on the peasants' farms have been mediocre--not exceeding 20 tons/ha. In a SAED study of the nearby Dagana Perimeter, the long-term predicted yield for tomatoes was from 20 to 30 tons/ha., with an average of 25 tons.[32/] This latter figure will be used as the intermediate estimate for the *ex post* analysis, with 20 and 30 tons being the high and low estimate, respectively, for the purposes of sensitivity testing. However, in that present yields are slightly less than 15 tons/ha., it is assumed that an average of 25 tons/ha. will not be attained until 1985, with yields rising linearly in the interim as the techniques of irrigated tomato production are mastered by the farmers and the personnel of SAED/Nianga.[33/]

32/ SAED, *Etude Sur le Cout d'Irrigation Sur le Perimetre de Dagana*, A Report Prepared by BEP (St. Louis, Senegal: SAED, June 1976), p. 27.

33/ Thus the assumed yields are as follows:

- DS 78/79: 17 T/ha.
- DS 79/80: 19 T/ha.
- DS 80/81: 21 T/ha.
- DS 81/82: 23 T/ha.

The total area cultivated in tomatoes is projected at 150 hectares in the dry season, as shown in Table 24. For agronomic reasons (avoidance of excessive heat, cryptogamic disease, etc.), it is highly unlikely that tomatoes will ever be double-cropped.[34]

Prices of Agricultural Outputs

As was done for the Without Case, all costs and benefits in the With Case are calculated in terms of 1975 constant CFA francs. Hence, of interest here are the prices of agricultural outputs in terms of 1975 francs. In addition, each commodity (rice and tomatoes) has two prices--one for financial and the other for economic analysis.

Rice

Financial analysis

Since 1974 the guaranteed producer price for rice paddy has been set at 41.5 CFA/kg. It should be noted that SAED/Nianga is merely a conduit through which the paddy passes on its way to the mill at Ross-Bethio, and as such has no financial involvement with the paddy beyond its boundaries. Since the scope of the financial analysis does not extend beyond the "Project gate," it is this price of 41.5 CFA/kg. which is appropriate.

Economic analysis

In order to determine the relevant price for the purposes of economic analysis, one must first answer the following question (cf. Chapter II): Does the additional production increase total supply,

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[34] SAED, Rapport Contre-Saison, 1975/76, p. 21.

or does it substitute for imports? Based on the available evidence, it would appear that the rice from Nianga is a substitute for imports. Indeed as Table 25 clearly shows, rice consumption did not increase in the eight-year period 1969-76. While there are no conventional trade barriers (tariffs, quotas, etc.) to limit imports, the flow is controlled nevertheless. Thus ONCAD, based on its estimation of the local supply and demand situation, determines the amount of rice to be imported in a given year. Prices at all levels are then regulated--from the importer to the retailer.

Clearly the overall policy is to limit the importation of rice. Such intent was clearly enunciated in a paper presented by GOS at a meeting between aid donor and recipient African countries in 1977.[35/] Whereas for several years ONCAD was actually selling below its costs, an increase in the fixed retail price (it is currently at 80 CFA/kg.) in November 1974, coupled with declining world prices from their peak in the same year, has ended the subsidization of rice by GOS to the consumers.[36/] From the foregoing, one can conclude, albeit with less than certainty, that GOS will attempt to reduce imports in proportion to increased local production of rice.

35/ Ministry of Rural Development and Water Resources, Food Investment Strategy, 1977-1985, A Report Presented at the Fourth Meeting of the Consultative Group on Food Production, and Investment in Developing Countries, Sept. 7-9, 1977, Washington, D.C. (Dakar: Ministry of Rural Development and Water Resources, February 1977).

36/ "Senegal:" Marketing, Price Policy, and Storage of Food Grains in the Sahel, Vol. II, Country Studies, A Report Prepared by the Center for Research on Economic Development (Ann Arbor, Michigan, 1977), p. 22.

TABLE 25.--Importation, production, and consumption of rice (grain) in Senegal, 1969/70-1976/77.[a]

Year	Imports	Domestic Production	Total
		000's metric tons	
76/77	130.0	72.8	202.8
75/76	130.0	91.0	221.0
74/75	124.0	76.1	200.1
73/74	141.3	41.6	182.9
72/73	188.5	28.6	217.1
71/72	169.9	70.2	240.1
70/71	187.5	64.4	251.9
69/70	110.6	91.7	202.3
Average	147.7	67.1	214.8

[a] Source: "Senegal:" Marketing, Price Policy

It will be recalled that according to SMD (cf. Chapter II), the appropriate value of an import substitute is its world price. Thus for the case at hand it is the c.i.f. Dakar price which is of interest. However, given that the greatest percentage of rice consumed in Senegal is of the broken rather than the whole grain type, the relevant price is that of brokens. This price for the period 1970-76 is shown in Table 26.

Since the base year for the <u>ex post</u> analysis is 1975, it would appear reasonable to use the price in that year as the base price. However, even if the usual assumption is made (i.e., that all inputs and outputs retain their relative prices), the volatility of the price of rice precludes any <u>one</u> year from being used as the base. Therefore, the procedure followed here will be to use the mean (deflated) price

TABLE 26.--Price of Thai 25-30 percent brokens (c.i.f. Dakar) for the years 1970-76.[a/]

Year	Price (CFA/metric ton)
1976	34,123
1975	59,021
1974	71,312
1973	51,853
1972	40,325
1971	46,548
1970	48,506
	$\bar{X}$ = 50,204
	S.D.(X)= 12,237

a/ Source: Direction de la Statistique, Importations Douze Mois, various years.

b/ Deflated by IMF All-Commodities Index, 1975=100.

for the years 1970-76 as an intermediate estimate, with plus and minus one standard deviation constituting the high and low estimates, respectively. This then yields a range from 38,004 to 62,478, with 50,204 CFA as the intermediate estimate.

In that the above figures represent landed prices at the port of Dakar, they implicitly assume that the imported rice is consumed in the immediate environs of Dakar. In order to value the home consumption, which accounts for about 32 percent of total production at Nianga, transport costs between the port and Nianga must be added to the c.i.f. Dakar price. At 10 CFA per ton-kilometer,[37/] this comes to 4460 francs.

37/ While the regulated rate for transport is 17 CFA/ton-kilometer, the Bechtel economists (USAID, Annex G, p. 10) estimated the economic rate (i.e.,net of taxes, tariffs,etc.) at 10 CFA/ton-kilometer. The distance from Dakar to Nianga via St. Louis is 446 kilometers.

No allowance is made for the milling costs of the rice consumed at home, on the assumption that the opportunity cost of the labor used for this process is zero.[38/]

Tomatoes

Financial Analysis

The peasants are paid 15.5 CFA/kg. for tomatoes by SAED. As is the case for rice, SAED/Nianga operates merely as a conduit through which the tomatoes pass; and therefore, the appropriate price for financial analysis is 15.5 CFA/kg.

Economic Analysis

Unfortunately, very little information concerning the tomato processing industry in Senegal is presently available. Based on fragmentary trade statistics, it would appear that Senegal is reducing its imports of tomato products (primarily paste) as local production increases. At the same time, it would also appear that self-sufficiency will not be reached any time soon. While a recent study[39/] projected the national demand for tomato paste at 8000 tons/per year in 1980, SAED's provisional budget for 1977/78[40/] projected production for that campaign at only approximately 4100 tons.[41/] Moreover, no major expansion of tomato production is envisaged in the near future.

38/ In fact, the peasants typically "mill" the rice with mortar and pestle. The hulls are removed later by winnowing.

39/ SONED, Bilan Diagnostique, A Report Prepared for the Government of Senegal (Dakar: SONED, 1977), p. 241.

40/ SAED, Budget Previsionnel, 1977/78.

41/ SAED estimated total production at 22,000 tons of tomatoes. At the rate of 5.42 kg. of fresh tomatoes for 1 kg. of paste, the resulting yield is 4,074 tons of paste.

Based on the foregoing, it will be assumed that the production from Nianga replaces imports; and that the appropriate valuation is the c.i.f. Dakar price of tomato paste. In the absence of any time series data for this price, the f.o.b. Italy price plus transport costs is used as a proxy, the rationale being that Italy is the major supplier of tomato products to Senegal.

To be more specific, the commodity for which the price will be used to valuate the benefits from tomato production is double concentrate (28-30 brix) tomato paste. Here again the data is extremely limited--only three years' prices (Table 27). Given there are only three observations, the standard deviation will not be used to set the boundaries for the purposes of sensitivity analysis. As before, the mean (132,906 CFA/ton) will constitute the intermediate estimate; but for sensitivity analysis, the low and high estimates will be arbitrarily set at plus or minus 20 percent from the mean. Finally, to arrive at the c.i.f. Dakar price, one must add transport costs from Italy to Dakar (17,600 CFA/ton)[42], which brings the intermediate estimate to 150,506 CFA/ton.

TABLE 27.--Price of double concentrate tomato paste, f.o.b., Italy (deflated by IMF all-commodities index, 1975=100).[a]

Year	CFA/ton
76/77	152,615
75/76	109,077
74/75	137,027

[a] Source: Foreign Agricultural Service, USDA.

[42] Letter from Italia di Navigazione, Genoa, Italy, October 17, 1978. The original cost data was deflated to 1975 prices by an IMF index of export prices for industrialized countries (1975=100).

Calculation of Project Benefits

The resulting benefits from the Pilot Project for financial and economic analysis are shown in Tables 28 and 29, respectively. While the amounts shown for the 1975 through the dry season 1977/78 reflect actual production (as reported by SAED), the figures shown for the remainder of the project life are derived from the estimated prices and quantities presented above.

In both Tables 28 and 29, the benefit stream calculated for RS 78 and after assume the intermediate use rate (75 percent) and the intermediate price and yield values. Moreover, the fact that tomatoes are not expected to reach their full production yield until 1983 is reflected in the escalating benefits up through that year, after which the benefit stream becomes constant.

TABLE 28.--Gross benefits for the Pilot Project in constant 1975 CFA (financial analysis).[a]

Agricultural Season and Year	Crop Type			Total Value (000's CFA)
	Rice (000's CFA)	Tomatoes (000's CFA)	Other (000's CFA)	
DS 75	2,855.9	-	267.5	3,127.4
DS 75/76	8,373.9	17,840.5	2,466.3	28,680.7
RS 76	69,077.3	-	-	89,077.4
DS 76/77	41,184.5	27,202.6	3,709.2	72,096.3
RS 77	80,569.3	-	-	80,569.3
DS 77/78	49,171.3	33,073.9	-	82,245.3
RS 78-RS2002[b]	82,730.3	-	-	82,730.3
DS 78/79	54,717.8	39,525.0	-	94,242.8
DS 79/80	54,717.8	44,175.0	-	98,892.8
DS 80/81	54,717.8	48,825.0	-	103,542.8
DS 81/82	54,717.8	53,475.0	-	108,192.8
DS 82/83-DS 2002/3	54,717.8	58,125.0	-	112,842.8

a/ Sources: (1) SAED, Rapport de Campagne, various years.
(2) Author's calculations.

b/ RS = Rainy season

c/ DS = Dry season

d/ All values past RS 78 assume the intermediate use rate (75 percent) and the intermediate price and yield values.

TABLE 29.--Gross benefits for the Pilot Project in 1975 constant CFA (economic analysis).[a]

Agricultural Season and Year	Crop Type Rice (000's CFA)	Tomatoes (000's CFA)	Other (000's CFA)	Total Value (000's CFA)
RS 75	2,312.4	-	257.8	2,570.1
DS 75/76	6,783.1	31,961.7	2,466.3	41,211.1
RS 76	72,646.9	-	-	72,646.9
DS 76/77	32,724.8	48,471.7	3,709.3	85,168.1
RS 77	65,764.4	-	-	65,764.4
DS 77/78	39,792.4	59,252.8	-	99,045.2
RS78-2002[b]	66,950.4	-	-	66,950.4
DS 78/79	44,280.9	70,810.0	-	115,090.9
DS 79/80	44,280.9	79,140.6	-	123,421.5
DS 80/81	44,280.9	87,471.2	-	131,752.1
DS 81/82	44,280.9	95,801.8	-	140,082.7
DS 82/83-DS 2002/03	44,280.9	104,132.4	-	148,413.3

a/ Sources: (1) SAED, Rapport de Campagne, various years.
(2) Author's calculations.

b/ All values past dry season 77/78 assume the intermediate use rate (75 percent) and the intermediate price and yield values. Shadow pricing of foreign exchange is not reflected in these estimates.

Project Costs

The costs of the Pilot Project will be divided into three general categories: investment costs, recurrent operating expenditures, and salvage value. While the latter is most often considered a benefit, it can just as easily (and perhaps more logically) be treated as a negative cost. Its inclusion here is solely for expository convenience.

While in principle, parallel sets of costs should be developed for economic and financial analysis (in analogy with the procedure followed for benefits), initial investment expenditures will be ignored in the financial analysis. To anticipate somewhat the discussion in Chapter VI, the Pilot Project was shown by SOGREAH to be clearly unprofitable, such that the only way to generate a positive cash flow was through total subsidization of initial investment costs and the costs of expatriate technical experts in the early years of the project.[40/] Within this context, financial analysis is of little interest. On the other hand, the FED did provide an outright grant covering all investment costs and has partially subsidized the operating expenditures through September 1978. The proper role for financial analysis, then, is to determine the commercial viability of the Pilot Project beyond 1978.[41/] Thus for the ex post analysis, only investment costs after this year will be included in the financial analysis.

[40/] SOGREAH, R11310-A, Memoire, Chapter 5.

[41/] Given its contractual commitment (Convention de Financement) with the FED to subsidize any operating losses at Nianga after a reasonable "break-in" period, the question is presumably of more than academic interest to GOS.

At the same time, one might question the validity of charging the Senegalese nation (i.e., assigning positive economic costs) with expenditures that were in fact paid by the FED. Here again, an economic analysis where all capital costs are zero is of only trivial interest. Moreover, the point of SCB is to determine the best allocation of resources; and thus a project which yielded negative returns would represent a misallocation regardless of the source of financing. Therefore, for the purposes of economic analysis, the investment costs will be treated as if they had been paid by the Senegalese nation.

Investment costs

Economic analysis

The total investment cost in 1975 constant francs comes to slightly over one billion CFA. Table 30 shows this cost by general type of expenditure. However, the figures in this table differ from those in Table 9 (cf. Chapter IV) in three aspects:

(1) they are pro-rated for 811 hectares, while those in Table 9 refer to actual expenditures;

(2) the base year here is 1975, while in Table 9 it is 1972;

(3) they are economic costs (i.e., taxes, tariffs, etc., have been netted out), while those in Table 9 are financial costs.

The pro-rating of the investment costs was done in recognition of the fact that much of the irrigation infrastructure was designed to serve Grand Nianga as well as the Pilot Project.[42] This procedure,

[42] The procedure adopted here is that used by HYDROPLAN. It will be recalled that the benefits from both the Seed Multiplication and Experimental Farms, and the BIT Center as well, were omitted from the SCB calculation. Likewise then, a reduction has been made in the hectarage to be counted for the costing of investment expenditures.

however, is applicable only to construction costs. Since all benefits were stated in 1975 prices, all costs must be stated in the same terms. Finally, the coefficients (see Table 30) used to derive the economic costs were adapted from the SOGREAH Study.43/

Construction costs. With respect to the categories of construction costs in Table 30, a brief caveat is in order. Each category, though some more than others, is highly aggregated. For example, "canals, drains, secondary dikes," includes the second phase of the construction of the interior dike (i.e., from the Wali Diali to a point near Guia). Unfortunately, given the nature of the data in HYDROPLAN's report, a more detailed breakdown of costs is not possible.

As for the Bretelle de Podor (cf. Chapter III) which, in addition to serving as a connector between Podor and the Route Nationale N2, serves also as the eastern dike for Grand Nianga, two alterations were necessary as a result of the Nianga Project. While in the 1960's it had been suggested that construction of the Bretelle might be an integral part of any ultimate irrigation project,44/ its construction was eventually undertaken by GOS's Service des Travaux Publics as a separate project. However, as a result of the Nianga Project, the Bretelle was built higher and wider than it would have been in the absence of its dual role as a protecting dike. Based on available

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43/ SOGREAH, R11310-A, Memoire, p. 3-7; p. 5-15.

44/ The BCEOM Study evaluated this proposition.

TABLE 30.--Total Investment Costs for the Pilot Perimeter, Pro-rated for 811 Hectares (in 1975 Constant CFA).[a]

Investment Category	Economic Cost : Financial Cost[c]	Economic Cost (CFA)
I. Initial Construction of Infrastructure (1973-78)		
1(a) Exterior Dike	64	17,211,280
1(b) Major Sluice Gate (P5)	73/75[d]	6,488,970
1(c) Alteration of Bretelle de Podor[b]	64	6,119,045
1(d) Interior dike (initial phase)	64	1,483,393
1(e) Brush clearing, de-stumping	64/91[e]	152,745,937
1(f) Canals, drains, secondary dikes	64	190,644,592
1(g) Minor sluice gates (masonry work)	75	67,101,803
1(h) Pumping station	73/75[d]	87,549,700
1(i) Leveling, deep-plowing, intra-maille dikes (DAM)	64/75[f]	76,249,963
1(j) Cite SAED(offices, warehouses, motor pool, etc.)	77	10,639,174
1(k) Hydro-mechanical devices (for irrigation work)	73[g]	24,551,135
Subtotal of initial construction		640,784,992
2. Initial purchase of autos,trucks(1975)	67[g]	13,167,000
3. Initial purchase of farm machinery(1975-78)	86.5[g]	65,306,616
4. Initial purchase of office eqpt. (1975-76)	77	3,284,721
Subtotal of initial eqpt. purchase (1973-76)		81,758,337
5. Engineering consultant services (1973-76)	91[g]	81,518,178
6. Partial replacement of pumping station (15 years)	73	38,812,519
7. Replacement of autos,trucks(every 7 years)	67	39,501,000
8. Replacement of farm machinery(every 7 years)	82	183,851,325
9. Replacement of hydro-mech. devices(20 years)	73	24,551,135
Subtotal replacement costs		286,715,979
Total Investment Costs		1,090,777,486

a/ Source: HYDROPLAN, 1973-75, and various unpublished data at the SAED/Nianga Office.

b/ Includes this author's estimates of the incremental construction cost incurred by Bretelle de Podor owing to its added role as exterior dike (3,356,172 CFA) plus the cost of backfilling inlets P_1, P_2, P_3.

c/ Excludes the 15 houses for SAED personnel as well as the guest house (which for costing purposes is treated here as being equivalent to two houses).

d/ 75 percent for masonry work component; 73 percent for equipment.

e/ 64 percent for mechanized component; 91 percent (reflecting social security costs) for manual component.

f/ 64 percent for earth-moving equipment; 75 percent for masonry work component.

g/ The rates that would have applied had these items not been exempt from all duties and taxes as a result of FED financing. In actuality, as a result of this exemption, financial costs were equal to economic costs.

data, a reasonable estimate of this additional cost (in 1975 prices) is 112,625,430 CFA: and when pro-rated for 811 hectares, this cost is estimated at 3,356,172 CFA.[45/]

The second alteration was the back-filling of the inlets (Ouvrages P_1, P_2, P_3) cut by Service des Travaux Publics in the Bretelle. This provision for inlets had been negotiaced between the latter and Genie Rural at the time when INSTRUPA's gravity-fed project at Nianga seemed a certainty. With the advent of the FAO/OMVS Pilot Project--i.e., the present project, involving full water control--these inlets had to be closed. The cost of this operation was reported by HYDROPLAN to be 581,361 CFA.

Finally, the category "leveling, deep-plowing, etc." includes work done by DAM in early 1978, which was essentially a re-working of the leveling it had done in 1975-76. The estimated cost of the 1978 operation, which covered approximately 85 hectares, is 1,223,850 CFA.[46/]

Purchase of equipment. Although the initial purchases of equipment constitute a small proportion of total investment (roughly 7 percent), the total cost of equipment over the life of the project

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45/ The calculation was made as follows: $\frac{22m^3}{\text{linear meter}} \times \frac{400.95 \text{ CFA}}{m^3}$ x 12,700, linear m = 112,025,430 CFA. To translate this result into economic costs, it must be multiplied by .64, which yields 71,696,275 CFA. Finally, given that the exterior dike is designed for 10,500 hectares (HYDRCPLAN, 1973-75, p. 69), the pro-rated cost (for 811 ha.) is 5,537,684 CFA--i.e., 71,696,275 ÷ 10,500) x 811.

46/ Estimate based on the FED's original estimate ("Devis No. 4").

amounts to approximately 368 million CFA, or 32 percent of total investment. Moreover, as can be seen in Table 31, these purchases add significantly to the foreign exchange burden engendered by the Project.47/

Salvage Value. For calculating the (negative) salvage cost, the initial values of all investments in Table 30, excluding items 1(e), 1(j), and 1(k), were multiplied by a factor of .16.48/ For Cite SAED, the factor used was .08.48/ The resulting salvage values are shown in Table 31.

Foreign exchange and unskilled labor components. So that the various shadow prices developed in Chapter II can be applied, it is necessary to divide the economic costs into their foreign exchange, unskilled labor, and domestic materials components. This division is presented in Table 31. Because the latter category, which includes skilled labor as well as various domestic physical materials, is nothing more than a residual, it has been labeled simply as "other." The coefficients used to derive the foreign exchange and unskilled labor components, adapted chiefly from the SOGREAH Study, are shown in Table 32. Following SOGREAH's procedure, the foreign exchange coefficient was applied to gross-of-tax values, while the unskilled labor component to net-of-tax values.

46/ Estimates based on the FED's original estimate ("Devis No. 4").

47/ That the replacement cost is significantly less (-43,094,925 CFA) than the original investment in farm equipment reflects the fact that much of the original equipment purchased is not likely to be replaced--due either to structural inadequacy or changing equipment requirements for SAED/Nianga. Moreover, since the equipment is no longer in use, maintenance costs will not be charged against it in the following section dealing with operating costs.

48/ SOGREAH, R11310-A, Memoire, p. 5-10.

TABLE 31.--Investment Costs Classified by Resource Type in 1975 Constant CFA (Economic Analysis).[a]

(000's CFA)

	1973	1974	1975	1976	1977	1982	1989	1990	1995	1996	2002 Salvage Val.	Total Invest Cost
Construction /Replacement of Infra.	31,302.7[b]	353,470.7	251,761.4	-	4,250.2[c]	-	-	38,812.5	24,551.1	-	(-) 73,545.4	630,603.3
-USKL[d]	5,117.0	136,870.3	79,689.1	-	183.6	-	-	1,595.0	7,369.5	-	23,068.5	207,800.0
-FEX[e]	14,882.3	133,513.4	102,372.5	-	3,184.3	-	-	36,685.8	16,940.3	-	30,756.0	276,820.7
-Other	11,243.3	83,806.9	69,699.9	-	882.3	-	-	531.7	241.3	-	19,698.9	145,986.5
Engineering Services (during const.)	-	-	81,518.2	-	-	-	-	-	-	-	-	81,518.2
-USKL	-	-	-	-	-	-	-	-	-	-	-	-
-FEX	-	-	81,518.2	-	-	-	-	-	-	-	-	81,516.2
-Other	-	-	-	-	-	-	-	-	-	-	-	-
Purchase of Autos, Trucks	-	-	13,167.0	-	-	13,167.0	13,167.0	-	-	13,167.0	-	52,668.0
-USKL	-	-	-	-	-	-	-	-	-	-	-	-
-FEX	-	-	9,216.9	-	-	9,216.0	9,216.9	-	-	9,216.9	-	36,867.6
-Other	-	-	3,950.1	-	-	3,950.1	3,950.1	-	-	3,950.1	-	15,800.4
Purchase of Farm Machinery	-	-	61,283.8	-	4,022.8	46,918.0	46,918.8	-	-	46,918.8	-	206,063.0
-USKL	-	-	-	-	-	-	-	-	-	-	-	-
-FEX	-	-	61,283.8	-	4,022.8	46,918.0	46,918.8	-	-	46,918.8	-	206,063.0
-Other	-	-	-	-	-	-	-	-	-	-	-	-
Purchase of Office Equipment	-	703.4	1,724.9	856.4	-	-	-	-	-	-	-	3,284.7
-USKL	-	-	-	-	-	-	-	-	-	-	-	-
-FEX	-	492.4	1,207.5	599.5	-	-	-	-	-	-	-	2,299.3
-Other	-	211.0	517.5	256.9	-	-	-	-	-	-	-	985.4
Purchase Hand Tools (Farmers)	-	-	4,263.7	-	-	-	4,263.7	-	-	-	-	8,527.5
-USKL	-	-	-	-	-	-	-	-	-	-	-	-
-FEX	-	-	1,065.9	-	-	-	1,065.9	-	-	-	-	2,131.9
-Other	-	-	3,197.8	-	-	-	3,197.8	-	-	-	-	6,395.6
Total Invest. Costs	31,320.7	354,174.0	413,719.1	856.4	8,273.1	60,085.8	64,349.5	38,812.5	24,551.1	60,085.8	73,545.4	928,664.6
-USKL	5,117.0	136,870.3	79,689.1	-	183.6	-	-	1,595.0	7,369.5	-	23,068.5	207,800.0
-FEX	14,882.3	134,005.8	256,664.8	599.5	7,207.2	60,085.8	10,281.9	36,685.9	16,940.3	60,085.8	30,785.0	605,700.7
-Other	11,243.3	83,297.9	77,365.2	256.9	882.3	3,950.1	7,147.8	531.7	241.3	3,950.1	19,698.9	169,170.0

a/ Source: (1) HYDROPLAN, 1973-75.
(2) Unpublished data at the SAED/Nianga Office.
(3) Author's calculations.

b/ Includes author's estimate of the incremental construction cost of the Bretelle de Podor resulting from its dual role as both dike and road (5,537,684 CFA).

c/ Includes author's estimate of the cost of DAM's re-leveling of 85 hectares in late 1977 (1,223,850 CFA).

d/ USKL = unskilled labor.

e/ FEX = foreign exchange.

TABLE 32.--Foreign exchange and unskilled labor coefficients for economic analysis.

Investment Activity/Category	FEX%	Unsk. Labor%
Earth moving	32 a/	15 b/
Concrete and/or masonry work	23 a/	25 b/
Equip. and install. of eqpt. (appareillage)	69 a/	3 b/
Furniture and office eqpt.	70 c/	N.A.
Farm machinery	86.5 d/	N.A.
Autos, trucks	70 c/	N.A.
Consultant services	91 e/	N.A.

a/ Source: SOGREAH, R11414-A, Memoire, P. 5-4.

b/ Source: SOGREAH, R11310-A, Annexe 9, P. 19.

c/ Since no rate was available for Senegal, that for Ghana was used, on the assumption that the two countries have similar industrial and tariff structures.

d/ Assumes no domestic materials component.

e/ This is a hypothetical rate, based on imposition of the domestic excise tax (ICA) at a rate of 9.89 percent. In actuality, this expenditure was exempt from any taxes, tariffs, etc. due to the fact that it was financed by the FED.

Financial analysis

As noted above, none of the initial investment costs will be included in the financial analysis. On the other hand, all replacement costs will be counted. This procedure will thus examine the capability of the Pilot Project to "pay its way" subsequent to the initial investment period.

Operating costs

Given that the prices paid by the farmers to SAED for the agricultural inputs bear little relationship to their true costs (cf. Chapter IV), and given the lack of reliable data, determining past costs is nearly as uncertain as predicting future operating costs. Moreover, since the beginning of crop production, there has been continual change with respect to input levels used. In view of these difficulties, the cost of all inputs which are likely to vary (more or less) linearly with hectares cultivated have been estimated. For overhead costs (with the exception of maintenance) recourse has been made to the most recent available SAED budget.[49/] Finally, for the period of actual operating experience--i.e., 1975 through 1977--actual costs (except fuel) of the variable inputs were used.

Since our unit of analysis, SAED/Nianga, encompasses peasant farms, all transactions between them and the former are transfers, and hence inappropriate for inclusion in the SCB framework. However, in order to examine profitability to the farmer (or more precisely, at the level of the collective farm), a farm budget has been estimated (see Annex D). The projected operating costs (intermediate estimates only) for the period 1978-2002 for both economic and financial analysis are shown in Table 33. The underlying data necessary for the calculation of these values, as well as estimates of the variable input costs for the low and high use rates are found in Annex E.

Economic analysis

Analogous to the procedure followed for investment costs, the operating expenditures have been classified according to their resource base for the purpose of shadow pricing in economic analysis (see Table 34). Details on the derivation of these values are also available in

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[49/] SAED, Budget Previsionnel, 1977/78.

TABLE 33.--Operating costs of the pilot project for the period 1978-2002 in 1975 constant CFA (economic and financial analysis).

Cost Item	Intermediate Case[c] Economic RS[e]	DS[f]	Financial RS[e]	DS[f]
Variable Inputs	13,001,232	13,047,405	9,851,537	9,599,141
-Seed[a]	2,810,281	2,476,250	2,810,281	2,476,250
-Fertilizer[a]	7,760,031[d]	8,156,032	3,356,832	3.605,336
-Insecticide, pesticides[a]	725,325	505,247	806,893	560,700
-Fuel[a]				
-Tractors	497,928[d]	510,416	1,294,673	1,181,660
-Threshers	85,828[d]	56,767	222,754	147,329
-Irrigation pumps	1,121,839[d]	1,342,693	1,360,104	1,627,866
Fixed Inputs	43,796,638	43,796,638	48,699,669	48,699,669
-Fuel (trucks,autos, generators)[b]	1,674,146[d]	1,674,146	3,372,750	3,372,750
-Maintenance				
-Farm machinery (spare parts)	1,675,671	1,675,671	1,675,671	1,675,671
-Vehicles (spare parts)	235,125	235,125	235,125	235,125
-Irrigation Infra-structure	5,744,907	5,744,907	8,375,923	8,375,923
-Misc. Supplies and Materials[b]	2,752,090	2,752,090	3,190,000	3,190,000
-Misc. Services[b]	600,000	600,000	1,100,000	1,100,000
-Insurance[b]	1,050,000	1,050,000	1,050,000	1,050,000
-Taxes[b]	N.A.	N.A.	675,000	675,000
-Personnel(SAED)[b]	16,787,999	16,787,999	15,748,500	15,748,500
-Family Labor[a]	13,276,700	13,276,700	13,276,700	13,276,700
Total Operating Costs	56,797,870	56,844,043	58,551,206	58,298,810

a/ Source: Calculated by author.

b/ SAED, Budget Previsionnel, 1977/78.

c/ 75 percent Use Rate.

d/ Includes transport costs from Dakar to Nianga (446 km.) @ 10 CFA/km.

e/ RS = rainy season.

f/ DS = dry season.

TABLE 34.--Operating costs classified by resource base in 1975 constant CFA (economic analysis).[a]

	(000's CFA)			
	1975	1976	1977	1978-2002 (Intermediate)
Variable Inputs				
Seed	1,302.3	7,110.1	5,515.0	5,286.5
-FEX[b]	-	-	-	-
-Other	1,302.3	7,110.1	5,515.0	5,286.5
Fertilizer	4,811.5	16,854.3	20,794.4	15,916.1
-FEX	3,898.3	13,759.4	16,970.4	12,993.1
-Other	913.2	3,095.0	3,824.0	2,932.0
Insecticides, Herbicides,etc.	957.5	6,230.4	1,025.8	1,230.6
-FEX	690.7	4,494.2	739.6	886.9
-Other	266.8	1,736.1	286.1	341.6
Fuel: tractors, threshers,pumps	1,233.5	3,456.5	3,384.0	3,615.5
-FEX	813.6	2,280.0	2,232.2	2,384.9
-Other	419.8	1.176.4	1,151.8	1,230.6
Total Variable Inputs	8,304.7	33,651.3	30,719.3	26,048.7
-FEX	5,402.6	20,533.6	19,942.3	16,267.0
-Other	2,902.1	13,117.7	10,777.0	9,781.7
Fixed Inputs				
Fuel(trucks,autos,generator)	3,348.3	3,348.3	3,348.3	3,348.3
-FEX	1,994.7	1,994.7	1,994.7	1,994.7
-Other	1,353.6	1,353.6	1,353.6	1,353.6
Maintenance	15,311.4	15,311.4	15,311.4	15,311.4
-FEX	10,515.5	10,515.5	10,515.5	10,515.5
-Unskl	1,577.0	1,577.0	1,577.0	1,577.0
-Other	3,218.8	3,218.8	3,218.8	3,218.8

(Continued)

TABLE 34 (Continued)

	1975	1976	1977	1978-2002 (Intermediate)
	(000's CFA)			
Fixed Inputs (continued)				
Personnel (SAED)	44,542.6	44,542.6	51,844.2	33,576.0
-FEX	21,580.0	21,580.0	26,133.8	-
-Unskl	2,375.0	2,375.0	3,000.0	7,117.0
-Other	20,587.6	20,587.6	22,710.4	26,459.0
Family Labor	18,059.6	18,059.6	26,553.4	26,553.4
-Other	18,059.6	18,059.6	26,553.4	26,553.4
Misc. Supplies, Services	6,704.2	6,704.2	6,704.2	6,704.2
-FEX	2,702.1	2,702.1	2,702.1	2,702.1
-Other	4,002.1	4,002.1	4,002.1	4,002.1
Insurance	2,100.0	2,100.0	2,100.0	2,100.0
-Other	2,100.0	2,100.0	2,100.0	2,100.0
Total Fixed Inputs	90,066.1	90,006.1	105,851.5	87,593.3
-FEX	36,792.3	36,792.3	41,346.1	15,212.3
-Unskl	3,952.3	3,952.3	4,577.0	8,694.0
-Other	49,321.7	49,321.7	59,938.3	63,686.9
Total Operating Costs	98,370.8	123,717.4	136,580.8	113,642.0
-FEX	42,194.9	57,325.9	61,288.4	31,479.2
-Unskl	3,952.3	3,952.3	4,577.0	8,694.0
-Other	52,223.6	62,439.2	70,715.4	73,468.8

a/ Sources: (1) SAED, Rapport de Campagne, various years.
(2) Author's calculations.

b/ FEX = Foreign exchange.

Annex E.

Financial analysis

It will be recalled that the objective of the financial analysis in the present case is to determine the profitability of the Pilot Project given that initial capital costs were borne by external agents. At the same time, renewal costs of trucks, automobiles, farm machinery (every seven years), as well as portions of the irrigation infrastructure[50/] are charged against the stream of financial benefits generated by the Pilot Project. Such renewals are provided for in the years 1982, 89, and 96 for the vehicles and farm equipment, in 1990 for the pumping station, and in 1995 for the hydro-mechanical components of the irrigation network. (See Table 35.)

Shadow Prices and Discount Rates

Where market prices do not adequately reflect the true costs or values to society, recourse is made in SCB to shadow prices (cf. Chapter II). The latter have been empirically estimated for foreign exchange, unskilled labor, and capital. While the estimated values of these parameters for Senegal is presented directly below, their derivation is found in Annex F.

Shadow exchange rate (SER)

As explained in Chapter II, the SER is the ratio of international to domestic prices. Based on trade data from the period 1966/67 through 1975/76, the SER for Senegal was found to be 1.13. Since

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[50/] cf. Annex E.

TABLE 35.--Operating costs for duration of the project life in 1975 constant CFA (financial analysis).[a]

(000's CFA)

	1975	1976	1977	1978-2002[b]	...	1982	1989	1990	1995	1996
Variable Inputs										
Seed	1,302.3	7,110.1	5,515.0	5,286.5	...	5,286.5	5,286.5	5,286.5	5,286.5	5,286.5
Fertilizer	2,356.1	7,838.2	9,692.7	6,962.2	...	6,962.2	6,962.2	6,962.2	6,962.2	6,962.2
Insecticide, Herbicides, etc.	1,062.6	6,914.2	1,138.4	1,367.6	...	1,367.6	1,367.6	1,367.6	1,367.6	1,367.6
Fuel:tractors, threshers, pumps	1,970.7	5,596.7	5,465.0	5,834.4	...	5,834.4	5,834.4	5,834.4	5,834.4	5,834.4
Total Variable Inputs	6,691.6	27,459.2	21,811.1	19,450.7	...	19,450.7	19,450.7	19,450.7	19,450.7	19,450.7
Fixed Inputs										
Fuel:trucks,autos,generator	6,745.5	6,745.5	6,745.5	6,745.5	...	6,745.5	6,745.5	6,745.4	6,745.4	6,745.4
Maintenance	20,573.4	20,573.4	20,573.4	20,573.4	...	20,573.4	20,573.4	20,573.4	20,573.4	20,573.4
Personnel	22,210.6	22,210.6	23,257.2	31,497.0	...	31,497.0	31,497.0	31,497.0	31,497.0	31,497.0
Misc. Supplies & Services	8,580.0	8,580.0	8,580.0	8,580.0	...	8,580.0	8,580.0	8,580.0	5,550.0	8,580.0
Insurance	2,100.0	2,100.0	2,100.0	2,100.0	...	2,100.0	2,100.0	2,100.0	2,100.0	2,100.0
Taxes	1,350.0	1,350.0	1,350.0	1,350.0	...	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Family labor	18,059.6	18,059.6	26,553.4	26,553.4	...	26,553.4	26,553.4	26,553.4	26,553.4	26,553.4
Total Fixed Inputs	79,619.2	79,619.2	89,159.5	97,399.3	...	97,399.3	97,399.3	97,399.3	97,399.3	97,399.3
Equipment Renewal	-	-	-	-	...	76,870.3	76,870.3	53,167.8	33,631.7	76,870.3
Total Operating Costs	86,310.8	107,078.4	110,970.6	116,850.0	...	174,269.6	174,269.6	150,567.1	131,031.0	174.269.6

[a] Sources: (1) SAED, Rapport de Campagne, various years.
(2) Author's calculations.

[b] Except for equipment renewal years.

there had been a major reduction in the rate of export taxes on peanuts--by far Senegal's leading export--in 1966, trade data prior to the latter year was excluded in calculating the SER.[51/]

Shadow wage rate (SWR)

SWR, as it has been developed in the present research, is purely the opportunity cost of a hypothetical worker who is removed from agricultural production in the traditional sector. This cost has been estimated at approximately 14,000 CFA per year. As such, this represents 6 percent of the minimum wage for the lowest category (ouvrier, categorie 1) of unskilled labor in the modern sector; and therefore the weight to be given unskilled labor costs (as found in Tables 31 and 34) in the SCB accounting is .06.

It should be noted, however, that SWR will be applied only to the unskilled labor component of the construction and operation of the Pilot Project, and not to family labor used in crop production. The latter, it should be remembered, has been assumed to have an opportunity value of subsistence consumption. In practice, however, it would make little difference here which figure was used, given that the agricultural worker's consumption was also estimated at approximately 14,000 CFA per year.

Shadow price rate of investment (P^{inv}) and the social rate of time preference (SRTP)

The shadow price of investment, P^{inv} and SRTP are inextricably linked for estimation purposes. Since SRTP is to be treated as

[51/] This reduction was in response to the end of preferential prices in peanut oil accorded Senegal by its principal customer, France. A glance at Equation (13) in Chapter II reveals that high export taxes result in a low SER and vice versa.

as an unknown, and hence estimated by what is in effect sensitivity analysis, P^{inv} being a function of the former, must be estimated in the same manner. The values to be tested for SRTP and P^{inv} are 5, 10, and 15 percent, and 10, 15, and 20 percent, respectively.

External Effects

Of the three external effects deemed appropriate by SMD for inclusion in the SCB framework (cf. Chapter II of this thesis), only two of them are relevant to the Pilot Project--namely, cost-reduction, and training effects.

Cost-reduction effects: the Experimental Farm

While officially the Experimental Farm (comprising 9.18 hectares) is an integral component of the Pilot Project, in practice it is operated in conjunction with the Seed Multiplication Farm. In short, the Experimental Farm at any one time consists of the parcels on which experimentation is being conducted. During the rainy season of 1977, only three crops (maize, tomatoes, sorghum) were grown experimentally on a total of 1.2 hectares. Moreover, in the most recent SAED/Nianga report available (Contre-Saison 1977/78), the Experimental Farm was not even accorded mention.

The potential for cost-reduction effects lies mainly with the generation of high-yielding varieties which are adapted to the rigors (extreme heat) of the Nianga climate. Such effects would reach beyond the boundaries of the Pilot Project--hence the rationale for considering them as external effects. However, all such effects remain potential, in that to date, no significant breakthroughs have been achieved. On the cost side, the per hectare cost of production is somewhat higher than on the peasant farms, due to more intensive use of agro-chemical inputs.

Training effects: the B.I.T. Center

No information is available concerning either the capital or operating costs of the B.I.T. Center (cf. Chapter IV). In addition to the 18 hectares of irrigated land currently under production for training purposes, there are several craft shops, dormitories, and classrooms still under construction. While the initial group of trainees (1975) was recruited from the ranks of the peasants who ultimately obtained access to land in the Pilot Project, it was the intent of B.I.T. that Nianga should evolve into a regional training center. As indicated in Chapter IV, this goal was achieved, albeit inadvertently, by 1977 when the Center was unable to recruit any trainees from among the farmers in the Pilot Project.

Admittedly, such a reaction on the part of the Center's intended beneficiaries renders the normal presumption of positive benefits from training programs somewhat open to question. Be that as it may, assuming there are indeed positive (if only long range) benefits from training, such benefits are virtually impossible to measure in the first instance, and incapable of being captured by the Project in the second. Moreover, it should be pointed out that many of the farmers presently working in the Nianga Project have also participated in various other irrigation schemes that have come and gone throughout the Senegal Valley. Thus to a certain degree, the present benefits from the Pilot Project are a result of on-the-job training gained from previous projects. Sorting all of this out is clearly beyond the scope of this research; and for that matter, it is also beyond the current state of the art in SCB.

Project Worth Using Alternative Investment Criteria

Given the uncertainty in the data used in this analysis, and the SMD stress on sensitivity analysis of national parameters, the sensitivity analysis will be incorporated directly into the analytical results. Thus in both the economic and financial analysis, the results will consist of a range of values rather than a single number. At the same time, the sensitivity of certain parameters is tested by the conventional method of varying each parameter singly against the intermediate values of the remaining variables.

Economic Analysis

The project worth for intermediate values (prices, yields, without case benefits, and use rate) at various discount rates is shown in Table 36. It should be noted that when shadow pricing is used, the Pilot Project does not turn unprofitable until roughly 12 percent (according to the BCR and NPV measures). To see the effect of shadow pricing, several computer runs were made--again with intermediate values, but with all shadow prices set equal to one. In this instance the project turns unprofitable between six and seven percent. In neither case, however, is the IRR negative.

The effect of changes in the production variables as well as the use rate is shown in Table 37. In both instances the low values result in an unfavorable BCR and NPV. As above, however, the IRR remains positive in all cases. Of particular significance is the finding that

TABLE 36.--Measures of project worth at various discount rates (economic analysis).

Case Description	i	Opportunity Cost s pinv+(1-s)	BCR	NPV (000's CFA)	IRR(%)
Inter. Values	.05	1.11904	1.322	744,236.6	11.82
Inter. Values	.05	1.26976	1.365	844,475.5	11.82
Inter. Values	.10	1.05568	1.052	79,198.3	11.82
Inter. Values	.10	1.11904	1.055	83,951.6	11.82
Inter. Values	.15	1.03648	0.851	-165,169.4	11.82
Intermed. (No shadow)	.05	1.00000	1.062	154,361.7	6.58
Intermed. (No shadow)	.06	1.00000	1.017	37,517.7	6.58
Intermed. (No shadow)	.07	1.00000	0.972	-57,535.5	6.58
Intermed. (No shadow)	.08	1.00000	0.930	-134,954.0	6.58

TABLE 37.--Measures of project worth at various yields, prices, benefits from Without Case, and various use rates (economic analysis).

Case Description	i	Opportunity Cost s pinv+(1-s)	BCR	NPV(000's CFA)	IRR(%)
Low production	.10	1.05568	0.733	-403,218.4	0.67
Intermed. production	.10	1.05568	1.052	79,198.3	11.82
High production	.10	1.05568	1.432	694,768.8	19.74
Low use (65%)	.10	1.05568	0.974	-39,126.4	9.80
Intermed. use (75%)	.10	1.05568	1.052	79,198.3	11.82
High use (100%)	.10	1.05568	1.256	400,224.8	16.36

a 33 percent increase in the use rate (from 75 to 100 percent) results in a substantial increase in the BCR and a five-fold increase in the NPV.

Finally, a series of runs was made to test the sensitivity of net benefits to the previous assumptions regarding the source of investment and disposition of consumption. Before, it was assumed that the project displaces both investment and consumption; and (2) benefits as well as costs were shadow priced (cf. Chapter II). For the following sensitivity analysis, it is assumed that all project costs are financed by displacing alternative investment(a^{inv} = 1.0); and further, only investment costs are shadow priced--i.e., all benefits are consumed. The investment shadow price factor is not $[s\ P^{inv} + (1-s)]$ as before, but simply P^{inv} (cf. Chapter II). When the results (Table 38) are compared with those shown previously in Table 36, it is readily seen that the effect of our modified procedure is to reduce substantially the profitability of the Project; and thus it can be concluded

TABLE 38.--Measures of project worth where a^{inv} = 1.0 and the opportunity cost of capital = P^{inv} (sensitivity analysis).

Case Description	i	P^{inv}	BCR	NPV (000's CFA)	IRR(%)
Intermed. values	.05	2.24	.978	-65,991.5	4.73
Intermed. values	.05	3.81	.750	-991,601,950	1.0
Intermed. values	.10	1.58	.872	-233,876,874	7.56
Intermed. values	.10	2.24	.731	-585,379,986	4.73
Intermed. values	.15	1.38	.734	-342,405.3	8.75

that the Project's worth is highly sensitive to the assumptions made about the financing of projects and the ultimate use of the resulting benefits.

Financial Analysis

It will be recalled from above that the justification for not including investment costs in the financial analysis was the earlier finding by SOGREAH of extreme unprofitability.[52/] In view of our present findings in the economic analysis above, wherein the Pilot Project was shown to be profitable under certain conditions, one might argue that this justification is no longer valid. However, for financial analysis, the appropriate rate of discount is not the SRTP, but rather the opportunity cost of capital, q, which has been assumed to range upward from 10 percent. At the same time, it was shown in Table 36 that with no shadow pricing (which is the case in financial analysis), the Project turns unprofitable at a discount rate of between 6 and 7 percent. Since q is by assumption greater than or equal to 10 percent, the Project could not possibly be viable from a financial standpoint if investment costs were included in the calculation.

In the same manner as was done for economic analysis, the production variables and use rate have been run at different levels for financial analysis. The sensitivity of project worth to the discount rate was also tested. These various runs are shown in Table 39. Based

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52/ More precisely, the cumulative net benefits streams for both financial and economic analysis were found to be negative <u>prior</u> to discounting.

TABLE 39.--Measures of project worth at various yields, use rates, and discount rates.

Case Description	q	BCR	NPV (000's CFA)
Low use (65%)	.15	1.176	106,980.4
Intermed. use (75%)	.15	1.267	165,249.5
High use (100%)	.15	1.518	329,509.9
Low yield	.15	1.104	64,114.8
Intermed. yield	.15	1.267	165,249.5
High yield	.15	1.349	238,492.8
Low q	.10	1.310	309,118.8
Intermed. q	.15	1.267	165,249.5
High q.	.20	1.222	92,687.0

on these findings, it can be stated unambiguously that once initial investment costs have been excluded, the Pilot Project is profitable. Since the IRR presupposes an investment period, its use here is precluded. Moreover, the scope of our sensitivity testing is somewhat reduced since the financial prices are fixed by the government and thus not subject to fluctuation.

Summary

This chapter concludes the *ex post* analysis of the Nianga Pilot Project. Readers will no doubt recall that Chapter IV, which detailed excessive costs and evidence of mismanagement, pre-saged a highly unprofitable project. To the contrary, the *ex post* analysis has shown, at least for economic analysis, the Pilot Project to be modestly profitable at a SRTP of 10 percent. In the chapter which follows, an attempt will be made to reconcile this finding with the conclusion of SOGREAH's *ex ante* study, which showed the Project to be uneconomic.

CHAPTER VI

COMPARISON BETWEEN EX ANTE (SOGREAH) AND EX POST COST-BENEFIT ANALYSES

The inevitable gap between an *ex ante* and *ex post* analysis is due generally to a difference in perspective. With the former it is a question of projection, while in the latter it is one of history. Moreover, in the case of Nianga the breadth of the gap is exacerbated by the fact that the present crop pattern (two crops rice, one crop of tomatoes per year) is quite different economically from that considered by SOGREAH (in addition to rice: corn, wheat, sorghum, and cowpeas). Given that each crop generates its unique cash flow, a rigorous comparison between the *ex ante* and *ex post* situation is out of the question. Nevertheless, it is possible to compare the *methodology* used in the respective studies. And finally, when some hypothetical changes are made with respect to SOGREAH's projection, a rough comparison can be made of the *results*.

Comparison of Methodology

While the methodological framework of the *ex post* analysis was explicitly based on SMD, that of the SOGREAH Study remains unclear. While on the one hand the benefits derived from crop production[1/] were

[1/] For minor crops not entering world trade (e.g., cowpeas), estimated domestic market prices were used.

calculated at border prices, all costs were valued at domestic prices in terms of domestic currency. But what might have accounted for SOGREAH's failure to shadow price foreign exchange and capital? While, of course, the effects method explicitly rules out the shadow pricing of inputs (cf. Chapter II), there is no evidence to suggest that SOGREAH was following this model. Given this ambiguity, it is difficult to distinguish real methodological differences from outright omissions. Be that as it may, in the sections which follow, an attempt will be made to highlight the more important differences between the two studies.

Treatment of the Without Case

Although they gave explicit recognition to the concept, the SOGREAH analysts ultimately dismissed the benefits from the traditional agricultural sector as negligible. Such omission is a serious error, as it leads to overestimation of the Project's benefits. In the _ex post_ study, the annual net revenues for the Without Case were estimated at approximately 21.4 million CFA per year, of which 7.2 million was lost in the With Case and hence deducted from the gross benefits stream of the With Case. While this deduction amounts to only 3.3 percent of gross benefits in those years following the attainment of full production, it is nevertheless an important factor in the early years of the project's life.

Financial vs. Economic Analysis

In effect, the economic and financial analyses in the SOGREAH Study concerned two different projects. The economic analysis examined the costs and benefits specific to the Pilot Project, while the financial analysis included all costs, whether specific to the Pilot Project or not. Thus many of the capital costs which should have been charged to the (hypothetical) Grand Nianga Perimeter were charged against the Pilot Project. In this instance it is not surprising that SOGREAH found a negative cash flow prior to discounting.[2/]

To be sure, a similar lack of comparability between the economic and financial analysis obtains in the ex post study, wherein the former includes all investment costs but the latter excludes them. In this case, the procedure is entirely logical, however, on the grounds that the turning point (vis-a-vis profitability) lies between six and seven percent.[3/] Since the minimum estimate of the opportunity cost of capital in Senegal was 10 percent, it then followed that a financial analysis which included capital costs would be a priori unprofitable. But what was the logic behind SOGREAH's procedure? Since one might normally expect that a benefit stream from 948 hectares could not possibly amortize the capital costs of an infrastructure intended for several thousand hectares anyway, SOGREAH's findings of negative return were of only trivial interest. The question still remained as to whether or not an irrigation scheme the size of the Pilot Project could be financially viable.

Use of Shadow Prices

Neither capital nor foreign exchange was shadow priced in the

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[2/] In fairness, SOGREAH had found a negative undiscounted cash for both economic and financial analysis. However, in the first case the deficit was 100 million CFA, while for the latter it was 500 million CFA.

[3/] Specifically, the BCR becomes less than one and NPV becomes negative between these two discount rates.

SOGREAH Study. The effect of the omission of course was to underestimate significantly the economic benefits of the Project, the bulk of which were in terms of foreign exchange saved. Similarly, the lack of any premium on savings resulted in an understatement of that portion of benefits saved (estimated at .096 in the *ex post* analysis). Somewhat offsetting these underestimations, however, was the fact that the foreign exchange costs of the Project were not shadow priced--i.e., increased--by the shadow exchange rate (estimated at 1.13 in the *ex post* study).

The shadow wage rate, assumed to be zero in the SOGREAH Study, was applied to the unskilled labor component of construction costs and (at least implicitly) to family labor used in agricultural production. However, as discussed previously (cf. Chapter II), in an area where migration is a realistic alternative to agriculture (and such is the case for the Senegal Valley), it is highly unlikely that the opportunity cost is indeed zero. With respect to family labor, it is also certain that the social cost is greater than zero--at a minimum, it must be a bundle of wages goods sufficient to keep the family alive and capable of physical labor. In both instances, the effect of SOGREAH's treatment of labor costs led to an understatement of the Project's costs.

Comparison of Results

Results of the *Ex Ante* (SOGREAH) Study

SOGREAH concluded that the Nianga Pilot Project, as proposed by FAO/OMVS,[4/] was highly unprofitable at any discount rate from both a

[4/] SOGREAH emphasized time and again that the working hypothesis of their study (i.e., a high degree of mechanization and a sophisticated irrigation network) had been forced upon them by FAO/OMVS. As a means of expressing their dissent, they proposed several variant schemes, all of which were less capital-intensive. (SOGREAH, R11310-A, Memoire, Chapt.6).

financial and economic standpoint for the following three reasons: (1) high capital costs for the irrigation infrastructure; (2) high operating costs as a result of mechanization; and (3) the relatively low-value crops to be produced--chiefly cereals. The high capital costs devolved from the sophisticated irrigation network insisted upon by FAO/OMVS, and the necessity to accommodate machinery by constructing relatively large rectangular parcels (cf. Chapter IV). Similarly, the high operating costs were seen as due mainly to the high level of mechanization. Finally, the proposed crop mix consisted mainly of cereals (rice, wheat, corn, sorghum) and legumes (cowpeas), and only to a lesser extent on higher value vegetable crops.[5/]

Results of the *Ex Post* Analysis

In contrast to the SOGREAH Study, the *ex post* analysis found the Project to be modestly profitable from a social perspective, with a switching value between profitability and loss at approximately 12 percent. However, when the effect of the shadow pricing was removed, the switching value fell to approximately 7 percent. On the other hand, the *ex post* financial analysis concurred in SOGREAH's findings that the Project was incapable of paying for itself. However, when investment costs were excluded, the Project was profitable even at a discount rate of 20 percent--our highest estimate of the opportunity cost of capital for Senegal.

5/ Industrial tomatoes had not been contemplated.

Reconciliation of Differences Between the *Ex Ante* and *Ex Post* Analyses

The seeming difference in the results between the *ex ante* and *ex post* studies is more apparent than real. In fact, as will be shown below, the divergence is due to a large extent to the advantage of hindsight in the projection of both benefits and costs.

Valuation of benefits

In the SOGREAH Study, the economic value of rice was an average calculated for the 12-year period 1960-71--a period which in general was characterized by relatively stable world commodity prices. This average price was found to have been 16 CFA/kg. paddy (c.i.f. Dakar). While the same method was used for the *ex post* study, the data was from the period 1970-76, a period of high worldwide commodity prices. The average price for this period when adjusted for inflation was found in the *ex post* study to be 32.5 CFA/kg. paddy (c.i.f. Dakar) in 1975 constant CFA--i.e., a real price double that used by SOGREAH. In the absence of a forecasting model of world rice prices, one can do no better than use this type of averaging procedure.

On the assumption then that this higher price (i.e., 32.5 CFA/kg.) is a more accurate projection of future benefits, it was subsequently inserted into the calculation of SOGREAH's gross benefits. For simplicity, all crops other than rice were ignored. Then a hypothetical gross benefit stream reflecting 948 hectares of double-cropped rice was generated, while the cost stream was inflated to 1975 prices.[6/]

[6/] HYDROPLAN (HYDROPLAN, 1973-75) used an update factor of 1.6285 to convert project construction costs in 1972 prices to 1975 prices. This factor was applied here to both construction and operating costs.

The resulting cash flow was no longer negative as SOGREAH had originally found; moreover, the Project was profitable at discount rates up to 3.7 percent.[7/] While this is still substantially lower than the switching value identified in the ex post study (between six and seven percent), it should be pointed out that the addition of industrial tomatoes to the crop mix would substantially increase the hypothetical SOGREAH gross benefit stream, and hence raise the Project's switching value even more.

Costs

Calculation of costs accounts for some of the remaining difference between the two studies. Whereas SOGREAH had projected a total expenditure of 380 million CFA over the 30-year project life, the ex post analysis projected an expenditure of only 206 million CFA.[8/] This lower figure is at least partially justified by the operating history of the Project, in that the initial purchase of farm equipment was substantially below SOGREAH's estimate. Moreover, as was noted previously (cf. Chapter V), much of the farm machinery included in the original procurement is unlikely to be replaced; and therefore, the expenditure for replacement of equipment was reduced accordingly in the ex post analysis.

In general, the trend at Nianga has been toward less mechanization and less reliance upon pesticides, herbicides, etc. (cf. Chapter

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7/ At 3 percent, BCR = 1.023; NPV = 105,106,816 CFA: and IRR = 3.68 percent. At 4 percent, BCR = .985; NPV = -59,760,100; and IRR = 3.68 percent.

8/ The difference of 174 million CFA amounts to 18 percent of the total estimated investment costs for the 30-year project life in the ex post analysis.

IV). This phenomenon contributed directly to substantially lower estimates of operating costs in the *ex post* analysis than in the SOGREAH Study.

Reformulation of Project Design

One of the obvious benefits of an *ex ante* feasibility study is that it permits a reformulation of the project design in the event that the original conception is found to be unprofitable. Yet, despite SOGREAH's conclusion that the Pilot Project was highly uneconomic, and despite the latter's proposals for a less capital-intensive scheme of irrigation, the decision makers of OMVS/FAO refused to reconsider their original design which, as was seen in Chapter IV, called for a relatively sophisticated irrigation network and a highly mechanized crop production system.

To be sure, the *ex post* analysis showed that primarily as a result of the post-1972 worldwide boom in commodity prices, the Nianga Project is marginally profitable, at least from a social if not from a financial perspective. But one does not plan a project on the hope that inflation will ultimately "bail it out." The fact remains that on the best information available at that time, the Project as designed was not economically viable. The end result is a marginal project which, had a meaningful reformulation of the design occurred, would in all probability (given the trend in world commodity prices since 1972) have been a profitable one.

Summary

In this chapter a comparison was made between the ex post cost-benefit analysis of Chapter V and SOGREAH's ex ante study. An attempt was made to compare the methodology as well as the results. Given the ambiguity in the conceptual framework of the SOGREAH Study, it was often not possible to distinguish definitively methodological differences from outright procedural omissions. Nevertheless, a number of procedural differences between the two studies were identified. With respect to the results, once the benefit stream of the SOGREAH Study was adjusted in accordance with the hindsight enjoyed by this author (especially with respect to rice prices), much of the apparent difference between the two studies was eliminated. One implication of the rise in commodity prices, clearly, is that projects such as this are now more profitable than was believed to be in the past. While the SOGREAH Study cannot be faulted for not perceiving the price increases, the current "conventional wisdom" (that such projects are highly unprofitable) can be faulted if the price increases are not factored into the analysis and evaluation process for future projects. It is quite possible that the "conventional wisdom" reflected in the SOGREAH Study was correct before the price increases, but is much less accurate given today's world commodity prices.

Finally, the failure of the decision-makers of OMVS/FAO to reformulate the Project's design following the negative conclusions of the ex ante feasibility study has resulted in a marginal project which otherwise might have been highly profitable. While we have not undertaken a detailed analysis of alternative project designs, there is clear evidence (cf. Chapter IV) that design changes would have made the project more profitable.

CHAPTER VII

CONCLUSIONS AND POLICY RECOMMENDATIONS

As was seen in Chapter I, the unhappy prospect facing donor agencies is that of passing judgment on funding requests for the development of additional tertiary irrigation projects in the Senegal Valley without any systematic economic evaluation of existing tertiary projects. Filling this information gap was the prime goal of this research, and thus it is toward this end that the conclusions below are directed. In Chapter II a brief review of the social cost-benefit literature was given; and in addition, the SMD approach to project analysis was presented in some detail--not only from a theoretical standpoint, but also with an eye toward practical application to the Nianga Pilot Project.

Chapter III, in describing the Project's locale, served two purposes. On the one hand, its emphasis on the harsh climatic conditions and the erratic weather patterns made understandable the persistent demands for intervention by man to develop irrigated agriculture. On the other hand, its description of the pre-project economy and social institutions made it amply clear that the local area, though poverty-stricken, is not a <u>tabla rasa</u> on which planners are completely free to inscribe their visions of economic development.

were treated as if they had been borne by the Senegalese nation. For the financial analysis, however, the only capital costs charged to the Project were for the replacement of machinery and equipment within its thirty-year life span.

Once the foregoing assumptions were made for analytical purposes, the Project was found to have been marginally profitable from a social standpoint at a discount rate of 10 percent when our intermediate estimates of yields and output prices were used. However, subsequent analysis proved this result to be sensitive to alternative levels of the yields and prices, such that the low estimate resulted in a highly unprofitable project. Of considerable interest also was the finding that any further reduction in the current use rate of the irrigable land (approximately 72 percent) would also drive the Project into the red. On the other hand, an increase of this rate to 100 percent of capacity showed substantial improvement in the Project's profitability. These results taken together illustrate one very important conclusion: although the purpose of the project was to reduce the variability and uncertainty in farming operations caused by weather variance, the variability in profitability still remains due to economic, institutional, and technical factors which could not be controlled.

From the financial standpoint, however, only when capital costs were not charged to the Project, was it able to yield positive returns. While this finding may be of little importance for the present Pilot Project, given that the FED has dutifully absorbed these capital costs, neither Senegal nor OMVS can be assured of finding such gracious benefactors for additional development in the Valley.

Profitability at the Farm Level

Almost entirely neglected heretofore has been the question of profitability from the farmer's point of view. Unfortunately it is on this point that we have the least information. In Annex D it was shown that a "typical GP" potentially could net a total of 4,075,674 CFA per annum. Given that this "typical GP" has 21 members, this comes to 194,080 CFA per annum per member, or roughly 2 1/2 times the estimated farm family income prior to the Project. However, lest any unwarranted conclusions be drawn, several caveats are in order. First, given the instability of the membership of the GP's (cf. Chapter IV), the notion of a "typical GP" is tenuous at best. Moreover, despite the official line (from SAED/Nianga officials and from the GP members themselves) that income is divided evenly among the members, there is evidence to suggest that some members are "more equal" than others. Second, the figures cited in Annex D assume the full production yields of both rice and tomatoes; but yields tend to vary substantially from one GP to another. Thus it is entirely possible that the Project is highly profitable for one GP and just the contrary for another.

Third, there is a question of timeliness of payments to the farmers. The problem appears to be most acute for tomatoes, and in fact this very problem nearly resulted in a peasant uprising in the summer of 1978. Finally, the estimates of the benefits for the Without Case in Chapter V are very crude indeed. Unfortunately, the lack of reliable data necessitates this type of gross approximation. While they do not necessarily negate the results in Annex D, these considerations point to the need for additional research at the farm level.

Profitability of Tertiary Irrigation in the Senegal Valley

To what extent can the results from the Pilot Project be legitimately generalzed to tertiary irrigation development in general in the Senegal Valley? Or more precisely, given that the Nianga Project is only marginally profitable, can it then be concluded that tertiary irrigation in general is of marginal economic importance? Clearly this is not the case. What emerged from Chapter IV was the fact that at various stages of the Project's development, different parties (M. Juton, SOGREAH, HYDROPLAN) made concrete suggestions for reducing its costs. None of these suggestions, it would appear, were heeded by the decision-makers of OMVS/FAO. As also pointed out in Chapter IV, the concept of tertiary irrigation is sufficiently broad to embody numerous technical schemes; and thus the present design of the Pilot Project represents only one possibility out of a large set of technical alternatives.

Viewed from the foregoing perspective, there is nothing in the *ex post* analysis which definitely refutes the validity of tertiary irrigation in the Valley. Indeed one of the surprising results of the *ex post* analysis, given the pessimistic findings of the *ex ante* feasibility study, was that at least from a social standpoint, the

Project is modestly profitable. The inevitable conclusion, then, is that it could have been more so had the aforementioned cost reduction measures been implemented. Therefore, a reformulation of this particular application of tertiary irrigation--i.e., the Pilot Project--is imperative prior to subsequent development in Grand Nianga.

Policy Recommendations

As far back as 1938 with the creation of MAS (cf. Chapter I) the primary motive for developing irrigated agriculture in the Senegal Valley was the need for substituting locally produced rice for imports. To be sure, increasing the peasants' well-being was also listed as an objective, but only, it would appear, as an afterthought. Combining this historical perspective with the fact that in 1967 a decision was made to develop Nianga as a zone pionnier (cf. Chapter III), despite the fact that the area was already populated, one is led to speculate that GOS never seriously took the farmers' interests into account. On the contrary, it would appear that a political decision was made to develop Nianga (and other similar projects) as a national bread basket which would alleviate the growing balance of payments deficits, regardless of the consequences for the local population.

Although there is nothing wrong per se with making agriculture an adjunct of a balance of payments policy, problems arise when policy makers fail to perceive (or for political expediency, fail to articulate) the fact that national interests might not coincide with regional or local interests. While the *ex post* analysis has shown (assuming certain cost-reducing modifications in the project design) that the national interest can be served by projects such as Nianga, it is by no means clear that the local farmers' interests (including such non-economic features as the quality of life, a sense of independence, etc.) are similarly met. On the contrary, the available evidence (cf. Chapter IV; cf. Annex E) suggests that the farmers as a whole are highly dissatisfied with the Nianga scheme.

Given this apparent divergence of interests, it is recommended that GOS rethink its strategy for development. For example, it might initiate a two-tier system of irrigation in the Valley. Large perimeters such as Nianga would be run entirely by and for the State. On another level, a series of small village-oriented perimeters (such as have been established in and around Matam), where the concept of the individual family farm is maintained, could be developed for the benefits of the bulk of the rural population.

Certainly the foregoing recommendation is no panecea. The general experience to date with state-run agricultural enterprises in Senegal and elsewhere in Africa has been grim; and at the same time the village-oriented scheme a la Matam, while encouraging, is still too new to permit a definitive judgment on its economic soundness. Fortunately, as we have seen, the alternatives are not limited to the above choices. Indeed it cannot be stressed enough that the concept of tertiary irrigation is flexible enough to permit an indefinite variety of public-private projects of varying scales of operation. Unfortunately, the decision makers of FAO/OMVS proceeded as if just the opposite was true.

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ANNEXES

ANNEX A

ESTIMATION OF MARKET PRICE FOR PRINCIPAL CROPS

IN THE TRADITIONAL SECTOR

Annex A

ESTIMATION OF MARKET PRICE FOR PRINCIPAL CROPS IN THE TRADITIONAL SECTOR

Millet/Sorghum

Given the existence of a largely subsistence economy on the one hand, and producer prices by fiat on the other, it is extremely difficult to value the agricultural production coming from the traditional sector. In the case of millet/sorghum, the price paid by ONCAD to the farmer in 1975/76 was 30 CFA/kg, while the free market price at Matam was observed to have been 50 CFA/kg.[1/]

Some corroborating evidence for a price at 50 CFA/kg has emerged from a preliminary analysis of data gathered by the Purdue West Africa Project. In the various villages surrounding the Pilot Project, rice paddy can be purchased for 100 CFA/moudou, or bartered for curdled milk at a 1:1 ratio. At the same time, millet (souna) can be bartered for milk at a 2:1 ratio; and therefore, one can infer that the latter has a value twice that of paddy. If one makes the simplifying assumption that millet (souna) is valued the same as sorghum,[2/] then the value of either millet or sorghum would be 200 CFA/moudou. Given that one moudou of a small grain (such as millet or

[1/] USAID, Annex G., p. 12.

[2/] This assumption is commonly made in the literature, and indeed ONCAD pays the same price for both commodities. At the same time, there are at least five different varieties of sorghum grown in the Podor-Nianga area, each with its unique qualities. Whether or not these perceived differences translate themselves into price differentials is an empirical question which can be solved only by additional research.

sorghum) is equivalent [illegible]os, then the free market price of millet sorghum is 50 CFA/kg (200 CFA/kg ÷ 4 = 50 CFA/kg).

Maize

The free market price of corn was observed to have been 40-50 CFA/kg in the Matam market in 1976. The middle price of this range--i.e., 45 CFA/kg--was thus selected as a reasonable estimate.

Cowpeas

In 1957/58, the price of cowpeas was 21 CFA/kg, while the price of millet/sorghum was 17 CFA/kg.[4/] On the assumption that the relative prices have not changed, then the price at which cowpeas should be valued for present purposes is 60 CFA/kg (50 CFA/kg x 1.2 = 60 CFA/kg).

Beref

Also in 1957/58 the average price of beref was 36 CFA/kg.,[5/] or 212 percent the price of millet/sorghum. Application of this factor to the millet/sorghum, again on the assumption of constant relative prices, yields a price of 106 CFA/kg--a price which is clearly unreasonable. Moreover, this author observed the price of beref in Richard Toll to be 65 CFA/kilo, the same price at which the millet was offered for sale. On the assumption then that the equality between the retail prices also holds for farm gate prices, beref was valued at 50 CFA/kg.

3/ USAID, Annex G., p. 12.

4/ Boutillier *et al*., p. 215.

5/ *Ibid*.

ANNEX B

ESTIMATION OF THE VALUE OF FAMILY LABOR

Annex B

ESTIMATION OF THE VALUE OF FAMILY LABOR

In the face of limited data, one method of estimating the value of family labor is to assume that the marginal productivity of a worker equals his subsistence wage--i.e., the value of the necessary food to keep him alive and fit to work.[1/] The validity of this assumption can be assayed only indirectly. While on the one hand there is good reason to reject the idea that the marginal worker's productivity might be zero,[2/] there is also good reason to think that it is something less than his average productivity, given that land has been shown not to be a limiting factor (cf. Chapter V) in the traditional sector in the Senegal Valley. Moreover, LM have also suggested that a crude estimate of the marginal productivity of labor in agriculture in traditional societies might be roughly one half that of its average productivity.[3/]

The estimated consumption wage which will serve as our estimate of the worker's marginal productivity is derived from the per capita consumption of items which would comprise a subsistence diet. As

1/ In principle, this subsistence bundle should also include the total amount of head taxes paid by the farm family. In Senegal, where the age of (head) tax liability ranges from 18-70, this cost would total 1500 CFA per family--i.e., 500 CFA per capita x 3 workers. However, since this cost is a constant for both With and Without Case regardless of the amount of labor performed, it can be netted out of the SCB calculation.

2/ T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), p. 70.

3/ LM, p. 277.

shown in Table B-1 the value of the estimated per capita consumption is 10,308 CFA.[4/] On the assumption that the typical farm family has 6 members, total annual consumption comes to 61,848 CFA. On the further assumption that a working member of the family consumes twice as much as a nonworker (i.e., a small child, a chronically ill or elderly person), the worker's consumption comes to 13,744 CFA/year,[5/] which is thus our estimate of his marginal productivity. This figure of 13,774 CFA when multiplied by the number of working members (3), yields a total amount of 41,232 CFA/year.

TABLE B-1.--Per capita food budget.

Item	Quantity (Per Capita)	Unit Price (CFA)	Value (CFA)
Sorghum (millet)	163 kg[a/]	50/kg	8150
Maize	13 kg[a/]	45/kg	585
Cowpeas	3.5 kg[b/]	60/kg	210
Beref	1.5 kg[b/]	50/kg	75
Peanut oil	N.A.	N.A.	1098[c/]
Salt	N.A.	N.A.	190[c/]
		Total	10,308

[a/] Source: Direction de la Statistique, Dakar, Senegal.
[b/] Source: Boutillier *et al.*, p. 215.
[c/] Minevielle, p. 46.

[4/] In that the consumption pattern shown in Table B-1 is derived from the averages of aggregated figures, it will not necessarily accurately reflect the consumption of a given family. Moreover, it is assumed here that the farm family engages only in agriculture, and that if either fish or milk is consumed (as is often the case), they will be obtained via barter.

[5/] Basically, the assumption is that 61,848 CFA is annual consumption for the family. That consumption is assumed to be distributed among family members such that workers consume twice the amount as nonworkers. Hence, consumption for a worker equals 61,848 CFA divided by 9 (for a family of 6) and multiplied by 2 which is 13,744 CFA/year.

As it turns out, the average productivity has been estimated to be roughly 25,500 CFA;[6/] and thus the marginal productivity, as calculated here, is 54 percent of average productivity. While certainly the similarity of our results with the rule-of-thumb suggested by LM cannot be held up as "proof" of our original proposition relating marginal productivity to the subsistence level of consumption, it does add further evidence supporting this concept of the opportunity value of family labor. The fact that the calculated shadow wage rate for non-family labor is approximately the same amount provides further support. Hence, while the resulting opportunity value of family labor is nothing more than an assumption, it appears to be the best available assumption.

6/ In Annex C, the intermediate estimate of total value of production of the typical farm is 76,473 CFA/year. Dividing this result by the number of workers (3) yields an average productivity of roughly 25,500 CFA.

ANNEX C

ESTIMATION OF GROSS VALUE OF PRODUCTION

(WITHOUT CASE)

Annex C

ESTIMATION OF GROSS VALUE OF PRODUCTION (WITHOUT CASE)

The fact that the bulk of crops in the traditional sector are intercropped rather than grown in pure stands creates severe difficulties for both economic and financial analysis. The truth of the matter is that very little is known from either an agronomic or economic standpoint about the workings of these intercropping systems. In general, however, it is safe to assume that crop yields are somewhat reduced as a result of intercropping.[1/],[2/]

In the absence of any empirical data on the matter, a simplifying assumption was made that the yield for a given crop is reduced in proportion to the reduction of plant density. Subsequently, based on this author's visual inspection of the fields and on qualitative descriptions provided by Boutillier *et al*., additional assumptions were made as to this reduction in plant density. Taken together, these assumptions resulted in what was referred to in the text as the intermediate estimate. Polar cases were then hypothesized to allow for sensitivity analysis--the high estimate hypothesizing no yield reduction with intercropping, the low estimate hypothesizing cultivati

[1/] This is not to say, however, that total production per unit of land is lower. In fact, it might be higher.

[2/] D. W. Norman, "Developing Mixed Cropping Systems Relevant to the Farmer's Environment," Invited Paper for the *Symposium on Intercropping in Semi-Arid Areas* (Dar-Es-Salaam, Tanzania, May 1976), p. 6.

of millet and sorghum in pure stands.[3/] The calculations and the resulting estimates are shown in Table C-1 below.

TABLE C-1.--Estimated gross value of agricultural production for the typical farm in the traditional sector (under varying assumptions.

	Value
Low Estimate (No intercropping)	
2.28 ha (oualo) x 400 kg sorghum/ha x 50 CFA/kilo =	45,600
1.49 ha (dieri) x 350 kg millet/ha x 50 CFA/kilo =	26,075
Total =	71,675
Intermediate Estimate (Intercropping of maize, cowpeas, and sorghum on oualo lands; intercropping of millet, cowpeas, and beref on dieri lands. Proportionate yield reduction assumed.)	
Oualo: 2.28 ha	
Pure sorghum (30%): 2.28 x 3 x 400 x 50 =	13,680
Sorghum intercropped (70%): 2.28 x .7 x 300 x 50 =	23,940
- With cowpeas (20%): 2.28 x .2 x 75 x 60 =	2,052
- With Maize + Cowpeas (50%): [2.28 x .5 x 163 x 45] + [2.28 x .5 x 37.5 x 60]=	10,927
Sub-total Oualo =	50,599
Dieri: 1.49 ha	
Pure millet (15%): .15 x 1.49 x 350 x 50 =	3,911
Millet intercropped (85%):.85 x 1.49 x 263 x 50 =	16,654
- With beref (35%): .35 x 1.49 x 75 x 50 =	1,956
- With cowpeas (50%): .5 x 1.49 x 75 x 50 =	3,353
Sub-total Dieri =	25,874
Total =	76,473
High Estimate (Same intercropping pattern as for intermediate estimate. No yield reduction.)	
Oualo: 2.28 ha.	
Sorghum (pure & intercropped) (100%): 2.28 x 400 x 50 =	45,600
- with cowpeas (20%): 2.28 x .2 x 150 x 60 =	4,104

[3/] In fact, this hypothesis was used by the Bechtel Corporation to estimate agricultural production in the Matam area (USAID, Annex G).

TABLE C-1 (Continued)

-with maize & cowpeas (50%):	2.28 x .5 x 650 x 45 + 2.28 x .5 x 150 x 50 =	43,605
	Sub-total oualo =	93,309
Dieri: 149 ha.		
Millet (pure & intercropped)(100%):	1.49 x 350 x 50 =	26,075
-with cowpeas (50%):	149 x .5 x 150 x 60 =	5,171
-with beref (35%):	149 x .35 x 300 x 50 =	7,822
	Sub-total dieri =	39,068
	Total =	132,377

Given that the hypothesized yield reduction in the intermediate estimate is due solely to reduced plant density, it is only logical then that the estimated seed cost will vary according to estimate of the value of production. Following a completely analogous procedure to that used in Table C-1 above, the total cost of seed for the three different production levels is estimated as follows:

Low estimate:	1131 CFA
Intermed. estimate:	1977 CFA
High estimate:	4290 CFA

ANNEX D

FARM BUDGET FOR THE "TYPICAL GP"

Annex D

FARM BUDGET FOR THE "TYPICAL GP"

In order to give some notion of profitability to the farmer, farm budgets are estimated for the "typical GP," consisting of 21 members. However, in that the latter represents nothing more than an arithmetic mean, it can only roughly reflect the financial returns for a given GP.[1/] All prices are in 1975 CFA; and the input levels are the same as those used for calculation of the Project's operating costs (see Annex E). The resulting budgets for the rainy and dry seasons are shown below in Tables D-1 and D-2, respectively.

TABLE D-1.--Budget for typical GP: rainy season (12.66 ha. rice).

Expense Item	Unit Cost (CFA)	Total Amount (CFA)
Land preparation (offset disc x 2)	5,000/ha.	126,000
Irrigation	25,000/ha.	316,500
Threshing (Borga)	10,000/ha.	126,600
Fertilizer		
- NPK	16/kg.	50,640
- Urea	20/kg.	37,980
Insecticides, pesticides	1,817/ha.	23,003
Seeds	70/ha.	88,620
Transport (tractor & wagon - 2 hrs.)	1,200/hr.	2,400
Amortiz. of hand tools	Amort. Period = 5 years @ 6% (subsidized)	14,460
TOTAL EXPENSES		786,803
REVENUE		
Sale of Paddy	41.5/kg. (Yield: 4500 kg/ha.)	2,364,255
NET GP INCOME		1,577,452

1/ For additional caveats, the reader is referred to Chapter IV.

TABLE D-2.--Budget for typical GP: dry season (8.37 ha. rice; 4.29 ha. tomatoes).

Crop	Expense Item	Unit Cost (CFA)	Total Cost (CFA)
Tomatoes			
	Land preparation (offset disc x 1.6)	5,000/ha.	34,320
	Ridging	5,000/ha.	21,450
	Irrigation	35,000/ha.	150,150
	Fertilizer		
	- NPK	16/kg.	18,533
	- Urea	20/kg.	12,870
	Insecticide, Herbicides, etc.	3,738	16,036
	Seeds	6,300/kg.	12,162
	Transport (tractor & wagon - 2 hours)	1,200/hr.	2,400
	Amortiz. of small tools	Amortiz. Period=5 years @ 6% (subsidized)	14,460
TOTAL EXPENSES			282,381
REVENUE			
Sale of Tomatoes		15.5/kg. (Yield:25T/ha.)	1,662,375
NET GP INCOME (Tomatoes)			1,379,994
Rice	Land preparation (offset x 2)	5,000/ha.	83,700
	Irrigation	25,000/ha.	209,250
	Threshing	10,000/ha.	83,700
	Fertilizer		
	- NPK	16/kg.	33,480
	- Urea	20/kg.	25,110
	Insecticides, Herbicides, etc.	-	-
	Transport (2 hours)	1,200/hr.	2,400
	Amort. of tools.	Amort. Period = 5 years @ 6% (subsidized)	7,230
TOTAL EXPENSES			444,870
REVENUE			
Sale of Paddy		41.5/kg. (Yield:4500kg/ha)	1,563,098
NET GP INCOME (Rice)			1,118,228
TOTAL NET GP INCOME (Tomatoes + Rice)			2,498,222

ANNEX E

DERIVATION OF OPERATING COSTS

(ECONOMIC AND FINANCIAL ANALYSIS)

Annex E

DERIVATION OF OPERATING COSTS

(ECONOMIC AND FINANCIAL ANALYSIS)

This annex explains the derivation of both the fixed and variable inputs which constitute the operating costs of the Pilot Project. The term variable inputs is used to indicate those inputs which are likely to vary directly with the use rate of irrigated land, while the term fixed inputs refers to certain costs which are likely to remain fixed within the range tested for sensitivity analysis here--i.e., between 65 percent and 100 percent use. Finally, the values for the variable inputs for the low and high use rate cases are shown in Table E-5 for both economic and financial analysis.

Variable Inputs

Seed

The per kilo cost of rice and tomato seed is shown in Table E-1 below. The economic and financial costs are the same in this instance, with the simplying assumption being made that there is no foreign exchange cost to seed production.[1/] Although the seeding rate has varied widely over the three years of operating experience at Nianga, a reasonable average is 100 kg/ha for rice and .45 kg/ha (hot beds) for tomatoes.[2/]

[1/] This same assumption was made by the Bechtel Overseas Corporation in its study of the proposed Matam Project.

[2/] SAED, Rapport de Campagne, various years.

TABLE E-1

SEED COSTS

Crop	Cost per Kilo (CFA)	
	Economic	Financial
Rice	70	70
Tomatoes	6,300	6,300

Insecticides, Herbicides

Calculation of this category of expenditures caused great difficulty due to the extreme fluctuation in use from one year to the next (cf. Chapter IV). What seems clear, however, is that these products are applied not preventively, but as a curative. Moreover, as was documented in Chapter IV of the text, the general trend has been toward decreased use of these products; and as a consequence, the recommended dosages as found in the technical bulletins (*fiches culturales*) are of little value for estimating future use. Instead, some assumptions were made (based on the most recent dosage) as to the future use of these products. The resulting costs, which include a 15 percent contingency factor, are shown in Table E-2 on a per hectare basis.

TABLE E-2

COST OF INSECTICIDES, HERBICIDES

	Costs (CFA/ha)			
	Economic			Financial
Crop and Season	FEX[a/]	Other	Total	
Rice				
- Rainy Season	1181[b/]	456	1637[c/]	1817
- Dry Season	0	0	0	0
Tomatoes				
- Dry Season	2430[b/]	1208	3368[c/]	3738

a/ FEX = foreign exchange

b/ Assumes the foreign exchange component to be 65 percent of the gross-of-tax cost (SONED, Bilan Diagnostique).

c/ Assumes 9.89 percent tax (taxe sur le chiffre d'affaires)

Fertilizer

There are three different fertilizers in use at Nianga: 18.46.0, Kcl, and urea. The first two a-e nufactured locally, while the latter is imported. Both the domestic and imported fertilizers for all farmers in Senegal have been heavily subsidized by GOS over the years. e financial costs then include this subsidy, while the economic costs are net of subsidies and taxes. Since fertilizer prices (both world and domestic) are highly volatile, those derived here are an average over the period 1974-77, and have been deflated to 1975 constant francs. Finally, transport costs have been estimated for the shipment of fertilizer from Dakar to Nianga for economic analysis. All of these prices are presented in Table E-3.

TABLE E-3

FERTILIZER PRICES (1975 CONSTANT CFA)

Cost Item	Cost			
	Economic			Financial
	FEX	Other	Total	
Domestic Fertilizer (CFA/kg)	26.87[b/]	10.38	37.25	17.87[e/]
Imported Urea (CFA/kg)	42.82[c/]	0.0	42.82	20.9[f/]
Transport Dakar-Nianga 446 km (CFA/ton/km)	7.3[d/]	2.7[d/]	10.0	N.A.

a/ FEX = foreign exchange.

b/ Assumes 65 percent of total gross-of-tax cost is foreign exchange.

c/ Assumes 100 percent of total net-of-tax cost is foreign exchange.

d/ Based on calculations made by ONCAD of its transport costs.

e/ Assumes tax of 9.89 percent and subsidy of 57 percent.

f/ Assumes tax of 13.5 percent and subsidy of 57 percent.

Fuel

Fuel as a variable input has three uses: tractors (light diesel); threshers (light diesel); and the generators used to power the electric irrigation pumps (heavy diesel). Each of these uses will be examined in some detail below.

In order to determine the economic cost of fuel, it was necessary to update a 1972 study by Rodts,[2/] wherein he showed the prices of fuel at various levels in the vertical production chain. These figures

2/ R. Rodts, Analyse Economique Pour un Programme de Developpement Hydroagricole, Vol. XII, Le Secteur de l'Energie et de l'Industrie Dans les Pays de l'OMVS (Dakar: OMVS, December 1972).

were then used to derive the foreign exchange component. A summary of the results is shown in Table E-4 below.

TABLE E-4

FUEL PRICES (1975 CONSTANT CFA)

	Cost (CFA/liter)			
	Economic			Financial
Fuel Type	FEX[a]	Other	Total	
Gasoline (high octane)	15.67	17.78	33.45	88
Light diesel (gas-oil)	13.97	8.25	22.22	68
Heavy diesel	27.99	14.31	42.30	50
Lubricants	54[b]	51[b]	105.0[b]	300

a/ FEX = foreign exchange

b/ Author's estimates based on averages for other petroleum products.

Fuel for tractors

Once the fuel prices are known, it then becomes necessary to determine the number of tractor-hours and the fuel consumption per hour. The following data on the tractors was provided by SAED:[3]

(1) Per hour consumption of fuel in 80 hp. crawler tractor: 9.6 liters 15 percent lubricants

(2) Per hour consumption of fuel for 45 hp. small tractor: 4.5 liters + 15 percent lubricants

(3) The tender tractor runs .11 hours for every hour of operation of the crawler tractor.

(4) Time necessary to prepare 1 ha. with offset disk: 1 hr. 40 min.

(5) Time necessary to ridge 1 ha with small tractor and ridger: 2 hrs. 15 min.

3/ SAED, Note Sur les Prix des Facons Culturales a la SAED, A Report Prepared by BEP (St. Louis, Senegal: SAED, December 1977).

Finally, based on this author's knowledge of the operations at Nianga, the following assumptions were made:

(1) The tractor used for general transport operates 810 hours per year (270 days x 3 hours per day)

(2) Soil preparation for rice consists of two passes with the offset disk per hectare.

(3) Soil preparation for tomatoes consists of (on the average) 1.6 passes of the offset disk plus one pass with the ridger.

Fuel for threshers Borga

Experiments elsewhere in the Senegal Valley have shown the Borga thresher to have an average capacity of 700 kg/hr.[4/] of paddy when threshing I Kong Pao rice (the primary variety grown at Nianga). Since the average yield at Nianga was found to be 4500 kg/ha, the average time to thresh one hectare is 6.43 hours. Fuel consumption is .10 liter/hr. plus 15 percent in lubricants.

Fuel for pumping

In the absence of reliable data on the quantity of fuel used to run the generator which in turn runs the irrigation pumps, it was necessary to estimate this cost. The theoretical capacity of the pumps is 16,200 m^3/hr.,[5/] while the per hectare water requirement is as follows:

- Rice (Rainy Season): 12,100 m^3 (not including rainfall)
- Rice (Dry Season): 13,500 m^3
- Tomatoes (Dry Season): 16,400 m^3 (assumes 65 percent of efficiency of fonde soils).

4/ FAO, Expert Consultation on the Mechanization of Rice Production, A Colloquium at the International Institute of Tropical Agriculture, Ibadan, Nigeria, June 10-14, 1974 (Ibadan: IITA, 1975), p. 162.

5/ HYDROPLAN, 1973-75, Annex, p. 2.

In addition to the water needs of the parcels, allowance must be made for a "fill-up" of the irrigation network (roughly 1,020,000 m^3).[6/] Fuel consumption norms are .17 liters/hr./hp. of diesel fuel and 4.5 liters of lubricants per 100 liters of diesel fuel. There are three 104 hp. pumps at Nianga.[7/]

Finally, the above elements were multiplied by the number of hectares cultivated and the price of diesel fuel to yield total pumping costs. The total was found to be 1,088,083 CFA and 1,302,293 CFA for the rainy and dry seasons, respectively. On the assumption that, even under the best circumstances, the pumps would never operate at 100 percent efficiency, these costs were increased arbitrarily by 25 percent.

Fixed Inputs

Maintenance of Vehicles and Farm Machinery

The usual procedure,whereby purchase price divided by machine life is subsequently multiplied by a "repair coefficient,"was not used here since such rule-of-thumb methods usually include the cost of labor in maintaining and repairing the equipment. Since the cost of mechanics' wages will be included elsewhere under personnel costs, their inclusion would be double-counting. Thus the maintenance costs used here are only the cost of spare parts to be used for repairs. The appropriate amount to allow for spare parts for farm machinery is 50

6/ SOGREAH, R11310-A, Annex 5, passim.

7/ SAED, Cout d' Irrigation de Nianga Hivernage 75-76, A Report Prepared by BEP (St. Louis, Senegal: SAED, July 1976).

percent of the initial (net-of-taxes) purchase price.[8/] For cars and trucks, the cost of spare parts is assumed to be only 25 percent of initial purchase, the rationale being that the latter have fewer moving parts than farm machinery.

Maintenance of the irrigation network

In order to estimate the repair and maintenance costs of the irrigation infrastructure, standard coefficients used by the World Bank were applied annually against the initial construction costs.[9/] The coefficients are as follows:

- electrical/mechanical equipment in the pumping station: 5 percent
- masonry and/or concrete work: 2 percent
- canals, drains, dikes, parcels: 2 percent

Personnel (SAED)

The major difference between financial and economic costs derive from the method of financing the Pilot Project. As indicated in Chapter IV of the text, GOS is obligated to pay the salaries of the top echelon personnel at SAED/Nianga. This amount, which was estimated previously at 4.2 million CFA annually, is not charged against the budget of SAED/Nianga. Likewise, the cost of expatriate personnel (approximately 1.2 billion CFA) in the early years of the operating phase was borne by the FED. Included in the costs of local personnel are a variety of fringe benefits including medical fees, clothing

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8/ Interview with equipment dealer at Hamelle Afrique (Massey-Ferguson agency) in Dakar, December 1977.

9/ J. Y. La Planche, Entretien et Reparations des Amenagements Hydroagricoles, A Report Prepared for SAED (St. Louis, Senegal: SAED, August 1977), p. 2.

allowances, etc. The only tax deducted for economic analysis is the IGR (Import General Sur Le Revenu), the average incidence of which has been estimated at 7.54 percent.[10/]

Family Labor

The annual cost of family labor used for both financial and economic analysis is the (intermediate) subsistence cost which was estimated in connection with the Without Case. Family labor is treated as a fixed input regardless of the use rate because of the (theoretical) surplus of labor. This surplus becomes apparent when the number of available man-days is contrasted with the time required to do the work according to established norms. Available man-days is obtained by multiplying the number of inscribed members in the GP's (740) by 274[11/] days, which yields a total of 202,760 man-days on an annual basis, or 16,897 on a monthly basis. At the same time it can be shown for the high use case that even during the three-month labor peak which occurs in October through December due to the overlapping of the harvest of rainy season rice with the planting of tomatoes, the maximum monthly labor requirement is less than 12,000 man-days.[12/]

10/ IBRD, Senegal: Tradition, Diversification..., p. 202.

11/ This assumes that 25 percent of the time throughout the year a given farmer is unavailable for work due to illness, holidays, or other social obligations.

12/ According to established norms, the labor requirement for hand harvesting rice in the Senegal Valley is 42 man-days per hectare (FAO Expert Consultation..., p. 161). For tomatoes, a total of 98 man-days is required for seed bed preparation, transplanting, spreading, of fertilizer, and pesticides, irrigation and weeding (SOGREAH, R11414-A, Annex 5, p.11). At Nianga, both the harvesting of the rainy season rice and the above operations for tomatoes occur roughly within the 90-day period between October 1 and January 1. For the high use case, there are 417.3 ha. for rice in the rainy season, and 173.59 ha. for tomatoes in the dry season (dry season rice is not planted until March). Therefore the monthly labor requirement during the period is: [(173.59x98) + (417.3x42)]/3 = 11,513 man-days.

Finally, the case for treating labor as a fixed input becomes even more compelling when other family members are included in the calculation of labor availability.

How does this idea of a labor surplus square with the fact that SAED/Nianga felt it necessary to reduce the hectarage of rice culivated in the rainy season of 1977 so as to permit the timely planting of tomatoes (cf. Chapter IV)? The answer to this seeming paradox would appear to be political in nature, whereby the peasants, unhappy with the collective system of agriculture as practiced in Nianga, in effect withhold their labor as a means of passive protest.13/

Variable Inputs for Sensitivity Analysis

The costs of the variable inputs for both economic and financial analysis to be used in sensitivity analysis are shown in Table E-5 below. Since the past obviously cannot be altered, these hypothetical costs will apply only to the period 1978-2002. Finally, since the intermediate values were shown in Chapter V of the text, only the low and high use rates will be shown here.

13/ J. L. Boutillier, "Rapport Provisoire," June 1978.(Mimeographed).

TABLE E-5.---Operating costs for the period 1978-2002 (low and high use rates) in 1975 constant CFA.

Cost Item	Economic Analysis				Financial Analysis			
	Low Use (65%)a/		High Use(100%)a/		Low Use (65%)a/		High Use (100%)a/	
	RS	DS	RS	DS	RS	DS	RS	DS
Seed	2,436,000	2,063,250	3,761,842	3,413,228	2,436,000	2,063,250	3,761,842	3,413,238
Fertilizer	6,726,000	7,122,528	10,350,795	10,675,102	2,909,760	3,141,068	4,477,544	4,787,851
Insecticides	628,723	505,247	967,482	584,706	697,728	560,700	1,076,282	648,879
Fuel (tractors, threshers, pumps)	1,440,925	1,617,916	2,201,901	2,458,740	2,258,501	2,296,561	3,446,506	3,484,637
Total Variable Inputs	11,232,176	11,308,941	17,282,020	17,131,776	8,301,989	8,061,579	12,762,174	12,334,605

a/ Low use: 384 ha. rice in rainy season; 234 ha. rice and 150 ha. tomatoes in dry season.

b/ High use: 590.9 ha. rice in rainy season; 417.3 ha. rice and 173.59 ha. tomatoes in dry season.

ANNEX F

DERIVATION OF SHADOW PRICES

Annex F

DERIVATION OF SHADOW PRICES

Shadow Exchange Rate (SER)

It will be recalled from Chapter II that the SER used here is the reciprocal of the standard conversion factor (SCF). Thus in Table F-1 below, the SCF for Senegal is calculated for each year in the period 1966/67-75/76. Finally, the recriprocal of the ten-year average SCF is obtained (1 ÷.8818 or 1.13)--which is thus our estimate of SER.

Shadow Wage Rate (SWR)

The formula from Chapter II which expressed Z, the opportunity cost of removing an unskilled worker from the traditional agricultural sector was Equation 9 repeated below:

$$Z = (P_1 W_a) + (P_2 W_1) + [(1 - P_1 + P_2) \cdot W_o] \qquad (9)$$

where:

- P_1 = probability of employment in the traditional agricultural sector,
- P_2 = V/U = probability of employment in the modern sector,
- V = the number of employment vacancies for unskilled labor in the modern sector,
- W_1 = wages for unskilled labor in the traditional agricultural sector,
- W_o = zero wages = 0

TABLE F.1.---Calculation of SER.[a/]

Year	(1) M = Imports	(2) X = Exports	(3) Imports + Import Taxes	(4) Exports - Export Taxes	(5) Col (1) + Col (2)	(6) Col (3) + Col(4)	SCF Col (5) ÷ Col (6)
75/76	123,540	98,726	151,540	95,776	222,266	247,316	.8937
74/75	119,382	93,983	145,082	92,138	213,365	237,220	.8994
73/74	79,766	43,237	98,886	41,937	122,003	140,823	.8664
72/73	70,551	54,412	88,551	52,612	124,963	141,163	.8852
71/72	60,561	34,707	76,511	33,442	95,268	109,553	.8696
70/71	53,587	42,182	69,350	40,575	95,769	109,925	.8712
69/70	51,294	31,907	65,290	30,068	83,201	95,358	.8725
68/69	44,527	37,369	57,748	34,587	81,896	92,335	.8869
67/68	38,898	33,890	53,351	31,213	72,788	84,564	.8607
66/67	38,283	36,764	52,359	33,901	75,047	82,260	.9123

a/ Source: U.N., Yearbook of International Trade Statistics.

There is only very limited use of hired labor for agriculture in the Senegal Valley. In 1958, less than 5 percent of salaried workers were employed in agriculture.[1/] Preliminary findings from the Purdue West Africa Study indicate that little has changed in the interim--at least for the area in and around the Nianga Pilot Project. For present purposes then, the probability of a worker being hired full time in agriculture is zero; and thus the first term in the right hand of Equation (9) above ($P_1 \cdot W_a$) is zero.

Since the third term in the right hand side must also be zero, the only remaining term which must be estimated is $P_2 \cdot W_1$. Rather crude estimates--unfortunately the only available--suggest that P_2 is approximately .06. The latter is obtained by dividing the estimate annual number of job openings for unskilled workers (V = 6400) by the number of unemployed (U = 110,000).[2/]

Our estimate of W_1 is given by the minimum wage paid to the lowest category of unskilled labor, which comes to 231,529 CFA[3/] on an annual basis. This annual wage when multiplied by six percent, yields 13,892 CFA--an amount surprisingly (albeit perhaps coincidentally) close to our previous estimate (13,744 CFA) of the marginal productivity of an agricultural worker in the traditional sector (where the marginal productivity of a worker was assumed to equal

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[1/] Boutillier _et al._, p. 68.

[2/] IBRD, _Senegal: Tradition, Diversification_..., pp. 55-7.

[3/] Ministere de la Fonction Publique du Travail et de l'Emploi, _Bareme_, 28/11/74.

his subsistence consumption). Were the number of man-years of unskilled labor used in the construction of the Pilot Project known, this shadow wage would then be multiplied by this number to yield the social cost of this component of project costs. However, since only the total cost of the unskilled labor is known, it is assumed here that all workers were paid at the same basic rate, and hence the weight to be used for the pricing of unskilled labor becomes synonymous with P_2--i.e., 6 percent. This same procedure is used for operating as well as investment costs.

Shadow Price of Investment P^{inv} and Social Rate of Time Preference (SRTP)

Given that SRTP, as conceived by SMD, is to emerge from a sensitivity-type process, and given that P^{inv} is a function of the former, these two parameters can only be estimated simultaneously. For convenience, Equation (4) which contains the formula for P^{inv} is repeated below:

$$P^{inv} = \frac{(1-s)q}{i-sq} \qquad (4)$$

where:

s = the economy-wide savings rate,

q = marginal productivity of capital in the private sector,[4/]

i = the social rate of time preference

[4/] In truth, however, marginal productivity is rarely observed, and thus for practical purposes this becomes an average.

Based on national accounts data for the period 1961-71, s, the percent of GNP saved, has been found to be .096.[5/] Given the general lack of precision concerning the true value of q, the procedure adopted here is to use sensitivity analysis, with 10, 15, and 20 percent constituting the low, intermediate, and high estimates, respectively.[6/]

Finally, following SMD's approach, i has been handled in a manner similar to q. It will be recalled from Chapter II that i is to be treated as an unknown, with the government cost of borrowing constituting the low and q the high estimates, respectively. Unfortunately, very little data is available concerning the rate at which GOS can raise capital locally. However, the rates fixed as of January 1973[7/] for savings accounts was 4.75 percent.[8/] It is highly unlikely that GOS can obtain funds at less than a rate of 5 percent; and therefore, the latter will serve as the low estimate of i.

With the above estimates of s, q, and i, all possible P^{inv}'s were generated by the computer. Combinations that yielded a P^{inv} less than 1.0 were ruled out on theoretical grounds.[9/] In a similar

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5/ IBRD, Senegal: Tradition, Diversification..., p. 320.

6/ A similar procedure was used by Horton wherein he estimated three ranges for the average productivity of capital. The central values of these ranges were 10, 15, and 18 percent, respectively. (Informal communication from Brendan Horton to Bela Balassa, December 8, 1975.)

7/ In general, interest rates are very "sticky" in Senegal; and thus it is not unlikely that these same rates were still applicable in 1975--the base year of our *ex post* analysis.

8/ IBRD, Senegal: Tradition, Diversification..., p. 49.

9/ SMD explicitly assumes that savings are valued more than consumption in underdeveloped economies, which in turn implies that P^{inv} is greater than one.

vein, the one combination which resulted in a P^{inv} greater than 5.0[10/] was ignored, on the assumption that such a high premium would be unreasonable. The resulting combinations are shown in Table F-2.

TABLE F-2.--Combinations of i, q, and P^{inv} to be used for economic analysis.

i	q	P^{inv}
5	10	2.24
5	15	3.81
10	15	1.58
10	20	2.24
15	20	1.38

10/ Given our estimated value of s =.096, where i = .05 and q = .20, P^{inv} = 5.87.

ANNEX G

SOCIO-ECONOMIC SURVEY ON THE NIANGA PILOT PERIMETER

Annex G

SOCIO-ECONOMIC SURVEY ON THE NIANGA PILOT PERIMETER

Under the aegis of the Purdue West Africa Study,[1] a socio-economic (sample) survey of farm families participating in the Nianga Pilot Perimeter was conducted from October 1977 through August 1978. The sample consisted of 30 farm families, each headed by an adult male who was at the same time an official member of a *Groupement de Producteurs* (GP). A total of five GP's were included in the survey. In four of the five GP's involved, five families per GP were surveyed, while in the case of the fifth GP, 10 families were thus interviewed.

While selection of the GP's was done with an eye toward the more obvious differences across groups--i.e., ethnicity, membership size, performance as judged by SAED Nianga officials, etc.--available resources did not permit a scientifically rigorous stratification. Within the GP's themselves, however, the choice of the families to be surveyed was made by random selection. As of this writing, only a preliminary analysis of the data has been made; and therefore, the results of the *ex post* cost-benefit study were obtained without the benefit of the former.

[1] Officially, this project is designated as *The Costs and Benefits from Small Irrigated Perimeters and Supplementary Irrigation in the Sahelian Countries* (Contract No. C-AFR 1258).