Adjustment programmes and agricultural incentives in Sudan: A comparative study

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Abstract

This study analyses the impact on agricultural price incentives of the main adjustment programmes implemented by the Sudanese government during the period 1978-1993, notably the Economic Recovery Programme (ECRP) 1978-1985 and the national economic Salvation programme (NESP), 1990-93.

The study addresses two basic questions: Did these programmes provide any tangible incentives to agriculture? And are improved price incentives an efficient and sufficient condition for increasing aggregate agricultural output?

The effects of the programmes on the level and stability of price incentives were measured, both at the sectoral (direct) and economywide (indirect) levels. The results indicate that both programmes failed to improve either the level or the stability of real farm prices. Poor macroeconomic policies appear to be the main cause.

With regard to the efficacy of price incentives in stimulating aggregate agricultural output, the findings tend to confirm the predominant view that increases in real farm prices have positive but limited overall effect on agriculture. Non-price factors appear to play a greater role in determining aggregate agricultural output. The analysis implies that without the provision of adequate credit, public investments and improvement in infrastructure, the aggregate response of agriculture to price incentives would be minimal.

I. Introduction

Domestic policy in Sudan, as in many developing countries, has discriminated against agriculture and exports. The agricultural sector over the period 1980-1990, and on all counts, showed poor performance, which was attributed to both domestic and external factors. In an attempt to improve the performance of agriculture a number of stabilization and structural adjustment programmes were implemented during the period 1980-1993.

The current economic programme, the national economic salvation programme (NESP), initiated in 1990, appreciating the fact that Sudan's agriculture has been heavily taxed and discriminated against, attempted to remove this bias. Like its predecessors, the economic recovery programme (ECRP) 1978-1985 and the four-year economic salvation programme (ESP) 1987-1989, the NESP sought the attainment of a balance of payments and a higher rate of investment and economic growth. Its main target was to promote agricultural production through a combination of reforms of the production systems and price incentives and the liberalization of farm prices and foreign trade.

The performance of agriculture under these programmes varied considerably. In terms of overall growth in agricultural output, the NESP is superior. But this should not be interpreted to mean that the NESP succeeded in promoting agricultural growth and that other programmes failed. The performance may vary considerably depending on factors such as the magnitude of the economic crisis that preceded each programme; the extent to which the government actually implemented and sustained the adjustment reforms; and the effect of exogenous factors, such as weather, civil war and changes in the terms of trade facing the country.

Stabilization, structural adjustment and agriculture in Sudan

In a study of Sudanese agriculture, Acharya (1979) found that the industrial and trade policy framework in 1970-1975 imposed sizeable implicit and explicit taxes on agricultural crops and harboured an overall incentive bias in favour of industry. On the basis of data for the period 1970-1980, Sudan was classified as a highly inward-oriented country with substantial bias against agriculture and exports (World Bank, 1987). This biased system of protection led to the over-valuation of the Sudanese pound, discriminating further against exportable goods, most of which are agricultural products.

The economic recovery programme (ECRP) was introduced in 1978 with the main

purpose of reforming the pattern of incentives both within agriculture and between agriculture and industry. The ECRP, implemented by the government then in power, was supported by the International Monetary Fund (IMF) and the World Bank. Its major targets were to adopt a more realistic exchange rate, reduce quantitative restrictions and remove export taxes. Several domestic measures were also taken to complement the trade reforms in order to promote exports.

Assessments of the ECRP in Sudan differ widely according to the methodology and evaluation used, but there is almost unanimous agreement that the ECRP failed to attain its objectives (Awad, 1983; Hussein and Thirlwall 1984; Ali, 1985; Umbadda and Shaaeldin, 1985; Brown, 1986; Hag Elamin, 1990). Disagreement exists over the causes of this failure. Critics of liberalization policies doubt the efficacy of the adopted policy reforms in Sudan in promoting agriculture, particularly devaluation (Hussein and Thirlwall, 1984; Ali, 1985). The IMF and the World Bank relate the failure to poor implementation and weak government commitment (World Bank, 1985). Others claim that exogenous factors were the main cause. Internal policy weaknesses, deteriorating terms of trade facing the country, weather and environmental hazards, and civil war that coincided with the implementation of the programme, all appear to have contributed to the poor performance of agriculture and exports over the period 1970-1990. The most devastating was the escalating civil war in the southern part of the country.

The actual cause seems likely to combine elements of all these factors, so that the impact of the adopted policies on agriculture thus remains unclear. Further investigation and analysis are necessary to help resolve the issues.

The NESP was introduced in 1990 with the objective of rectifying the shortcomings of previous stabilization and adjustment programmes. Whether it succeeds or not is still a question open for discussion and empirical investigation. The critical consideration in assessing its impact on agricultural production is its effectiveness in improving incentives for farmers.

Aims and approach of the study

The common feature of the adjustment programmes in Sudan is their heavy emphasis on the importance of reforming the pattern of incentives in agriculture. In order to assess such programmes it is necessary, therefore, to answer the following two basic questions:

- Did the programme provide any tangible price incentives to farmers?
- Are improved price incentives an efficient and sufficient condition for improving agricultural performance in an economy such as Sudan's?

Evidence on the positive response of agriculture to price changes in developing countries is accumulating. Empirical studies on Sudan have shown mixed results, but generally there is consensus that individual crops are reasonably responsive to prices.[1] Disagreement exists on whether aggregate output responds positively to price changes, and whether the low supply elasticities justify emphasis on price policies. Notwithstanding

these different perspectives, there is agreement on the importance of incentives, both price and non-price, as the main instrument required to promote agricultural production and exports. The question remains as to whether the stabilization and structural adjustments have actually created the required price incentives and whether these price incentives were supported by the appropriate non-price policies to bring about the required changes in the agricultural sector.

The ECRP and NESP differ considerably in terms of programme design, government commitment, magnitude of policy changes, and external influences. Thus one would expect the two programmes to have created different effects on agriculture based on their impact on price and non-price incentives. Comparing the two programmes may help, therefore, in understanding the major problems constraining the sustainability and implementation of adjustment reforms in Sudan, and whether these problems are related to weaknesses in implementation, exogenous factors or the inadequacy of the prior policies.

This study attempts to measure and compare the impact on agricultural price incentives of the two main stabilization and structural adjustment programmes implemented over the period 1978-1993. These two programmes are the economic recovery programme (ECRP) 1978-1985, and the national economic salvation programme (NESP) 1990-1993. The comparison of the two programmes gives more valuable insights than would be obtained from studying one or the other. In analysing farm price incentives, the study attempts to distinguish programme effects (policy-induced effects) from non-programme effects (exogenous effects). The effects of exogenous factors are best examined in a counterfactual analysis, i.e., what would agricultural incentives have been like in the absence of the adjustment programmes? Given the difficulty of establishing the counterfactual case, this study concentrates on the assessment of the level of policy-induced effects, with some attempt at assessing effects of a major exogenous factor, terms of trade. Within the policy-induced effects, a further distinction is made between the effects resulting from sectoral policies and those resulting from economy-wide policies. This distinction is important given that the two programmes differed in the content and sequence of each of these type of policies. Although the two programmes pursued more or less the same kind of policies, NESP seemed to place greater emphasis on sectoral policies than did ECRP.

The comparison of the ECRP and the NESP may be criticized because the latter is still ongoing and its impact on agriculture may not yet be fully visible. This problem is actually less acute because the study is largely concerned with the comparison of the two programmes in terms of their effects on agricultural incentives rather than on agricultural output. In addition, four years have elapsed since the start of the NESP in 1990, and this period is sufficient to assess effects on incentives.

Recognizing that the success of any policy to promote agricultural performance depends critically on how agricultural producers respond to price changes, the study, by improving data quality and econometric tests, examines the supply response of aggregate agricultural output to changes in both price and non-price incentives.

The study proceeds as follows: Section II describes the main policy measures adopted

by the ECRP and NESP and the overall performance of agriculture in each programme. In Section III the effects of these programmes on the level and stability of agricultural price incentives are measured and compared. Section IV examines the response of agricultural output to changes in price and non-price incentives, and Section V presents conclusions and policy implications.

II. Agricultural sector performance and policies

Structure of the agricultural sector

The agricultural sector plays a pivotal role in Sudan's economy. It contributes, on average, about 36% of the country's GDP, over 90% of export proceeds and 75% of the productive sectors' value added, and employs 70% of the labour force. In addition, it produces over 90% of the national food requirements. Most of the productive capacity of the country depends heavily on agriculture as a source of raw materials, wage goods, foreign exchange earnings, and markets for goods and services produced by other sectors. Therefore, the productivity and efficiency of agriculture are central to any programme for economic recovery.

The agricultural sector comprises five main sub-sectors: irrigated; mechanized rainfed; traditional rainfed; livestock; and forestry. Out of Sudan's total area of approximately 200 million feddans (1 feddan = 0.42 hectares) of cultivable land, only about 25 million to 30 million feddans are currently under crop. The irrigated crop subsector contributes, on average, about 27% of the agricultural GDP. It produces over 95% of Sudan's cotton, most horticultural products, all the wheat and almost half of the groundnuts. Sorghum production in irrigated areas is deliberately kept low, for only subsistence purposes, as it is assumed to be produced more economically in rainfed areas. All major irrigated agricultural schemes are publicly owned, and are operated in collaboration with tenants. The crop mix, input use and variety selection are controlled by the government. The major public agricultural schemes include Gezira, Rahad, New Halfa and Suki. Each scheme has a typical farm size that varies between 10 and 40 feddans. For instance, in the Gezira scheme, the biggest agricultural scheme in Sudan, the standard tenancy size is 40 feddans.

Mechanized rainfed farming covers about 9 million feddans. Farms are privately owned and operated. This subsector is characterized by large farm size, with typical holdings of 1,000 and 1,500 feddans. Principal crops are sorghum and sesame, with sunflower and short-staple cotton assuming increasing importance. The traditional rainfed crop subsector covers about 11 million feddans. Farm size in traditional agriculture varies considerably, but holdings are generally small (fewer than 10 feddans). The important crops grown are sorghum, groundnut, sesame, gum arabic and millet. Farms are privately owned and operated.

The livestock subsector contributes about 35% of agricultural GDP and 15% of agricultural export products. It absorbs about 0.5 million members of the labour force. The animal population is estimated at about 60 million head.[2]

Economic reform programmes

During the late 1970s Sudan's economy began to experience severe interdependent structural problems that inhibited economic growth (World Bank, 1985). The internal sector has long suffered from excess aggregate demand resulting in inflationary pressures in the economy. This is further aggravated by the devastating effects of the civil war in the south and frequent incidence of drought. In the external sector there has been a continuous deficit in the balance of payments and accumulation of external debts.

To address these issues, the government has launched a series of development plans and programmes. These include the five-year plan (1972-1977), the economic recovery programme (ECRP - 1978-1985), the four-year economic salvation programme (1987-1989), the national economic salvation programme (NESP - 1990-1993) and more recently the ten-year national comprehensive development strategy (1992-2002). All these plans and programmes were either adjusted or terminated due to either their failure or a change of government. The programmes that had a better chance of implementation were the ECRP and the NESP. The remaining part of this section describes the performance of the economy under each of these two programmes.

ECRP policies and performance (1978-1985)

The main economy-wide policy action taken by the government during the ECRP was the devaluation of the Sudanese pound followed by attempts to adopt tighter demand-management policies. The potential effects of these policies, however, were undermined by rising inflationary pressures. During 1978/79-1984/85 the official exchange rate was devalued, on average, by 14.5% per annum, whereas the domestic inflation over the same period grew by 27% per annum.

A series of sector-specific policies were implemented in agriculture, the most important of which were the introduction of the individual account (IA) system of production relations in the Gezira scheme; general rehabilitation of the major public agricultural schemes; reduction of export taxes for agricultural exports; and the dismantling of the monopoly power of the Oilseeds Company in oilseeds exports. In 1981 the joint account (JA) system of production relations in the Gezira scheme was replaced by the individual account (IA) system. Accordingly, each tenant paid fixed land and water charges that varied from one crop to another depending on the cost and the amount of water used. The disincentive effects of the JA system were partly removed, since under the new arrangement the tenant's incremental income was not shared with the government. Another important characteristic of the IA was that costs of production were charged per unit area (feddan), rather than per unit output as was the case in the JA, thus providing incentive for increasing yield. This movement represented the initial step in the privatization of the public irrigated schemes in Sudan.

Despite the government effort of introducing changes in the areas of exchange rate, pricing policies, export taxes, production relations and public investment, a host of other policy variables were left untouched. The irrigated sector continued to be controlled by

the Agricultural Public Corporations (APCs). The government continued to decide the crop rotation, varieties to be grown and input quantities, and to control farm-gate prices of cotton, wheat and gum arabic. The APCs also continued to recover land and water charges of all crops from cotton proceeds simply because cotton marketing was controlled by the government, while the marketing of other crops was managed by the tenants, a factor that made cotton a relatively less profitable crop.

Marketing of principal exports like cotton, gum arabic and oil seeds was monopolized by the government through its public marketing parastatals. Although these export marketing parastatals were described by various government reports as less than efficient, little was done to change their marketing policy. They failed to stabilize producer prices and reduce seasonal price variations. Furthermore, they dampened incentives for producers by keeping agricultural prices at very low levels compared with international prices.

Formal credit to agriculture was confined principally to the Agricultural Bank of Sudan (ABS), and rural financial markets in Sudan were dominated by informal lenders. The ABS credit was channelled mainly to a limited number of large-scale farmers who could provide guarantees. The ABS was unable to recover enough of its loaned funds, and experienced several additional problems including high administrative costs, interest rates fixed at negative real values, capital erosion, poor coordination and inadequate supply of loanable funds. The other source of formal credit to agriculture was the Bank of Sudan. It provided loans to the APCs, which were in most cases regarded by farmer unions as a subsidy from government. This resulted in accumulation of debts against APCs, a factor that contributed significantly to the inefficiencies of APCs. The commercial banks' credit to agriculture was negligible since they concentrated on financing industry and foreign trade.

The economy in general and agriculture in particular were crippled by a series of cumbersome bureaucratic procedures such as import licensing, registration of exporters, reporting of stocks and restrictions of crop movements. These administrative interventions greatly discouraged production and exports. Moreover, domestic policies were unstable, which was clearly manifested in the pricing and marketing of agricultural products. Abolishing and then reinstating government monopolies in oilseeds is one example of the changes in government policies that created a discouraging environment for production and exporting.

These policy changes were not the only variables that affected agriculture. A host of exogenous negative shocks coincided with the implementation of the adjustment policies in 1978-1985. Most notable were the civil war, the spread of droughts and famines, and the influx of refugees from neighbouring countries. The drought effect was more devastating to rainfed crop production and livestock (Teklu *et al.,* 1991).

Performance of the economy

The basic macroeconomic indicators during the ECRP period are presented in Table 1. As can be seen from the table there was a heavy variability in the real GDP during 1978-

1985 with an annual average growth rate of -0.3%. Given the population growth of 2.9% a year, the poor performance of GDP implies a decline in real per capita GDP. The agricultural GDP was even worse. The poor performance of agriculture originated mainly from the decline in productivity especially in the irrigated sector due to the deterioration of irrigation infrastructure, worn out capital and the disincentive effects brought about by the application of the joint account system of production relations in the public irrigated schemes before 1980/81.

Agriculture recorded an exceptional growth rate of 32% in 1981/82, which was believed to be the result of the implementation of the agricultural rehabilitation programme and the replacement of the joint account system by the individual account system (World Bank, 1985). During the period 1982/83-1984/85, however, both GDP and agriculture recorded negative growth rates. This was attributed to the severe drought at that time.

The country's balance of payments deteriorated significantly during 1978/79-1984/85. Exports were declining with heavy annual fluctuations. Imports increased steadily from US$1,116 million in 1978/79 to US$1,754 million in 1981/82 and then declined to US$1,178 million in 1984/85 as a consequence of restrictive measures adopted by the government. The trade gap was partially covered by increasing receipts of remittances[3] and commodity aid, but there was still substantial deficit in the current account.

Table 1: Macroeconomic indicators during ECRP (1978/79-1984/85)

	78/79	79/80	80/81	81/82	82/83	83/84	84/85
GDP value (S£ million)*							
constant 1981/82 price	5396	5589	5671	6237	6264	6084	5806
Agricultural GDP (S£ million)							
constant 1981/82 price	2030	1897	1814	2369	2214	2159	1651
GDP growth rate	-10.0	3.6	1.5	10.0	0.4	-2.9	12.8
Agricultural GDP growth rate	-17.0	-6.6	-4.4	32.0	-7.6	-2.5	-23.6
Exports (US$ million)	527	594	538	439	568	721	549
Imports (US$ million)	-1116	-1339	-1540	-1754	-1543	-1370	-1178
As % of GDP							
-Agriculture	37.6	33.9	32.0	38.0	35.3	35.0	28.4
-Investment	13.2	15.1	15.3	19.0	17.4	16.5	16.2
-Revenue	9.0	11.0	13.0	16.0	14.0	12.0	12.0
-Expenditure	15.0	17.0	25.0	22.0	19.0	18.0	23.0
-Budget deficit	6.0	5.0	12.0	6.0	5.0	8.0	12.0
Money supply (S£ million)				1825	2543	2975	4421
Inflation rate (19..=100)				13.4	21.5	28.2	45.5

Sources: 1) World Bank (1990).
2) Ministry of Finance and Economic Planning (1993).
*S£ = Sudanese pounds

Up to 1982/83 Sudan was able to compensate for the poor export performance by external borrowing and assistance. By the late 1980s, however, access to external financing was severely curtailed and Sudan failed to meet its debt service obligations. Despite several Paris Club scheduling arrangements, Sudan's external debt began to mount. In 1984 the total outstanding external debt was about US$6 billion; the arrears were US$1.5 billion in 1985, with a debt service ratio of about 30%.

The fiscal performance of the economy for 1978/79-1984/85 was weak. The share of total revenue to GDP remained stagnant with an annual average rate of 12%, while the share of government expenditure to GDP increased from 15% in 1978/79 to 23% in 1984/85, mainly due to the increasing costs of the civil war in the southern part of the country. The poor fiscal performance resulted in large budgetary deficits. External finance and use of foreign aid counterpart funds covered about 60% of the overall deficit, leading to more dependence on foreign aid. There was a considerable increase in money supply, with the annual rate of monetary expansion reaching about 40% during 1981/82-1984/85. The average inflation rate for the same period was 27%.

The performance of agriculture

The performance of agriculture shows a sharp contrast between irrigated and rainfed subsectors (Table 2). While both production and yield levels improved in the irrigated subsector they declined significantly in the rainfed subsector, thus overall agricultural performance remained stagnant. Despite the slight improvement in yield in the irrigated sector, yield levels in both subsectors were very low compared with proved potential and the attainable levels in countries with similar resource potential. Furthermore, production and yield were more stable in the irrigated subsector than in the rainfed subsector, which is more vulnerable to fluctuations in rainfall.

Table 2: Production and yield indexes 1978/79-1984/85

	78/79	79/80	80/81	81/82	82/83	83/84	84/85
Production*							
-Irrigated	72	81	58	75	77	83	98
-Rainfed	110	77	108	146	80	78	41
Yield*							
-Irrigated	87	77	85	116	107	110	117
-Rainfed	89	86	104	106	81	74	60

*A weighted average for various crops is used.

Source: Calculations based on data obtained from the Department of Agricultural Economics and Statistics, Ministry of Agriculture, Sudan.

Several factors contributed to the poor performance of agriculture in 1978-1985. Most

important of these was the domestic policy bias against agriculture. The over-valued exchange rate, production taxes, state monopolies, inadequate credit and the heavy regulatory environment all contributed to the poor performance of agriculture. In addition, the sector continued to face severe structural and technological constraints.

The government allocated substantial resources to the agricultural sector in 1978-1985, amounting on average to about 28% of public investment. The bulk of this investment was directed to the irrigated sector as part of the agricultural rehabilitation programme. The rainfed subsector, despite its significant contribution to the national economy, received only a small share of public investment.

NESP policies and performance (1990-1993)

The programmes prior to 1989 allowed only for partial adjustment measures rather than a comprehensive policy reforms. These partial adjustments led to increased inflation, under-utilization of capacity and stagnation in economic growth. As a result, Sudan became heavily dependent on commodity aid and external foreign assistance. In an attempt to reverse the economic decline and stimulate economic growth, the government embarked on a medium-term three-year economic programme referred to as the national economic salvation programme (NESP) 1990-1993.

Objectives of the NESP

The NESP aimed to reallocate available resources in favour of the production sectors, particularly agriculture, with the following objectives:

- Concentrating on agricultural production to achieve self-sufficiency, food security and social equity.
- Liberalizing the economy, deregulating price controls and removing administrative and legal barriers in order to stimulate agricultural exports to generate more foreign exchange.
- Enhancing the role of the private sector and privatizing state-owned enterprises.
- Achieving financial and social stability.

The programme declared that the vulnerable segments of the society would be given special consideration, through social welfare programmes, to alleviate adverse effects of the adjustment process.

NESP policy package

The policy measures adopted to achieve these objectives can be broadly categorized as:

- Economy-wide policies:
  - Unifying the foreign exchange rate and freeing the circulation and use of foreign exchange by commercial banks, firms and individuals.

- Lifting price controls and regulations to allow market forces to interact.
- Abolishing minimum export prices and licensing systems and lifting import restrictions.
- Adopting more restrictive fiscal and monetary policies (efforts in this regard were not successful due to the increasing government spending on the civil war).

- Agriculture sector-specific policies:
  - Removing subsidies on goods and services provided by the APCs, most important of which are fertilizers, insecticides, land and water.
  - Significantly reducing subsidies on food products.
  - Lifting price controls and regulations imposed by the government on agricultural commodities; the exception is wheat, where government intervention is maintained by determining the minimum procurement price.
  - Abolishing the monopoly of public marketing parastatals: the Oil Seeds Company, Livestock Marketing Corporation and Cotton Company.
  - Reducing export taxes to 5% for all exports except cotton and gum arabic, for which export tax was reduced to 10%
  - Shifting APCs financing to a consortium of commercial banks and retaining credit ceilings for agriculture at higher proportion, where 50% of total credit was devoted to agriculture. The banking services were also expanded through the establishment of new specialized banks and expansion of the services of the existing ones. A major change in agricultural finance was the adoption of Islamic forms of lending (*Murabaha and Salam*).
  - Rigorously revising the 1990 Investment Encouragement Act to include more concessions and privileges to attract national and foreign investment.
  - Reforming government administrative structures to cope with liberalization policies and enhance the role of the private sector.

The overall performance of the economy

The performance of the macroeconomic indicators during the NESP period are summarized in Table 3. The GDP growth rate increased from 1.2% in 1990/91 to 11.3% in 1991/92, and reached its highest level of 13.1% in 1992/93. The average annual growth rate over the three years was 8.5%. This improvement in GDP performance was attributed mainly to the significant recovery in agriculture, as its growth rate rose from -4% in 1990/91 to 31% in 1991/92 and 27% in 1992/93. Other sectors of the economy remained stagnant.

Table 3: Macroeconomic indicators 1990/91-1992/93

	90/91	91/92	92/93
GDP value (S£ million) constant 1981/82 prices	6691.00	7447.00	8473.00
Agricultural GDP (S£ million) constant 1981/82 price	1918.00	2522.00	3206.00
GDP growth rate	1.20	11.30	13.10
Agricultural GDP growth rate	-4.20	31.50	27.00
Exports (US$ million)	343.00	347.00	385.00
Imports (US$ million)	-1486.00	-1268.00	-1005.00
As % of GDP			
- Agriculture	28.70	34.00	38.00
- Investment	15.10	17.20	25.60
- Revenue	8.00	8.00	11.00
- Expenditure	10.00	15.00	17.00
- Budget deficit	2.00	7.00	6.00
Money supply (S£ million)	31645.00	51497.00	132998.00
Inflation rate	114.00	106.00	112.00

Source: Ministry of Finance and Economic Planning (1993).

The balance of payments position was not encouraging, as export performance was declining and foreign debts were mounting. During the period 1990-1993 the value of exports stagnated at an annual average of about US$360 million. This was too low compared with US$500 million average for the 1980s. The current account deficit was US$1.9 billion in 1990/91 and US$1.2 billion in 1992/93, while the trade account deficit was US$1.14 billion in 1990/91, US$0.94 billion in 1991/92 and an estimated US$0.62 billion in 1992/93. The net capital inflow recorded a continuous decline as foreign aid fell sharply, reaching its lowest level of US$101 million in 1992/93. Sudan's outstanding debts reached about US$15.0 million in 1992/93, with the arrears estimated at US$8.4 billion. The debt service ratio in 1989 was about 118%.

In terms of fiscal performance, the ratio of domestic revenue to GDP was about 8% in 1990-1992, but rose to 11% in 1993. There was a considerable improvement in the contribution of tax revenue, which rose from 122% in 1991/92 to 214% in 1992/93. The total expenditure as a share of GDP increased from 10% in 1990/91 to about 17% in 1992/93. Despite this improvement, the budget deficit remained high and was mainly financed internally by central bank borrowing with no or little external finance.

Money supply during the NESP increased fourfold, from (Sudanese pounds) S£31.6 billion in 1990/91 to S£51.5 billion in 1991/92 and an estimated S£133 billion at the end of the programme. The money supply grew at an average annual rate of 83%. This led to a high level of inflation, estimated at 114% in 1990/91, 106% in 1991/92 and 112% in 1992/93.

Agricultural policies and performance

The policy reforms assigned agriculture its leading role as the engine of economic growth. These policy changes were taken as an active initiative towards a change in strategy rather than a temporary adjustment to internal and external shocks.

The nominal exchange rate of the Sudanese pound per U.S. dollar was devalued from the official rate of S£4.5/US$1.0 in 1991 to 90 in February 1992 and 140 in May 1993. Recognizing the adverse effects of liberating the foreign exchange rate on the prices of imported inputs, the government adopted a preferential exchange rate (between the official and market exchange rates) for the import of essential inputs. Substantial improvements were achieved in the area of pricing of products, where the role of the Ministry of Commerce in controlling prices was frozen and ministerial committees were set up to oversee a set of flexible induced prices.

To reinforce the role of the private sector the government launched a phased programme for privatization and liquidation of public sector enterprises. Some of the APCs were liquidated, e.g., Nuba Mountain Corporation and Livestock and Meat Marketing Corporation, while several others were identified as targets for privatization. As for the major irrigated APCs (Gezira, Rahad and New Halfa), their boards of directors were reconstituted with farmers given 50% of the seats to enhance their role in decisions affecting their well-being. Staffing of parastatals was reduced by 30%-40% following restructuring so as to emphasize commercialization. Plans are underway to privatize ginneries and agricultural machinery services, offering farmers the key role in any privatization plan.

The agricultural sector showed significant growth in 1990/91-1992/93, with rates outpacing those of the economy as a whole. This resulted from the increase in both area and yield (Table 4). The production and yield indexes based on 1986/87-1988/89 seasons (Table 4) indicate substantial increases in production, particularly in the irrigated sub-sector. Food crops recorded a higher growth rate than export crops. This is largely attributed to the food security action deemed necessary by the government.

Table 4: Production and yield indexes 1990/91-1992/93 (1986/87-1988/89=100)

	90/91	91/92	92/93
Production*			
- irrigated	119	164	123
- rainfed	25	91	119
Yield*			
- irrigated	92	175	157
- rainfed	78	104	97

Source: Calculations based on data obtained from the Department of Agricultural Economics and Statistics, Ministry of Agriculture, Sudan.

*A weighted average for the major crops is used.

Similarities and differences between ECRP and NESP

Before discussing the areas of differences between the two programmes, it is important to mention their common features. The types of policy measures adopted by the two programmes are largely similar, as both aimed to reduce the budget deficit and control the money supply in order to restore macroeconomic balance, and to restore or create incentives to produce tradeable goods (exports and import substitutes). The main policy components include devaluation of the exchange rate, removal of subsidies on food and energy products, trade reforms, and increased emphasis on the promotion of agriculture and exports. (See Table 5).

While the two programmes pursued more or less similar price policies, they differ in various key areas:

First, the ECRP was perceived as an adjustment programme to correct structural imbalances resulting from both internal and external factors. The NESP, on the other hand, was seen as a step towards a change in strategy rather than a temporary adjustment to unfavourable events. Thus, the first three years of the NESP were immediately followed by the launch of the ten-year national comprehensive strategy (1993-2002). The NESP calls for outward orientation, but at the same time advocates self-reliance especially in food. These two targets were seen to be largely conflicting and difficult to compromise (Hassan, 1991).

Second, the NESP receives greater attention and commitment from the government than did the ECRP. Government commitment to the programme and popular support for its implementation are crucial for the success of an adjustment programme (World Bank, 1985; FAO, 1991). Government commitment does not necessarily result in better implementation, however. Track records of the two programmes show that while the implementation of the proposed reforms in ECRP were uneven and characterized by delays, most NESP reforms were too hasty and lacked proper sequence and coordination.

Third, the NESP witnessed sudden drastic policy changes, while the ECRP appears to have introduced changes at a lesser speed and magnitude. Fourth, NESP gave greater attention to the non-price determinants of agricultural production, particularly agricultural credit and institutional reforms. It is now well known that adequate funding is a key determinant of the success of reforms. Inadequate funding was among the reasons for policy failures in a number of sub-Saharan countries (FAO, 1991). The NESP extended a substantial amount of credit to farmers. This credit extension was largely financed from non-real resources, which tends to hurt farmers indirectly through increased inflation. In addition, the profit margin of the newly introduced forms of credit is very high compared with the extremely low interest lending previously provided by the Agricultural Bank of Sudan (ABS). There is a controversy on the appropriate profit margins to be charged, but many observers believe that the adopted profit margins are so excessively high that they may adversely affect farmers' profitability. In spite of this, the new forms received wider acceptability by farmers and provide higher returns than non-agricultural loans (Elhiraika, 1996). The non-price policies of the NESP also include several actions to remove institutional barriers. The government dissolved a number of marketing boards, parastatals and public agricultural corporations.

Table 5: Summary of similarities and differences between ECRP and NESP

ECRP	NESP	
Donor support	High	Low
Government commitment	Moderate	High
Speed of policy implementation	Slow	High
Privatization	Slow and low commitment	High commitment
Liberalization of prices	Moderate	Highly liberalized
The exchange rate	Multiple	Unified for most of period
Rate of devaluation	From S£0.3/US$ to S£2.5/US$ in 1985	From S£12/US$ in May 1993
Monetary expansion	60%/annum	130%/annum
Inflation rate	27%/annum	112%/annum
Public investment in agriculture	The leading sector	The leading sector
Non-price policy including		
Agricultural credit	Less dominant	More dominant
Agricultural exports	US$550 million	US$350 million
Annual average		
Net capital inflow	High	Low
Food security	Low commitment	High commitment

Table 6: Dates of devaluations of Sudanese pound

Period	Official exchange rate (£S/US$)
ECRP	
Jun 1978	0.4
Sep 1979	0.5
Nov 1981	0.9
Feb 1982	1.3
Feb 1985	2.5
NESP	
Nov 1990	4.5
May 1991	12.2
Oct 1991	15.0
Feb 1992	90.0
Jul 1992	112.0
Nov 1992	135.0
Jun 1993	145.0
Aug 1993	164.0
Sep 1993	172.0

Source: Bank of Sudan (various years) *Annual Report.*

Fifth, external donor support for the ECRP was pronounced, particularly from the multilateral sources, the World Bank and IMF (Brown, 1986). The NESP, on the other hand, has received almost no donor support. Moreover, world prices of Sudan's major export crops have witnessed a relatively high rate of deterioration during the NESP period. During the ECRP period the foreign support was not only confined to financing the deficit of the balance of payments; it was also extended to bridge the overall budget deficit through extra revenue collected from sales of the aid programme commodities. This has disappeared during the NESP period.

Sixth, as indicated earlier, macroeconomic policies were more unstable and poorly implemented during the NESP. The increasing spending related to the civil war in the south and the acute shortage of foreign exchange contributed significantly to resultant poor macroeconomic policies.

Finally, there is some degree of difference between the two programmes in terms of timing of adjustment. Timing of adjustment, especially devaluation, is an important issue for agriculture. The ultimate effect of devaluation, for example, depends on whether it raises input or output prices first. Most of Sudan's agricultural commodities are annual summer crops grown in the June-July period and harvested and sold in October-January. These crops include sorghum, sesame, millet, gum arabic and groundnut, which together account for more than 65% of total value of agricultural output. Any change in the exchange rate in the period after December and before July the next year will raise input (fuel, fertilizer, seeds, etc.) prices long before the higher prices on output are received. Such devaluation can prevent output growth or force cutbacks.

As shown in Table 6, the two programmes do not seem to have been successful in terms of the timing of exchange rate changes, although the NESP is relatively better. Seven out of the 14 devaluations during the two programmes were undertaken at times when farmers would first be faced by an increase in their production costs.

With such policy changes and reforms it is difficult to judge *a priori* which programme would be more likely to succeed in removing distortions and improving incentives for agriculture. Although the NESP policy package looks more comprehensive (Table 5), with sound sectoral and institutional reforms, its deficient macroeconomic policies make it difficult to judge how overall price incentives would look.

III. Measurement of agricultural price incentives

The stabilization and structural adjustment measures of the reform programmes in Sudan are sufficiently varied, and the responses to them sufficiently complex, that no single analytical scheme can hope to encompass them. In comparing the two programmes (ECRP and NESP) the idea is to measure the effects of each programme on the level and stability of agricultural price incentives. The level of price incentives is analysed by identifying direct effects resulting from sector-specific policies and indirect effects resulting from economy-wide policies, as well as exogenous effects that stem mainly from international terms-of-trade movements. Sectoral policies include policies such as land and output taxes, marketing duties, and export taxes. The economy-wide (trade, exchange rate and macroeconomic policies) policies affect farm real prices indirectly through movements of the real exchange rate. Economy-wide policies appear to represent a dominant source of bias against agriculture and exports in developing countries (Krueger *et al*,. 1988). Empirical findings for Sudan tend to support this evidence (Hag Elamin, 1990; Elbadawi, 1993). The measurement of stability in price incentives, on the other hand, is meant to examine the impact of policy changes on the variability of farm-gate prices and incomes.

Level of price incentives

Direct and indirect price incentives were estimated using the following simple decomposition of real farm-gate price:

$$P_{fi}/P = (P_{fi}/E_{i}) (P^{*}_{bi}/P^{*}) (E_{i}P^{*}/P) \quad (1)$$

Where:

P_{fi} = farm-gate price of product i
P = aggregate domestic price
E_{i} = official exchange rate applicable to product i
P^{*}_{bi} = border equivalent price of product i in foreign currency (adjusted for transportation and marketing costs)
P^{*} = aggregate international price

P_{fi}/P is a measure of real farm-gate price of product i (R_{fi}); $P_{fi}/E_iP^*_{bi}$ is the nominal direct protection coefficient of product i (NPC_{di})[6]; P^*_{bi}/P^* is the international terms of trade for product i (TOT_i); and E_iP^*/P is a measure of the real exchange rate facing product i (RER_i). All these variables are expressed as indexes relative to a base year.

Equation 1 can therefore be rewritten as:

$$Rf_i = NPC_{di}.TOT_i.RER_i \quad (2)$$

The direct nominal protection coefficient (NPC_d) measures the direct effect on farm prices resulting from sectoral policies. The term TOT_i, international terms of trade for agriculture, reflects the effect of movement in terms of trade on farm real prices. The measure of the real exchange rate (RER_i), on the other hand, reflects the indirect effect on real farm prices resulting from economy-wide policies. The RER_i as indicated in Equation 1 follows from Bautista (1987). Where E_i is defined as the price of one unit of the reporting country's currency in terms of foreign currency expressed as an index number relative to the base year. Actual calculations use the exchange rate vis-a-vis the U.S. dollar. P^* and P are also expressed as indexes of the same base year. Thus, an increase in the real exchange rate index relative to the base year shows depreciation of the exchange rate, while a decrease in the index implies appreciation. This index has therefore been used as an approximate measure of real appreciation or depreciation of the currency.

The aggregates of NPC_d, RER and ATOT for agriculture are specified as:

$$NPCd = \sum w_i NPC_{di} = \sum w_i (Pf_i/EP^*_{bi}) \quad (3)$$
$$RER = \sum w_i RER_i = \sum w_i (EiP^*/P) \quad (4)$$
$$ATOT = \sum w_i TOT_i = \sum w_i (P^*_{bi}/P^*) \quad (5)$$

Where w_i is the share of product i in the value of total agricultural output, with total sum of w_i equal to one.

On the basis of the above definitions, and assuming that terms-of-trade movement is the only exogeneous factor that affects real farm prices, the above decomposition of aggregate farm real prices for agriculture can be rearranged and defined as follows:

$$NPC_d = \sum w_i NPC_{di} \text{ (direct price incentives)} \quad (6)$$
$$NPC_p = NPC_d\, RER \text{ (direct and indirect incentive or policy-induced incentives)} \quad (7)$$
$$NPC_t = NPC_d\, RER\, ATOT \text{ (total price incentives)} \quad (8)$$

These coefficients could be expressed as rates as follows:

$$NRP_d = NPC_d - 1$$
$$NRP_p = NPC_p - 1$$
$$NRP_t = NPC_t - 1$$

NRP_d can be interpreted as the rate of the equivalent tariff (tax or subsidy) that would yield the given domestic price. NRP_d is thus an ex post measure of the price gap resulting from market price altering measures that directly affect producer and border prices of the commodity. As such, it measures the effect of direct (sectoral) policies. Positive NRP_d indicates subsidization, i.e., the domestic price of the commodity exceeds its border price equivalent, while negative NRP_d indicates taxation. This information, however, does not say anything about the protection of the commodity relative to other sectors in the economy, nor does it tell which among the sectoral policies are responsible for the protection level found. Because of the limitations associated with the measurement of NRP_d (see, for example, Grubel and Johnson, 1971; Westlake, 1986), it is much better suited to measure the attempt at removing distortions than to measure the size of these distortions (Scandizzo, 1989). NRP_d is therefore used to assess the effects of sectoral policy changes that were adopted as part of the adjustment policies in Sudan.

NRP_p, on the other hand, measures the effect of both sectoral and economy-wide policies; as such it accounts for the policy effects on farm incentives, and is therefore referred to as "policy-induced incentives". NRP_t measures the aggregate effects on farm incentives resulting from policy variables as well as term-of-trade movements.

Farm price incentives at the three levels (NRP_d, NRP_p and NRP_t) were estimated for Sudan's agriculture using data for the period 1970-1993. In calculating these measures, the year 1970 is used as the base year, i.e., the year in which relative prices were assumed to be at equilibrium. In 1970, the balance of payments and the trade balance stood at S£5.9 million and S£9.6 million, respectively, which are fairly close to equilibrium. At the same time, the average inflation for 1970 was at a comparable rate to world inflation (6% domestic inflation compared with 4% world inflation). Then, aggregate weighted indicators, based on the shares of individual crops in agricultural GDP, were estimated.

General pattern of agricultural price incentives

Price incentives for agriculture were assessed by calculating NRP_d, NRP_p and NRP_t for both the major agricultural crops and the aggregate agricultural output for the period 1970-1993. The major crops considered are cotton, groundnut, sesame, gum arabic, sorghum, millet and wheat. Paucity of data prevents the inclusion of livestock and forestry products.

Results of the analysis show that agricultural producers were, on aggregate, taxed throughout the period 1970-1993 (Table 7). The NRP_d for agriculture, except in 1985 and 1988-1991, was consistently negative, indicating that the prices paid to producers were less than border equivalents. Adjustment for RER substantially increased taxation for agriculture. Comparing NRP_d and NRP_p results indicates that indirect taxes (resulting from economy-wide policies) were greater than direct taxes most of the time. This result supports the findings of Elbadawi (1993), although the magnitude of indirect taxes is less pronounced here.

This taxation was significantly reduced by the continuous improvement in terms of trade over the period 1970-1985, but nonetheless left agriculture with negative levels of overall protection except in 1985. Between 1986 and 1993, however, terms of trade added a substantial amount to the total taxation of agriculture.

Table 7: Average price incentives for agricultural producers due to direct and indirect policy measures and terms of trade

Years	NRP_d Direct price effect %	NRP_d Direct and indirect price effects %	NRP_t Total (direct, indirect and terms-of-trade effects) %
Aggregate agriculture:			
1970-78	-40	-50	-47
1979-85 (ECRP)	-14.5	-27	-30
1990-93 (NESP)	01	-44	-73
Cereals:			
1970-78	-41	-51	-51
1979-85 (ECRP)	-8.1	-11.9	-37
1990-93 (NESP)	14	-37	-75
Non-cereals:			
1970-78	-41	-50	-42
1979-85 (ECRP)	-36	-46	-25
1990-93 (NESP)	-32	-62	-76

Source: Extracted from tables A4, A5 and A6 in Appendix A.

While non-cereal crop producers were subjected to both direct and indirect taxation throughout the period, cereal crops growers received some positive nominal protection in 1983-1985, 1988-1989 and 1990-1991. This positive protection is not fully policy-induced, however. It is largely the result of the sharp increase in domestic prices of cereals during periods of food shortages that result mainly from climatic hazards.

Comparison between ECRP and NESP

In comparing ECRP and NESP in terms of their effects on agricultural price incentives, the following points are worth noting:

1. The NRP_d for aggregate agriculture improved significantly during the NESP period, as it increased from -16% in 1978-1985 to 1% in 1990-1993 (Table 7). Given that domestic prices of cereals substantially increased following the 1984/85 and 1990/91 crop failures, when their exports were banned, one should not rely on the level of overall price incentives (for agriculture as a whole). The major cereal crops (sorghum and millet) are produced mainly for domestic consumption and are occasionally exported. During periods of shortages the government bans their export and as a result their domestic prices, which become a function of domestic demand changes, exceed their international equivalent prices.

   When decomposing agriculture into cereal and non-cereal crops, it appears that direct price incentives for cereals increased substantially while those for non-cereals increased only slightly. Thus, NESP seems to have produced only little improvement in direct price incentives (from -38% to -32%).

   It is estimated that 70% of Sudan's agricultural output consists of exportables, 12% of importables and 18% of non-tradeables. These shares fluctuate heavily over time, however. During periods of drought and crop failure, for example, most of the exportable food crops, especially sorghum, tend to become import substitutes. This shift increases the prices of these food crops, moving them closer to their import substitutes. The price of sorghum, for instance, approximates and sometimes exceeds that of wheat during periods of shortages. The shift of a crop such as sorghum, the main staple food in Sudan, from the exportable category to the import competing category increased the share of the latter to more than 50%. Therefore, during years of drought, cereal crops and agriculture as a whole appear protected.

2. When comparing the policy- induced (direct and indirect) effect of the two programmes, NESP does not seem to have created any improvements. On the contrary, total direct and indirect price incentives (NRP_p) deteriorated significantly. The NRP_p fell from -29% during the ECRP to -44% during NESP. Thus, although the NRP_d for cereals, non-cereals and agriculture as a whole showed some improvement during the NESP, NRP_p deteriorated significantly during the same period, indicating that the bias resulting from poor economy-wide policies more than offset the positive effect of the sector-specific policies. Although the NESP appears to have taken more active steps towards liberalization of farm prices compared with the ECRP, the resultant price incentives seem to have been worse than under the ECRP.

3. The international terms-of-trade movement aggravated the bias against agriculture more during the NESP than during ECRP. Terms of trade increased the aggregate agricultural taxation rate from -44% to -73% during the NESP, and from -29% to -32% during the ECRP.

   International terms of trade for agriculture (ATOT) did not decline during 1970-1978, in fact they improved at an average rate of 3% per annum. This improvement could simply be related to the rapid increase in international prices of cotton, sesame and gum arabic (the major exports of Sudan). During the ECRP period (1979-1985) there was no clear deterioration in ATOT. In 1990-1993, however, the ATOT declined

at an annual rate of 32%. With the exception of gum arabic, all of Sudan's tradeable crops witnessed a decline in their international prices from 1990-1993 levels.

These results suggest that neither of the adjustment programmes adopted in Sudan (ECRP and NESP) created clear improvement in price incentives for agriculture, although the ECRP appears to have been marginally better. However, during the implementation of these programmes, the agricultural sector faced several shocks due to hazardous climate, deteriorating international terms of trade and the civil war, which all acted to offset policy efforts to improve incentives. The effect of the climatic shocks was to increase food prices (cereals) and dampen real prices for exportable crops. The civil war (the war in southern Sudan) effect is very difficult to identify but it can simply be read from the rising budget deficit since 1983, and its consequent inflationary impact.

In an attempt to remove the effect of exogenous factors, NRP_d and NRP_p were calculated again after excluding years of drought, namely, 1984-1985, and 1990.[5] The results show that while price incentives for non-cereal crops improved, price incentives for cereals and agriculture as a whole decreased substantially. The adjusted results also show that the impact of NESP was less than that of ECRP.

Instability in agricultural price incentives

Level of instability

The foregoing analysis presents estimates of the level of real farm price incentives. Price incentives to which farmers react, however, are not only a function of the level of farm prices but also of the variability in these prices. We assessed the effect of adjustment programmes on the variability of real farm prices by calculating the ratio of instability indexes of real farm prices and real border prices. We also attempted to identify the contributions to price variability resulting from sectoral (direct) and economy-wide (indirect) policies.

Table 8 shows the ratio of instability indexes for real producer prices to border prices for the main agricultural crops for the periods 1970-1978, 1979-1985 and 1990-1993. The instability index is calculated as the relative absolute deviation from trend.[6] A ratio greater than unity indicates that real domestic producer prices vary at a higher rate than do real border prices. Based on this measurement, the results show that price incentives are more stable for non-cereals than for cereals and that instability increases during the NESP period. The wide fluctuations during the NESP period could be attributed mainly to the heavy fluctuations in the real exchange rate as a result of the frequent and uneven adjustment of the nominal exchange rate and monetary policies. This, coupled with the unstable nature of export marketing in the first few years following the removal of the export marketing parastatals, seems to be the main factor contributing to the high variability in real farm prices.

Table 8: Ratios of instability indexes for real producer and real border prices

Crops	1970-78	1979-85	1989-93
Non-cereals:			
Cotton	-	-	-
Groundnut	0.98	1.05	0.91
Sesame	0.86	1.09	1.13
Gum arabic	0.39	0.11	1.03
Cereals:			
Sorghum	0.41	2.31	6.85
Millet	0.98	1.86	5.25
Wheat	0.38	0.73	2.30

Sources of instability

The identification of the source of real farm price instability has important implications for the effort to stabilize farm prices. Traditionally, farm price stabilization efforts concentrate on direct measures of managing nominal rather than relative producer prices. Such stabilization measures may succeed within agriculture but not necessarily between agriculture and other sectors of the economy.

Based on the previous analysis, variability of the policy-induced incentives (NPC_p) can be decomposed as:[7]

$$\begin{aligned} Var\ logNPC_p &= Var(logNPC_d + logRER) \\ &= Var(logNPC_d) + Var(logRER) \\ &\quad + 2\ Cov(logNPC_d, logRER) \end{aligned} \tag{9}$$

where, Var = variance and Cov=covariance

The percentage contribution of instabilities in NPC_d and RER to variation in NPC_p can be derived from Equation 9 as:

Contribution of variability in NPC_d $= Var(logNPC_d)*100/Var(logNPC_p)$
Contribution of variability in RER $= Var(logRER)*100/Var(NPC_p)$
Interaction of NPC_d and RER $= 2Cov(logNPC_d,RER)*100/Var(NPC_p)$

As can be seen from Table 9, the NPC_d represents the main source of variability in NPC_p for the entire period 1970-1993. For the sub-periods (1970-1978, 1979-1985 and 1990-1993), however, the RER dominates. Table 9 also indicates that during the sub-periods examined NPC_d and RER showed an offsetting movement (negative covariances), which acted to reduce instability in real farm prices. The offsetting movement was particularly pronounced during the ECRP period, indicating that at the time when sector-

specific policies (agricultural production and export policies) were acting to push real prices up, economy-wide policies worked in the opposite direction.

Table 9: Decomposition of variance of NPC_p, 1970-93

Period	Var	Contribution of components to Var (log NPC_p)		
	(log NPC_p)	NPC_d	RER	(NPC_d, RER)
1970-93	0.0230	187	60	-146
1970-78	0.0052	117	185	-206
1979-85	0.0273	65	240	-205
1990-93	0.0265	05	157	-063

Having thus broadly assessed the effects of the reform programmes on agricultural incentives, the rest of the study confines its attention to the examination of the possible effect of changes in price incentives on agricultural output, as this is the key to the effectiveness of policy reform.

IV. The aggregate response of agriculture to price and non-price incentives

The central focus of the adjustment reforms in agriculture is to increase agricultural production by improving price incentives. Price incentives mean higher returns to farming (farm profits) in the short run, which will attract more capital both physical and human into agriculture and encourage farmers to adopt new technologies in the long run. Thus, the efficacy of adjustment reforms in agriculture depends on their short run and long run effects on economic incentives. The extent to which farm decisions respond to economic incentives should, therefore, be of central concern to policy makers. The adjustment programmes in Sudan have been implemented with the implicit assumption that individual crops as well as aggregate agricultural output are responsive to price changes. There seems to be little dispute over the positive response of individual crops, but it is not yet clear how aggregate output responds to price changes.

This study is interested not only in the price effect, but also in the effects of non-price factors, such as the impact of infrastructure (roads), research and extension, and agricultural credit on aggregate agricultural output. Non-price factors could be grouped into two categories: non-policy variables (weather, distance to market, etc.) and policy variables–public goods that respond to policy intervention (irrigation, research, market structure, etc.). Empirical evidence shows that the two categories are important determinants of agricultural output (Evenson, 1988; Binswanger, 1989). Measuring the response of agriculture to availability of public goods is important in the analysis of adjustment as the delivery of these public goods is expected to decline sharply under the thrust of fiscal austerity in the context of adjustment programmes (Mosely and Toye, 1988; Lipton, 1987).

Empirical estimates of supply response of individual crops in Sudan have shown mixed results. Findings differ in terms of the magnitude of response to prices, but there is consensus that individual crops respond positively to price changes (Medani, 1970; Ali, 1978; Chhibber and Hrabovszky, 1983; Kabalo, 1984; El Tohami and Bateson, 1986; Hag Elamin, 1995). There are a few studies on the impact of prices on aggregate agricultural output. Elbadawi (1993) and Hag Elamin (1995) address this issue. The results obtained, as in many other developing countries, indicate a positive but generally low aggregate response.

This part of the study attempts to evaluate the response of aggregate agricultural output in Sudan. Aggregate output is disaggregated into rainfed and irrigated production, on the basis of production mode, and into cereal and non-cereal production, on the basis of commodity composition. The distinction between the responses of rainfed agriculture

and irrigated agriculture and between cereals and non-cereals has important implications for policy reforms.

Both price and non-price (credit, infrastructure and public investment) determinants of agricultural output are considered. Data for the period 1970-1993 are pooled for a number of regions in Sudan and a free-form autoregressive distributed lag model is first developed to establish a more parsimonious adjustment model based on the Nerlovian specification.

Previous time-series estimates of aggregate supply elasticities

Since the 1960s numerous studies have been carried out on the magnitude and direction of farmer response to agricultural prices. The studies have generally focused on the estimate of short- and long-run supply price elasticities for individual crops. Positive but low short-run price elasticities were reported in almost every case. Long-run price elasticities have been found to be higher. For detailed summary of findings, see for example, Askari and Cummings (1976), Scandizzo and Bruce (1980), Bond (1983), and Beynon (1989).

The response of aggregate agricultural output is an issue that has recently attracted greater attention. Evidence indicates that aggregate agricultural supply response tends to be smaller than the response of individual crops. Most of the empirical estimates of aggregate agricultural supply response have been largely based on variants of Nerlove's (1958) formulation (see, for example, Reca, 1980; Bapna, 1981; Chhibber, 1982; Bond, 1983). These studies produced broadly similar results with short-run aggregate supply elasticities around 0.2 and long-run elasticities of about 0.4. Attempts have been made to take into account other factors that affect production decisions such as weather, size of farm, credit, etc.

Supply response studies, however, have been plagued with numerous methodological problems and data limitations that limit the reliability of supply elasticity estimates. As noted by Binswanger (1989), the common problems related to the aggregate agricultural supply response models are the neglect of non-price factors, simultaneity and other problems associated with econometric estimation. This study improves data and econometric tests and incorporates some important non-price variables into the model in its examination of the supply response of aggregate agricultural output in Sudan.

Model specification

Among the numerous econometric models estimated for aggregate agricultural supply response, there exist two major approaches in modelling time-series supply elasticities. The first approach, aggregation of input demand elasticities, is an indirect method of estimating aggregate supply elasticity of output by aggregating over the product of the elasticity of supply of inputs and the elasticity of demand of inputs (Chhibber, 1989).

The second, and most widely adopted approach, is the direct method of using supply functions. The problem with the first method is that detailed data on input use and input prices are not readily available especially in the developing countries; studies thus generally concentrate on the second approach.

The question arises as to whether the models that have been used by economists to analyse agricultural supply response are adequate to capture the complexity of the processes involved and derive effective policy recommendations. In these models the fundamental determinant of the impact of policy changes on efficiency is the flexibility in resource allocation captured in production through price elasticities of supply.

Price variables

In order to capture fully the response of agriculture to relative price changes one needs to examine the dynamic effects associated with changes in relative prices. This may need a more comprehensive macroeconomic framework that integrates the domestic price structure, production patterns and income distribution (Mundlak *et al.*, 1988). Lack of comprehensive relevant data precludes the development of such a model for Sudan. The alternative approach is to use a single equation dynamic model that allows for the estimate of long-run response of output. Most of the models used in this respect are based on the Nerlovian specification, which postulates desired output as a function of expected output prices as follows:

$$Q^e = a_o + a_1 P^e + a_2 Z + U \qquad (10)$$

Where Q^e is the desired output, P^e is expected price and Z is a shift variable. But neither desired output nor expected price are observable. In order to overcome this problem, Nerlove (1958) introduced a price expectation specification and an adjustment mechanism:

$$P^e_t = P^e_{t-1} + C[P_{t-1} - P^e_{t-1}] \quad 0<C<1 \qquad (11)$$

$$Q_t = Q_{t-1} + B[Q^e_t - Q_{t-1}] \quad 0<B<1 \qquad (12)$$

Where expected price, P^e, is explained as the sum of past expected price (P^e_{t-1}) plus a fraction C of the difference between last period's actual and expected prices. C is the coefficient of price expectation. Equation 12 indicates that actual output (Q_t) adjusts by some fraction (B) of the difference between the desired output and actual output of the previous period. Like C, B is constant and is referred to as the Nerlovian coefficient of adjustment.

By imposing a restriction that C=1 and substituting Equations 11 and 12 into Equation 10, a reduced form equation is derived as:

$$Q_t = b_o + b_1 P_{t-1} + b_2 Q_{t-1} + b_3 Z_t + U_t \qquad (13)$$

where:

$b_o = Ba_o$
$b_1 = Ba_1$
$B_2 = 1\text{-}B$
$b_3 = a_2(1\text{-}B)$

The diversity and inconsistency of empirical findings of agricultural response using the Nerlovian specification, as in Equation 13, cast doubts on its appropriateness to capture fully the dynamics of agricultural supply (Rao, 1989; Binswanger, 1989). Criticisms of the model results, however, tend to be of an econometric rather than theoretical nature. Inaccurate and/or short time-series data and the neglect of important non-price variables are among the major problems facing supply response estimates in general and estimates of aggregate supply response in particular.

Non-price variables

While Equation 13 depicts the theoretical description of the adjustment model, its final form of empirical estimation must capture the revelant factors underlying agricultural supply. Agricultural supply represents the response of farmers to changes in farm profits. Changes in farm profits, however, are the result of the interplay in changes in prices, infrastructure, agricultural credit, technology, etc. Available empirical findings tend to suggest that the association between real farm prices and agricultural output in Sudan is weak, which implies the importance of non-price factors in determining farm output. The specification of the supply response should, therefore, consider these non-price variables. Non-price factors are found to be significant determinants of crop responses and aggregate output in many developing countries (see, for example, Delgado *et al.*, 1987; Binswanger, 1989). Introducing measures for infrastructure, credit and public investment in agriculture, Equation 13 could be rewritten as:

$$Q_t = b_o + b_1P_{t-1} + b_2Q_{t-1} + b_3R_t + b_4F + b_5CR + b_6V + b_7DUM + U_t \quad (14)$$

where:

Q_t = aggregate agricultural output at time t
P = real farm gate price
R = average rainfall index
F = infrastructure (taken as the ratio of paved to unpaved roads)
CR = agricultural credit per feddan
V = public investment (investment/unit cropped area)
DUM = dummy variable for weather hazards
U = error term

The dummy variable, DUM, is intended to capture the effects of the unusual

environmental hazards of drought (1983/84) and floods (1988/89), where considerable drops in production occurred. The introduction of such a dummy may look repetitive because a measure of weather (rainfall) is already incorporated into the model. Rainfall index per se may not account for the effects of the unusual weather changes, however. The effect of excessive rainfall may be similar to that of little or no rainfall, which cannot be captured by the rainfall index.

This version of the model can be estimated using ordinary least squares (OLS) if the original $U_t s$ are not serially correlated. Pre-tests of the model showed that, in terms of statistical fit of the data, the double-log transformation was superior to the linear and semi-log models. The supply response function (Equation 14), is therefore estimated in a logarithmic form, which allows interpretation of coefficients as elasticities. Positive parameters are expected for all explanatory variables. The short- and long-run price elasticities can be derived from the log form of Equation (14) as $b\hat{}_1$ and $b\hat{}_1/(1-b\hat{}_2)$ respectively.

Data: Definitions and characteristics

Estimation of aggregate supply elasticities, using time-series data, complicate the construction of index for aggregate output, prices and other supply factors. The aggregate output, *Q*, is measured on the basis of produced quantities rather than cropped areas, the aggregation of which has little meaning from the economic standpoint. Aggregate output is then calculated as a weighted average of the production index of individual crops, the weights being the share of each crop in the total value of agricultural output.[8]

The price variable, *P*, the indicator of price incentives for producers, is a measure of relative prices. Clearly, relative prices rather than absolute prices are likely to affect profitability. The numeraire of relative farm prices could be taken as prices of inputs, prices of consumer goods or prices of other competing crops.[9] Prices of agricultural inputs or manufactured goods may not be a good indicator as these goods were mostly rationed especially during the 1970s. Analysis of supply response based on prices of rationed goods is not very meaningful (Berthelemey and Morrison, 1987). This, in addition to the fact that the study emphasizes the examination of aggregate response of agriculture, suggests that it is more relevant here to define real prices as the aggregate prices of agricultural goods relative to the aggregate prices of non-agricultural goods. Given paucity of time-series data on non-agricultural goods prices, the consumer price index (CPI) is taken as a proxy.[10]

The real aggregate farm-gate price is calculated as a weighted average of the farm-gate price indexes of the major agricultural crops in Sudan. An index of the ratio of paved to unpaved roads is specified as a proxy for infrastructure. Agricultural credit is estimated as the average credit per unit of cropped area. Rainfall is taken as the average annual rainfall index.

Time-series data covering the period between 1971/72 and 1992/93 were used. Data on agricultural output, farm-gate prices and rainfall were obtained from the Department of Agricultural Economics and Statistics, Ministry of Agriculture, Sudan. Data on

agricultural credit, infrastructure and public investment in agriculture were obtained from the Ministry of Finance and Economic Planning, Gezira scheme, and the Agricultural Bank of Sudan. In order to improve the degree of freedom for the estimates, a cross section time series is used, where, on the basis of the data available, Sudan is divided into four agricultural regions. These include the irrigated subsector (Gezira, Rahad and New Halfa schemes), the mechanized subsector (Gedarif and Damazin areas), Kordofan Region and Darfur Region.

Two important defects of the data need to be mentioned. First, due to lack of data, the southern part of the country is excluded. Second, and for the same reason, some food crops, mainly horticultural crops that are produced almost entirely for domestic consumption, were not considered. The exclusion of such minor domestic goods, however, may serve to minimize the possibility of simultaneity in the model. When the prices of non-tradeable goods, such as horticultural crops in the case of Sudan, increase and supply expands, prices may fall again as domestic demand may not be responsive enough to absorb the excess supply.

Testing for stationarity of the series

The Nerlovian adjustment model is based on strong theoretical and economic grounds, but the dynamic interactions of agricultural response are thought to be too complex to be fully captured by theoretically based constructs. Generally, if the variables included in the model are non-stationary,[11] then the partial adjustment coefficient will generally fail to capture the structural characteristics of the model. Data admissibility considerations are, therefore, important determinants of the short-run dynamics of models (Adam, 1992). Recent developments in econometrics have introduced some techniques and tests of the short-time dynamics of models. Equation 14 is therefore used as the core conditional model around which a more parsimonious econometric representation is sought by examining the short-run dynamics of the model.

On the estimation procedures, we draw on recent developments in examination of time-series characteristics of data. To test for the stationarity characteristics of the data, the order of integration (unit root) tests were conducted for each of the variables. The tests used were Dickey-Fuller (DF), augmented Dickey-Fuller (ADF) and Sargan-Bhargava Durbin-Watson (SBDW).[12] PC-GIVE (Hendry, 1989) software was used to calculate the data in Table B1 in Appendix B, which reports the results of these tests for each series. All the tests strongly accept I(0), which can be interpreted as indicating that all variables are stationary. This suggests that spurious regression is less likely to be encountered in the application of a dynamic specification such as in Equation 14.

Estimation results

In order to identify the main dynamic patterns of the model an over-parameterized autoregressive distributed lag model (ADL) is first developed, using ordinary least squares (OLS), with a three-lag length for all variables in the model. The regression results

(from PC-GIVE) for the ADL version of Equation 14 are reported in Appendix B (Table B2).

The model is further simplified into a more interpretable Nerlovian adjustment variant. The simplification is guided by data admissibility with the main concern that the model remains theory consistent. Dropping the lagged insignificant variables led to improved t-ratios for the remaining regressors. Furthermore, to eliminate cross regional (district) variability, due to possible correlation between explanatory variables with unobserved district endowments, district-specific intercepts were included. This served to improve predicted values relative to actual values.

The most interesting result of the ADL model is that current price does not seem to have significant impact on current output. This is not surprising, as only a few crops, mainly wheat, have their prices set before planning and farmers therefore have to form their expectations on the basis of past prices, as appears to be supported by the ADL results. Lagged rather than current public investment appears to be important in determining current output.

The final model produced by the simplification process is reported in Table 10. This model performed better than did the ADL. The simplification resulted in an improvement in the Schwartz information criterion (SC) compared with the ADL model. The Durbin h-statistic indicates no serious serial correlation in the error term. Overall, the model is considered to be reasonably specified based on its statistical significance and its ability to track historical records. All the estimated coefficients, except infrastructure, are of the expected sign.

The coefficients for lagged real price, rainfall, credit and lagged public investment are positive and significant at least at the 5% significance level. Surprisingly, infrastructure does not have the expected sign and is significant at the 15% level of significance. This may be the result of inappropriate specification of this variable due to the poor data base. Infrastructure is therefore dropped from the model.

The results indicate that the aggregate supply response to three of the non-price factors included in the model (rainfall, credit and public investment) is positive and significant. The coefficient for rainfall, which is significant at the 1% level, suggests that rainfall is an important factor determining aggregate agricultural output in Sudan. The positive elasticities for credit and public investment, which are highly significant at the 1% level, are theoretically plausible as credit and public investment represent additional resources for agriculture that promote its overall growth. Improvement in credit and public investment in agriculture will promote the implementation of new and more productive techniques that are capital intensive (McGuirk and Mundlak, 1992).

The estimated supply price elasticity (0.24) indicates that the response of Sudanese agriculture, as in other SSA countries, is rather restricted. Using FAO data for nine African countries and taking the per capita agricultural output as an expression of total agricultural production, Bond (1983) obtained an average aggregate supply price elasticity of 0.12. This average is a bit smaller than our estimate of 0.24.

Low price elasticity of aggregate agricultural supply could be attributed to a host of constraints to which Sudanese agriculture is particularly prone. The dominance of the rainfed agriculture with hazardous weather and frequent incidence of pest and diseases,

acute shortage of seasonal labour, and inadequate rural infrastructure are among the major factors that hinder the growth of agriculture in Sudan. There is a severe shortage of labour during certain critical agricultural operations, especially harvesting (El Bashir, 1984).

Table 10: Modelling aggregate agricultural output (in Q) by OLS pooled time series/cross section data for four regions for the period 1971/72-1992/93

Variable	Coefficient	Std Error	HCSE[1]	t-Value	Partial r^2
In Qt-1	.410	.080	.075	5.15	.26
In Pt-1	.240	.107	.118	2.22	.06
In R	.570	.187	.233	3.05	.11
In CR	.160	.066	.092	2.50	.08
In Vt-1	.240	.107	.090	2.25	.06
DUMw	-.460	.084	.093	-5.41	.28
DUM1	-.004	.101	.076	-.04	.00
DUM2	.192	.104	.091	1.86	.04
DUM3	-.149	.100	.081	-1.48	.03
CONSTANT	-2.147	1.228	1.549	-1.75	.04

R^2 = .69 σ = .2786406 F(9,77) = 16.84 DW = 1.836 SC^2 = -2.164445

HCSE = heteroscedastic consistent standard error
SC (Schwarz information criterion) provides a guide and parsimonious information reduction so that a fall in SC is an indication of parsimony.)
Q = aggregate agricultural output
P = real farm-gate price
R = average rainfall index
CR = agricultural credit per feddan
V = public investment (investment/unit cropped area)
DUMw = dummy variable for weather hazards
DUM1, DUM2 and DUM3 = intercept dummies for regions
In = natural logarithm

Disaggregation of agricultural output

Supply elasticities for the aggregate rainfed, irrigated, cereal and non-cereal production were estimated using the same core model (Equation 14) and following the same estimation procedure. The short-run price responsiveness of agriculture is expected to increase with further product disaggregation. Shifting resources between agricultural and non-agricultural production is more difficult than shifting them between activities within agriculture. The disaggregation of agricultural production could be considered at different levels, but the one of immediate concern to policy-makers is the disaggregation on the basis of mode of production, rainfed versus irrigated, or on the basis of commodity composition, cereals versus non-cereals. The distinction between food crops and export crops in Sudan may not be meaningful, since food crops (e.g., oil seeds) are often potent exports. Decomposition of agricultural output into cereals and non-cereals may give a better indicator of the food/cash crop mix.

Table 11: Modelling aggregate rainfed production (ln Q) by OLS pooled time series/cross section data for three regions for the period 1971/72-1992/93

Variable	Coefficient	Std Error	HCSE	t-Value	Partial r^2
ln Qt-1	.424	.097	.088	4.38	.25
ln Pt-1	.226	.136	.151	1.67	.05
ln R	.570	.221	.252	2.58	.11
ln CR	.181	.087	.125	2.08	.07
ln Vt-1	.201	.130	.107	1.55	.04
DUMw	-.474	.099	.097	-4.81	.29
DUM1	.189	.120	.096	1.57	.04
DUM2	-.146	.115	.084	-1.28	.03
CONSTANT	-2.149	1.464	1.764	-1.47	.04

R^2 = .69 σ = .3102992 F(8,57) = 13.79 DW = 1.833 SC = -1.915723.
HCSE = heteroscedastic consistent standard error
SC (Schwarz information criterion) provides a guide and parsimonious information reduction such that a fall in SC is an indication of parsimony.)

Q	= aggregate agricultural output
P	= real farm-gate price
R	= average rainfall index
CR	= agricultural credit per feddan
V	= public investment (investment/unit cropped area)
DUMw	= dummy variable for weather hazards
DUM1, DUM2 and DUM3	= intercept dummies for regions

Equation 14 is estimated for the aggregate outputs of rainfed agriculture, irrigated agriculture, cereals and non-cereals. The function was estimated in a similar fashion to the aggregate supply function, where an ADL model is first developed from which a more reasonably parsimonious model is derived. Tables 11, 12, 13, and 14 contain the estimated regression coefficients. The overall fit of each of the estimated functions is quite satisfactory; the estimated coefficients of the lagged price are positive and significant, at least, at the 5% level of significance. The estimated short- and long-run supply price elasticities for the aggregate agricultural output, and the aggregate output of cereals, noncereals, rainfed and irrigated sectors are summarized in Table 15. As expected, the short-run price elasticities of aggregate output are low compared with other disaggregated levels. While this is to be expected, the difference is markedly low.

The disaggregated supply functions yield some interesting results. First, contrary to expectation, the state-managed irrigated agriculture is more responsive to prices, in the short run, than the privately-managed rainfed agriculture. Natural hazards and infrastructural constraints are more prevalent in the rainfed areas than in the irrigated areas. This, coupled with the fact that a large proportion of the rainfed production is for subsistence purposes, may explain the low response of rainfed agriculture.

In the long run, however, the response of rainfed agriculture is markedly high. This discrepancy in long run response indicates that potential growth in output is higher in rainfed than in irrigated agriculture. This is plausible as the acreage expansion and the marginal returns on additional investment in technology are expected to be higher in rainfed agriculture.

Second, the disaggregation of agriculture on commodity basis (cereal/non-cereals) yields higher elasticities than that on mode of production. This is plausible as resources could more easily be allocated between cereal and non-cereal crops than between rainfed and irrigated sectors. Paradoxically, cereals output, which is mainly for domestic consumption, is more responsive to prices than is non-cereal cash output.

Table 12: Modelling aggregate irrigated production (in Q) by OLS pooled time series data for one region (Gezira) for the period 1971/72-1992/93

Variable	Coefficient	Std Error	HCSE	t-Value	Partial r^2
ln Qt-1	.04	.149	.158	.24	.00
ln Pt-1	.29	.138	.135	2.09	.24
ln CR	.21	.060	.073	3.61	.48
ln Vt-1	.47	.129	.098	3.64	.49
ln F	-.77	.299	.358	-2.58	.32
DUMw	-.46	.120	.038	-3.83	.51
CONSTANT	4.76	1.366	1.459	3.48	.46

R^2 = .86 σ = .1145209 F(6,14) = 13.60 DW = 1.554 SC = -3.724620

Table 13: Modelling aggregate cereals output (in Q) by OLS pooled time series/cross section data for four regions for the period 1971/72-1992/93

Variable	Coefficient	Std Error	HCSE	t-Value	Partial r^2
ln Qt-1	.290	.108	.092	2.66	.11
ln Pt-1	.454	.140	.147	3.24	.16
ln R	.244	.229	.211	1.07	.02
ln CR	.287	.087	.088	3.31	.16
ln Vt-1	.489	.166	.170	2.95	.13
DUMw	-.794	.196	.264	-4.06	.23
DUM1	.325	.124	.114	2.62	.11
DUM2	-.0301	.114	.115	-.26	.00
CONSTANT	-2.287	1.449	1.511	-1.58	.04

R^2 = .70 σ = .3536085 F(8,56) = 11.57 DW = 1.697 SC = -1.650173

Table 14: Modelling aggregate non-cereals output (in Q) by OLS pooled time series/cross section data for four regions for the period 1971/72-1992/93

Variable	Coefficient	Std Error	HCSE	t-Value	Partial r^2
ln Qt-1	.298	.219	.269	1.36	.11
ln Pt-1	.338	.212	.195	1.59	.15
ln F	-.620	.233	.237	-2.66	.32
ln Vt-1	.889	.326	.372	2.73	.33
ln CR	-.260	.129	.179	-2.01	.21
DUMw	-.026	.281	.481	-.09	.00
CONSTANT	3.954	1.568	1.784	2.52	.34

R^2 = .79 σ = .2913328 F(8,56) = 9.15 DW = 1.825 SC = -1.866057

Table 15: Agricultural supply price elasticities

	Adjustment coefficient	Short-run elasticity	Long-run elasticity
Aggregate output	0.59	0.24	0.41
Disaggregation on the basis of mode of production:			
-rainfed agriculture	0.58	0.23	0.40
-irrigated agriculture	0.97	0.29	0.30
Disaggregation on the basis of commodity composition:			
-cereals	0.71	0.45	0.63
-non-cereals	0.70	0.34	0.49

Long-run elasticity = (short-run elasticity)/(1 - adjustment coefficient)

V. Conclusions and policy implications

This study investigated the influence of structural adjustment programmes on price incentives for agricultural production in Sudan. The examination shows that the two main programmes implemented in Sudan over the period 1978-1993 (ECRP and NESP) failed to improve either the level or the stability of real farm prices. Partial implementation of programmes and weak macroeconomic policies constitute the underlying causes. International terms of trade aggravated the bias against agriculture during the NESP (1990-1993). The findings indicate that the real exchange rate is an important determinant of agricultural price incentives. The economy-wide policies (exchange rate, trade and macroeconomic policies) form a dominant source of tax on agriculture. If agriculture is to contribute to Sudan's economic recovery and long-term growth, not only do the sector-specific policies need to be improved, but also – and mainly – the trade and macroeconomic environment determining the real exchange rate must be enhanced.

Analysis of agricultural supply response indicates that the supply price elasticity of aggregate agricultural output in Sudan, as in other developing countries, is positive but low. This adds to the accumulating evidence of the positive response of developing countries' agriculture sectors to price incentives. This evidence suggests that the target of the adjustment programmes in Sudan (ECRP and NESP) of raising producer prices is reasonable and advisable, although evidence shows the failure of both programmes to produce any significant increase in real farm prices. But more seriously, the two programmes seem to have underplayed the role of the non-price factors, though the NESP has an edge in this respect. Non-price factors appear to play an important role in determining agricultural growth. The importance of the non-price factors arises from their direct effects on the magnitude of farmers' response to price incentives.

The analysis implies that without the provision of adequate credit, infrastructure and public investment, aggregate agricultural supply response to increased price incentives will be minimal. Agricultural price policy measures must be implemented carefully, complemented by suitable macroeconomic policies and much needed non-price policies.

Three important implications may be drawn from the aggregate supply elasticities. First, aggregate output responds positively to output prices, but negatively to reduction in public inputs. Raising farm prices and improving the provision of public inputs are difficult to achieve simultaneously, however. The government's high fiscal dependence on agriculture suggests that raising agricultural prices may reduce government's capacity to finance public goods in the short run. The net effect of such a policy on agricultural output may well be negative. Given the fiscal constraint that usually faces the government during adjustment programmes, it would be extremely difficult to avoid the short-run negative impact of reduced public inputs. Supply price elasticity alone does not reflect

fully the likely effect of changes in real farm prices following adjustment reforms. The actual outcome in the short run is the net composite effect of changes in real farm prices and the consequent change in the provision of public goods in agriculture emanating from changes in real farm prices.

It is theoretically plausible that higher prices may serve in the long run to promote private investments in research, technology and public goods. At the present level of development in the country, however, it is less likely that the private sector will be able to invest significantly in response to higher prices.

Second, the aggregate response of cereals (staple food crops) to price changes seems to be positive and much higher than expected. This finding does not lend support to the generally held notion that an increase in the general price level for agriculture increases cash crop production at the expense of food production. Cereal crops in Sudan are not produced entirely for domestic purposes. The distinction between food and cash crops is perhaps inaccurate for Sudan, as increasingly cereals and non-cereals provide alternative sources of cash income for the farmer.

Third, while the adjustment reforms seem to have paid more attention to increasing incentives to producers, some of the measures adopted (as part of these reforms) actually worked to reduce farmers' response to incentives. The tight control on consumer goods imports and the removal of subsidies from consumer goods, for instance, have resulted in shortages of basic commodities such as fuel, tea, sugar and clothing. Shortages of these commodities undermine farmers' response to price incentives. Acute shortages of imported foods in the semi-arid region where tribesmen tap the gum trees have resulted in a sharp decline in gum arabic production (Nashashibi, 1980). Recent studies on SSA have shown the significant impact of consumer goods availability on cash crop expansion (Berthlemey and Morrison, 1987; Bevan, *et al*., 1987). These problems appear to be more acute in rainfed agriculture. Furthermore, adjustment programmes, through their short-term effects on price stability and supply of imported inputs, tend to create a significant element of risk and uncertainty, which may reduce farmer's response to prices. The rate of adoption and diffusion of production technologies in Sudanese agriculture, for example, was shown to depend a great deal on the associated risks (Hassan, D'Silva and Hallam, 1992).

The findings of this study hold some important implications for policy making in Sudanese agriculture. The current three-year economic programme (1994-1996) liberalized large sectors of the Sudanese economy from public sector control and attempted to promote the role of the private sector. Significant developments have taken place in this respect: farmers' representation in the boards of directors of APCs increased to 50%; all decisions on credit and financing are negotiated by farmers; and cotton marketing is completely controlled by the Farmers' Union, which owns the Cotton Marketing Company since its privatization. It is too early to judge on the impact of such changes in agriculture. But the findings of the study call for special attention to the need for a more balanced policy change that gives due consideration to public investment in agriculture. At this level of development in the country, growth in agriculture can hardly be achieved without public investments.

It is hoped that further improvements in data quality and methodology may help in producing a more accurate vision of the way agriculture responds to policy changes.

Notes

1. Some of the previous studies on the supply response of Sudanese agriculture are cited in Section 4 of this study.
2. Estimates of livestock population vary widely according to source. Recent official estimates go as high as 103 million. The facts will have to be revealed by the livestock census, which is long overdue.
3. During the 1980s remittances constituted an important source of foreign exchange earnings in Sudan. For instance, in 1986 remittances represented 67% of the country's total value of merchandise exports (FAO, 1990).
4. The use of border price equivalents (adjusted for transportation and marketing costs) means that the NPC_d for exportables and importables can be expressed as:

$$NPC_d = Pf/(EPb-c) \text{ for exportables}$$
$$\text{and } NPC_d = Pf/(EPb+c) \text{ for importables}$$

   where c is the marketing and transportation costs from the farm gate to the border and EPb is the border price before adjustment for transportation and marketing costs. In other words, EPb* is equivalent to EPb-c for exportables and to EPb+c for importables.

5. Terms-of-trade effects were automatically excluded as only NRP_d and NRP_p are used.
6. The instability index is specified as:

$$1=\Sigma(|X-X^*|)/X^*$$

Where the sign || indicates absolute value

X = actual producer/border price
X^* = linear trend of producer/border price

7. This method was previously used for isolating the contributions of price and quantity effects to revenue instability (Murray, 1979; Wiebelt *et al.*, 1992).

8. Aggregate agricultural output is specified as:

$$Q_a = \Sigma w_i Q_{it}$$

where:

Q_a = aggregate output
W_{it} = share of the ith crop in total value of agricultural output in year t
Q_{it} = output index (1980=100) of crop i in year t

Aggregate farm-gate prices were estimated applying the same formula.

9. For the appropriate use of each of these prices, see, for example, Askari and Cummings (1976).
10. The GDP deflator is a better proxy than CPI, but incomplete data preclude its use.
11. Non-stationary series have a variance that is asymptotically infinite and the series rarely crosses its mean. In contrast, stationary series have a finite variance with a tendency to return to the mean value.
12. The DF and ADF are tests against the null that there is a unit root I(1) of the series (see Dickey and Fuller, 1981; Adam, 1992). The SBDW is a test against the null that the series is stationary [I(0)].

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Appendix A

Table A1: Nominal protection coefficients NPC_d (Pf/Pb*) for the major agricultural commodities, 1970-1993

	Sorghum	Wheat	GN	Gum	Millet	Sesame	Cotton	Aggregate	Cereals	Non-Cer.
1970	0.76	1.13	0.63	0.67	0.92	0.59	0.00	0.79	0.80	0.62
1971	0.49	1.00	0.46	0.67	0.39	0.72	0.00	0.53	0.52	0.57
1972	0.34	1.06	0.51	0.32	0.68	0.71	0.00	0.45	0.42	0.56
1973	0.38	1.20	0.46	0.31	1.29	0.42	0.00	0.52	0.53	0.44
1974	0.42	1.02	0.69	0.63	1.48	0.54	0.00	0.58	0.56	0.64
1975	0.31	1.81	0.94	1.32	0.72	0.73	0.00	0.52	0.45	0.90
1976	0.46	0.57	0.50	0.72	0.85	0.79	0.00	0.52	0.50	0.63
1977	0.67	1.33	0.53	0.56	0.91	0.44	0.00	0.72	0.74	0.50
1978	0.73	1.23	0.43	0.44	0.95	0.57	0.00	0.76	0.79	0.48
1979	0.52	0.79	0.43	0.52	2.62	0.48	0.00	0.71	0.74	0.46
1980	0.41	0.87	0.55	0.30	1.75	0.68	0.00	0.58	0.57	0.57
1981	0.51	1.27	0.48	0.28	2.76	1.09	0.88	0.80	0.78	0.81
1982	0.47	1.24	0.61	0.44	0.98	0.93	0.92	0.66	0.57	0.84
1983	0.95	0.91	0.44	0.42	0.97	0.81	0.69	0.87	0.95	0.65
1984	0.90	1.16	0.52	0.74	1.04	0.97	0.65	0.87	0.93	0.68
1985	1.96	1.51	0.55	0.52	1.41	0.40	0.46	1.49	1.88	0.48
1986	1.04	1.14	0.63	0.43	0.96	1.01	0.93	1.00	1.04	0.86
1987	0.55	2.29	0.89	0.67	1.01	0.84	0.86	0.77	0.72	0.86
1988	1.44	0.91	1.09	0.82	1.23	0.83	0.74	1.23	1.38	0.83
1989	0.94	2.57	0.54	0.77	1.09	1.50	0.86	1.02	1.07	0.88
1990	1.16	1.27	0.97	0.80	1.56	0.58	0.99	1.14	1.23	0.93
1991	1.91	0.88	1.01	0.78	2.40	0.54	0.76	1.28	1.50	0.78
1992	0.87	1.03	0.66	0.73	1.45	0.97	0.51	0.87	0.97	0.63
1993	0.98	0.60	0.35	0.50	1.79	0.94	0.26	0.73	0.86	0.41

Source: Computations are based on data obtained from the Department of Agricultural Economics and Statistics, Ministry of Agriculture; and Bank of Sudan *Annual Report* (various issues).

Table A2: Terms of trade TOT (Pb*/P*) for the major agricultural commodities, 1970-1993

	Sorghum	Wheat	GN	Gum	Millet	Sesame	Cotton LS	Aggr.	Cereals	Non-cer.
1970	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00
1971	0.96	1.15	0.93	1.00	0.97	0.74	0.95	0.97	0.97	0.93
1972	0.92	1.04	0.93	2.04	0.93	0.78	1.02	0.96	0.93	1.01
1973	0.83	0.91	1.01	1.97	0.79	1.35	1.20	0.95	0.83	1.21
1974	1.20	1.49	1.32	1.50	0.85	1.23	1.62	1.29	1.19	1.50
1975	2.00	0.78	0.80	1.24	0.78	1.21	1.27	1.63	1.79	1.17
1976	0.88	2.30	1.10	1.22	0.81	0.95	1.25	1.04	0.97	1.18
1977	0.75	0.90	1.30	1.41	0.67	0.84	1.54	0.94	0.75	1.39
1978	0.82	0.91	1.23	1.16	0.60	1.01	1.14	0.91	0.80	1.15
1979	0.98	1.18	1.22	1.15	0.37	1.19	1.18	1.02	0.93	1.19
1980	0.65	0.73	0.53	1.95	0.31	0.61	1.31	0.76	0.62	1.08
1981	0.89	0.65	1.00	2.41	0.33	0.45	1.26	0.92	0.81	1.14
1982	0.83	0.59	0.46	1.70	0.92	0.52	1.42	0.92	0.82	1.11
1983	0.79	0.92	1.09	2.23	0.75	0.83	1.83	1.02	0.80	1.56
1984	0.84	0.90	1.34	2.09	0.91	0.89	2.26	1.16	0.85	1.88
1985	0.51	0.50	0.98	3.59	0.82	2.08	1.90	0.91	0.54	1.80
1986	0.72	0.95	1.39	2.49	1.01	0.82	0.96	0.86	0.76	1.09
1987	0.39	0.28	0.45	2.97	0.35	0.47	0.72	0.48	0.38	0.71
1988	0.33	0.80	0.36	1.70	0.44	0.52	0.53	0.42	0.37	0.54
1989	0.25	0.24	0.48	1.26	0.23	0.32	0.44	0.31	0.25	0.46
1990	0.31	0.58	0.62	0.95	0.26	1.01	0.47	0.49	0.43	0.62
1991	0.36	0.78	0.64	0.97	0.32	0.83	0.53	0.57	0.54	0.64
1992	0.34	0.48	0.88	1.12	0.31	0.66	0.66	0.50	0.40	0.73
1993	0.26	0.44	0.86	0.53	0.20	0.36	0.46	0.40	0.34	0.52

Source: Computations are based on data obtained from the Bank of Sudan *Annual Report* (various issues) and the IMF, IFS (1980, 1990, 1994).

Table A3: Real exchange rate index RER (EP*/P) for the major agricultural commodities, 1970-1993

	RER for cotton and gum	RER for other crops	Aggregate RER
1970	0.99	0.99	0.99
1971	1.05	1.05	1.05
1972	0.95	0.95	0.95
1973	0.89	0.89	0.89
1974	0.80	0.80	0.80
1975	0.72	0.72	0.72
1976	0.77	0.77	0.77
1977	0.71	0.71	0.71
1978	0.92	0.69	0.74
1979	0.77	0.65	0.67
1980	0.68	0.68	0.68
1981	0.61	0.65	0.64
1982	0.52	1.35	1.18
1983	0.42	1.09	0.95
1984	0.33	0.85	0.74
1985	0.23	1.17	0.98
1986	0.58	0.86	0.81
1987	0.67	1.14	0.04
1988	0.93	0.93	0.93
1989	0.84	0.58	0.63
1990	0.70	0.37	0.43
1991	0.33	0.21	0.23
1992	0.58	0.96	0.88
1993	1.02	1.02	1.02

Source: Computations are based on data obtained from the Bank of Sudan *Annual Report* (various issues) and the IMF, IFS (1980, 1990, 1994).

Table A4: Nominal aggregate agriculture protection rates, 1978-1993

	NRP_d	NRP_p	NRP_t
1970	-21.37	-21.77	-20.99
1971	-46.80	-44.23	-46.09
1972	-55.40	-57.67	-59.42
1973	-47.65	-53.46	-55.85
1974	-42.17	-53.82	-40.47
1975	-48.34	-62.69	-39.21
1976	-47.54	-59.67	-58.07
1977	-28.30	-49.06	-52.00
1978	-24.32	-44.10	-49.22
Average (70-78)	-40.21	-49.61	-46.81
1979	-28.87	-52.06	-51.28
1980	-41.74	-60.15	-69.66
1981	-20.01	-48.77	-53.05
1982	-34.21	-22.25	-28.84
1983	-12.73	-16.91	-14.88
1984	-13.22	-35.50	-25.34
1985	49.07	46.26	32.68
Average (79-85)	-41.53	-27.06	-30.05
1986	-0.29	-19.54	-30.52
1987	-23.45	-20.21	-62.09
1988	23.33	14.80	-51.22
1989	2.45	-35.21	-79.78
1990	14.26	-50.31	-75.70
1991	28.36	-70.29	-82.97
1992	-13.07	-27.54	-63.47
1993	-27.44	-25.99	-70.39
Average (90-93)	0.53	-43.53	-73.13

Source: Computed from tables A1-A3 using the formulas of equations 4-6, where the total value of agriculture is taken as the total value of the selected crops.

Table A5: Nominal cereals protection rates, 1970-1993

	NRP_d	NRP_p	NRP_t
1970	-20.06	-20.46	-20.54
1971	-48.24	-45.74	-47.38
1972	-57.87	-60.02	-63.01
1973	-47.14	-53.01	-61.02
1974	-43.92	-55.22	-46.91
1975	-54.96	-67.47	-41.67
1976	-49.88	-61.47	-62.73
1977	-26.13	-47.51	-60.73
1978	-21.32	-45.49	-56.34
Average (70-78)	-41.06	-50.71	-51.15
1979	-26.12	-51.90	-55.11
1980	-42.53	-60.69	-75.46
1981	-21.64	-49.15	-58.60
1982	-42.64	-22.70	-36.30
1983	-5.01	3.13	-17.88
1984	-6.71	-20.93	-32.75
1985	87.77	119.32	17.85
Average (79-85)	-8.13	-11.85	-36.89
1986	3.76	-10.29	-31.66
1987	-28.42	-18.73	-69.52
1988	37.92	28.38	-51.97
1989	6.72	-38.02	-84.58
1990	23.13	-54.53	-80.59
1991	49.95	-68.83	-83.09
1992	-3.02	-12.14	-64.79
1993	-13.98	-12.25	-70.32
Average (90-93)	14.02	-36.94	-74.70

Source: Computed from tables A1-A3 using the formulas of equations 4-6, where the total value of cereals is taken as the total value of the selected cereal crops (wheat, sorghum and millet).

Table A6: Nominal non-cereal crops protection rates, 1970-1993

	NRP_d	NRP_p	NRP_t
1970	-37.73	-38.04	-37.82
1971	-42.74	-39.98	-44.40
1972	-43.78	-46.64	-46.08
1973	-56.37	-61.22	-52.88
1974	-36.41	-49.22	-23.64
1975	-10.12	-35.08	-24.19
1976	-37.43	-51.90	-43.02
1977	-49.72	-64.28	-50.17
1978	-51.59	-64.24	-59.01
Average (70-78)	-40.65	-50.07	-42.36
1979	-54.17	-69.11	-63.25
1980	-42.51	-60.67	-57.65
1981	-18.86	-48.04	-40.64
1982	-15.51	-0.15	10.90
1983	-34.94	-38.06	-3.47
1984	-32.41	-49.77	-5.38
1985	-52.35	-53.25	-15.93
Average (79-85)	-35.82	-45.58	-25.06
1986	-13.80	-30.44	-24.18
1987	-13.76	-10.11	-36.22
1988	-17.02	-22.76	-58.52
1989	-11.84	-44.25	-74.34
1990	-7.16	-59.62	-74.82
1991	-22.38	-82.04	-88.58
1992	-37.24	-47.69	-61.59
1993	-59.27	-58.45	-77.72
Average (90-93)	-31.51	-61.95	-75.68

Source: Computed from tables A1-A3 using the formulas of equations 4-6, where the total value of non-cereals is taken as the total value of the selected non-cereal crops.

Appendix B

Table B1: Unit root tests on annual data

Variable	DF	SBDW	Order of integration
ln Q	-5.6	1.07	I(0)
ln P	-5.2	1.01	I(0)
ln R	-7.7	1.60	I(0)
ln CR	-4.8	0.89	I(0)
ln F	-5.6	1.10	I(0)
ln V	-5.3	1.24	I(0)

The DF and ADF tests are run against the null hypothesis that there is a unit root of I(1) (non-stationarity) of the series. With a sample size of 88 the critical t-value for the DF and ADF is -2.93. The SBDW, on the other hand, is run against the null that the series is I(0) (i.e., stationary). The critical value for SBDW for a sample size of 88 is 0.39. Values of SBDW less than the critical value indicate rejection of the null.

Table B2: Regression results from ADL equation (Modelling aggregate agricultural output [LQ] by OLS pooled time-series/cross section data for four regions for the period 1971/72-1992/93)

Variable		Coefficient	Std error	HCSE	t-Value	Partial r^2
ln Q	1	.4115772	.12146	.14107	3.38871	.1677
ln Q	2	.0547317	.11953	.13263	.45789	.0037
ln Q	3	-.1097896	.11134	.10098	-.98610	.0168
ln P		.0105748	.13977	.13436	.07566	.0001
ln P	1	.2473839	.14501	.17067	1.70594	.0486
ln P	2	.1852657	.15868	.14843	1.16756	.0234
ln P	3	.0421557	.15733	.15175	.26795	.0013
ln R		.0931408	.27633	.34501	.33706	.0020
ln R	1	-.3337941	.25494	.23595	-1.30931	.0292
ln R	2	.0837506	.25843	.25403	.32407	.0018
ln R	3	-.2373359	.25776	.23316	-.92077	.0147
ln CR		.3117097	.14804	.13901	2.10561	.0722
ln CR	1	-.3574698	.14894	.14298	-2.40010	.0918
ln CR	2	.0695764	.12904	.12321	.53918	.0051
ln V		-.0929376	.21021	.17127	-.44212	.0034
ln V	1	.2307167	.18913	.14649	1.21992	.0254
ln V	2	-.4136180	.17052	.14276	-2.42563	.0936
ln V	3	-.1051635	.18510	.19618	-.56815	.0056
ln F		.4309628	.53753	.43549	.80175	.0112
ln F	1	-.1599082	.47971	.45292	-.33335	.0019
ln F	2	.1544978	.46545	.43673	.33193	.0019
ln F	3	-.4219068	.51425	.42097	-.82043	.0117
DUMw		-.3986914	.11117	.11769	-3.58638	.1841
DUM1		-.0338756	.12638	.10467	-.26804	.0013
DUM2		.1646466	.12481	.11038	1.31915	.0296
DUM3		-.1015674	.14124	.13008	-.71910	.0090
CONSTANT		4.1423068	4.00925	3.58910	1.03319	.0184

R^2 = .7604658 σ = .2721212 F(27,57) = 6.70 [.0000] DW = 1.797
Information criteria: SC = -1.539154
HCSE = heteroscedastic consistent standard errors

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