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An African Fertilizer Crisis: Origin and Economic Effects in the Gambia

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In 1985, fertilizer did not arrive in the Gambia in time for the cropping season, since a fertilizer grant was not being properly managed and coordinated. The costs of such policy failure are high. Fertilizer use was down by 64%. In this situation of scarcity, fertilizer use was even more skewed than before towards rich farmers. Output lost was about 10% of agriculture's GDP. Even in normal years in the Gambia, fertilizer use in millet and groundnuts is found far below optimal levels.

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The supply of agricultural production inputs in small African countries depends heavily on assistance from donors. This is especially true in the case of fertilizer supplies. Fluctuations in donor-assisted fertilizer supply may therefore have a significant effect on fluctuations in the availability of fertilizer. These fluctuations are substantial. Between 1980 and 1984 bilateral and multilateral assistance for fertilizer supplies to Africa fluctuated between $16 million and $328 million per annum.[1]

Small countries in Africa may depend on a small number of donor-assisted supply sources for fertilizer. If there are disruptions in the supply channel with just one such important donor, the consequences are detrimental for farmers and the recipient country's agriculture. Such a crisis occurred in the Gambia in 1985.

The focus of this article is the micro-level production and distributional effects of the fertilizer crisis and its costs. Policy conclusions are drawn from an identification of the institutional and policy changes which triggered the crisis.

The fertilizer crisis also provides a unique basis to assess the effects on output and income of varying levels of fertilizer in this West African setting. Primary farm survey data collected during the years around the crisis form a basis for addressing the broader issue of the potentials and effects of increased fertilizer use in a complex production system, with communal and individual farming carried out separately by men and women farmers who are both engaged in staple food and export crop production.

The 1985 fertilizer crisis in the Gambia

Since the early 1970s fertilizer has been used in sizeable quantities in the Gambia, especially for the groundnut crop. In the early 1980s the fertilizer marketing system worked as follows:

- The parastatal company, the Gambian Produce Marketing Board (GPMB), imported fertilizer and organized domestic handling;
- The Gambian Cooperative Union (GCU) organized the retailing of fertilizer and gave credit to finance fertilizer purchases through its cooperative societies.

[1]Food and Agriculture Organization, *Atlas of African Agriculture*, FAO, Rome, 1986, p 67.

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Loan repayments were a persistent problem. For instance in 1985/86, 35 out of 82 societies were not qualified to receive new loans under a newly introduced 75% repayment eligibility criterion. Fertilizer was available for cash only to farmers in many of these societies. Average loan recovery ranged between 17% and 61% in the years 1980–1986.[2]

In 1984/85 the system changed. Under the umbrella of a multi-donor-sponsored agricultural development programme, a single donor had taken over the fertilizer grant component of the programme for 1985. Before this programme, the grant component of imported fertilizer had been small (less than 10%). Internally, under the new programme in 1985, the wholesale importation and handling of fertilizer was transferred from GPMB to GCU, so as to have only one organization in charge.

Because of managerial problems, the first fertilizer shipment of 19 000 tons under the programme, supposedly covering the total demand of the country for the year, did not arrive in time for the 1985 cultivation season. Only existing stocks and some of the fertilizer that arrived late could be used for the crop. As a result, fertilizer use was down by 64% compared to the previous year's level. This was particularly unfortunate, as 1985 was the first year when there were reasonable rains after an extended drought period in the Gambia. The fertilizer crisis hit the country when it was also grappling with an adjustment of major distortions in the economy. This supply disruption points to the riskiness of donor dependence for strategic input supplies.

Arrangements for imports and domestic distribution of fertilizer are to be seen as closely related. The 1985 supply disruption resulted in a large carryover stock (see Table 1). Sizeable carryover stocks add to the cost of production forgone induced by the lack of supply in the crisis year. The time series of the fertilizer stock figures also reveals that in 1984 – the year before the crisis – stocks were at a level below average. Apparently the GPMB, which used to handle the import business, had run down its stocks because of the impending transfer of fertilizer import rights to GCU – a changeover that was tied to the fertilizer grant in the programme. The consequences of the supply disruption were therefore aggravated by the change in institutional responsibilities in the recipient country.

High fluctuations in fertilizer sales are not unique to the crisis year 1985. During the five-year period from 1981 to 1985, sales had a setback in two years, 1982 and 1985. Sales in 1982 were 31% lower than in 1981; sales in 1985 were 64% lower than in 1984. In both 1982 and 1985,

[2]Government of the Gambia, *Fertilizer Sub-Sector Paper: Marketing and Price Policy Analysis*, Paper 11, Planning, Programming and Monitoring Unit for the Agricultural Sector, Banjul, 1986, pp 13-14.

Table 1. Volume of fertilizer sale and its total supply in the Gambia from 1981 to 1985 (in tons of fertilizer materials).

Year	Import in respective year (1)	Stocks from previous year: GPMB[a] (2)	GCU[b] (3)	Total[c] (4)	Total supply (5)	Total sale (6)
1980	11 493	NA	NA	NA	NA	NA
1981	11 563	5 147	3 032	8 179	19 742	12 135
1982	12 875	6 333	1 204	7 539	20 414	8 357
1983	2 854	11 335	587	11 922	14 776	9 582
1984	13 027	3 580	354	3 934	16 961	12 066
1985	22 466[d]	2 935	1 240	4 175	26 641	4 338
1986	NA	NA	NA	22 303	NA	NA

[a]At wholesale level, GPMB is the Gambia Produce Marketing Board.
[b]At retail level, GCU is the Gambia Cooperative Union.
[c]The reported carryover stocks (Col 4) in year $t + 1$ are usually very close to the difference in total supply (Col 5) and total sale (Col 6). The biggest difference is in 1983/84, with actual stock reported 3 934 while imputed carryover equals 5 124 tons (14 776 – 9 582). Although part of the discrepancies may be storage losses, the differences cannot be fully explained by these.
[d]Due to late arrival, most of this shipment ended up in stock.
Source: Government of the Gambia, *Fertilizer Sub-Sector Paper: Marketing and Price Policy Analysis*, Paper 11, PPMU, Banjul, 1986, pp 25, 53.

imports were higher than in the preceding years and considerably higher than sales; the quantity of imports cannot explain the reduction in sales. Also in 1982, imports were not effectively transferred on time to farmers, thus leading to high carryover stocks. It is also worth noting that, in both 1982 and 1985, stocks from previous years accounted for 90% to 95% of sales, which suggests that whatever was in the distribution pipelines at the outset was sold. Disruptions in the supply system appear to dominate the fluctuations in the final use of fertilizer.

The institutional setting before the 1985 fertilizer grant, with GPMB as the sole importer and wholesaler of fertilizer, entailed substantial fertilizer subsidies and high wholesaling costs. The subsidy amounted to about 50% of CIF price; wholesaling costs plus storage and handling losses amounted to about 45% to 55% of the CIF-import price of fertilizer in 1982 and 1983.[3] Yet rapid displacement of this fertilizer marketing system without appropriate consideration of external and domestic constraints triggered the 1985 crisis that left the country, particularly its farmers, worse off in the short run. It remains to be seen at this stage to what extent these 'adjustment costs', which occurred in changing the system, will pay off in the long run.

Effects of the crisis at the farm level

How did the reduced availability of fertilizer affect the use of fertilizer for the various crops, and how did the scarcity affect different types of farmers? A detailed farm-household survey was conducted by the International Food Policy Research Institute (IFPRI) in collaboration with PPMU[4] in the Gambia covering the 1984/85 and 1985/86 growing seasons. The survey was not designed to address the fertilizer issue specifically, but it yields interesting insights into the effects of the crisis.[5] The survey is a structured random drawing from 10 villages located on the south bank of river Gambia, about 300 kilometres east of the capital city, Banjul. Since the survey was mainly designed to address issues related to commercialization and technological change in the context of a rice production project, the results are presented separately for the total sample – with and without that project. While the latter is a more appropriate basis to address generalizable effects of the crisis, the former addresses the issues of how a specific high-input project coped with the crisis.

In 1985, 66% of fertilizer sold in the Gambia was NPK-compound 15–15–15; 27% was single super phosphate (SSP) used mostly for groundnut; and 6% was urea. While sales of NPK-compound were approximately at the 1984 level, SSP and urea supplies were down markedly.

The survey area, located in the middle of the Gambia in MacCarthy Island Division, was affected by the fertilizer shortage in a similar pattern to the country as a whole. Excluding the local rice production scheme, fertilizer use was down by 61% in the sample farms (see Table 2), while it was down by 64% for the country as a whole. Farmers in the local rice project benefited from the ability of the project management to secure fertilizer even during the scarcity. Fertilizer use in the project's rice fields increased by 14% (Table 2). The crops most adversely affected by the reduction in fertilizer activity were millet and sorghum (−73%), followed by groundnuts (−66%; see Table 2).

For other crops (maize and cotton), fertilizer use was relatively less

[3] *Ibid*, pp 28–31.

[4] PPMU is the Planning, Programming and Monitoring Unit for the agricultural sector in the Gambia.

[5] The survey was part of a research project on the effects of increased commercialization of traditional agriculture, funded by the International Fund for Agricultural Development (IFAD), Rome.

Table 2. Change in fertilizer use, by crops, from 1984 to 1985.

Crops	Percentage change in total fertilizer use in sample farms
Groundnuts	-65.5
Millet, sorghum	-73.1
Rice outside project[a]	-44.4
Rice in project[a]	+14.2
Other crops (maize and cotton)	19.7
Total average	-44.6
Total average *without* project	61.1
Country average	64.0

[a]This refers to an irrigated rice project in the survey area.

Source: IFPRI/PPMU survey, 1985/86, and Government of the Gambia, *Fertilizer Sub-Sector Paper: Marketing and Price Policy Analysis*, Paper 11, Planning, Programming and Monitoring Unit for the Agricultural Sector, Banjul, 1986

reduced during the shortage, which can be attributed to the promotion of special maize and cotton production programmes in the area in 1985.

These changes have also affected the structure of fertilizer use by crop. The share of fertilizer for groundnuts out of overall fertilizer use went down to 50.6% (excluding the rice project), while less than one-fifth of the fertilizer ended up on millet and sorghum (see Table 3).

Fertilizer use in the Gambia is fairly widespread by Sub-Saharan African standards. In 1984, 67% of the groundnut area and 53% of millet area received some mineral fertilizer. In the crisis year of 1985, only 30% of the groundnut area and 21% of millet area was fertilized.

There is considerable change among the groups of farmers who obtained fertilizer in one year or the next. Of those 33% of farmers who obtained no fertilizer for groundnuts in 1984, 16 out of 100 farmers received some in the crisis year of 1985. Of those 67% who obtained some fertilizer in 1984, 27 out of 100 farmers got some in 1985. Only 26% of all groundnut areas did not receive fertilizer in both years.

An evaluation of the distributional effects of the fertilizer shortage has to take into account the specific situation of the organization of production in the Gambia. This is characterized by a high proportion of communal farming in the context of the extended family (the 'compound') which parallels individual farming by men and women farmers. We therefore assess the change in fertilizer use during the crisis separately by:

- income levels of the households ('compounds');
- communal (*mariro*) and individual (*kamanyango*) production;
- men and women farmers.

Fertilizer use more skewed towards high-income groups

Table 4 shows the use of fertilizer by per capita income group (lowest 25% to highest 25%), and by crop. Income from agriculture, non-agriculture and transfers is accounted for by forming the income quartiles. It clearly shows that fertilizer use is generally skewed towards the higher-income groups. This is more the case for millet/sorghum and

Table 3. Use of fertilizer shares, by crops, in 1984 and 1985 (in percentages).

Crops	1984 Total	1984 Total without rice project	1985 Total	1985 Total without rice project
Groundnuts	44.6	57.1	27.7	50.6
Millet, sorghum	20.8	26.7	10.1	18.5
Rice (outside project)	3.1	4.0	3.2	5.8
Rice (in project)	22.0	—	45.3	—
Other crops[a]	9.5	12.2	13.7	25.1
Total	100.0	—	100.0	—
Total *without* rice project	--	100.0	—	100.0

[a]Includes maize and cotton as major crops.

Source: IFPRI/PPMU survey, 1985/86.

Table 4. Fertilizer use by crop and per capita income quartiles, 1984 and 1985 (in percentage of total fertilizer use by crop and year).

Crops	Year	Lowest income quartile	Lower middle quartile	Upper middle quartile	Highest income quartile
Rice (including rice project)	1984	17.3	26.5	30.3	25.9
	1985	12.6	26.6	31.8	28.9
Millet, sorghum	1984	10.2	27.3	23.7	38.7
	1985	6.1	14.2	30.4	49.3
Groundnuts	1984	16.3	23.2	22.6	37.9
	1985	9.1	25.2	22.1	43.7

Source: IFPRI/PPMU survey, 1985/86.

groundnut than for rice, which is dominated by the local smallholder rice project which accounts for 88% of fertilizer used in rice by sample farmers. With the supply crisis in 1985, fertilizer use became even more skewed towards the upper-income groups than in the normal year (1984), and this is particularly true in the case of upland cereals, millet and sorghum. Nearly 50% of the fertilizer used in millet and sorghum is in the highest-income quartile (Table 4).

This distribution pattern of fertilizer by income groups is not only the result of differences in land use or land availability. Upland fields are not really scarce in the region. The same pattern of skewness by income groups also shows up in the use of fertilizer per hectare (see Table 5). The pattern in fertilizer application is most equal in the case of rice, while it is most skewed in the case of coarse grains. In all the three major crops, the poor used the least amount of fertilizer per unit of land and they tended to reduce fertilizer use in the crisis year relatively more than the richer farm households. The fertilizer crisis apparently had a regressive impact on the income distribution.

The role of fertilizer credit

The more equal distribution and more stable use of fertilizer in rice growing provides some interesting insights. This pattern is due to the influential rice project, which assured availability of fertilizer and the functioning of an input credit scheme. About 92% of the fertilizer for rice was acquired through loans in 1985 but only 29% of that for coarse grains and 41% of that for groundnuts (see Table 6). As the share of fertilizer acquisition through loans is reduced, the use of fertilizer becomes more skewed towards the richer farmers who are less constrained by cash availability in the middle of the 'hungry season', when input purchases have to be made. In 1985, only 9% of farmers in the bottom income quartile obtained fertilizer for groundnuts through fertilizer credit, compared with 37% in 1984. In the top income quartile,

Table 5. Fertilizer use per hectare, by income quartiles, 1984 and 1985 (in kg per hectare).[a]

Crops	Year	Lowest income quartile	Lower middle quartile	Upper middle quartile	Highest income quartile
Rice[b]	1984	159	193	176	172
	1985	92	123	131	170
		(−42)	(−36)	(−26)	(−1)
Millet, sorghum	1984	32	66	68	84
	1985	8	11	24	26
		(−75)	(−73)	(−65)	(−69)
Groundnuts	1984	64	82	91	102
	1985	22	34	32	41
		(−66)	(−60)	(−65)	(−60)

[a]Percentage changes are in parentheses.
[b]In the local project and for other rice production.

Source: IFPRI/PPMU survey, 1985/86.

Table 6. Acquisition of fertilizer through loans or cash purchases, 1984 and 1985 (in percentage of total acquisition for each year).

	Acquisition on loans		Cash purchases		Other (barter, gifts, etc)	
	1984	1985	1984	1985	1984	1985
Rice (including local project)	89.4	92.2	8.6	3.6	2.0	4.3
Millet, sorghum	38.6	28.8	60.4	65.6	0.9	5.6
Groundnuts	38.5	41.3	50.8	49.3	10.7	9.4

Source: IFPRI/PPMU survey, 1985/86.

48% obtained fertilizer through credit in 1985, compared with 36% in 1984. Thus access to fertilizer credit became more skewed to the higher-income groups in the crisis year. An effective input financing scheme in the Gambia, therefore, would have not only favourable efficiency effects by increasing the output per unit of land and labour, but also positive equity effects.

Relatively more fertilizer for communal fields

As mentioned above, crop production in the Gambia is organized in communal (*maruo*) fields under the leadership of the compound head, and in fields managed individually by men and women farmers (*kamanyango*). In 1984, 49% of fertilizer was used in *maruo* crops and 51% in *kamanyango* fields. In the crisis year of 1985, however, the share of fertilizer for the communal fields increased to 66%, while the share for the individual fields dropped correspondingly to 34% (see Table 7). Since the *maruo* fields are primarily for the provision of food for the extended family, most of them are rice and coarse grain fields and only a small share of groundnut fields for home consumption. The data suggest that, when fertilizer became so scarce, it was applied relatively more to the crops in the communal *maruo* fields and disproportionately reduced in the individual fields within the extended production–consumption units (compounds). This is probably the result of the decision-making power of the compound heads, aiming for household-level food security. The situation is different only in the case of groundnuts, which are seldom grown as a *maruo* crop.

Women farmers maintained their fertilizer share

How were women farmers affected by these changes? Table 8 shows that on total sample average, women farmers maintained their share of about 20% in fertilizer in the crisis year of 1985. Their share in fertilizer for upland crops (coarse grains, groundnut) increased slightly, while it was reduced in rice. The fertilizer crisis appears to have been more or less neutral for relative access to fertilizer by gender.

These average distribution effects, of course, cover numerous complex constellations of losers in different degrees due to the fertilizer

Table 7. Fertilizer use, by type of fields, 1984 and 1985 (%).

Crops	Year	*Maruo* (communal)	*Kamanyango* (individual)
All crops (including other crops not listed below)	1984	49.4	50.6
	1985	66.1	34.0
Rice	1984	91.5	8.5
	1985	96.3	3.7
Millet, sorghum	1984	65.9	34.1
	1985	81.4	18.5
Groundnuts	1984	17.1	82.9
	1985	18.7	81.3

Source: IFPRI/PPMU survey, 1985/86.

Table 8. Share of fertilizer use by men and women farmers, in 1984 and 1985 (%).

Crops	1984 Men	1984 Women	1985 Men	1985 Women
Groundnuts	78	22	72	28
Millet, sorghum	97	3	94	6
Rice	64	36	81	19
Total average	81	19	80	20

Source: IFPRI/PPMU survey, 1985/86.

crisis. Most hard hit were poor households who had no access to fertilizer through credit and had no fields in the local rice project. Their output was consequently reduced; those who ended up as net purchasers at the end of the season were also affected by the relative increase in the prices of cereals because of the fertilizer shortage.

The output price effects of the crisis are difficult to measure since the cereal trade pattern in the absence of the crisis can only be guessed at. Fertilizer prices as observed at the farm level increased by 27% for cash purchases from 1984 to 1985 and by 69% for loan purchases. The pattern of fertilizer/crop price ratios for cereals and groundnuts changed. Using the cash purchase prices of the crop-specific fertilizer and the actual sales prices of crops, the following ratios can be calculated: in 1984 the fertilizer/coarse grain price ratio was 0.51, compared to the fertilizer/groundnut price ratio of 0.68.[6] In 1985 these price ratios increased somewhat for coarse grains to 0.68, but went down for groundnuts to 0.38. This is largely due to a substantial increase in groundnut procurement prices but more or less stable millet prices.

One may wonder why fertilizer prices did not adjust more flexibly with the sharply reduced supply situation. The complex reasons for the rigidity are related to the marketing system. Release prices are fixed at the cooperative outlets. The village-level market is not impersonal. Although there is reselling of fertilizer within the village and even within the extended family unit, the original purchase price is known and resale in the community is frequently more like passing on the commodity at its original price than actually trading.

Production effects of the fertilizer crisis

The sharply reduced availability of fertilizer in the 1985 cropping season became evident to farmers only at short notice. Until the last moment, even after the rains had started, it was assumed by many that fertilizer from the announced shipments would be available. This situation left little room for farmers to make adjustments through switching crops or adjusting area. The fertilizer crisis is therefore largely expressed in the effects on yield per hectare resulting from reduced fertilizer use. To quantify these effects, we estimated yield functions for the two crops mostly affected: groundnut and millet. The parameter estimates were then used to extrapolate the output losses at the sector level.

Yield functions

The yield functions take cropping practices, level of labour use and other input use into account. The dependent variable in the models is production per hectare in kilograms as reported by the farmers, based on total outputs reported in local volume measures and plot sizes; 610 groundnut fields and 200 millet fields are included in the samples.

The main inputs are labour (in person days), fertilizer (in kilograms), and, in case of groundnuts, seed quantity (in kilograms) which is

[6]While the fertilizer/coarse grain price ratio is dominated by the compound-fertilizer price, it is the SSP price that is more relevant in the case of groundnut.

important to indicate plant density. For labour and fertilizer, the squared terms of input quantities are included in the model to account for potentially decreasing marginal productivity. In addition, relevant variables are included which represent certain technologies used (draft-powered multipurpose tool for field preparation and weeding), characteristics of the responsible farmer (sex and age), type of field (communal or individual), and characteristics of the field.

Table 9. Yield functions for groundnuts and millet, 1985.

A. Groundnuts

Variable	Parameters	*T*-values	Sig *T*
HALAB	4.46013	6.518	.0000
HALABSQ	4.30752E-03	3.419	.0007
HAGNFERT	2.55301	2.524	.0119
HAGNFESQ	2.37936E-03	0.485	.6273
HAGNSEED	1.98383	6.727	.0000
DISTANCE	1.59735	2.077	.0382
SINEUSE	207.26560	4.157	.0000
TYPE	29.28679	0.411	.6812
AGEREC	77.60419	1.315	.1891
GN3YEARS	159.15290	2.831	.0048
GNTRAD	338.73676	6.380	.0000
SEX	225.93810	-4.321	.0000
(Constant)	264.45385	1.657	.0980

R^2 = 0.363
F = 29.9
DF = 597

Variable names

HALAB	labour input per hectare in person days
HALABSQ	labour input per hectare squared
HAGNFERT	fertilizer per hectare in kilogram of material
HAGNFESQ	fertilizer per hectare squared in kilogram of material
HAGNSEED	groundnut seeds per hectare in kilogram
DISTANCE	distance of field from village (minutes walking)
SINEUSE	dummy = 1 if sinehoe was used (multi-purpose tool)
TYPE	*maruo* = 1, *kamanyango* = 2
AGEREC	dummy = 1 if person responsible for field is above 20 and below 60 years of age
GN3YEARS	dummy = 1 if groundnuts have been cultivated last 3 years consecutively
GNTRAD	dummy = 1 if village has a traditionally high share of groundnut production
SEX	1 = male, 2 = female

B. Millet

Variable	Parameters	*T*-values	Sig *T*
HALAB	15.67903	6.521	.0000
HALABSQ	0.03900	-4.821	.0000
HAMIFERT[a]	2.71559	2.885	.0044
DISTANCE	5.04688	-1.544	.1241
SINEUSE	225.99372	2.251	.0255
TYPE	-220.01684	-2.280	.0238
AGEREC	321.75314	3.057	.0026
MITRAD	587.82658	5.530	.0000
SEX	-336.44375	-2.366	.0190
(Constant)			

R^2 = 0.420
F = 16.94
DF = 189

Variable names

HALAB	total labour input per hectare in person days
HALABSQ	total labour input per hectare squared
HAMIFERT	fertilizer per hectare in kilogram of material
DISTANCE	distance of field from village (minutes walking)
SINEUSE	dummy = 1 if sinehoe was used (multi-purpose tool)
TYPE	*maruo* = 1, *kamanyango* = 2
AGEREC	dummy = 1 if person responsible for field is above 20 and below 60 years of age
MITRAD	dummy = 1 if village has a traditionally high share of millet production among crops
SEX	1 = male, 2 = female

[a]The square term of fertilizer use was excluded from this model because the estimated parameter was insignificant with the implausible positive sign.

Table 10. Yield response of fertilizer in groundnuts and millet, 1984 and 1985 (in kg of output, calculated at mean values).

Crops	Kg of output per hectare yielded by one additional kg of fertilizer[a] 1984	1985
Groundnuts	2.65	2.39
Millet	2.52	2.72

[a]Expressed in kg of material (rather than nutrients). In groundnuts, mainly SSP; in millet, mainly NPK-compound, 15–15–15, used.

Source: Calculated on the basis of yield functions separately estimated for the two years. For results of the 1985 models, see Table 9.

The parameters for 1984 in the yield function for groundnut were

3.738 HAGNFERT − 0.00558 HAGNFESQ
(5.420) (−2.96)

for millet

3.273 HAMIFERT − 0.00405 HAMIFESQ
(1.89) (−0.90)

(*t*-values in parentheses, for variable names see Table 9)

The estimated yield functions show sensible results (and, given the output and input data, are based on recall information) and the explained variance of 36% in the groundnut model and 42% in the millet model, respectively, appears quite satisfactory (see Table 9).

At the margin, productivity of labour is estimated to be higher in millet than in groundnuts. Holding everything else constant, an additional person day yields 3.3 kg of groundnuts, equivalent to 3.65 Dalasi (about US $0.49), which was close to the prevailing rural wage rate in 1985 (4.00–5.00 Dalasi). Marginal labour productivity in millet is estimated to be 7.38 Dalasi (8.8 kg), which may be higher than in groundnuts in that year because of intra-seasonal rainfall distribution patterns. Average labour productivity in crops was certainly adversely affected by the reduced availability of fertilizer in 1985. The effect of this is the focus of the following discussion.

Output response to fertilizer

Output response to fertilizer is apparently high and stable in the Gambian agriculture at current levels of fertilizer use. One additional kilogram of fertilizer material yields about 2.4 kg of groundnuts and 2.7 kg of millet at current mean values of fertilizer use. This refers to SSP in the case of groundnut, and compound NPK (15–15–15) in the case of millet, in terms of volume rather than in terms of nutrient quantities. With the fertilizer/output price ratios of 0.38 for groundnuts and 0.68 for millet, the marginal productivity of fertilizer for both crops indicates that fertilizer use is far below optimal levels. This remains true if the unsubsidized price of fertilizer is taken into account, rather than the actual price ratios at farmgate which were distorted by the fertilizer subsidy. Fertilizer subsidies per unit were 64% for compound 15–15–15 and 50% for SSP in 1984.[7]

It is interesting to note that the marginal output effects of fertilizer in 1984 were hardly different from those in 1985 (see Table 10). This is particularly noteworthy as the climatic pattern was remarkably different in the two years; 1984 was affected by a drought while 1985 was a year with reasonable levels and distribution of rainfall. While in the 1985 yield functions the output effects of fertilizer do not significantly decrease at the margin, this was clearly the case for groundnut in 1984, as indicated by a negative significant parameter of the squared fertilizer input in the 1984 yield function (Table 10). Yet the negative effect at the margin is small in the range of current fertilizer use for groundnut and millet. Most farmers who apply fertilizer apparently operate in the nearly linear segment of the fertilizer-yield function even in a year of normal fertilizer supplies such as 1984 (Table 9), and the fertilizer response was hardly affected by the 1984 drought condition. This indicates substantial scope for expansion beyond these 'normal' levels of fertilizer use, for both groundnuts and millet.

[7]Government of the Gambia, *op cit*, Ref 2, p 63

Cost of the crisis

The cost to the Gambia of the fertilizer crisis was substantial. Even taking into account that the fertilizer was a grant that did not arrive on time, and thus the material was not purchased at foreign-exchange cost by the Gambia, the country incurred losses because domestic resources were underutilized. The marketing system and the farmers' productive resources could have been used more efficiently. The net returns to fertilizer, if it had continued to be imported commercially, would certainly have been positive.

The calculation of losses due to the crisis shown in Table 11 takes a different point of reference for the evaluation: the gross output forgone is calculated applying the yield functions and by contrasting the 1985 actual fertilizer use with the 1984 actual use, assuming that 1984 levels would have been achieved had the fertilizer shipments arrived on time in 1985. This is a rather conservative scenario as even higher fertilizer use levels have been achieved in years past (see Table 1).

For a complete accounting of the cost of the crisis from these gross losses due to production forgone, the costs saved at the margin due to the late arrival of fertilizer, such as variable costs saved for inland transportation of fertilizer and output produce, a reduced labour input for harvesting, and so on would have to be deducted. To these would have to be added the cost due to losses in fertilizer value because of its late arrival and related deterioration in storage. This latter item probably exceeds the former (especially in the case of urea fertilizer in storage). No attempt is made to guess the net effect of these two groups of benefit and cost items which partly offset each other; it would not substantially affect the gross value of loss.

The gross value of production forgone amounts to about 10% of agriculture's GDP in 1985 (see Table 11). While farmers lost about 19 million Dalasi due to lower output, they also spent about 4 million Dalasi less for fertilizer. This net loss in farm income of 15 million Dalasi corresponds to about 375 Dalasi per farm family (or $50 at the 1986 exchange rate).

The lack of fertilizer has substantially affected the agricultural trade balance in a year when the Gambia was in a severe foreign-exchange crisis. The unavailability of fertilizer had reduced groundnut exports, the country's main export commodity, by about 16% and increased cereal import requirements by about 15%,[8] thus widening the trade and foreign exchange problems on both sides of the account.

A hidden cost also results from disruptions in fertilizer supply which prevent the development of an effective fertilizer distribution system. The Gambia's experience in the early 1980s suggests that growth in fertilizer use is a function of farmers' effective demand for fertilizer and

[8]These figures are based on preliminary estimates of groundnut export and cereal import figures for 1985–86.

Table 11. Production lost due to fertilizer crisis, 1985.

Crops	Output lost per hectare (in % of 1985 yield in sample survey)	Approximate output lost at country level[a] (tons)	Value of output lost at 1985 prices[b] (1000 Dalasi)	(in % of agricultural GDP, estimated)
Groundnuts	10.4	7 883	8 829	4.6
Millet	13.2	12 276	10 226	5.3
Total			19 055	9.9

[a]The 1985 preliminary production estimates were used as basis.
[b]The 1985/86 after-harvest prices were used as basis.

the timely availability of adequate fertilizer of the right type at a growing number of geographically dispersed locations. This, in turn, depends on the development of adequate and efficient supply and distribution systems.

Policy conclusions

Use of chemical fertilizer per hectare of cropland in the West African semiarid tropics is below that in any other area of the developing world. Peter Matlon identifies the following major factors that explain the low use rates: (1) costs of foreign exchange, (2) high transport costs, (3) low and variable response rates to local cereal varieties, (4) poorly developed extension and distribution systems, and (5) inadequate farm-level liquidity.[9] While fertilizer use rates in the Gambia are far above West African averages, the 1985 supply crisis and its effects at the micro-farm level were clearly shaped by some of these factors. The shift towards donor dependence in fertilizer supplies brought about by foreign-exchange constraints, inadequate farm-level liquidity and malfunctioning distribution systems resulted in use patterns skewed towards richer farmers in general, especially in a year of acute shortage such as 1985.

The potential of fertilizer use is far from being exploited in this area of West Africa, as indicated by stable and high marginal output response to fertilizer, in both traditional cereals (millet) and groundnuts, which by far exceed marginal cost. However, to tap the potential short-term increase in agricultural output requires fulfilment of some simple conditions which in reality turn out to be complex: fertilizer of the right type needs to be available at the right time if it is to be profitable.[10] This requires functioning distribution systems and well-planned import and distribution policies. Appropriate interaction between government and private sector is called for to cope with the problem. The 1985 Gambian fertilizer crisis shows that the problem is increased in small countries because a management problem in a single public-sector organization or in a single donor institution may completely disrupt the system. Such insecurities effectively preclude a significant opportunity for the private sector to develop. A lesson learned in this case is that adjustment costs of rapid fertilizer policy changes with donor support may be high. The move to abolish existing inefficient systems may easily lead to short-term crisis, which appears avoidable. More careful programme planning and risk-averse strategies to policy reform should avoid total dependence on single programmes for strategic inputs.

In a supply crisis in this West African setting, numerous institutional factors determine on which crops and on whose fields the scarce fertilizer actually ends up. As has been shown, local power of projects, household-level influence of the heads of extended families, and income (or status) level of households are important factors. When fertilizer availability was reduced by 64% in 1985 over the previous year, relatively more of the remaining fertilizer ended up on communal fields of the extended families than on the individual fields. Food security objectives of households who are driven by a desire to have high levels of self-sufficiency in an environment of vulnerable markets are important for final use patterns of fertilizer.

An ill-designed credit scheme increases the unequal distribution effects of a fertilizer crisis as exemplified by the case study. An effective

[9]Peter J. Matlon, 'The West African semi-arid tropics', in *Accelerating Food Production in Sub-Saharan Africa*, John W. Mellor, Christopher L. Delgado and Malcolm J. Blackie, eds, Johns Hopkins University Press, Baltimore, MD, 1987, p 73.

[10]On this issue, see John W. Mellor, Christopher L. Delgado and Malcolm Blackie, eds, *Accelerating Food Production in Sub-Saharan Africa*, Johns Hopkins University Press, Baltimore, MD, 1987, p 360.

credit scheme reaching the poor who have seasonal cash constraints, especially before the cultivation season, is essential to reduce the regressive effect of fertilizer for rural income distribution. Women farmers in the Gambia use significant quantities of fertilizer and need to be included in such schemes to assure their efficiency.

The price effects of a fertilizer supply disruption can be small in a situation with public-sector marketing and 'markets' at the local level which are personal. Trading and price adjustments during the crisis did not apparently play any significant role in redirecting the increasingly scarce commodity to its most profitable use.