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1988/89 Progress Report
Fertilizer Policy Research Program
for Tropical Africa
IFDC/IFPRI Cooperation

Period Covered: August 1, 1988 to December, 1989
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1988/89 Progress Report
Fertilizer Policy Research Program for Tropical Africa
IFDC/IFPRI Cooperation

I. Introduction

This report outlines the progress for the August 1, 1988, to December 31, 1989, period for work undertaken by the Fertilizer Policy Research Program for Tropical Africa. Future progress reports will be made on a calendar year basis to coincide with annual workplan submissions which are now also on a calendar year basis.

During the progress report period, the Lomé, Togo, team was put into place at IFDC-Africa and a substantive research program was outlined and implemented. Many of the research projects draw from data and information from completed or on-going IFDC and IFPRI projects in sub-Saharan Africa providing a high return in research output for the Fertilizer Policy Project.

The only major change from the workplans for the period covered in this report is the re-scheduling of the workshop. A workshop was not held in this period but preparations are underway to hold a workshop in the January-February period of 1991. It was our view that a more substantive body of project research would be available for discussion at this time which would enable a better dialogue between workshop participants and researchers on fertilizer policy issues.

The following IFDC-Africa, IFDC-Muscle Shoals and IFPRI-Washington researchers were involved in the Fertilizer Policy Research Program:

Dr. C. A. Baanante,IFDC
Dr. B. L. Bumb, IFDC
Dr. G. Desai, IFPRI
Dr. V. Gandhi, IFPRI
Dr. J. Henao, IFDC
Dr. D. Jha, IFPRI
Dr. J. G. Nagy, IFPRI/IFDC-Africa
Dr. T. A. Reardon, IFPRI
Dr. J. F. Teboh, IFDC-Africa
Dr. T. B. Tshibaka, IFPRI
Dr. J. von Braun, IFPRI

II. Progress Report by Sub-Project

A. Priority Setting of Crops by Subregion for the Accelerated Growth of Fertilizer Use in Sub-Saharan Africa

Researchers: J. G. Nagy, J. Henao

A methodology was outlined to research the priority setting of crops by subregion with respect to fertilizer use. Information needs and information sources to be exploited were identified and an implementation plan outlined for West Africa. Secondary data and information was gathered on agroecological zone characteristics. Fertilizer-crop response data from West African IFDC sources were analyzed.

ISRA/IFPRI/IFDC Contract

To facilitate work on fertilizer-crop response information for the sub-project, an agreement was entered into with the Institut Senegalese de Recherches Agricole, Senegal (ISRA) to estimate fertilizer-crop response functions for several crops (see Annex A for a copy of the Agreement). Data on millet, sorghum, maize, rice, groundnuts and cotton collected from ISRA fertilizer trials conducted in the peanut basin and the Casamance between 1964 and 1982 will be analyzed. ISRA has been provided with the funding and computer equipment. The data has been screened and is being put on computer file. The fertilizer-crop response estimations will be made available for a preliminary report that will be produced by the end of 1990.

B. Macroeconomic Policies and Fertilizer Use in Malawi

Researcher: T. B. Tshibaka

The search for a national collaborator and the development of an implementation plan for the project has been completed. Government approval for the work has also been received. The collaborating institution is the National Research Council of Malawi and Mr. Grey M. Limwado, Principal Scientific Officer is the national collaborator. Primary and secondary data collection is being undertaken in the first six months of 1990. Primary data are being collected through a small scale household survey and secondary data are being gathered from both published and unpublished sources. Data processing and analysis will start in mid-1990.

C. Fertilizer Pricing Policies in Sub-Saharan Africa: A Survey

Researchers: B. L. Bumb, J. F. Teboh

The preliminary survey of existing pricing policies in Sub-Saharan African countries that was initiated in 1989 continues. Country collaborators were identified for Benin, Cameroon, Ghana and Togo and data and information collection for these countries are underway. Data for the 1975 to 1989 period is being collected on annual average retail prices of specific food crops, fertilizer product prices, fertilizer imports, consumption and stocks, fertilizer yield response rates, subsidy rates and absolute amounts, national and agricultural sector budgets, and official exchange rates. Recent political events in Benin have curtailed work in that country for the present although there is every hope of continuing with the project in the near future.

D. Structural Adjustment and Fertilizer Policies in the Gambia

Researcher: J. von Braun with Detlev Putez
and Gambian collaborator Kem Johm

The resources provided by the Fertilizer Policy Project augmented ongoing research by IFPRI in the Gambia on "agricultural development constraints and adjustment effects". Two papers related to fertilizer use have been produced (see Annex B for copies).

The first paper, "Technology Constraints and Policy Options," discusses the relative roles of land, labor and capital (which includes fertilizer) in crop production within the Gambian farming systems. This leads into an assessment of constraints to agricultural growth and related policy options, a key one being improving fertilizer use. The analysis indicated that for all crops, labor is the most important production factor relative to land and capital. Labor availability during peak labor use times (planting and weeding) may constrain agricultural growth because there is no landless labor class from which to draw hired labor. Capital inputs show a very significant impact on production especially for groundnuts. The analysis indicated high returns to the use of capital (including fertilizer) revealing the underutilization of capital inputs and explains the willingness of farmers to pay high interest rates. Land, at present, is not a constraint except for irrigated rice land which is scarce.

Gambian farmers use fertilizer on both food and cash crops. Thirty-nine percent of fertilizer consumption is used on groundnuts, 31% on irrigated rice, 24% on coarse grains and 6% on swamp rice. Value-cost ratios for all crops at current input and output prices range from 3.5 to 5.5 and nearly all are above 2.0 when all subsidies are removed. Despite the high returns to fertilizer, fertilizer use is only

20% of recommended levels. This suggests that there are constraints to fertilizer use beyond the farm gate.

The second paper produced for the Fertilizer Policy Project entitled "Attempts for market deregulation and institutional constraints" looks at constraints in the input marketing and distribution system. In the past five years, fertilizer use in The Gambia declined by 75%. This coincided with institutional changes in the logistics of fertilizer marketing in 1985 and the deregulation of fertilizer marketing in 1986-87. The decline in fertilizer use can be partially attributed to subsidy removal which sharply increased fertilizer prices but most of the decline comes from the result of delivery failures, a restrictive distribution policy of the official fertilizer retail system, and a failure to involve private traders in the marketing system following the decision to deregulate.

What emerges from The Gambian experience is that the rules of deregulation and privatization need to be clearly spelled out if such an undertaking is to be successful. There must be a clear indication of the roles of private and public sector involvement and how private and public enterprises can coexist during a gradual shift to privatization. The paper offers some suggestions on the role of public sector policy regarding deregulation and privatization.

E. Macroeconomic Policy and the Senegalese Fertilizer Sector

Researcher: T. B. Tshibaka

The work related to the Senegalese fertilizer sector is in an advanced stage. Data collection from secondary sources has been completed and the data are now being analyzed. Since both supply and demand issues are considered, and given the complexity of the whole agricultural situation in Senegal as it relates to the groundnut sector, the analysis of the data and the production of a report can be expected only by the end of 1990.

F. Examination of the Processes Required to Convert the Potential for Fertilizer Use into Effective Farmer Demand

Researchers: V. Gandhi and G. Desai

The primary data collection for the study, which is being undertaken for the Gazaland District in Zimbabwe, has been completed and received in IFPRI, Washington, D.C. The data for 231 households have been cleaned, coded and entered on computer files. A framework for the empirical analysis has been developed and a preliminary analysis of the data is being done. The analyses will continue in the first half of 1990 and a preliminary paper on the available results will be prepared by mid-1990.

G. Analysis of Farmer Investment Behavior and Implications for Fertilizer Use in Togo

Researcher: T. B. Tshibaka

This study started in August, 1989 and is still in the early stages of implementation. A detailed implementation plan and questionnaire have been prepared, a survey site has been selected and enumerators have been hired. Also, the Togolese Government (Ministry of Rural Development) has been informed of the work to be carried out. Selection of a national counterpart and final government clearance for the project are underway. The farm household survey is expected to start in April, 1990, the beginning of the cropping season.

H. Analysis of Farmers' Fertilizer Adoption and Use Practices

Researcher: D. Jha

Data from 300 households in the Eastern Province of Zambia that IFPRI collected in collaboration with the Rural Development Studies Bureau, National Council, and Eastern Province Agricultural Development Project has been assembled and is in the preliminary stages of analysis. A report is expected in early 1990.

I. Farmers' Investment in Fertilizer Within the Context of Household Decisionmaking

Researchers: T. Reardon and V. Kelly

A first draft of a preliminary paper "Impact of Liquidity Sources on Chemical Fertilizer Use in Semi-Arid West Africa" by Reardon and Kelly has been completed. Data for the analysis was drawn from the ICRISAT cost-route farm household survey for the time period of September 1981 to August, 1985 which covers four production periods. The analysis uses probit and OLS estimation techniques to explain the determinants of fertilizer use in the Guinean and Sudanian savanah zones of Burkina Faso. The sample size is 50 households per agroclimatic zone. Emphasis is placed on determining the effects of non-cropping liquidity sources versus other factors such as limitations in credit, infrastructure, extension and fertilizer distribution systems. The preliminary results indicate that local off-farm income (liquidity from non-cropping income sources) and infrastructure (using distance from main roads as a proxy) emerge as variables that have a very positive effect on the probability of fertilizer use by a household. These results, although tentative, indicate that liquidity and infrastructure are two important determinants

of fertilizer use to be included in the design of a policy on accelerating the use of fertilizer.

The paper in its preliminary form was presented as a select paper at the 1989 American Agricultural Economics Association Meetings in Baton Rouge. A second draft of the paper is in progress and will be available in early 1990. The analysis is to be expanded to better capture the effects on fertilizer use from differences in agricultural years, the seasonality of income receipts, institutional versus private credit facilities, and infrastructure.

J. Constraints on Fertilizer Production in Sub-Saharan Africa: A Policy Perspective

Researcher: B. L. Bumb

In 1989, information on existing capacity and production of fertilizer products was collected for all those countries which have such capacity in existence. Only 10 out of 40 countries produce fertilizer products and 4 of these 10 countries account for nearly 70% of total fertilizer production in sub-Saharan Africa.

Information on capacity utilization and the factors affecting capacity utilization was also collected. Technical, economic, and financial constraints were identified. Some of the existing plants never operated because they were nonviable from the start. The cost of producing fertilizers from such plants are higher than the cost to import fertilizer.

Information on the availability of agrominerals for fertilizer production is in the process of being collected. A draft of a paper on the constraints to fertilizer production in sub-Saharan Africa and policy implications will be produced in the coming year.

K. Institutional Reform and the Fertilizer Sector: A Case Study

Researcher: J. F. Teboh with assistance from B. L. Bumb and J. G. Nagy

The Fertilizer Sub-Sector Reform Program (FSSRP) of the Government of the Republic of Cameroon (GRC) is in the process of fertilizer price liberalization and is moving the fertilizer sector toward more private participation. The FSSRP is starting its third year of operation and the experience gained by the program is a valuable stock of information for other countries contemplating similar programs.

Annex A

Agreement Between Institute Senegalais de Recherches Agricoles Senegal, International Food Policy Research Institute, and International Fertilizer Development Center–Afrique, Lomé, Togo

1'

AGREEMENT BETWEEN

INSTITUT SENEGALAIS DE RECHERCHES AGRICOLES

SENEGAL

AND

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

WASHINGTON D.C.

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER - AFRIQUE

LOME, TOGO

This agreement, made and entered into as of the 1 st day of September, 1989, between the Institut Senegalais de Recherches Agricoles (hereinafter referred to as "ISRA") and the International Food Policy Research Institute (hereinafter referred to as "IFPRI") and the International Fertilizer Development Center (hereinafter referred to as "IFDC") for cooperative research on estimating fertilizer-crop response analysis and associated economic analysis of existing ISRA data.

As a result of a contractual agreement between the United States Agency for International Development (USAID) entitled " Fertilizer Policy Research Project for Sub-Saharan Africa", and a joint project involving the two international research institutes, IFPRI and IFDC, funds have been made available to research fertilizer policy issues ranging from the farm level to macroeconomic issues in sub-Saharan Africa. Under this contract, IFDC and IFPRI agrees to provide up to US $21,000 (Twenty-one thousand U.S dollars) to ISRA to carry out a cooperative research program.

The work involves estimating fertilizer-crop response functions from data collected from ISRA fertilizer trials conducted in Senegal between 1964 and 1982. The data sets provide a time series of fertilizer-crop response information for various crops (millet, sorghum, maize, rice, groundnuts and cotton) for different levels of NPK, agricultural practices and range across several agricultural zones throughout the peanut basin and the Casamance. An economic analysis based on the fertilizer-crop response functions will be undertaken by IFPRI and IFDC in collaboration with ISRA and the results integrated into the overall Fertilizer Policy Research Project.

OBLIGATIONS OF ISRA

A. Staffing and Facilities

1. To provide necessary facilities and infrastructure to implement the project beginning September 1, 1989.

2. To appoint Dr. Jean Pierre Ndiaye, ISRA soil scientist to work with Dr. Guy Pocthier, agronomist and CIRAD representative, who will be the principal investigators and conduct the fertilizer-crop response estimations.

3. To hire research assistant(s) for up to 12 person-months of time to work on data management and to carry out duties under the direction of the principal investigators.

4. To hire enumerator(s) up to 3 person-months to obtain information for the economic analysis and to carry out duties under the direction of the principal investigators. Duties of the enumerator will be to collect fertilizer prices, product prices, harvesting and threshing costs and fertilizer application and fertilizer and product transport costs for the economic analysis component.

B. Research

1. Assemble, clean, and put in computer usable format the fertilizer response data from ISRA's "Amelioration Fonciere" and "Type de Fumure" data sets for millet, sorghum, maize, groundnuts, and cotton for the following locations;

2. Estimate fertilizer-crop response functions over time by crop and by location.

3. Prepare reports that (1) describe the research protocol and data sets, (2) describes the original agricultural zones of the experiment locations and changes that have occurred over time, and (3) presents and discusses the fertilizer-crop response functions.

4. Liaison with Dr. J.G. Nagy in the preparation of the economic analysis using the fertilizer-crop response functions.

5. Presentation of a seminar of the work by Ndiaye at IFDC-Africa in Lome, Togo.

OBLIGATIONS OF IFPRI AND IFDC

1. To provide the necessary staff to complete an economic analysis and write-up based on the fertilizer-crop response functions.

2. To make payments to cover agreed expenses incurred in carrying out the project according to the agreed plans. A bank account will be set up in Dakar in the name of the Department Systems, ISRA. The budget for this project is attached to the back of this contract document.

REPORTS

1. A report, authored by Ndiaye and Pocthier, on the fertilizer-crop response estimations and associated issues as mention above will be presented to IFPRI and IFDC by the end of August, 1990.

2. A report, authored by Nagy (and collaborators), of the economic analysis will be produced once the first report is completed and submitted.

GENERAL PROVISIONS

1. If ISRA, IFPRI or IFDC chooses to use the results of this collaborative study for further analysis, due credit to the participation of the other parties should be given but assuming full responsibility for any statements on which there is a difference of opinion.

2. In all matters relating to the performance of the project, the Director of IFPRI or his designated representative shall act for IFPRI, the Managing Director of IFDC or his designated representative shall act for IFDC and the Director of ISRA or his designated representative shall act for ISRA.

3. This agreement will become effective as of September 1, 1989, and will continue in effect until August 31, 1990.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be executed as of the day and year first above written.

PROTOCOLE - D' ACCORD

Entre

- INSTITUT SENEGALAIS DE RECHERCHE AGRICOLE - SENEGAL

et

- INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
  WASHINGTON - D.C., U.S.A.

- INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
  AFRIQUE, LOME - TOGO.

Le présent accord, signé et prenant effet à compter du 1er Septembre 1989, entre l'Institut Sénégalais de Recherches Agricoles (dénommé ci-après ISRA), l'Institut International de Recherche sur les Politiques Alimentaires (dénommé IFPRI ci-après), le Centre International pour le Développement des Engrais (dénommé IFDC ci-après) en vue d'une coopération pour des recherches relatives à l'analyse agronomique et économique de la réaction des cultures aux engrais sur la base des données existant au niveau de l'ISRA.

Suite à un accord de contrat entre l'Agence du Développement International des Etats-Unis (USAID) et les deux instituts internationaux de recherche, l'IFPRI et l'IFDC, relatif au Projet, des fonds ont été dégagés pour permettre de faire des recherches sur les politiques des engrais tant au niveau micro-économique qu'au niveau macro-économique.

Dans le cadre de ce contrat avec USAID, l'IFDC et l'IFPRI acceptent de fournir à l'ISRA une somme n'excédant pas 21.000 dollars américains (vingt et un mille dollars) afin que ce dernier puisse exécuter le programme conjoint de recherche ci-haut mentionné.

Parmi les activités, il est prévu l'estimation de la réponse des cultures aux engrais en utilisant les données de l'ISRA au nivaeu du Sénégal entre 1964 et 1982. Les données fournissent des informations sur les réactions des engrais selon les périodes, et les différentes formes de pratiques agricoles et couvrant plusieur zones agro-écologiques à travers le bassin arachidier et la Casamance.

Une analyse économique de la réaction des cultures aux engrais sera entreprise par l'IFPRI et l'IFDC en collaboration avec l'ISRA et les résultats de cette analyse seront intégrés à l'ensemble du Projet de Recherche sur les Politiques de l'Engrais.

RESPONSABILITES DE L'ISRA

A. <u>Personnel et Locaux</u>

1) Fournir les locaux et infrastructures nécessaires à l'exécution du projet à compter du 1er Septembre 1989.

2) Désigner le Dr. Jean Pierre Ndiaye, Pédologue de l'ISRA, pour qu'il travaille avec Monsieur Guy Pocthier, Agronome du CIRAD ; ils seront les principaux chercheurs et auront à mener l'analyse agronomique de la réaction des cultures aux engrais.

3) Embaucher un (des) assistant(s) de recherche pour une période de travail n'excédant pas 12 hommes-mois. Ces assistants travailleront sous la direction des chercheurs principaux.

4) Embaucher des enquêteurs pour une période de travail n'excédant pas 3 hommes-mois pour recueillir des informations sous la direction des cher-

cheurs principaux. Les tâches des enquêteurs principaux consisteront à recueillir les prix des engrais, les prix des produits agricoles, les coûts de moisson-battage, l'application des engrais, les coûts de transport des engrais et des produits agricoles, ceci pour le volet analyse économique.

B. Recherches

1) Rassembler, reviser et enrégistrer sous une forme exploitable par ordinateur, les données de réponse de l'engrais tirées des documents : "Amélioration Foncière" et "Type de Fumure" de l'ISRA, concernant le mil, le sorgho, le maïs, l'arachide, le coton dans les localités suivantes : Boulel, Nioro, Keur Jorodon, Maka, Sila, Keur Samba, Sainthou Malem, Missirah, Velingara et Séfa. Ce travail constitue un préalable à la poursuite du présent projet.

2) Estimer la réaction des cultures aux engrais au fil du temps, par culture, et par localité.

3) Préparer des rapports :
   (1) décrivant le protocole de recherche et l'ensemble de données.
   (2) décrivant les zones agro-écologiques ayant abrité les expérimentations, de même que les changements qui sont survenus au fil du temps, et
   (3) présentant les analyses de courbes de réactions.

4) Assurer la liaison avec Dr. J.G. Nagy dans la préparation de l'analyse économique sur la base de l'analyse agronomique exécutée par Dr. Jean Pierre Ndiaye et Mr. Guy Pocthier.

5) Présentation du travail par Ndiaye lors d'un séminaire devant se tenir au bureau de l'IFDC-Afrique à Lomé au Togo.

RESPONSABILITES DE L'IFPRI ET L'IFDC

1) Fournir le personnel nécessaire pour la réalisation et la rédaction d'une analyse économique sur la base de l'analyse agronomique présentée par l'ISRA.

2) Effectuer les payements pour couvrir les dépenses approuvées et occasionnées par l'exécution de ce projet. Ce projet aura un compte bancaire à Dakar. Ce compte sera géré par le Département de Recherche sur les Systèmes de Production et Transfert de Technologies en Milieu Rural, ISRA. Le budget alloué à ce projet se trouve en annexe du présent contrat.

RAPPORTS

1) Un rapport rédigé conjointement par Ndiaye et Pocthier, et portant sur l'analyse agronomique de la réaction des cultures aux engrais et problèmes associés tel que mentionné plus haut, devra être présenté à l'IFPRI et l'IFDC au plus tard à la fin du mois d'Août 1990.

2) Un rapport rédigé par Nagy (et ses collaborateurs), et portant sur l'analyse économique, devra être produit une fois que le premier rapport aura été terminé et soumis.

PROVISIONS GENERALES

1) Si l'un des partis : l'ISRA, l'IFPRI ou l'IFDC décide d'utiliser les résultats de cette étude conjointe pour d'autres analyses, il devra accorder aux autres partis le crédit mérité de par leur participation, tout en assurant l'entière responsabilité pour toute opinion n'ayant pas fait l'objet d'une unanimité.

2) Pour tout aspect relatif à la réalisation du projet, le Directeur de l'IFPRI ou son représentant désigné agira au nom de l'IFPRI; le Directeur Général de l'IFDC ou son représentant désigné agira au nom de l'IFDC; et le Directeur Général de l'ISRA ou son représentant désigné agira au nom de l'ISRA.

3) Le présent accord entrera en vigueur à compter du 1er Septembre 1989, et aura effet jusqu'au 31 Août 1990.

En foi de quoi, les partis concernés acceptent l'exécution du présent acte à compter de la date (du jour et de l'année) sus-memtionnée.

SIGNATURE AUTORISEES

Pour l'Institut Sénégalais de Recherches Agronomiques (ISAR)	Pour l'Institut International de Recherches sur les Politiques Alimentaires (IFPRI)	Pour le Centre International pour le Développement des Engrais (IFDC)
Daté du	Daté du	Daté du

ANNEXE

(BUDGET - ISRA / IFPRI / IFDC)

		MONTANT TOTAL en Francs CFA
Personnel		
1)	Salaires de l'Assistant de Recherche 12 mois X 190.000 CFA/mois	2.280.000 F
2)	Salaires des enquêteurs 3 mois X 90.000 CFA/mois	270.000 F
3)	Secrétariat (pour un homme/mois/CFA)	160.000 F
Voyages et Missions		
4)	1 voyage/mois (St. Louis et Dakar) Ndiaye et Pocthier, 1000 Km A/R, à 70 litres/voyage. 350 CFA/litre X 70 = 24.500 CFA/voyage 24.500 CFA X 12 voyages	294.000 F
5)	Perdiem : 6000 CFA/Jour X 3 Jours X 12 mois	216.000 F
Séminaire		
Participation Financière de l'IFDC-Afrique		
6)	Achat d'un IBM 286 avec 40 mégabytes et imprimante	1.560.000 F
7)	Logiciels - SPSS PC - WORD PERFECT - LOTUS - MATERIELS - ONDULEUR	650.000 F
8)	Imprévus (15%)	814.500 F
	TOTAL :	6.244.500 F

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Annex B

Policy Papers – Gambia

ANNEX B

5. TECHNOLOGY CONSTRAINTS AND POLICY OPTIONS

Detlev Puetz
Joachim von Braun
Ken Johm

In the past, much emphasis has been put on improved crop yields per unit of area, especially rice. While increased yields per hectare are desirable, the real issue in the Gambia is to focus on total productivity, and on labor productivity in particular.

Technologies for improving overall labor productivity--through area extension and intensification--are known and to a limited extent available in The Gambia. The key is the promotion of the relevant technologies at the appropriate scale in the various agro-climatic environments.

In this section we will first assess the relative roles of production factors - land, labor, and capital. Production function analysis is employed for the purpose. This leads us into an assessment of constraints to agricultural growth and related policy options. Three elements of growth oriented agricultural policy are then discussed which are not to be understood as alternatives, but as complements:

- upland crop promotion (i.e. implements)
- technologies for rice (irrigation)
- improving input use: fertilizer, seed, and crop protection

Unrestricted Cobb-Douglas functions were estimated using 1985 and 1987 input/output data. For these two seasons, separate functions were estimated for the total sample and upland villages. Additionally, in order to test for parameter consistency over time, separate estimations were conducted for 1985 and 1987.

Under the given technological conditions, farm output is viewed as a function of cultivated area, labor, and capital. Formally, this relationship can be expressed as:

$$Q_{ij} = F(A_{ij}, L_{ij}, K_{ij}) \qquad (4.1)$$

where:

Q_i^h = output per farm (h) of individual crop (kilogram) or aggregate production (crop value) (i),

A_i^h = land, which is measured as total area cultivated. Except for rice, this is a simple sum of hectares. In rice production, land is weighted to reflect different technologies (irrigated area, etc.),

L_i^h = farm labor input, which is measured in terms of labor days worked (equal for male and female) with adjustments made for children's labor input. Both family and hired labor are included, and

K_i^h = capital, which includes fertilizer, seeds, and the annualized value of fixed capital (tools and draught animals). Interest costs are assumed to amount to 20 percent/annum for working capital. For individual, upland crop production fixed farm capital was allocated to groundnuts and coarse grains, according to production shares of the crop in question.

In aggregate production functions, rice land (in irrigated land equivalents) is included as an explanatory variable.

For the purpose of aggregating the total production value of all crops and for calculating the value of marginal products, output is valued at mean 1985/87 deflated prices for the stacked 1985/87 models, and at the respective deflated annual prices for the separate 1985 and 1987 estimations.

Elasticities of production with respect to increased factor use and marginal factor productivities (in production value) are presented in Table 5.1. The related parameters are largely robust and significant. Elasticities describe the percentage change of output with respect to a one percent change of input. Thus, the sum of factor elasticities (the "returns to scale") is a measure for the effect of a simultaneous one percent change of all inputs. Elasticities are also a measurement of the relative importance of a factor in the production process. On the other hand, marginal productivities represent the change in output that results from an increase (or decrease) of one unit of input, other factors held constant--i.e., of one additional day worked, one more Dalasi invested, or one more hectare cultivated.

For all crops and villages combined, the analysis shows that labor is the most important production factor. But what comes as a surprise is the high share of capital in aggregate production. Access to production capital allows farmers to take crop allocation decisions that increase overall production value. But then, once these decisions on what crop to grow are taken, labor relative to capital and land is still the most important factor affecting the production of the respective crop, at least in upland crops where land is in ample supply. Yet capital retains a high impact, particularly in groundnuts.

Table 5.1--Marginal productivities and production elasticities (derived from Cobb-Douglas functions)

	Mean Production/ Farm		Sum of Elasti-	Labor			Capital			Land		
	Kilogram	Dalasi	cities	Elasti- cities	Marginal Productivity	Mean	Elasti- cities	Marginal Productivity	Mean	Elasti- cities	Marginal Productivity	Mean
						(Days)			(Dalasi)			(ha.)
Groundnuts												
1985/87	2,689	1,990	1.23	0.77	6.03	254	0.50	2.12	556	(-0.04)	(neg.)	2.10
1985/87 upland	4,025	2,979	1.17	0.84	7.17	349	0.51	2.34	794	(-0.18)	(neg.)	2.86
1985	2,100	1,764	1.27	0.51	4.41	203	0.50	2.19	504	0.26	264	1.76
1987	3,275	2,063	1.21	0.98	6.66	304	0.52	2.01	609	-0.29	-245	2.44
Upland cereals												
1985/87	1,308	895	1.39	0.74	4.88	129	0.33	1.84	274	0.32	161	1.71
1985/87 upland	2,267	1,552	1.07	0.67	5.53	178	0.26	1.83	413	0.14	87	2.33
1985	1,553	1,227	1.40	0.59	5.03	143	0.29	2.47	246	0.52	354	1.79
1987	1,038	530	1.38	0.85	3.93	115	0.53	1.76	306	(0.01)	(3.7)	1.61
Rice												
1985/87	1,380	999	1.21	0.24	1.36	142	0.23	1.11	196	0.74	571[a]	0.65
1985/87 upland	705	534	0.80	0.11	0.46	95	0.18	0.45	203	0.51	332[a]	0.47
1985	1,769	1,416	1.28	(0.12)	(1.11)	159	0.39	3.39	193	0.77	985[a]	0.69
1987	691	263	1.04	(0.18)	(0.42)	112	0.03	0.05	202	0.83	218[a]	0.58
Aggregate												
1985/87		3,578	1.08	0.50	3.55	503	0.42	2.67	630	0.16	135	4.15
1985/87 upland		4,844	1.11	0.28	2.18	613	0.48	3.08	897	0.35	302	5.67
1985		4,708	0.86	0.23	1.94	556	0.45	4.13	616	0.18	200	4.36
1987		2,447	1.16	0.39	2.10	450	0.51	2.28	644	0.26	159	3.93

Note: ( ) = not significant.

[a] Rice area weighted for different technology levels.

As expected, land is most valuable in rice cultivation since area, particularly irrigated area, is scarce and is highly productive. Therefore, the marginal productivity of rice land is highest--on average, Dal. 571 for one additional hectare. This figure also can be interpreted as the amount a farmer may be willing to pay for renting a hectare of rice land.

Returns to scale are mostly above one--for aggregate production 1.08 (1.11 in upland villages)--which means that output increases disproportionately more with increases in overall input levels. Increasing returns to scale suggest that farmers are not maximizing potential farm profits and that economies of scale exist--i.e., larger farms can produce relatively more efficiently. This is not surprising given the scarcity of labor and particularly capital in the area and the under-equipment of many farms with capital, largely as a result of limited credit markets.

LABOR

The condition for allocative efficiency is that marginal products of a particular factor are the same across all activities. But in the present case, the marginal productivity of labor is higher in upland crops--Dal. 4 per day and more--than in rice, where it does not exceed Dal. 1.36. This means that by reallocating labor from rice to upland crops, farmers could actually increase their total revenue: by working an additional day in upland crops, they would gain more than they would lose by not working that day in rice. Strict work schedules in the rice project that put more emphasis on maximum yields than equating marginal returns with labor opportunity costs have been identified as one reason for this finding (von Braun, Puetz, and Webb 1989).

Marginal labor productivities in groundnuts and upland cereals fluctuate--with yield levels, output prices, and other factors--but all range between about Dal. 4 and 7, across location and years. These very stable marginal productivities across upland crops are proof that farmers manage to efficiently allocate their factors across these crops. There is no marked difference in allocative efficiency in the separate estimation for upland villages; but their marginal labor productivities are higher than in the total sample, despite higher average labor inputs (+37.4 percent in groundnuts and +37.9 percent in coarse grains). Decreasing returns to labor are avoided by increased use of capital (e.g., in groundnuts + 42.8 percent) and land (+36.1 percent).

The neoclassical condition for profit maximization is to produce the quantity of output to a point where marginal revenue equals marginal costs. In our case, marginal revenue has already been established as the value of marginal production (marginal factor productivities) for labor, capital, and land. But what represents marginal costs, or factor opportunity costs? This question is easy to answer

for capital, since capital is already expressed in monetary terms: the unit is one Dalasi. But for land, no price can be determined since there is (nearly) no land market in the area. In case of labor, the usual approach is to take agricultural wage rates as factor opportunity costs.

Table 5.2 shows a comparison of agricultural wage rates and marginal labor productivities for total output and groundnuts. We find that in aggregate production, Gambian farmers are not far off from equating marginal productivity and labor opportunity costs. While it seems that an additional day worked as hired labor would yield

Table 5.2--Wages and marginal labor productivity

	Wage Rate[1]	Marginal Labor Productivity	
		Aggregate Production	Groundnuts
		(Dalasi)	
Average 1985/87	3.92	3.55	6.03
1985	2.97	1.94	4.41
1987	4.86	2.10	6.66

[1] in 1984 Dalasi

higher returns we need to consider that wage rates reported here are those achieved during the peak cropping season and do not necessarily reflect annual or even seasonal everyday wages in this environment. They tend to be higher than average labor opportunity costs.

On the other hand, marginal productivities in upland crops generally exceed wage rates. This difference can partly be explained by transaction costs involved in hiring labor (not included in the wage rate), liquidity constraints (that keep farmers from hiring labor although it may be profitable at current wage rates), and quality differences between hired and family labor.

Table 5.3 presents a comparison of marginal and average labor productivities (all in February 1986 prices). Average labor productivities are defined as the gross margins per day worked in the respective crop. Marginal and average productivities are very close in upland crops, which is consistent with the concept of excess land (Delgado and Ranade 1987).

CAPITAL

Capital shows a very significant and stable impact on production, although its influence differs by crop. Groundnuts are most capital intensive--i.e., if one excludes the capital which is invested in irrigation structure for rice cultivation from the capital variable--and one Dalasi expended in groundnut production will return at least two Dalasi. Aggregate production benefits substantially from more capital (between Dal. 2.67 and 3.08 in upland villages for each Dalasi invested). This return was even higher in 1985, a year of good harvests, while it dropped in 1987 when problems turned up in cereal production. High returns to capital reveal the underutilization of this factor, and explain the willingness of farmers to pay high interest rates.

Table 5.3 -- Comparison of marginal and average labor productivity (in February 1986 prices)

	Groundnuts	Coarse Grains	Rice
1985/87 - All villages			
Marginal productivity	8.15	6.98	2.19
Average productivity	8.82	7.87	9.49[a]
			5.24[b]
			2.61[c]
1985/87 upland villages			
Marginal productivity	9.69	7.91	0.74
Average productivity	9.80	10.20	10.43[a]
			4.59[b]
			5.45[c]
1985 - All villages			
Marginal productivity	5.25	5.92	1.32
Average productivity	8.64	8.98	14.65[a]
			7.36[b]
			3.83[c]
1987 - All villages			
Marginal productivity	10.57	5.62	1.05
Average productivity	8.99	6.76	4.33[a]
			3.24[b]
			1.39[c]

[a] Irrigated rice.
[b] Tidal rice.
[c] Traditional swamp rice.

LAND, LABOR, AND CAPITAL CONSTRAINTS

Technology options for increased agricultural productivity largely depend on availability and constraints of the three major production factors--land, labor, and capital.

Land

With about 56 persons/sq. km., The Gambia is relatively densely populated compared to other African countries. But there is still arable upland area available that is not being used by agriculture so far. Estimates of additional suitable land range from 20 percent to nearly 100 percent of the presently cultivated area (FAO 1985b). In addition, a reduction of fallow periods on the presently farmed area could mobilize another 30-40 percent.

Although overall land is presently not a scarce commodity in The Gambia and is often available at virtually no cost, unused land is not equally distributed across the country. Among other factors, regional differences in the level of mechanization lead to higher demand for land in upland villages compared to lowland villages. One indicator is the amount of fallow land in crop rotation. On average, 39 percent of all fields cultivated with groundnuts in 1987 had been left fallow the previous year. But we observe a high variation across the sample villages: figures range from 13 percent to 88 percent. On the other hand 21 percent had not been rotated but continuously planted with groundnuts.[10] It is an indication of pressure on land when upland villages have less fallow area and less rotation in their cropping system. This also affects yields: results from the regression analysis show that yields on groundnut fields that have not been rotated are 8.4 percent lower. On millet fields, fallow periods are rare, and continuous planting is common, particularly in upland villages. These grain fields usually are located close to the villages to make use of organic manure from the herds which are mostly kept in vicinity of the village. The finding of more continuous cropping in upland villages is in line with the results of the production functions where in upland villages land assumed more importance as a production factor and had a higher production elasticity than in the overall sample.

But despite positive price incentives and apparently no direct constraint on land the cultivated area was not extended between 1984 and 1987, an indication of the critical role of labor and capital constraints.

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[10] 16% in lowland and 24% in upland villages

Labor

Agriculture in The Gambia is organized almost exclusively on smallholder farms that rely largely on family labor or other non-related residents of the compound (e.g., strange farmers). There is no landless labor class to draw hired labor from since access to land is free and average returns in cultivating one's own farm usually exceed wage rates. Thus hired labor is confined to individuals or groups of individuals who supplement their own farming activities. But during peak seasons (planting and weeding) the mobilization of this work force is limited. Hiring labor, except for rice cultivation, is not very common. In 1985 only 8.3 percent of all work was performed by hired labor. This figure even went down to 4.8 percent in 1987.

There is a marked difference in the share of female labor by village location and farming system: in lowland villages women provide about 39.7 percent of family labor, while women in upland villages are less involved in agriculture (26.7 percent). This distinction also shows up in female involvement by crop: rice, an important crop in lowland villages, has a high share of female labor, while coarse grains and groundnuts--most prevalent in upland villages --show lower proportions of female labor input. In general, the high demand from household chores reduces women's time in agriculture, particularly in upland villages where the tedious processing of upland grains is very time consuming.

Altogether, in 1985 the average household (sinkiro)[11] of 11.6 persons in the survey area had a workforce of 4.61 members.[12] The size of a household's workforce has a significant impact on farm production: a (cross-sectional) comparison between farms shows that a 10 percent increase in the number of farm workers will raise production by 7.6 percent and farm size by 7.0 percent.[13] In upland villages where alternative employment opportunities are rarer than in lowland villages, production will go up by as much as 8.9 percent. The increase affects groundnuts and rice to a larger degree than coarse grains.

As a result of the ERP and the change of relative prices and wages in favor of the agricultural sector vis-a-vis other sectors

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[11] On household concepts in the Gambian compound, see von Braun, Puetz, and Webb (1989).

[12] To determine the resident workforce of a farm all adult men and women (in working age 15-60 years) of a household were weighted according to their respective average share of labor input in 1985 and 1987 children between 10 and 14 were counted as a quarter of an adult.

[13] For details of related analysis see D. Puetz (1989).

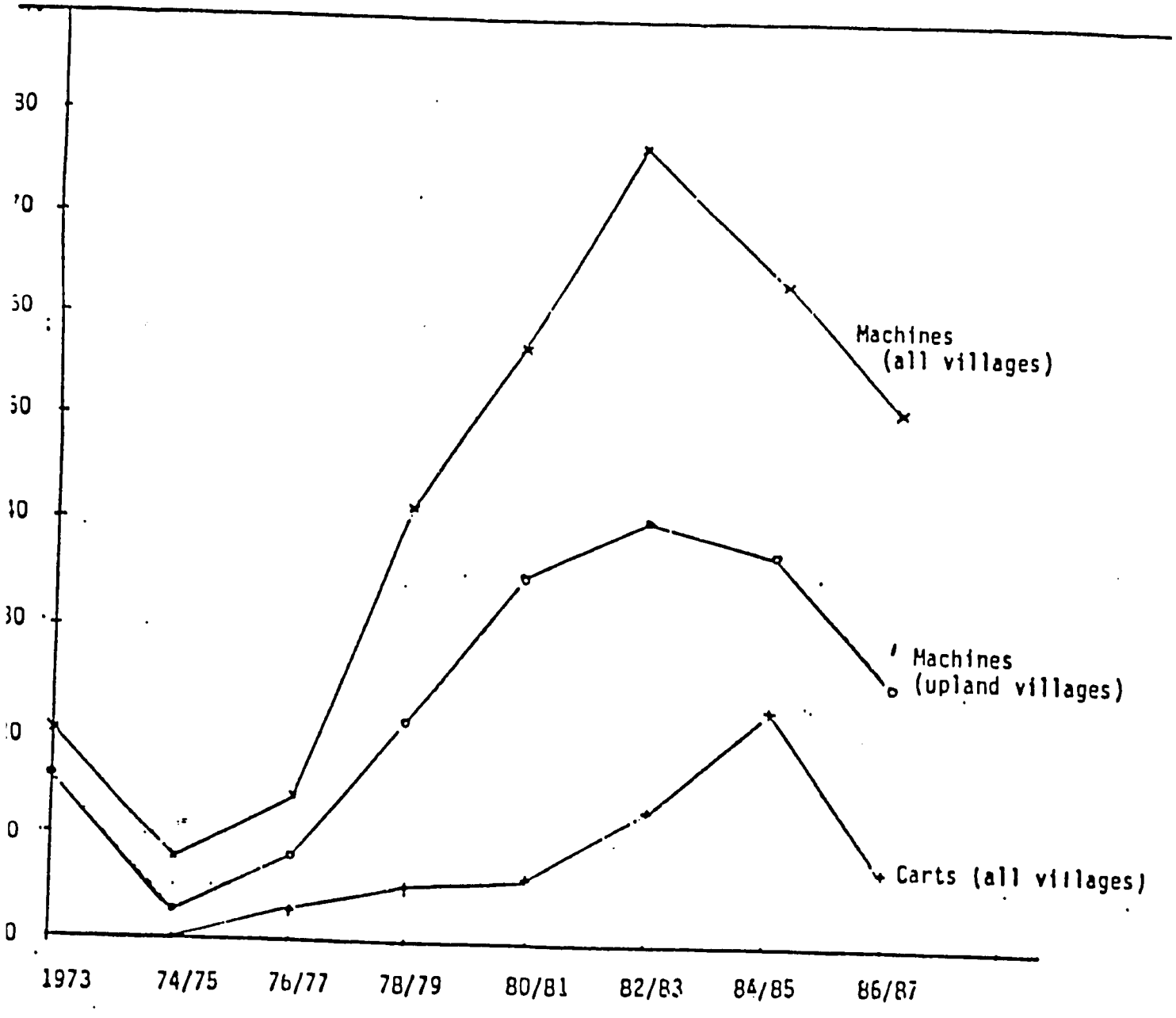
additional labor moved into agriculture. After correcting for natural population growth, the average size of farm households rose by about 5 percent between 1985 and 1987. This net-immigration is more pronounced in upland (+6.5 percent) than in lowland villages (+3.9 percent). At the extremes we observe that the village of Njoben with highly favorable conditions for groundnut production had a net growth rate by +10.1, while the labor force in Patcharr, most affected by the disturbances in the J.P. project actually shrunk by 0.9 percent. But the overall intertemporal increase in the workforce in 1987 did not translate into increased labor in farming. The number of days per farm worked in agriculture actually went down in 1987, compared with 1985 (Table 5.4). Large increases in groundnuts could not fully compensate for the decrease in other crops, particularly rice. Thus the potential of an enlarged workforce for increased production was not realized. The noted capital scarcity was certainly a key factor. Labor seems to be more pushed out of the contracting urban economy rather than pulled into the rural sector.

Capital

Labor, and not land, is the constraint to increased production in The Gambia. Therefore, the key to higher production lies in increasing low labor productivity through improved technologies and more intensive capital use. So far the ERP had only limited success in adding to accumulated capital in agriculture and improving the use of purchased production inputs.

Between 1985 and 1987, farmers did make investments in draught animals: on average, they increased their stock by 18 percent, more so in upland villages. But the machine stock by and large stagnated and machine purchases actually declined in 1986/87 compared with the period of 1982-85 (see Figure 5.1). Credit restrictions for purchases of new machines as well as availability and quality of second-hand implements were major constraints. Marketing problems and credit availability also led to a 54 percent decline in the use of fertilizer, the major purchased production input in the survey households, between 1984 and 1987.

Figure 5.1--Implement stock currently (1988) in use by year of purchase[a]



Source: IFPRI-PPMU sample surveys

[a] The graph shows acquisition of implements over time, thus net and replacement investments in implements currently in use.

Table 5.4--Wet season labor input/farm (including hired labor)

	All Villages		Lowland		Upland	
	1985	1987	1985	1987	1985	1987
	(person days worked/farm)					
All crops	556	450	505	337	624	602
Rice	225	90	303	134	121	32
Coarse grains	131	96	81	54	199	152
Groundnuts	175	264	100	149	275	418

In the following, we identify three major areas for technological change in The Gambian agriculture.

FARM IMPLEMENTS FOR UPLAND CROPS

As pointed out above, productivity of incremental capital in Gambian agriculture is quite high. This is the case even though most farmers in The Gambia have access to machines (like ploughs, seeders, multiple purpose cultivators) and draught animals (donkeys, horses, or oxen), either inside or outside their own compounds: 80.3 percent of groundnuts and 86.9 percent of millet fields are mechanically treated at least twice during the season. Production functions show for instance that use of weeders may increase yields per hectare by as much as 19 percent.

Farmers frequently borrow or rent these implements for use on their own fields: thus 73.4 percent of seeders and 86.4 percent of weeders on groundnut fields were borrowed or rented. But these sharing arrangements--however useful they are--do not make best use of the potential of animal-drawn implements in The Gambia. This is because sharing often leads to delays in task execution (and thereby yield losses) and to plot sizes below those that could be cultivated if more implements were available.

Women are a prominent example for underutilizing these technologies which contribute to relatively low female labor productivity. Women own less than 1 percent of all machines and their use rates are lower, particularly in weeding: 72.2 percent compared to men's 82.3 percent in 1987.

A comparison of farms with different levels of machine and draft animal ownership shows (see Table 5.5) that in upland farms the area

cultivated per farmer is 79 percent higher in those 25 percent of farms that are best equipped versus those who own least implements. Machines are commonly associated with area extension but they also allow higher yields per hectare--in groundnuts 1.6 tons/hectare versus 1.2 tons/hectare--(e.g., by earlier planting, timely execution of tasks, overall weed management).

They play an important role in breaking labor bottlenecks in highly seasonal agriculture, particularly in planting and weeding, that usually constrain the area managed per farmer. Thereby they increase overall labor input and income per farm worker. While labor input per hectare decreases from 132 days in those farms with least

Table 5.5--Mechanization level and farm characteristics[a] (upland villages)

Mechanization Level	Farm Size	Work-force[b]	Farm Size/ Worker	Frequency of Machine Use/Field	Ground-nut Yield	Wet Season Crop Income Per Worker	Wet Season Crop Income Labor Day
	(ha.)	(no.)	(ha.)	(no.)	(kg/ha.)	(Dalasi)	
Least equipped (25 percent of farms)	3.11	3.40	0.91	1.85	1,224	1,112	8.24
Lower medium	4.89	4.46	1.10	2.35	1,415	1,552	11.67
Upper medium	5.94	4.20	1.41	2.40	1,588	2,099	15.67
Best equipped (25 percent of farms)	7.30	4.49	1.63	2.41	1,597	2,606	17.03

Source: IFPRI/PPMU survey, 1987/88.

[a] By quartiles of machine and draft animal capital per farm worker.
[b] In labor units: men = 1, women = .41 (upland villages).

equipment to 103 days per hectare in those with most (the "labor saving effect"), overall farm labor input increases--because of increased area--by more than 30 percent: from 123 days to 168 days per worker and season, the "labor augmenting effect" (Figure 5.2). Thus implements provide for more employment by smoothing out labor demand across the season and allowing more work in off-peak seasons (Figure 5.3).

Figure 5.2--Agricultural labor use, by mechanization level (upland villages)

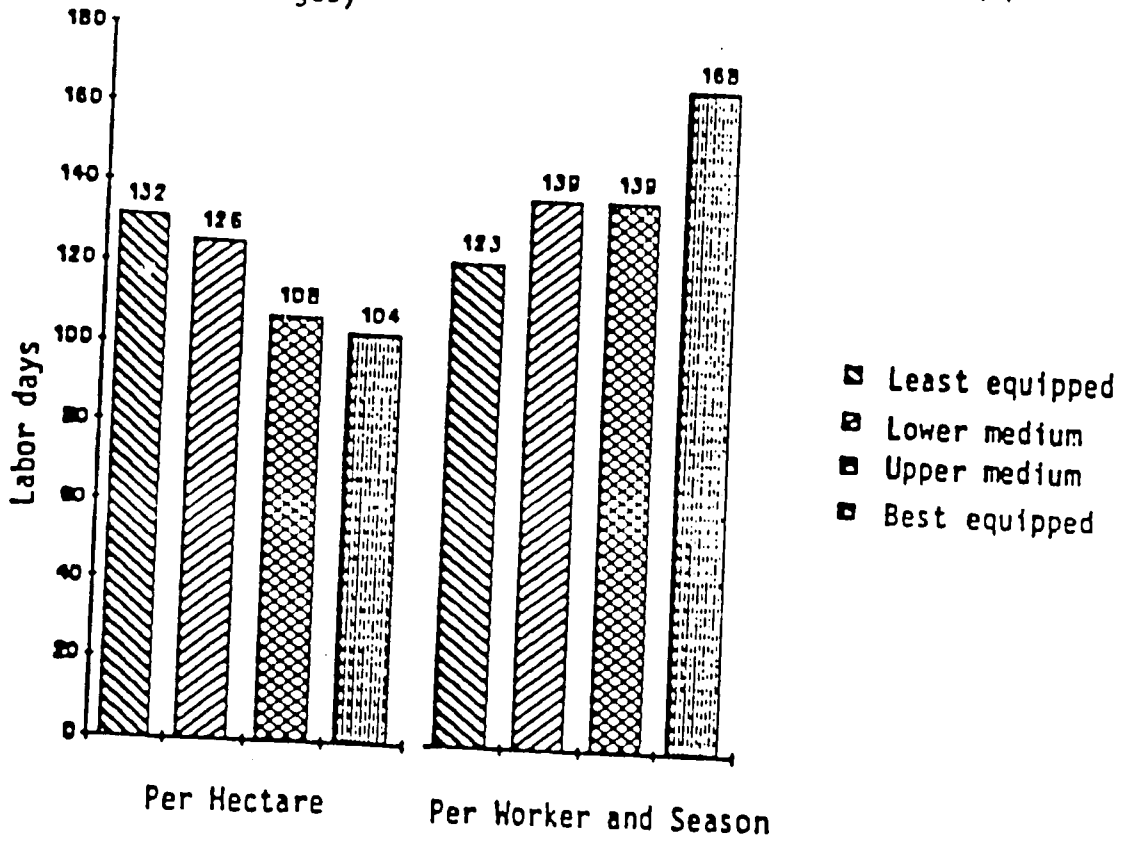
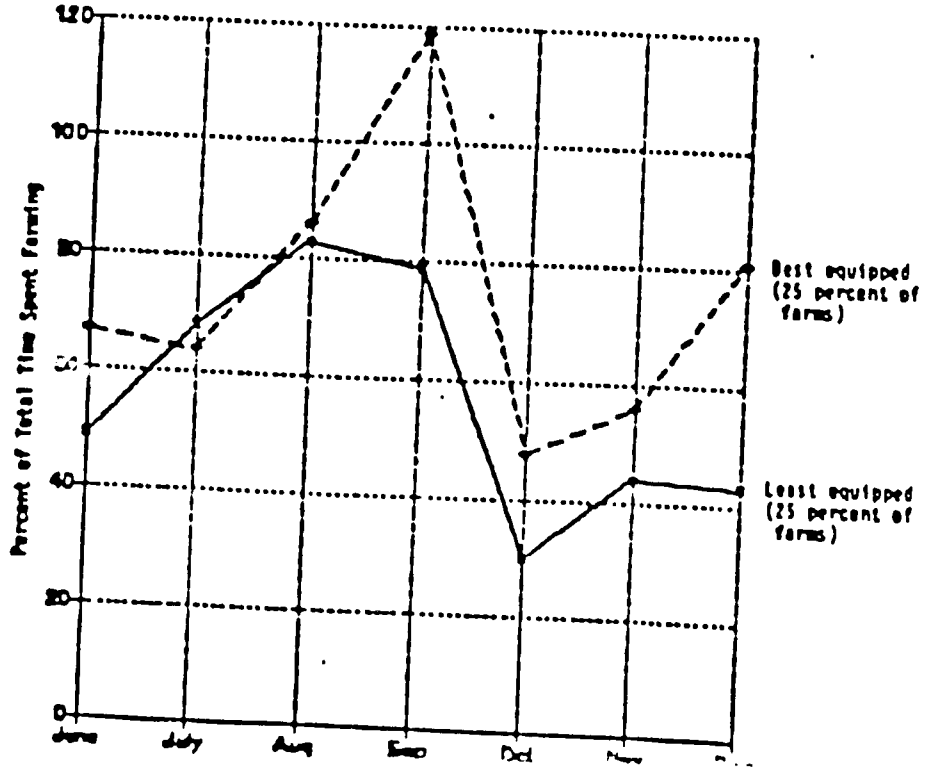


Figure 5.3 --Monthly labor use, by mechanization level (upland villages)



Income rises as much as 134 percent from the bottom to the top 25 percent of farms grouped by implement availability.

Investment in machines and draught animals have to go hand in hand. Doubling machine/draught animal stocks will increase area cultivated by 51 percent, of which draught animals account for 39 percent and machines 12 percent. Presently, money spent on draft animals has a bigger impact on production than money spent on machines. This is in line with the observation that farmers invested more in draught animals than in new machine equipment between 1985 and 87.

TECHNOLOGIES FOR RICE

Much speaks for a focus on rice in agricultural development programs: the irrigation-seed-fertilizer technology is well known; rice is the main marketed cereal, the import substitution effect is favorable for the foreign exchange situation; and fertile lowland soils are waiting to be used. Key issues in choosing the appropriate rice technology include:

1. The cost of rice production under various technologies, and their sustainability,
2. The competition of rice and upland crops for scarce labor in the wet season, and
3. The distributional effects of alternative policies especially their implications for women farmers.

Rice is produced under various technologies, roughly categorized as (1) traditional swamp rice, (2) partly water controlled, improved swamp rice and (3) fully water controlled, double-cropped irrigated rice. In 1985, production costs in a major scheme (Jahally-Pacharr), and in surrounding areas--at shadow prices of inputs, including recovery of investment costs and family labor input--were roughly $323 per ton of milled rice in fully water controlled rice, $411 in partly water-controlled rice, and $256 in the off-project traditional swamp rice (Table 5.6). These figures compared with costs of $288 per ton of imported rice (5 percent broken) and thus call for lower cost swamp rice improvement schemes, particularly considering even higher production costs in 1987 when project yields were not sustained.

Swamp Rice Development Helpful for Women Farmers

Main constraints for improved labor productivity in traditional swamp rice production, where women are in charge of 91 percent of the plots, are ploughing of heavy lowland soils, access to the swamps, and water and soil management (e.g., salinity problems). Policy should emphasize the promotion of ploughing services--tractor or oxen, preferably decentralizeo and private--and appropriate seed variety devel-

Table 5.6--Costs of production of clean rice, 1985

	Fully Water-Controlled Rice[a]	Partly Water-Controlled Rice[b]	Traditional Rice
		(in Dalasi)	
Costs per hectare			
Annualized investment cost per hectare (10 percent interest, 30 years)[c]	5,370	1,497	...
Annual operation costs/hectare (land preparation, water)	1,785	432	...
Other variable production costs/hectare[d]	1,860	527	160
Opportunity cost of unpaid (family) labor/hectare[e]	1,427	756	718
Milling, transport, handling[f]	937	286	121
Rice yield/hectare (in tons of clean rice, dry and wet season 1985)[g]	6.96 tons	1.68 tons	0.772 tons
Total costs/ton	1,635	2,082	1,297
Total costs/ton (in U.S. $)[h]	(323)	(411)	(256)
Total costs/ton, excl. investment costs (U.S. $)	(171)	(235)	(256)

[a] Jahally-Pacharr (pump-irrigated, double-cropped, dry and wet season).
[b] Jahally-Pacharr (tidal irrigated/rainfed, wet season 1985).
[c] Total investment costs are based on appraisal report figures; they exclude monitoring and evaluation, social services, and personnel (personnel costs, including expatriates, account for U.S. $3.2 mio. in the initial four years of the project; costs of pumps and related structures are assumed to amount to U.S. $1.3 mio for fully-water controlled rice; other investment costs are distributed proportionately per hectare across fully and partly water-controlled fields; and same land development costs/hectare are assumed in fully and partly water-controlled fields (pumps excluded).
[d] Including fertilizer, seed, hired labor, and interest on working capital.
[e] For both fully and partly water-controlled rice, wet season: D 3.5/person day; dry season: D 1.5/person day; for traditional rice, wet season: D 3.5/person day.
[f] These costs are assumed as 10 percent of value of total output.
[g] For fully water-controlled rice, wet season yield: 5.2 tons/hectare unhusked rice (paddy); dry season yield: 6.4 tons/hectare; for partly water-controlled rice, wet season yield: 2.8 tons/hectare unhusked rice (paddy); 60 percent milling ratio.
[h] U.S. $1.00 = Dalasi 5.06 at 1985 parallel exchange rate.

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opment and distribution. Micromanagement is required for area specific infrastructure improvement, mainly access and water control.

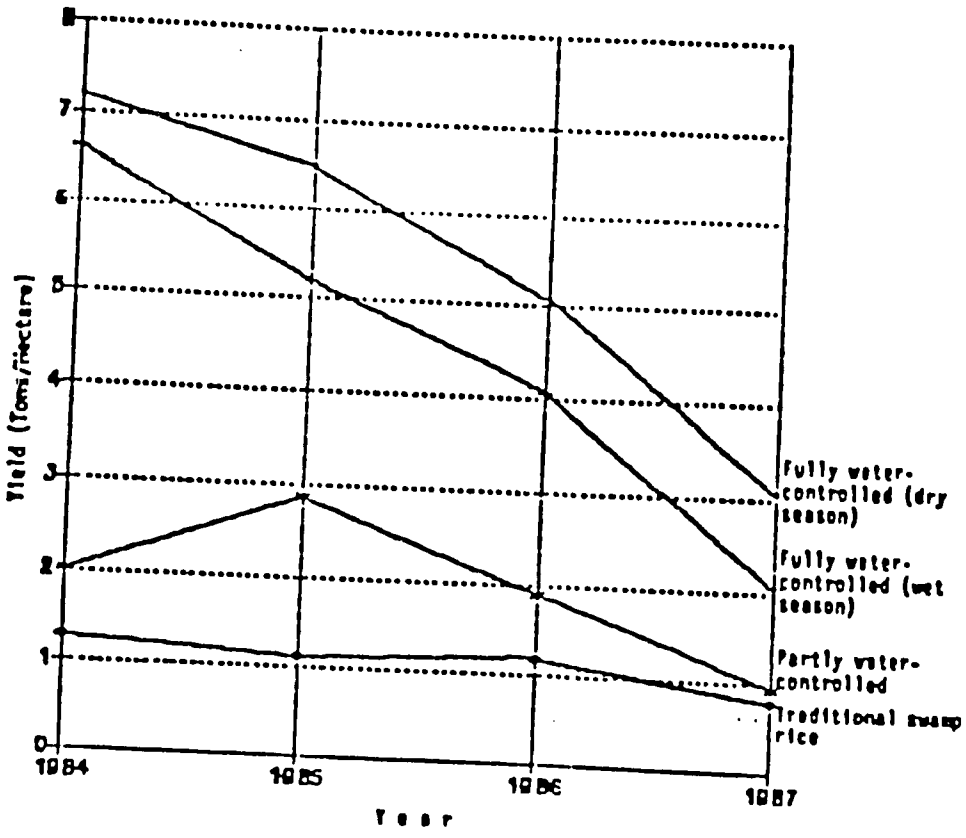
As a technically more advanced option of improving traditional swamp rice, more attention should be given to the partly water-controlled rice technology (with larger structural investments in gravity irrigation, land leveling, etc.). This technology is still a more secure means of producing cereals than traditional swamp rice or the purely rainfed upland farms and for households in the lowlands important for diversification. It also is beneficial for women who are more involved in this technology than in fully water-controlled rice (77 percent versus 10 percent of fields cultivated by women). Development of this technology, however, is only justified, if production costs (and especially investment costs) for these schemes can be drastically reduced and yield levels can be sustained. This was not the case in the J.P. Project where average yields fluctuated between 2.86 tons/hectare (1985) and 0.94 tons/hectare (1987) [Figure 5.4].

Double Cropping Improves Food Security

Although the scope for fully water controlled, double cropped irrigated rice is limited because of dry-season water constraints, its potential should not be neglected, given the highly favorable impact of the dry season harvest on smoothing out seasonality in income, food availability and nutritional status at the household level. Figures from the J.P. Project area show that women with most access to the project had the lowest weight losses in the rainy season (1.1 kilograms versus 2.9 kilograms for those with least access).

Sustaining irrigated rice schemes--and particularly double-cropping--has proven difficult in the past. Also, the J.P. Project experienced serious problems in 1987 in maintaining its double cropping schedule: in the wet season, only slightly more than 50 percent of the potential irrigated area was cultivated and yield levels dropped to 2 tons/hectare (compared with 5.2 in 1985 and 4.07 in 1986) [Figure 5.4]. Fluctuating yields in irrigation schemes must not necessarily be viewed as a failure. In general, a major impediment for sustained double cropping and even overall wet season rice cultivation are the year to year changes of opportunity costs of labor resulting from mostly rainfall induced productivity fluctuations of competing crops traditional cereals, groundnuts). Thus, in the 1985 wet season, every ton of paddy incrementally produced in the J.P. scheme resulted in a combined reduction of 201 kilograms of upland cereals production, 10 kilograms of traditional rice and 241 kilograms of groundnuts. Moreover, a substantial number of farmers reach higher productivity in upland crops than in rice. For instance in 1985, 23 percent of farmers with upland cereals and 17 percent with groundnuts exceeded the average return to labor in fully water-controlled rice. Thus the two main alternatives for irrigation policy are:

Figure 5.4--Yield fluctuations in rice, 1984-1987



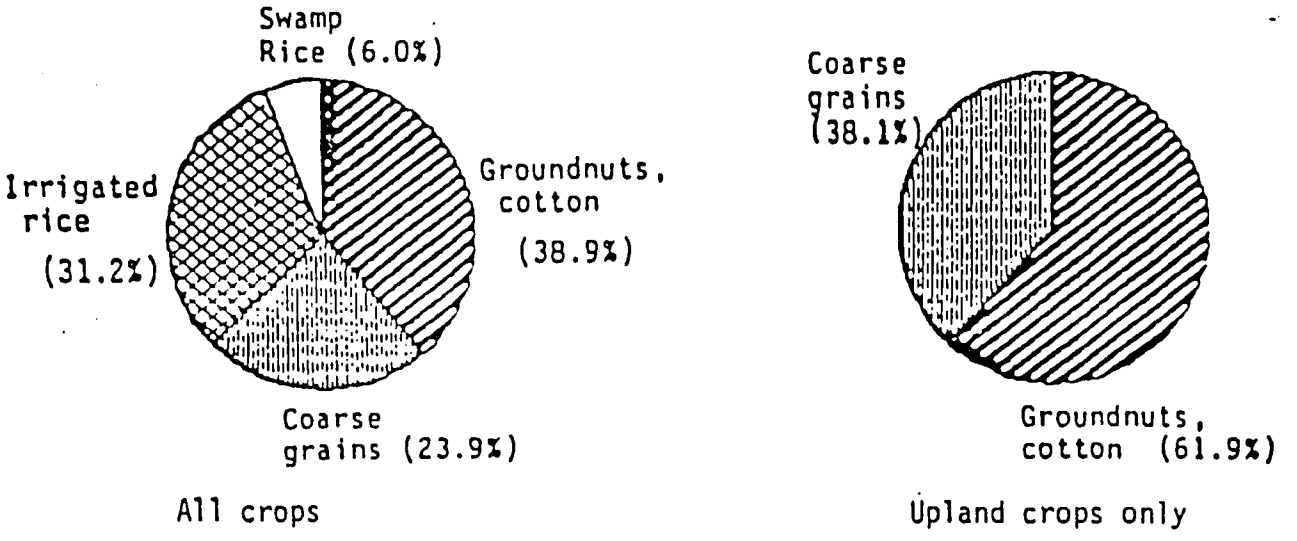
1. setting up small schemes, mainly focused on food security, that provide a convenient dry season crop and some "drought insurance" in the wet season, but are not necessarily focused on high use intensity, and
2. developing a class of specialized rice farmers who are able to master the management difficulties in connection with sustained double cropping. There is, however, no distributional objective in this option that might justify subsidies for rice production.

IMPROVING INPUT USE: FERTILIZER, SEEDS, AND CROP PROTECTION

Marginal productivity of fertilizer in upland crops is high: results from production functions reveal that under the most conservative assumptions and model specifications in 1987, one additional kilogram of fertilizer material would have yielded about 2.66 kilograms of groundnuts and 2.7 kilograms of millet at current mean values of fertilizer use. Similar figures were estimated for 1985 and 1984 indicating the stability of output response to fertilizer. Even in the year of a local drought in 1984 additional output per kg. fertilizer was above 2.5 kg. in groundnuts which may hint at a positive impact of fertilizer on drought resistance. These figures translate into value cost ratios - i.e., the marginal value of produce from one additional Dalasi spent on fertilizer - that range between 3.5 and 5.5 under current input and output prices. The ratios are also nearly all above 2 when a removal of all subsidies is accounted for. Alternative model specifications showed that marginal output may be as high as 4.2 kg. for groundnuts and 2.9 kg. for coarse grains in 'average' years and even higher in years with good harvests. For the same area a study by Mills et.al. (1988) comes up somewhere in between with a marginal productivity of about 3.5 kg. of groundnuts per kilogram fertilizer (SSP).

Gambian farmers use fertilizer on all crops, cash and food crops. Figure 5.5 shows fertilizer shares by crop for 1984 and 87. A remarkably high share, on average more than 60 percent, goes to cereals. Looking only at upland crops, the share of coarse grains is about 38 percent, with a higher share in the year when fertilizer was scarce (Table 5.7). But fertilizer use per hectare is far below recommended levels (in 1987 for upland cereals and groundnuts less than 20 percent of recommendations of about 200 kg/hectare) and has dropped significantly since 1984 except for the rice project where availability of and access to fertilizer are better.

Figure 5.5--Fertilizer shares, by crop (average 1984, 1985, and 1987)



High *seed* prices combined with distribution restrictions and failures by the cooperative have decreased the use of groundnuts seeds from 184 kg./hectare in 1984 to 141 kg/hectare in 1987. This decrease definitely reduced potential yield levels as a result of lower plant densities.

Constraints in *crop protection* has contributed to serious problems in coarse grain production in 1987 (average yields in millet declined from 1.1 tons/hectare in 1985 to .8 tons/hectare in 1987). Much of this decline was due to infestation with blister beetles and other insects.

The above discussed three areas for technological improvement are not alternatives but complementary elements of a Strategy for vitalized growth in agriculture. They all require increased attention by public policy.

Table 5.7--Fertilizer use 1984, 1987

	Share by Crop				Use Intensity	
	Including Rice		Excluding Rice			
	1984	1987	1984	1987	1984	1987
	(percent of total)				(kg/hectare)	
Groundnuts, cotton	46.6	34.0	63.1	53.8	90	38
Coarse grains	27.2	29.2	36.9	46.2	52	36
Irrigated rice	21.7	28.2			271	324
Swamp rice[a]	4.5	8.6			69	72

Source: IFPRI/PPMU survey, 1985/86, 1987/88.

[a] Traditional and improved.

6. ATTEMPTS FOR MARKET DEREGULATION AND INSTITUTIONAL CONSTRAINTS

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CONTINUED PUBLIC INTERVENTIONS

In the past four years, The Gambia has made efforts to develop and stimulate the private sector to take over functions of agricultural input and output marketing. This usually takes time and creates frictions, at least in transitional periods where governments reduce their interventions only gradually and have substantial continuing influence on unofficial markets. The evolution of private markets remains closely interrelated with activities on the official markets.

The prominent cases of continued intervention in The Gambia are the still regulated groundnut market and the liberalized, but state influenced fertilizer market. Official credit has been restricted, adding to the problems on the input markets. This section sheds some light on the effects of changed market organization for farmers in the groundnut, fertilizer, and credit markets. In the context of this assessment we particularly looked into distributional effects of the policy changes.

GROUNDNUTS: THE PARALLEL MARKET TAKES OFF

A parallel market is a structure generated in response to those government interventions that create a situation of excess supply or demand in a particular product or factor market (Lindauer 1989). By imposing price and market controls and indirectly taxing the country's major agricultural export commodity, groundnuts, the Gambian government generated a surplus supply of groundnuts at the tax-exclusive price. As a result, a parallel market arose for groundnuts to avoid these controls.

During the mid-1980s both The Gambia and Senegal embarked on structural adjustment programs that included large price increases for groundnuts. The goal was to improve the terms of trade for the agricultural sector. But in both countries this policy raised domestic prices above world market level (the nominal protection rates, the ratio of domestic to world market prices were close to 2 in 1986/87). Subsidies were needed--and partly provided by international donors--to facilitate the export of groundnuts. Since 1984/85, the Gambian groundnut price has been between 73 and 84 percent of the Senegalese price (see Table 6.1). There has always been an outflow of ground-

nuts, especially from the villages close to the border, but very favorable price differentials in 1988 and a purchase ceiling of the marketing board combined to stimulate the outflow. In the 1987/88 season, limited subsidy funds in The Gambia forced the government to decrease guaranteed prices, thereby increasing the price differential to Senegal. But even at a lower price level the government was unable to guarantee the price for the country's total groundnut output

Table 6.1--Groundnuts price ratio in The Gambia and Senegal and fertilizer subsidy and use, 1981/82-1987/88

Year	Groundnuts - Price Gambian/Senegalese	Fertilizer Subsidy Per Unit
	.....(percent).....	
1981/82	102.0	72.0
1982/83	108.0	77.0
1983/84	94.0a	63.0
1984/85	79.0b	31.0
1985/86	82.0	22.0
1986/87	84.0	26.0
1987/88	73.0	17.0

Source: Computed from various unpublished sources of Ministry of Agriculture and Gambian Cooperative Union.

[a] Down to 75 percent when the local currency was devalued during the trading season.
[b] After price increases in The Gambia during the trading season.

and established a purchasing ceiling that covered only about two-thirds of the estimated marketing volume for the year. Because groundnuts sold to the parallel Senegalese market save The Gambia expenses on the export subsidy, the government did not attempt to prevent smuggling or to enforce sales to the cooperative.

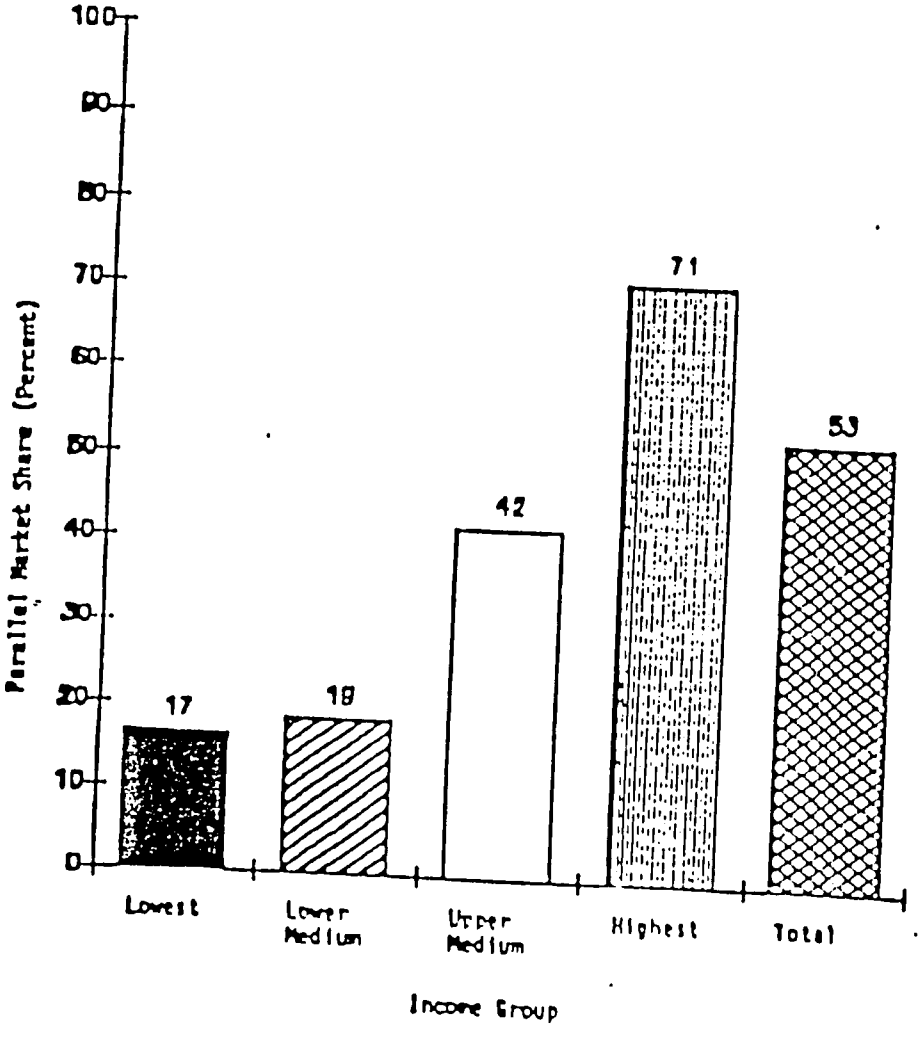
The Gambian cooperative (GCU), on the other hand, has some vested interest in official market sales because its marketing allowance increases with the volume marketed. GCU also needs to recover input loans from farmers, which is easier when groundnuts are sold to the cooperative. Thus GCU put some pressure on farmers to market to the official channel.

A semi-legal parallel market evolved which tolerates parallel structures on the Gambian side and attempts to safeguard its procurement system on the Senegalese side. The Senegalese government in

1987/88 tried to discourage Gambian sales by ordering stores along the border to close down, demanding Senegalese identification documents from groundnut sellers, and increasing its border controls. But the border is long, and during the course of the trading season most of these measures could not be fully enforced or were offset by bribes. Moreover, Senegalese groundnut-buying agents had an incentive to purchase Gambian nuts, since their allowances also depend on the volume of groundnuts purchased.

Parallel market participation was highest in the upland villages and thereby added to the unequal income distribution--upland villages, in general, have higher income levels. As Figure 5.1 shows, participation in the parallel market is significantly lower for the poorer income groups.

Figure 6.1--Groundnuts sold on parallel market, by income groups, 1987/88



GNSOLDKG	=	total groundnuts sold, in kilograms,
BORDER	=	dummy = 1, for villages close to the border,
FEMALE	=	male = 0; female = 1,
MIGRANTW	=	dummy = 1, if groundnut seller is a migrant worker,
COOPCRED	=	dummy = 1, if farmer received any credit from the Gambian cooperative during the same cropping season.

the official market. On the other hand, women farmers trade more in the parallel markets; women, especially from the Wolof community, are very active in village and inter-village food and commodity trading.

When we correct for these factors, the analysis also shows that a farmer's volume of groundnut output does not play a significant role in participation on the parallel markets. This result suggests that there are no diseconomies of scale; marginal costs for marketing on the illegal market do not rise with volume.

FERTILIZER: A MARKET SHUNNED BY THE PRIVATE SECTOR

In the past five years, fertilizer use in The Gambia has declined by 75 percent. While some of this can be attributed to lower demand in response to sharp price increases (subsidy removal, see Table 6.1), most of it is a result of delivery failures, restrictive distribution policy of the official fertilizer retail system, and failure to involve private marketing at large.

First, in 1985 a national fertilizer crisis developed when a fertilizer grant was provided to the country by an international donor, and at the same time the institutional responsibility for the logistics of fertilizer marketing in The Gambia changed. This led to a disruption of supply, since fertilizer shipments arrived in the country too late for the 1985/86 cropping season. In the end, only carryover stocks from previous years were used during that season, resulting in substantial production losses for the country (von Braun and Puetz 1987). In this situation of limited short-term supply, farmers had to compete for scarce fertilizer on a parallel market. Although unauthorized fertilizer trading was officially illegal at that time, there was little enforcement to actually discourage trading of small quantities.

Then, second, more disruptions and uncertainty followed when fertilizer markets were officially deregulated in 1986/87. But the official marketing system was maintained, and until now, private traders who were invited to take over part of the retail trade have not embarked on fertilizer marketing. On the other hand, government and GCU policies restricted fertilizer supplies to the cooperative's primary societies despite ample supply in government stores. As a matter of policy, annual allotments to each of GCU's 85 primary societies are based on its sales the year before and adjusted downward

for outstanding loan repayments from each society. Until 1985 GCU had provided loans under generous interest and repayment conditions. Individual loan defaulters did not lose access to new loans as long as their primary cooperative society maintained a certain collective repayment rate. With the structural adjustment program this policy changed in 1986, and from then on individual loan defaulters were strictly excluded from further loans. The new credit policy also limited new input loans to the amount individual farmers had received the previous year, and only cooperative members who actually got credit the year before are eligible for new credit.

Tightening access to credit had an adverse effect on overall input use, since GCU did not put out special contingencies for cash sales. Thus in 1987 GCU purchased only 3,000 tons of fertilizer in the public auction. Fertilizer shortages and excess demand remained symptomatic for the fertilizer market. At the local level a parallel fertilizer market exists but is limited in its size, since private traders--operating interregionally--have not gotten involved.

The decline in overall fertilizer consumption affected disproportionately the poorer income groups. Tracing the development of fertilizer use in upland crops from 1984 to 1987 (Table 6.3) we find that while overall fertilizer use went down by more than 50 percent during that period, the share of low income groups in total fertilizer consumption fell continuously. In 1987, the two bottom income groups still consumed 37 percent of all fertilizer, but for 1987 this figure went down to only 25 percent.

Some of this decline is also a consequence of limitations in credit access. Fertilizer cash purchases are lowest in poorest income groups: 44 percent versus 57 percent in the top. Since poorer farmers need credit more than the rich to buy fertilizer, the reduced credit availability had a higher impact on the poor.

Table 6.3--Fertilizer use in 1984, 1985, and 1987 for identical households in all upland crops, by income group

Year	Consumption	Share by Income Quartiles			
		Lowest	Lower Medium	Upper Medium	Highest
	1984=100	(percent)			
1984	100	17	20	24	39
1985	41	15	20	24	41
1987	46	10	15	32	43

Source: IFPRI/PPMU survey, 1985/86 and 1987/88.

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CREDIT MARKET: SUPPLY AND DEMAND IMBALANCES

A variety of factors limits the supply of agricultural credit on local markets: in an environment with high production risks (drought and pests) lenders who cannot spread their risks over large areas will be reluctant to mobilize capital. The same lenders also face problems of charging interest in often highly personalized relationships; the lack of collateral and high opportunity costs for alternative capital use are additional constraints.

Where the private (informal) sector is not able or is unwilling to provide more credit, and many farmers' cash outlays are limited by low income and risk aversity, the way out of this vicious circle is a comprehensive government credit policy in the villages. Such a policy should encourage loan repayment by providing long-term loan perspectives and small group responsibility for repayment.

Capital has a high marginal productivity in The Gambian agriculture: the analysis on the basis of the IFPRI-PPMU survey finds that one additional Dalasi spent in crop production increases output by 2.67 Dalasi (see section 5). Thus farmers are willing to pay high interest for credit. For instance, average interest charged on the informal seasonal credit market for agricultural inputs amounts to 85.8 percent/ annum. The importance of agricultural credit is also underlined by the fact that--in 1987--46 percent of all seasonal credit was for agricultural purposes.

In the survey area, the official market (GCU) in 1987 covered about 45 percent of agricultural input credit--mostly fertilizer and groundnut seed. Friends and family members provided 49 percent. Local traders had a low share of 6 percent (see Figure 6.2).

Even though the share of agricultural loans received by the bottom half of the households is only 30 percent of total agricultural loans given out, this share is higher than their share of the total crop income (22 percent). For these loans, they depend significantly more on the official market: 63 percent of agricultural credit that the poor receive is provided by the cooperative as opposed to an average of 40 percent in the top income groups.

Although farmers' total input demand is constrained by insufficient credit facilities, it is noteworthy that farmers do pay cash for inputs (Table 6.4): 51 percent of fertilizer purchases, 21 percent of groundnut seeds that are not from own production, and 86 percent of machines are paid for by cash.

Figure 6.2--Participation in official and informal agricultural credit market, by income groups, 1987/88

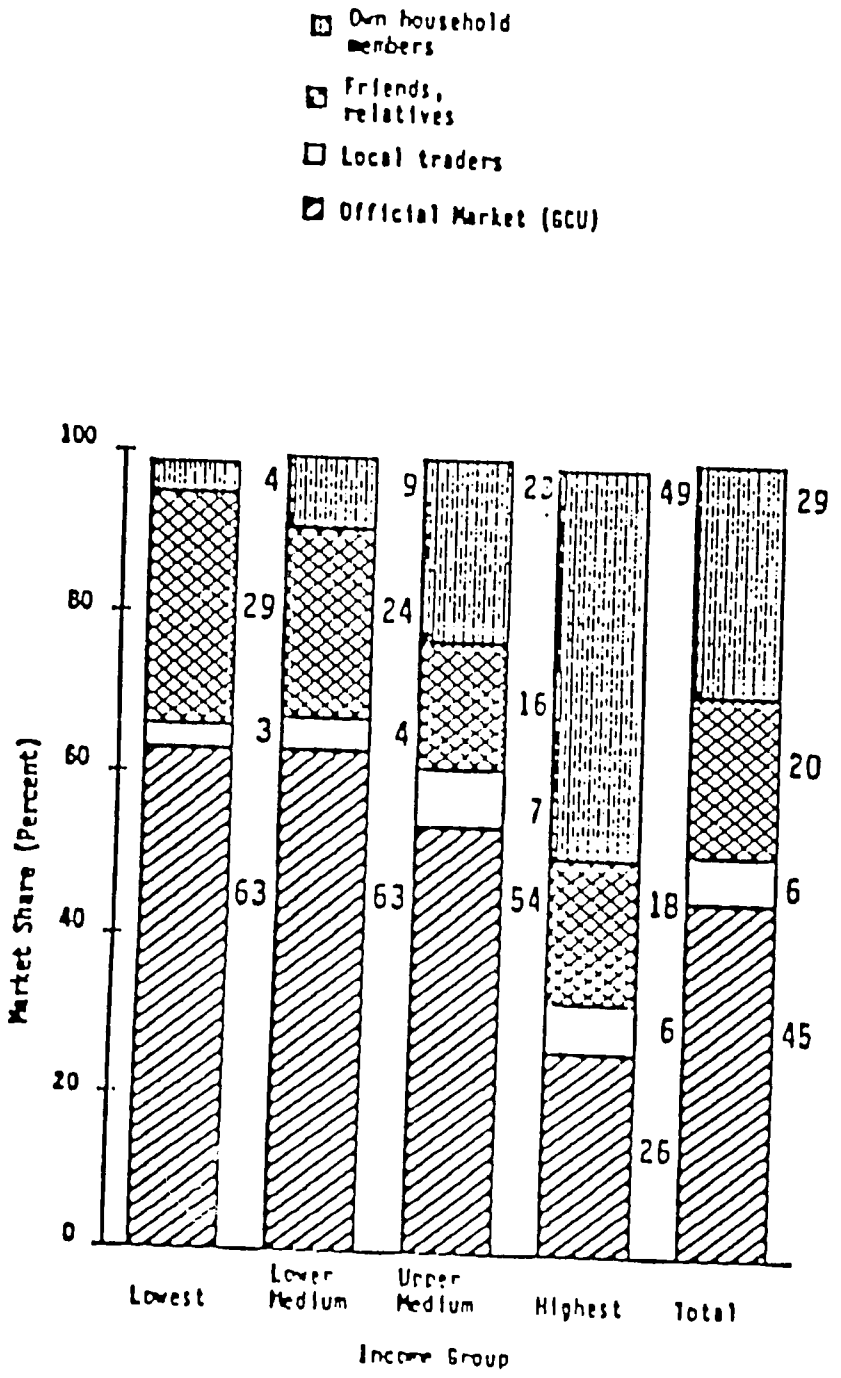

Table 6.4--How are inputs acquired?

	Groundnut seeds 1987	Machines 1974-87	Fertilizer 1987
		(percent)	
Own production	64	...	...
Cash	7	86	51
Loan	18	9	41
Other	9	5	8

Source: IFPRI/PPMU survey results, 1985/86 and 1987/88.

POLICY CONCLUSIONS

The major challenge for the coming years is to determine the proper role of public sector policy with regard to market interventions. Sustained public interventions and investments are appropriate and necessary

1. where private benefits are not directly capturable, e.g. in major infrastructure investments, emergency supplies, research and agricultural extension;
2. where private investments are slow to take off and the public sector can serve as a catalyst for private initiatives (e.g. by taking over wholesale and import/export functions in agricultural input supply, or promoting the set-up of viable rural financial institutions);
3. where the public sector has to provide fall-back institutions if private initiatives fail to develop immediately, these are particularly important during the transition period to avoid destabilizing signals (e.g. broken down fertilizer market), and
4. where the government must assume a supervising function, to assure

    a. that developing private markets are competitive, to avoid monopolistic practices like overpricing, speculation or hoarding, and
    b. that private markets for crucial inputs and outputs actually do develop and that appropriate action will be taken if they fail to reach farmers.

The need emerges for a strategy of gradual privatization where public and private enterprises and initiatives can and should coexist. Neither the rapid dismantling of public services without replacement by private enterprises, nor some halfhearted approaches of partial

liberalization--that keep key markets under public control and maintain subsidized public institutions--are viable alternatives (see also Kinteh on these issues in Section 1).

In pursuing a strategy of stimulating private initiative, one major priority is to abolish unilateral subsidies and preferential status of public and parastatal institutions that make private enterprises uncompetitive (the best example in The Gambia is GCU with its large institutional subsidies). Policy coordination is also called for to prevent continued destabilizing interventions, that have for instance characterized the fertilizer market in the past. These volatile interventions and subsidies are the biggest constraint for private sector involvement at large.