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IMPACT OF THE STRUCTURAL ADJUSTMENT PROGRAM ON AGRICULTURAL PRODUCTION AND RESOURCE USE IN EGYPT

Peter B.R. Hazell, Nicostrato Perez, Gamal Siam, and Ibrahim Soliman

Environment and Production Technology Division

International Food Policy Research Institute
1200 Seventeenth Street, N.W.
Washington, D.C. 20036-3006 U.S.A.

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ABSTRACT

This paper uses an agricultural sector model to evaluate the effects of an ambitious and ongoing policy reform program on agricultural production and resource use in Egypt. The results show that Egypt has already gained from the policy reforms, but that much larger gains depend on increased exports of high value crops.

Water is found to be emerging as an important constraint on agriculture, and it will be essential to establish more effective institutional and pricing mechanisms to encourage greater water use efficiency in the future. Because many of the new lands compete with the more productive lands of the Nile delta for water, the economic return to the development of new lands is also found to be low.

The policy reforms are not likely to lead to substantial increases in agricultural employment, even if exports of high value crops could be increased. However, the model results also show that more employment intensive strategies could be designed that would involve little sacrifice in economic efficiency.

CONTENTS

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1. INTRODUCTION

Egypt is currently engaged in an ambitious set of macroeconomic and market reforms known as the Structural Adjustment Program (SAP). These reforms began in 1987 when the Ministry of Agriculture and Land Reform began removing taxes and subsidies in the agricultural sector. In 1992, Egypt undertook a more widespread policy reform designed to affect all sectors of the economy. These reforms are currently being implemented.

The adjustments caused by these reforms are likely to be substantial. Within the agricultural sector, not enough is known about the impact of the adjustment process on resource use, national food supplies, employment and farm incomes. The objectives of this study are *(i)* to assess the short-term impacts of the SAP on cropping patterns, agricultural production including food, resource use, employment and farm income; and *(ii)* to identify current and emerging constraints on agricultural growth that, if not offset, could slow longer-term supply response to the SAP.

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[*] Director, Environment and Production Technology Division, International Food Policy Research Institute.
[**] Research Analyst, Environment and Production Technology Division, International Food Policy Research Institute.
[***] Professor of Agricultural Economics, Center for Agricultural Economics Studies, Cairo University.
[****] Professor of Agricultural Economics, Zagazig University.

The chronology and main features of the SAP as it affects agriculture are discussed in Appendix A. Prior to 1986, the government controlled nearly all aspects of the agricultural sector, including crop rotations, the area planted to most food and cash crops, producer and consumer prices, agricultural processing, marketing and trade, farm input supplies and credit. Most of these policies were dismantled shortly after 1986, and by 1990 the only remnants of the old policies were minimum area constraints on cotton, rice and sugarcane, a compulsory procurement quota for rice, subsidies on several farm inputs, and tariffs that prevented full border pricing. Most of these policies were also abandoned by 1993.

2. AGRICULTURAL SECTOR MODEL AND RESULTS

MODEL SPECIFICATION

In order to analyze the impact of the SAP, and to explore options for the future, a mathematical programming model of Egypt's agricultural sector was constructed. The model, described in Appendix B, simulates competitive market equilibrium behavior through maximization of the sum of consumer and producer surpluses across markets (Hazell and Norton, 1986). Commodity prices, production, consumption, imports and exports are all endogenous, and the model is able to simulate market responses to changes in the economic environment, including those induced by the SAP.

An initial model (EASM89) was obtained from the Ministry of Public Works and Water Resources, and this was extended in the following ways: (i) all coefficients and prices were updated to 1990; *(ii)* the livestock sector was introduced on an endogenous

basis (i.e., livestock numbers and production of livestock products are determined as part of the model's solution); *(iii)* technology choices were added with respect to crop planting dates, intensity of irrigation water use, and methods of fattening and feeding livestock; and *(iv)* the new lands were added.

The model includes a detailed regional specification of agricultural production with eight regions (Nile Valley: Upper Egypt, Middle Egypt, and Eastern, Middle and Western Delta; and New Lands: Sandy soils, canal fed; clay/calciferous soils, canal fed; and sandy soils, groundwater fed). There are 37 different types of cropping activities with three water treatments and three planting dates for each. Five types of livestock are included (buffalo, cattle, sheep and goats, broiler chickens, and laying hens); and buffalo and cattle are divided in breeding and fattening units. The breeding units produce milk and calves, and calves not reared for replacements can be sold for veal or fattened into one or two-year old animals. Draft animals (donkeys, horses, and camels) are included in the model on an exogenous basis to ensure that their feed and labor requirements are met. The processing of agricultural commodities is also included in the model, and many of these activities generate by-products for livestock feed.

The major resource constraints in the model are monthly land and labor supplies by region, an annual water constraint, seasonal feed requirements for livestock, technical constraints on crop rotations and maximum feasible areas for some individual crops (e.g., rice). Additionally, all markets are required to clear, whether they are markets for intermediate commodities like calves or livestock feeds, or wholesale or retail markets for final products.

MODEL VALIDATION

The model was first solved for 1990 as the base year and the results checked against actual 1990 prices and domestic consumption. For this purpose, policy interventions still in effect in 1990 were included in the model specification. The key assumptions are as follows: *(i)* a procurement policy for rice of one metric ton (mt) per feddan of paddy,[1] with excess production sold in the private (parallel) market; *(ii)* 1990 area controls on cotton, sugarcane and rice; *(iii)* all import and export activities constrained not to exceed 1990 values; *(iv)* all import and export prices set at 3-year average (1988 to 1991) border prices, adjusted for 1990 tariff rates; and *(v)* inputs (credit, fertilizers and pesticides) subsidized at 1990 levels.

Key validation results for 1990 are shown in Table 1. The model fits the base year actuals reasonably well in terms of the relative magnitudes of the individual commodity quantity and price variables. On average, the predicted prices are 88 percent of their base year actuals, and the predicted quantities consumed are 109 percent of their actuals.

THE 1990 BASE SOLUTION

The 1990 base solution provides useful insights into the economics of Egyptian agriculture, which are elaborated in this section.

Total agricultural sector income, including labor income and marketing and processing activities, is LE16.86 billion (Table 2). At a 1990 exchange rate of LE3.1=US$1, sector income is $5.44 billion, which compares with a World Bank

[1]A feddan equals 0.42 hectares, or 1.04 acres.

estimate of $5.6 billion (World Bank, 1992). Given a total rural population in 1990 of 27.6 million, sector income is also LE611 ($197) per rural person.

Producers' surplus is LE9.84 billion, consumer surplus is LE24.77 billion, and the sum, which is a rough measure of social welfare, is LE34.61 billion. The agricultural sector also generates 1,569 million mandays of employment (farm family plus hired labor), equivalent to some 6 million full-time jobs, with a total value of LE7.0 billion. Of this, only LE 226 million (3.2 percent) is paid to hired laborers. Agricultural exports are worth LE970 million, but with imports of LE2,414 million (mostly wheat, see Table 3), the agricultural sector has a trade deficit of LE1,444 million. This estimate does not include the value of imported inputs for agriculture. The gross cropped area is 13,437 thousand feddans on a net area of 7,730 million feddans. The overall cropping intensity is therefore 1.74. The old lands account for 86 percent of the gross cropped area and 75 percent of the net area, giving them an overall cropping intensity of 1.98 (Table 4). The new lands have a much lower cropping intensity of 1.01.

Table 1--1990 Model validation: Domestic consumption and prices

Commodity	Domestic Consumption		Domestic Prices	
	1990 Actual	1990 Base Solution	1990 Actual	1990 Base Solution
	(1,000 metric tons)		(LE/metric tons)	
Barley	101	84	221	412
Beans	394	451	1,350	1,041
Lentils	12	16	2,630	1,574
Legumes	37	41	1,350	1,098
Sesame	32	43	3,450	2,276
Groundnuts	20	10	565	846
Soybeans	6	-	375	750
Onion	668	956	549	179
Potato	1,835	2,666	494	203
Tomato	4,824	7,028	408	159
Vegetables	3,232	4,581	526	237
Sorghum	260	301	532	401
Maize	4,056	5,310	610	333
Citrus	2,351	1,408	350	436
Vegetable Oil	846	286	800	1,241
Flax	86	125	600	330
Sugar	1,684	2,091	500	288
Cotton (MLS)[a]	68	-	3,000	3,857
Cotton (LS)	187	194	5,160	5,093
Cotton (ELS)	33	44	5,635	4,910
Rice	1,499	1,809	801	576
Wheat	10,987	11,209	763	735
Beef	547	462	9,800	10,421
Milk	2,230	2,371	1,008	937
Sheep/goat meat	99	122	10,980	9,546
Poultry meat	203	395	6,760	3,834
Eggs	156	236	4,000	2,175
Predicted as % actual[b]		109		88

[a] MLS is medium-long staple cotton; LS is long staple cotton; and ELS is extra-long staple cotton.

[b] Calculated as

1 over n~ smallsum from j (x hat sub j / x sub j) where

x hat sub jis the predicted consumption or price for commodity j, x_j is the corresponding base year actual, and $n=27$ is the number of commodities.

Table 2--Summary variables from various model solutions

Item	1990 Base Solution	1990 with 10% less water	Full liberalization with 1990 export boundso	Liberalization with Export Promotion	Liberalization with Super Export Promotion	2000 With Zero Growth in Per Capita Income	2000 with 2% Annual Growth in Per Capita Income
Total cropped area (thousand feddans)	13,437	12,696	13,807	13,660	13,897	13,600	13,182
Shadow price land (LE/feddan)							
Upper Egypt	1,026	939	1,150	1,062	1,396	1,299	1,250
Middle Egypt	1,203	1,117	1,297	1,247	1,489	1,476	1,454
East Delta	1,120	1,043	1,155	1,143	1,400	1,441	1,455
Middle Delta	1,105	1,026	1,140	1,125	1,380	1,414	1,460
West Delta	1,230	1,059	1,153	1,190	1,443	1,457	1,443
New Lands							
- Clay, canal	126	64	261	94	93	128	87
- Sandy, canal	19	-	238	-	-	-	-
- Sandy, ground water	431	444	281	425	504	684	806
Shadow price water (LE/m^3)	0.056	0.071	-	0.048	0.049	0.084	0.107
Total value of exports (million LE)	970	970	970	6,632	12,864	6,651	6,618
Total value of imports	2,414	3,130	2,784	3,633	4,798	8,210	14,014
Trade balance (million LE)	-1,444	-2,160	-1,814	2,999	8,066	-1,559	-7,396
Total Sector Employment (million mandays)	1,569	1,541	1,608	1,583	1,599	1,558	1,846

Total sector income* (billion LE)	16.86	16.64	15.43	22.79	31.35	24.18	26.92
Producer surplus (billion LE)	9.84	9.77	8.24	15.69	24.14	19.38	21.05
Consumer surplus (billion LE)	24.77	24.54	26.18	22.00	16.76	28.86	39.58
Sum of producer and consumer surplus (billion LE)	34.61	34.31	34.42	37.69	40.90	48.24	60.63

[a] Includes agricultural labor income, including the reservation value of farm family labor used.

Table 3--Agricultural trade in various model solutions

Commodity	1990 Base Solution	1990 with 10% less water	Full Liberalization with 1990 Export Bounds	Liberalization with Export Promotion	Liberalization with Super Export Promotion	2000 With Zero Growth in Per Capita Income	2000 with 2% Annual Growth per in Capita Income
(1,000 metric tons)							
Exports							
Legumes	3.9	3.9	3.9	39.1	78.2	39.1	39.1
Sesame	1.5	1.5	1.5	15.0	30.0	15.0	15.0
Groundnuts	3.3	3.3	3.3	16.4	32.8	16.4	16.4
Onion	59.9	59.9	59.9	598.5	1,197.0	598.5	598.5
Potato	135.6	135.6	135.6	677.9	1,355.7	677.9	677.9
Tomato	20.4	20.4	20.4	102.2	204.4	102.2	102.2
Citrus	150.3	150.3	150.3	450.9	901.8	450.9	450.9
Flax	9.7	9.7	9.7	96.7	193.4	96.7	96.7
Sugar	2.3	2.3	2.3	23.0	46.0	23.0	23.0
Cotton (LS)[a]	26.0	26.0	26.0	260.3	520.6	260.3	260.3
Cotton (ELS)	13.4	13.4	13.4	67.0	134.1	67.0	67.0
Rice	75.7	75.7	75.7	757.0	1,051.0	757.0	719.5
Milk	-	-	-	-	-	22.8	22.8
Imports							
Wheat	2,310.6	32,44.5	1,903.4	2,705.5	4,252.4	6,819.5	9,701.9
Sheep/goat meat	-	-	-	-	-	15.9	102.5

* LS is long-staple cotton and ELS is extra-long staple cotton.

The shadow prices, or annual rental values, for land are shown for each of the model's eight regions in Table 2. The shadow prices for the old lands fall in the LE1,000 to LE1,250 range per feddan, but they are much smaller for the new lands (only LE19/feddan for sandy-soil, canal-fed land, LE126/feddan for clay/calciferous soil, canal-fed lands and LE431/feddan for sandy soil, groundwater- fed land). Low yields and poor returns to water make these lands uncompetitive with the rich soils of the Nile valley, particularly as the canal-fed lands compete with the delta for water. Given these results, it seems paradoxical that considerable investment is being made to develop additional new agricultural lands in the desert while at the same time fertile land in the delta is being lost to urbanization. Surprisingly, very little of the new lands is used for high value horticultural crops other than citrus in the model's base solution (Table 4), but instead are planted to cereals, legumes and sugar beet.

Water is a binding constraint in the model and has a shadow price of LE0.056/cubic meter (m^3). This is the average price that farmers ought to be willing to pay for water if it were sold in a competitive market. The price seems reasonable; cotton, for example, needs 3,800 cubic meters of water per feddan, which would cost LE213/feddan if water were costed at its full economic value.

Table 4--Cropping pattern by region in 1990 base solution

Commodity	Upper Egypt	Middle Egypt	East Delta	Middle Delta	West Delta	NewLands		
						Sandy, Canal fed	Clay Canal fed	Sandy Ground-waterfed
				(1,000 feddans)				
Berseem	347	268	105	313	82	11	3	-
Maize (forage)	200	-	-	-	-	-	-	-
Maize (grain)	50	906	-	821	278	-	-	-
Wheat	133	548	618	1,720	343	582	947	5
Barley	-	73	-	-	-	-	-	-
Beans	334	-	-	-	-	-	-	-
Flax	-	-	-	-	-	52	-	-
Onion	75	-	-	-	-	-	-	-
Tomato	-	408	-	-	-	-	-	-
Vegetables	3	131	-	-	290	-	-	-
Cotton	181	94	208	89	290	-	-	-
Paddy	-	-	515	375	148	-	-	-
Soybeans	-	-	-	748	-	-	-	5
Potatoes	174	-	-	-	-	-	-	-
Sorghum	156	-	-	-	-	-	-	-
Sugar (beet)	-	-	-	-	-	65	81	-
Sugar (cane)	250	-	-	-	-	-	-	-
Citrus	-	-	-	-	155	-	-	77
Other legumes	-	-	-	-	-	53	-	-
Lentils	-	-	-	-	-	25	-	-
Sesame	82	8	-	-	-	-	-	-
Groundnut	-	-	-	-	-	-	16	-
Total cropped area	**1,985**	**2,436**	**1,446**	**4,066**	**1,586**	**787**	**1,047**	**87**
Available land area	**1,067**	**1,136**	**723**	**2,033**	**871**	**787**	**1,031**	**82**
Cropping intensity	**1.86**	**2.14**	**2.00**	**2.00**	**1.82**	**1.00**	**1.02**	**1.06**

Figure 1 -- Agricultural demand for water
Egypt ,1990

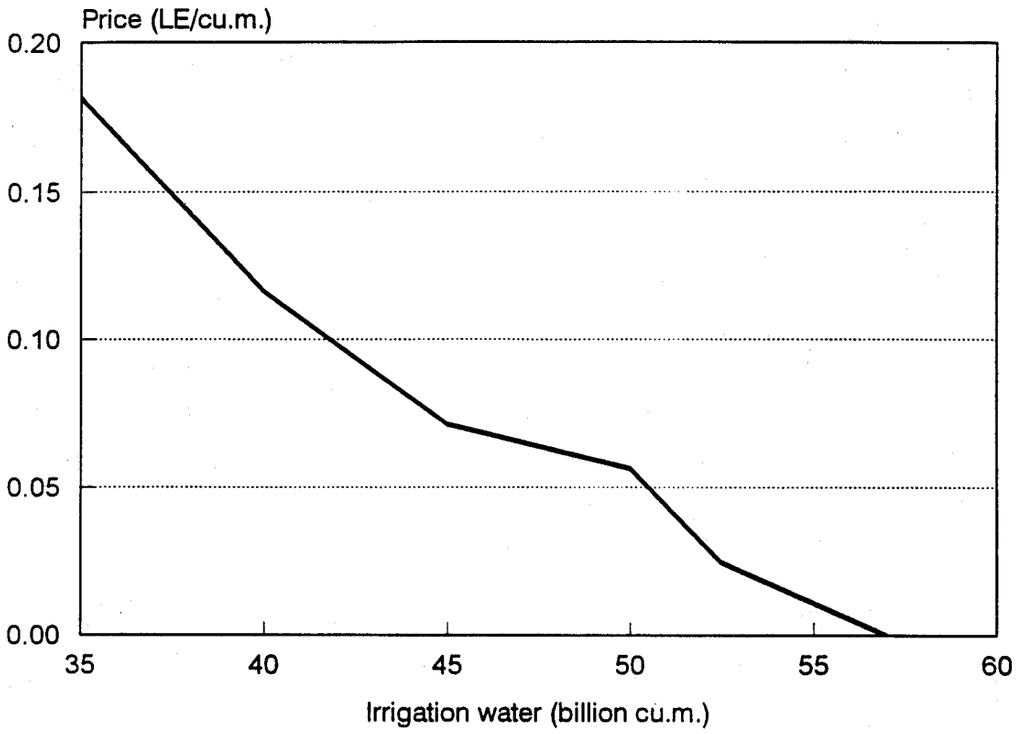


Figure 1

Table 5--Effect of changes in water supply, 1990 base model

Water Supply	Shadow Price	Sector Income	Sum Producer and Consumer Surpluses	Gross Cropped Area	Share New Lands in Gross Cropped Area
	(LE/m^3)	(LE billion)	(LE billion)	(million feddans)	(percent)
+10%	0.000	16.59	34.74	14.18	17.5
+ 5%	0.025	16.83	34.70	13.80	16.4
1990 base	0.056	16.86	34.61	13.44	15.0
-10%	0.071	16.64	34.31	12.70	9.6
-20%	0.116	16.25	33.84	11.75	3.0
-30%	0.182	15.94	33.11	11.38	5.3

The main mechanism for coping with changes in water supply is the gross cropped area. This declines by 15 percent when water supply is reduced 30 percent, and increases by 6 percent when the water supply is increased 10 percent (Table 5). The new lands bear a proportionally higher share of the changes in the gross cropped area than the old lands; their share falls from 15.0 percent to 5.3 percent when the water supply is reduced 30 percent (Table 5). Most of the cropped area adjustment is borne by wheat, berseem, and cotton (LS); their cropped area is positively associated with water supply. There is also a switch to low-intensity water use practices for the crops that are grown, but there is no expansion into high-value horticultural crops as water becomes scarcer.

IMPACT OF THE STRUCTURAL ADJUSTMENT PROGRAM

Several features of the SAP had already been implemented by 1990, and the analysis reported here is limited to the impact of the subsequent SAP changes implemented between 1990 and 1993. During this period, the procurement policy for rice was abandoned, area controls on cotton, rice and sugarcane were removed, and

subsidies on all farm inputs except cotton pest control were removed. These changes were introduced into the 1990 model to obtain the solution titled *"Full Liberalization with 1990 Export Bounds"* in the Tables. Note that this solution corresponds to 1990 resource endowments, technology prices, and export bounds but to 1993 policy. It depicts what might have happened in 1990 had the SAP been fully implemented at that time. All changes between the full liberalization solution and the 1990 base solution are, therefore, entirely due to the policy changes implemented between 1990 and 1993.

The 1990-93 policy reforms have a negative impact on the agricultural sector; sector income declines 8 percent from its value in the 1990 base solution and the producer surplus declines by 16 percent (Table 2). The cropped area and production of individual commodities do not change very much (Tables 6 and 7), but prices fall 3 percent on average (Table 8) and input costs increase with the removal of subsidies. These results indicate that the agricultural sector enjoyed net protection under the policies in place in 1990.[2] Consumers gain LE1.41 billion (or 6 percent) from the policy changes

[2]In parallel work with a CGE model of the Egyptian economy, Robinson and Gehlhar (1995) show that the agricultural sector gained as a result of all the policy changes implemented between 1986 (1995) and 1993, so that the net protection shown here for 1990 was transitory. It arose because many input subsidies were still in place that year.

Table 6--National crop and livestock production in various model solution

Commodity	1990 Base Solution	1990 with 10% Less water	Full Liberalization with 1990 Export Bounds	Liberalization with Export Promotion	Liberalization with Super Export Promotion	2000 with Zero Growth in Per Capita Income	2000 with 2% Annual Growth in Per Capita Income
				(1,000 metric tons)			
Crops							
Berseem	29,459	29,444	30,146	29,999	29,993	43,891	61,154
Maize fodder	2,521	2,521	2,521	2,521	2,401	2,469	2,521
Barley	84	84	86	86	86	101	108
Beans	451	448	457	457	481	542	554
Lentils	16	16	16	16	16	19	20
Legumes	45	46	44	81	120	91	93
Sesame	44	44	47	56	70	69	71
Groundnut	13	11	23	26	43	24	19
Onion	1,016	1,014	1,015	1,542	2,127	1,753	1,856
Potato	2,802	2,801	2,796	3,307	3,914	3,885	4,163
Tomato	7,048	7,046	7,025	7,081	7,162	8,662	9,410
Vegetables	4,581	4,571	4,553	4,501	4,481	5,497	5,991
Sorghum	301	297	322	290	160	336	316
Maize	6,926	6,910	7,127	6,778	6,378	8,211	9,024
Citrus	1,558	1,531	1,784	1,726	2,002	1,418	1,771
Processed crops							
Vegetable Oils	286	288	234	192	264	167	159
Flax	134	134	132	222	319	248	270
Sugar	2,093	2,099	2,078	2,116	2,137	2,605	2,668
Cotton (LS)	220	213	252	381	521	317	294
Cotton (ELS)	57	56	60	99	137	94	94
Rice	2,559	2,474	2,705	3,010	3,094	3,363	3,393
Wheat flour	8,898	7,964	9,306	8,503	6,956	6,978	4,646

Table 6--National crop and livestock production in various model solution (continued)

Commodity	1990 Base Solution	1990 with 10% Less water	Full Liberalization with 1990 Export Bounds	Liberalization with Export Promotion	Liberalization with Super Export Promotion	2000 with Zero Growth in Per Capita Income	2000 with 2% Annual Growth in Per Capita Income
				(1,000 metric tons)			
Livestock products							
Beef	462	461	477	470	467	753	1,133
Milk	2,371	2,369	2,389	2,380	2,415	3,997	5,288
Sheep/goat meat	122	122	122	122	122	122	122
Poultry meat	395	394	402	389	375	490	573
Eggs	236	236	240	234	227	288	435

Table 7--National cropping pattern in various model solutions

Commodity	1990 Base Solution	1990 with 10% Less water	Full Liberalization with 1990 Export Bounds	Liberalization with Export Promotion	Liberalization with Super Export Promotion	2000 with Zero Growth in Per Capita Income	2000 with 2% Annual Growth in Per Capita Income
				(1,000 feddans)			
Berseem (long season)	1,115	1,096	1,144	1,131	961	1,588	2,272
Berseem (short season)	14	75	-	24	377	196	98
Maize (forage)[a]	200	200	200	200	200	200	200
Maize (grain)	2,054	2,049	2,157	2,060	1,998	2,275	2,454
Wheat	4,896	4,141	5,105	4,662	3,626	3,297	2,191
Barley	73	61	75	74	60	70	66
Beans	334	332	339	350	356	465	467
Lentils	25	25	18	18	18	22	23
Legumes	53	54	51	95	141	107	109
Flax	52	52	51	86	123	100	104
Onion	75	75	75	113	156	129	136
Tomato	408	407	401	404	409	494	537
Vegetables	424	422	556	503	469	648	590
Sugar (beet)	145	156	312	318	321	391	400
Sugar (cane)	250[b]	250[b]	-	-	-	-	-
Cotton	862	830	1,041	1,660	2,310	1,384	1,243
Paddy	1,037[b]	1,037[b]	1,088	1,200[c]	1,200[c]	1,200[c]	1,200[c]
Sesame	90	90	94	111	388	384	394
Soybeans	753	774	464	-	-	-	-
Groundnut	16	12	23	30	48	28	23
Potatoes	174	174	174	205	243	241	258
Sorghum	156	152	176	157	93	164	153
Citrus	233	231	264	258	398	218	263

[a] Restricted to a maximum of 200,000 feddans for technical reasons.
[b] Minimum quota constraint.
[c] Maximum area allowed because of canal capacity limitations on water delivery.

Table 8--Domestic prices in various model solutions

Commodity	1990 Base Solution	1990 with 10% Less water	Full Liberalization with 1990 Export Bounds	Liberalization with Export Promotion	Liberalization with Super Export Promotion	2000 with Zero Growth in Per Capita Income	2000 with 2% Annual Growth in Per Capita Income
				(LE/metric ton)			
Barley	412	412	381	385	388	429	435
Beans	1,041	1,052	1,007	1,005	877	1,010	1,124
Lentils	1,574	1,547	1,522	1,545	1,530	1,648	1,672
Legumes	1,098	1,057	1,192	1,070	1,086	1,036	1,036
Sesame	2,276	2,314	1,971	2,523	2,596	2,161	2,161
Groundnut	846	898	560	849	853	963	1,091
Soybean	750	750	750	750	750	750	764
Onion	179	181	181	194	212	202	212
Potato	203	204	205	216	241	225	232
Tomato	159	160	162	165	167	168	173
Vegetables	237	239	243	254	259	262	270
Sorghum	401	415	332	435	563	489	540
Maize	333	336	295	361	437	391	423
Citrus	436	438	415	448	464	492	516
Vegetable Oil	1,241	1,239	1,283	1,315	1,259	1,360	1,380
Flax	330	330	348	323	326	344	351
Sugar	288	285	296	287	288	285	287
Cotton (MLS)	3,857	3,857	3,857	3,857	3,857	3,857	4,045
Cotton (LS)	5,093	5,159	4,801	5,769	7,831	6,459	7,008
Cotton (ELS)	4,910	4,988	4,684	5,710	7,715	6,380	6,915
Rice	576	638	574	761	866	829	866
Wheat flour	735	735	735	735	735	735	735
Beef	10,421	10,429	10,316	10,364	10,387	9,322	9,912
Milk	937	938	929	933	915	507	510
Sheep/goat meat	9,546	9,546	9,546	9,546	9,545	10,155	10,155
Poultry meat	3,833	3,843	3,719	3,915	4,137	3,779	3,924
Eggs	2,175	2,181	2,100	2,230	2,378	2,234	2,309

Table 8--Domestic prices in various model solutions (continued)

Commodity	1990 Base Solution	1990 with 10% Less water	Full Liberalization with 1990 Export Bounds	Liberalization with Export Promotion	Liberalization with Super Export Promotion	2000 with Zero Growth in Per Capita Income	2000 with 2% Annual Growth in Per Capita Income
				(LE/metric ton)			
Price index[a]							
- 1990 base = 100	100	100.9	96.8	-	-	-	-
- Liberalization with 1990 export bounds = 100	-	-	100	108.6	115.9	110.9	116.1

[a] Calculated as
1 over n~ smallsum from j (x hat sub j / x sub j sup o)x 100, where
x hat sub jis the price for commodity *j* in the solution of interest,
x sub j sup ois the price in the relevant base solution, and n=27 is the number of commodities

because of the decline in prices (Table 2).[3] Overall, however, producers lose more than consumers gain, and the sum of producer and consumer surpluses decreases by LE 190 million or 0.5 percent (Table 2). But this sum does not factor in the value of reduced input subsidies to taxpayers, so the net social payoff is undoubtedly positive.

Total agricultural employment does not change much with liberalization, and the agricultural trade balance also worsens; the deficit increases from LE1.44 billion to LE1.81 billion. But this is based on the assumption that export opportunities remain the same as in 1990, and that the liberalization policy is not accompanied by any private or government attempt to expand export opportunities.

THE VALUE OF EXPORT PROMOTION

The preceding results about the impact of the SAP between 1990 and 1993 are disappointing, but hinge critically on the assumption that exports of individual commodities cannot be increased beyond 1990 levels. In this section, we re-evaluate the impact of SAP under alternative assumptions about export opportunities. We assume that with greater exposure to international trade and world markets, the private sector will respond by promoting its products and seeking to expand its export outlets overseas. Similarly, the government might engage in export promotion activities of its own, including the development of stronger marketing infrastructure and entering into trade negotiations to expand export quotas (e.g., for horticultural products to the European Union).

[3]These calculations do not include the value of food subsidies that consumers lost as a result of a policy reform, but nor they include the taxes and debt payments that were required to fund the consumer and producer subsidies.

Two export scenarios were developed. The first is thought to be a realistic goal for the country in the short- to medium-term. It assumes that exports of cotton (ELS), tomatoes, and potatoes could be increased fivefold over 1990 actuals, that citrus exports could be increased threefold, and that onions, rice, and poultry meat exports could be increased tenfold. Even with these rates of increase, the quantities involved would still be small (Table 3). The solution labelled *"Liberalization with Export Promotion"* in the tables was obtained after increasing the export upper bound constraints to these new limits.

The second scenario is more aggressive, and assumes that exports could be increased by twice the above amounts. The corresponding model solution is labelled *"Liberalization with Super Export Promotion"* in the tables.

The results show that export promotion has a dramatic impact on the benefits to be obtained from the SAP. Under the first export scenario, sector income increases by 48 percent (or LE7.4 billion) over the liberalization solution with 1990 export bounds (Table 2). The gains originate from a nearly seven-fold increase in export earnings (the agricultural trade balance even becomes positive, Table 2), and a 9 percent average increase in domestic prices (Table 8). Consumers lose LE4.2 billion (or 16 percent), but the gain to producers is sufficiently large that national welfare (as measured by the sum of producer and consumer surpluses) increases by LE3.3 billion (or 9.5 percent).

With the more aggressive export scenario, agricultural sector income increases to LE31.4 billion. This is twice the income level achieved with SAP under 1990 export

constraints. Agricultural export earnings also increase to LE12.9 billion, with a trade surplus of LE8.1 billion.

The downside to the strategy is its adverse impact on consumers. Domestic prices increase by 16 percent on average because of reduced production for the domestic market, with sizeable increases for cotton and basic foods like maize, rice, poultry meat and eggs (Table 8). Consumer surplus falls to LE16.8 billion, which is 36 percent smaller than when the 1990 export constraints are imposed. The loss to consumers is less than the gain to producers, so national welfare continues to increase, but the divergent changes in the welfare of the two groups might need to be addressed. One option is to constrain exports, though this has a high national economic cost, as approximated by the potential loss in the sum of the consumer and producer surpluses. A better alternative would be to explore policy options for transferring some of the additional income gains from farmers (especially the better-off ones) to consumers (especially the poorer ones). Appropriate changes in taxation and food subsidies would be one way to approach this problem.

Increased agricultural exports do little to create additional employment in agriculture; in fact employment declines modestly with both export strategies from the solution with 1990 export bounds (Table 2). Evidently, expansion into high-value horticultural crops is not effective in increasing employment because of other changes induced in the national cropping plan.

More export oriented strategies also fail to increase the economic value of many of the new lands (Table 2). While the shadow price of sandy soil/ groundwater-fed land

increases (because water becomes more valuable and groundwater does not compete with Nile water in the model), the shadow prices of the canal-fed new lands remain low.

STABILITY OF EXPORT EARNINGS

An export oriented strategy, particularly one that promotes high-value horticultural crops, could expose Egypt to considerable price risk. To evaluate the impact of fluctuations in export prices, additional model solutions for the *"liberalization with export promotion"* scenario were obtained for the worst and the best export price years experienced by Egypt during 1980-90. Because not all export prices move together (i.e., the best and worst prices for one commodity need not occur in the same years as those for other commodities), the best and worst years were defined as those in which the value of a given export bundle (the one in Table 3 for the *"liberalization with export promotion"* solution) reaches its maximum and minimum values when evaluated each year with historical export prices from 1980 to 1990. This procedure led to identification of 1985 as the best price year, and 1988 as the worst price year.

The results in Table 9 confirm that sector income, export earnings and national welfare (as measured by the sum of consumer and producer surpluses) would change in response to export price fluctuations. However, the changes are not that large, and even in the worst price year, both the agricultural sector and the nation would be considerably

Table 9--Impact of export price fluctuations in the liberalized situation with export promotion

Export year	Sector Income	Sum Producer & Consumer Surpluses	Export Earnings	Gross Cropped Area	Employment Water	Price
(million	(LE billion)	(LE billion)	(LE billion)	(1,000 feddans)	mandays)	(LE/m^3)
Worst price year (1988)	21.00	37.09	5.46	13,715	1,598	0.032
1989-91 average	22.79	37.69	6.63	13,660	1,583	0.049
Best price year (1985)	23.66	38.57	7.51	13,660	1,583	0.049

better off than with 1990 levels of exports. For example, agricultural sector income is still LE21.0 billion with the worst year (1988) export prices, which compares to a sector income of LE15.4 billion in Table 2 for the liberalization strategy with 1990 export bounds and more favorable average export prices. Export price fluctuations also have little impact on sector employment.

Although not shown in the table, the optimal cropping areas, and production, import and export quantities change little between the model solutions. In other words, these aspects of the sector would be robust and would not need to be adjusted much in response to export price movements.

EMPLOYMENT CREATION

Total agricultural sector employment changes little in the model solutions discussed so far, but remains within the 1,500-1,600 million manday range. It appears that neither the SAP nor the suggested export promotion strategies would, by themselves, be effective in increasing agricultural employment in the short run.[4]

Given the importance of employment creation as a national goal, additional model solutions were obtained for the *"liberalization with export promotion"* scenario in which total employment was forced to increase by varying amounts. The results are summarized in Tables 10 and 11 and Figure 2.

A very encouraging feature in these results is that employment could be significantly increased beyond the initial 1,583 million mandays at little cost to the national economy, consumers, or the agricultural sector. An initial 10 percent increase in employment over the optimal for the liberalization with export promotion scenario can be obtained at a cost of only 0.2 percent reduction in national welfare (as measured by the sum of producer and consumer surpluses), and a LE738 million worsening of the agricultural trade balance. Moreover, consumer surplus actually increases by 4 percent because of reduction in the domestic prices of several food commodities. This favorable tradeoff between the creation of additional employment and the associated economic efficiency cost is shown by the initial flatness of the graphs in Figure 2 as one moves to the right of the starting solution. Of course, the economic cost of creating additional employment beyond the initial optimal amount increases with the amount of

[4]Employment in agricultural marketing and processing activities may increase, but these changes are not captured in the model.

employment, and the graphs became increasingly steeper as employment is increased. At the extreme, the forced doubling of employment would reduce sector income and national welfare by 27 percent and 15 percent, respectively.

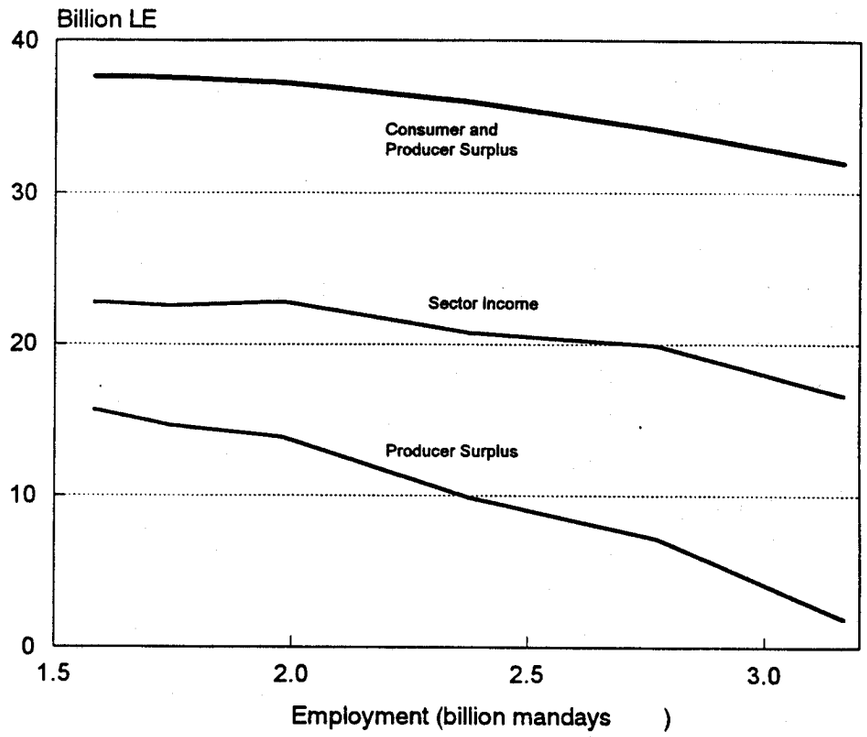
Table 10--Aggregate effects of forcing increased employment with the liberalization with export promotion scenario

Items	Liberalization with Export Promotion	Employment Constraint				
		+10%	+25%	+50%	+75%	+100%
Employment (million mandays)						
- *Farm family labor*	1,548	1,662	1,784	1,906	1,907	1,946
- *Hired labor*	35	80	195	469	864	1,221
- *Total*	1,583	1,742	1,979	2,375	2,771	3,167
Hired labor wage earnings (LE millions)	200	415	963	2,297	4,204	5,938
Agricultural sector income (LE billion)	22.79	22.52	22.80	20.76	19.92	16.62
Producer surplus (LE billion)	15.69	14.70	13.87	9.90	7.15	1.92
Consumer surplus (LE billion)	22.00	22.90	23.36	26.09	27.05	30.04
Sum producer and consumer surpluses (LE billion)	37.69	37.60	37.23	35.99	34.20	31.96
Total cropped area (million feddans)	13,660	13,989	14,102	14,037	14,083	14,260
Total value exports (LE million)	6,632	6,632	6,632	6,718	6,959	6,959
Total value imports (LE million)	3,633	4,371	4,219	5,920	6,676	8,002
Trade balance (LE million)	2,999	2,261	2,413	798	283	-1,043
Price water (LE/m^3)	0.049	0.056	0.059	0.078	0.083	0.095
Shadow price land (LE/feddan)						
- *Old lands*	1,149	1,182	1,241	1,317	1,339	1,370
- *New lands*						
Canal fed	53	60	75	73	76	73
Groundwater fed	425	514	602	799	851	965

Table 11--Changes in national cropping patterns and livestock production associated with increases in employment

Commodity	Liberalization with Export Promotion	Employment +10%	Employment +25%	Employment +50%	Employment +75%	Constraint +100%
Crop areas (thousand feddans)						
Berseem (LS)	1,131	1,230	1,120	1,428	1,524	1,765
Berseem (SS)	24	148	109	123	111	123
Maize (forage)	200	200	200	200	200	200
Maize (grain)	2,060	2,104	2,115	2,124	2,126	2,135
Wheat	4,662	4,429	4,706	4,318	4,269	3,979
Barley	75	68	69	57	57	57
Beans	350	367	360	361	363	511
Lentils	18	18	18	19	19	19
Legumes	95	96	97	100	107	108
Flax	86	86	86	92	92	93
Onion	113	114	114	114	114	114
Tomato	404	406	407	410	411	413
Vegetables	503	512	526	554	563	607
Sugar (beet)	318	319	320	345	347	349
Sugar (cane)	-	-	-	-	-	-
Cotton	1,660	1,723	1,691	1,593	1,549	1,517
Paddy	1,200	1,200	1,200	1,199	1,194	1,200
Sesame	111	313	323	346	353	367
Groundnuts	30	27	30	31	31	30
Soybeans	-	-	-	-	-	-
Potatoes	205	206	206	205	205	206
Sorghum	157	160	148	145	146	154
Citrus	258	261	255	273	301	311
Livestock numbers (thousands)						
Breeding buffalo	2,851	2668	58	-	-	-
Breeding cattle	4,427	5,981	12,600	16,829	20,808	24,672
Chickens	409	418	421	458	464	477
Sheep/goats	9,254	9,254	9,254	9,254	9,254	9,254

Figure 2 -- Income and employment in Egypt



Additional employment is taken by both farm family workers and hired laborers, but hired laborers gain the largest proportional increase. Hired labor accounts for only 35 million mandays (2.2 percent of total employment) in the initial optimal solution in Table 10, and this increases to 1,221 million mandays (38.6 percent of total employment) when total employment is doubled. Total wage earnings for hired laborers also increase sharply with total employment.

As more employment is forced into the model, land and water resources become scarcer relative to labor, and this is reflected in their increasing shadow prices in Table 10. Water, for example, increases in value from LE0.049/m^3 to LE0.056/m^3 when employment is increased by 10 percent. Although the shadow prices of land increase with increased employment, the canal-fed new lands still lag far behind. Only the groundwater-fed new lands begin to achieve price parity with the old lands, a reflection of their independent source of water.

The cropping and livestock changes induced by the employment constraint are shown in Table 11. The total cropped area increases with employment as a result of increases in berseem, maize, beans, vegetables, sesame, citrus and sugarbeet production. Wheat and cotton areas decline. The number of breeding buffalos also declines rapidly with increasing employment, though this is more than offset by an increase in the number of breeding cattle. There is a net increase in beef and milk production.

These results suggest that agricultural employment could be increased by 10-25 percent at an acceptable economic cost to the country. Unfortunately, the model

solutions do not indicate how this could be achieved.[5] Simply enforcing employment constraints (as in the model) is not a viable policy instrument for the government, particularly at a time when all attempts to regulate farmers' cropping patterns have been abandoned. What is needed is an appropriate mix of policies (e.g., tariffs and subsidies) that could be used to induce farmers to make the equivalent changes in their production and hence employment patterns. The model solutions provide the target crop and livestock plans that give desired levels of employment. Further work is needed to identify practical policy interventions that, if introduced into the model in the absence of the employment constraint, would still give similar employment enhancing solutions. Solving this problem would likely require a multi-level programming approach in which the existing sector model is embedded within, or interacts with, a government policy model (Hazell and Norton, 1986, Ch. 7). This exercise lies beyond the scope of the present study.

LONGER-TERM PROSPECTS FOR AGRICULTURAL GROWTH

So far, all the model solutions have been based on 1990 resource endowments, technology, border prices and domestic demand parameters. This is relevant for analyzing the immediate impacts of the policy reforms, but the longer-term effects cannot be evaluated without more relevant assumptions about how resource endowments, technology, demand and world prices will also change.

[5]One way to implement the desired change would be to subsidize the agricultural wage rate by the amount of the shadow price on the total employment constraint in the model. But this is not considered a realistic policy solution.

Two scenarios for year 2000 were developed for analysis with the model. In both cases, population growth is assumed to continue to grow at 2.1 percent per year and this leads to corresponding changes in the parameters of the national demands for agricultural commodities and in the farm population and work force. It is also assumed that *(i)* an additional half million feddans of new lands will be developed by 2000 on sandy soils with canal-fed irrigation; *(ii)* increased urbanization and industrialization will lead to a loss of 100,000 feddans of delta land, and to a 3 billion m^3 reduction in the amount of water available to agriculture; *(iii)* yields will increase by 1 percent per year; and *(iv)* exotic breeds of cattle (e.g., holstein) may be adopted, but not to exceed 20 percent of the breeding population by year 2000. Border prices are held at 1990 levels, and exports are constrained to the same levels as in the earlier *"liberalization with export promotion"* scenario. The distinguishing feature between the two scenarios for 2000 is the assumption about growth in national per capita income. This is assumed to grow by 2 percent per year in one scenario, but to be zero in the other. Income growth affects the model through the location of the national demand curves. The demand parameters are appropriately adjusted for per capita income growth with the aid of available estimates of the income elasticities of demand for different commodities.

The results for year 2000 show continued increases in sector income, consumer welfare, and the sum of the consumer and producer surpluses (Table 2), and these would be even larger if export opportunities could be increased further. Per capita income growth has its largest impact on consumers' surplus; it is 37 percent as large again as in the no-growth scenario. Producer surplus and agricultural sector income, on the other

hand, are only 9 and 11 percent larger when per capita incomes increase. There is also an increased dependence on wheat imports (Table 3), and the agricultural trade balance becomes negative under both scenarios for 2000 (Table 2).

The shadow prices for new canal-fed lands remain low in both scenarios, and are zero for the canal-fed sandy soils that the government is planning to develop. These do not appear to be a wise investment from an agricultural point of view. The groundwater-fed new lands fare better, but even in the scenario with per capita income growth, their economic worth is only about 55 percent of the old lands.

Water becomes an increasingly scarce resource by 2000, and its economic value attains LE0.107/m^3 when per capita incomes grow. It will be imperative to develop more efficient ways of pricing and allocating water if water is not to become a major constraint on agricultural growth in the years ahead.

Agricultural employment increases beyond the 1990 levels in the 2000 scenario with 2 percent income growth, but not by enough to offset the accompanying population increase. As discussed in the previous section, it may be advisable to develop appropriate policies to promote more employment intensive patterns of agricultural growth, especially if this can be achieved at little economic cost.

3. CONCLUSIONS

The modeling analysis in this paper shows that Egypt has already gained from the agricultural policy reforms associated with the structural adjustment program. However, much larger gains could be had, especially by farmers, if export opportunities for high

value crops could be increased above 1990 levels. The private sector may well take the needed initiative itself in promoting exports now that it more exposed to international markets, but the government also needs to be more aggressive in developing needed marketing infrastructure, in promoting exports overseas, and in negotiating improved export opportunities.

The model results suggest that the current policy reform, even allowing for increased export possibilities, is unlikely to lead to substantial increases in agricultural employment. However, the model has also identified more employment intensive cropping patterns that involve little sacrifice in economic efficiency. Further work should be directed towards identifying appropriate modifications to the policy reforms that could enhance their employment creation effects.

The model has also been used to derive the agricultural sector's demand for water. Water has an economic value of LE0.056/m^3 in the 1990 base solution, and this is likely to double by the year 2000. Increasing water-use efficiency in agriculture will be critical for sustained agricultural growth in the years ahead. At the same time, the model has demonstrated considerable inefficiency in the use of water in agriculture at present. If farmers had to pay a full economic price for their water, total water use in agriculture would decline, yet at little cost to agricultural income. Priority should be given to identifying institutional and pricing mechanisms for improving water allocation in agriculture so that its use is more closely tied to its economic returns.

Finally, the model results show that the economic returns to developing the new lands are low. These do not appear to be a good investment from an economic point of

view, and many of them compete for water that has a much higher return in the Nile delta.

APPENDIX A.—AGRICULTURAL POLICY REFORM IN EGYPT, 1986-1994

Deregulation of the Egyptian economy has been conducted through a reform program consisting of two major components: stabilization policies and a structural adjustment program. Stabilization policies, designed in consultation with the IMF, are oriented to reductions in expenditures to bring about an adjustment of domestic demand to reduce the level of dependence on external resources, and thus correct inflationary fiscal and monetary policies and allow interest rates and exchange rates to respond to market forces.

The Structural Adjustment Program (SAP) is planned in collaboration with the World Bank and USAID and supported by a 1991 World Bank Structural Adjustment Loan (SAL) of US$300 million. Moreover, a standby arrangement with IMF, equivalent to SDR 278 million, was approved in the same year. The SAP is also supported by the African Development Bank and others.

The SAP is designed to improve the conditions of supply, correct distortions in economic policies, improve allocation of domestic resources and produce institutional transformations to help reduce vulnerability to external shocks in the future. It consists of five components: price reform measures; private sector reforms; foreign trade liberalization; public sector reforms; and the Social Fund.

Starting in 1986, important reforms have been introduced under the SAP to the agricultural sector of Egypt (Table A.1). The broad context of these reforms was the

Table A.1--Agricultural policy changes between 1986 and 1993

	1986	1987-93
Production	- Crop areas and rotations determined by the government. - Vegetables, fruits, and berseem unrestricted. - Minimum area of cotton. - Maximum area of rice (1.2 mill feddans).	- Crop areas and rotations decided upon by farmers except that a maximum area of rice (1.2 mill feddans) was retained. - Minimum area of cotton was relaxed.
Input delivery	- All inputs are distributed by PBDAC through coops with fixed quantities (on per feddan basis) for different crops, and feed is delivered on per head basis.	- Inputs are marketed freely.
Input prices and subsidy	- Input prices are set by the government with an average 50 percent subsidy (fertilizer, pesticides, seeds, and feed)	- Prices of inputs are market determined except: 20 percent subsidy on fuel 15 percent tax on fertilizer imports 50-75% subsidy on cotton seeds 80% subsidy on cotton control costs
Credit and interest rate	- All inputs are supplied by PBDAC according to predesigned crop rotation as in-kind credit. - PBDAC supplies cash credit to finance labor costs (also on per feddan basis) and other purposes such as fattening. - Credits are at subsidized interest rate (50 percent less than market interest rate). - All imported inputs are imported through PBDAC.	- At the beginning, 40 percent of the input requirements were left to be distributed by private agencies. Now, PBDAC is taking over again as the private dealers did not expand successfully, especially for fertilizers and seeds. - However, PBDAC is working on a competitive basis with private agencies. - Interest rate is not subsidized any more and includes a 2 percent per annum commission for PBDAC.

Output marketing and prices	- Compulsory delivery of all cotton, sugarcane, soybeans, groundnuts and sesame to government marketing agencies. Delivery quotas on a per feddan basis were also required for: wheat (0.3 ton), maize (0.28 ton), rice (1.5 ton), fava-beans (0.31 ton), winter onions (7.0 tons). - Other crops, vegetables, fruits, livestock production were free of delivery quotas. - Prices set by the government for quota deliveries. These prices were only about 40-70% of the border prices. - Production in excess of delivery quotas sold in the free market at prices which were usually higher than quota prices.	- Compulsory delivery system is still applied to cotton and sugarcane (100% of the output is delivered to government). - Quota system for rice until 1990 1.0 ton/feddan delivered to government. - Optional delivery system is now applied for all crops except for cotton and sugarcane. - Prices for optional deliveries are set by the government. For cotton the farmgate prices is 66% of 5-year average of world prices of ELS and LS. Wheat optional deliveries are priced at LE 500 per ton which is higher than world price equivalent. Paddy optional deliveries are priced at 400 LE/ton, 300 LE for Philippine varieties. For maize, the price is 300 L.E./ton.
Exchange rate	- There were two exchange rates in 1986, the first was the official exchange rate which was equal to 1.43 US$/1L.E., the second was the free market rate which was equal to 0.47 US$/LE. - Official exchange rate (ER) was applied to all exports of cotton and rice, but it was applied to only one half of exports of other crops, while the other half enjoyed the free market ER. This overvaluation of ER effectively maintained artificially low producer prices, which was equivalent to imposing an export tax.	- In 1990, official ER was devaluated to 0.5 US$/LE whereas the free market ER decreased to 0.34 US$/LE. - In 1991, the two exchange rates were unified and the free market, exchange rate was 0.30 US$/L.E.

Agricultural trade	- The greatest part of the agricultural trade was controlled by the government, leaving very little for the private sector other than exporting horticultural crops. - There were a number of constraints such as: limiting the exporter to 25% retention of the foreign currency received from exports; overvaluation of the dollar; shortage of transportation facilities; and shortage of finance. - Cotton and rice are exported by foreign trade companies of the public sector. Revenue in dollars is collected by the Central Bank and its value is paid to the exporting companies at the official exchange rate of L.E.70/$1.	- Private sector is encouraged to play greater role in exportation of agricultural commodities. - Revenue in dollars is paid to the exporters at the free market exchange rate. - Restrictions on private exports of oranges were removed, and the private sector was permitted to establish stations for packing and preparing citrus for export.

redefinition of the policy regime from government controlled economy to a free market economy. These reforms aim at overcoming agricultural stagnation which has been dominant for decades.

SCOPE OF AGRICULTURAL POLICY BEFORE 1986

The period 1965-86 witnessed a very extensive involvement of government in the agricultural sector. Crop area controls, fixed producer prices and compulsory procurement of crops were important policy instruments used by the Egyptian government during this period. According to these instruments, crops can be divided into four major groups:

1. Cotton and sugarcane areas were determined every year by the government (on a variety - region basis for cotton), and prices were set (on a cost-plus basis) and farmers were obliged to deliver all their product to the government at prices substantially below border prices (Table A.2). Public companies for cotton and sugar were responsible for processing the entire product;
2. For rice, wheat, maize, broad beans, lentils, winter onions, sesame, and groundnuts, crop prices were set for a certain quota of production (on a per-feddan basis) that farmers were obliged to deliver to the pooling centers. Production in excess of these quotas could then be sold in parallel private markets. Areas of these crops were determined in the context of crop rotations for each village set by Ministry of Agriculture (MOA) agricultural engineers in the cooperatives. While there was some flexibility in determining the areas of crops other than rice, rice area was determined strictly on a regional basis in the light of total water availability at the national level and canal capacity to each region. The quantities delivered of these crops were an important source of subsidized or rationed consumer foods. Generally, procurement prices for these crops were set 40 to 60 percent below border prices, representing substantial indirect taxation of farmers;

Table A.2--Government procurement of various crops

Crop	1986	1987-1990	1991-1993
Cotton	100%	100%	100%
Sugarcane	100%	100%	100%
Soybeans	100%	-	-
Groundnuts	100%	-	-
Sesame	100%	-	-
Paddy (ton/feddan)	1.5	1.0	optional
Wheat (ton/feddan)	0.3	optional	optional
Maize (ton/feddan)	0.28	optional	optional
Fava-beans (ton/feddan)	0.28	optional	optional
Onion (winter) (ton/feddan)	7.0	optional	optional
Lentils (ton/feddan)	0.14	optional	optional

3. In the case of livestock products, meat, poultry, and frozen fish prices were determined indirectly by the government through import constraints (tariffs and quotas); and
4. Cropped areas of other commodities were determined freely by farmers, and prices were determined by market forces. This group included all vegetables, fruits and fodder crops (long and short-season berseem, alfalfa, fodder maize and elephant grass, etc.)

Farm inputs were distributed to farmers by the Principal Bank for Development and Agricultural Credit (PBDAC) which is controlled by the Ministry of Agriculture and Land Reclamation. PBDAC, the most important parastatal in Egyptian agriculture, acted as a holding company with 17 affiliated banks which together operated a network of some 750 village banks. PBDAC distributed most basic agricultural inputs to farmers and provided extension and financial services. The distribution of inputs among farmers was determined on the basis of regional cropping plans. Input prices were heavily subsidized, and farmers paid almost 50 percent below border prices. The four most

important agricultural subsidies were on fertilizer, credit, cotton pest control, and yellow corn seed. Other input subsidies included sugarcane irrigation, extension services, and pest control for crops other than cotton. Both the manufacture of domestically produced fertilizer and distribution of domestic and imported fertilizer were subsidized.

Different types of agricultural taxes were applied in Egypt in the period 1965-1986. An explicit land tax averaged 30 LE/feddan during the decade 1976-86. Small farmers (less than 3 feddan) were exempted from this tax. However, much more distorting methods of taxing agriculture were implicit in setting producers prices below international prices as mentioned above. Moreover, an overvalued exchange rate and other trade policy instruments led to an increase in the relative price of nontraded to traded goods, and thus reduced farmers profit margins and weakened incentives to produce traded goods. As a result, fodder crops like berseem and livestock products enjoyed relatively higher profit margins than were economically optimal, which led to their expansion at the expense of tradable crops.

On the consumption side, there has been a long history of intervention in food distribution. The General Authority for Supply Commodities (GASC), controlled by the Ministry of Supply and Internal Commerce, procured locally produced crops and was the sole importer of food items. In the early 1980's, sugar, tea, cooking oil, rice, beans, lentils, meat, poultry, and frozen fish were sold at subsidized prices under a food rationing scheme. Wheat flour and bread were also subsidized and sold at fixed prices, but while flour was rationed, bread was available in unrestricted amounts.

POLICY REFORMS IN THE AGRICULTURAL SECTOR SINCE 1986

The agricultural reform program effectively began in 1986. Five major components were included in this program:

- removal of government farm price controls,
- removal of government crop area controls,
- removal of government crop procurement controls,
- elimination of subsidies on farm inputs,
- removal of government constraints on private sector processing and marketing of farm products and inputs.

Specific actions in support of these objectives were developed in a multi-year program.

1986 - removal of compulsory procurement of all crops with the exception of paddy, cotton and sugarcane.

- procurement make optional at floor prices for wheat, maize, and other crops.

1991 - removal of compulsory procurement of paddy.

- optional procurement with floor price for paddy.
- elimination of exchange rate subsidy for imported inputs.
- partial reduction of input subsidies.

1992 - cotton procurement price was increased to 66 percent of previous 5-year average of the world price.

- elimination of all crop area controls except for minimum area requirements for cotton and rice.

1993 - elimination of all input subsidies with the exception of cotton pest control subsidy.

- elimination of cotton area control (however, regional allocation of cotton varieties is still determined by government).

1994 - private sector allowed to compete with the public sector in buying, selling, and ginning seed cotton. At the same time, the old administrative marketing system was allowed to continue until 1996 before complete liberalization will take place.

Institutional measures have also been implemented with the intent of liberalizing the policy environment. These measures can be summarized as follows:

(i) Removal of government constraints on private sector imports, exports, and distribution of farm inputs to compete with PBDAC.

(ii) Removal of government constraints on the private sector in importing and exporting agricultural commodities.

(iii) Gradual transformation of PBDAC into a financial institution.

(iv) Abandoning public ownership of newly reclaimed land and sale of such land to private individuals and companies.

(v) Adjusting the land tenancy system. In 1992 a new law was issued increasing the official rent from a value of 7 times the land tax to a value of 22 times the land tax (3 LE/feddan on average). After a transitory period of five years, i.e., by 1997, the land tenancy system will be completely liberalized, and rental values will be determined by market forces.

APPENDIX B.—SPECIFICATION OF THE 1994 EGYPTIAN AGRICULTURAL SECTOR MODEL

The 1994 version of the Egyptian Agricultural Sector Model (EASM94), which treats livestock endogenously and includes the new lands, can be subdivided into three subsectors: the Crop, Livestock, and Feed subsectors. Although these subsectors are interlinked with each other, for the purpose of presenting the different assumptions and parameters of the model, each subsector will be described separately.

CROPS SUBSECTOR

There are 37 crop production activities in the model. They are:

long berseem	short berseem	fodder maize
wheat	barley	fava-beans
lentil	other legumes	flax
winter onion	winter tomato	winter vegetables
sugarbeet	cotton (medium-long staple)	cotton (long staple)
cotton (extra-long staple)	rice (japonica)	rice (philippine)
sesame	ground nut	soybeans
summer onion	summer potato	summer tomato
summer vegetables	sorghum	summer maize (trad.)
summer maize(hybrid)	nili potato	nili tomato
nili vegetables	nili sorghum	nili maize (trad.)
nili maize (hybrid)	citrus	sugarcane
alfalfa		

The above list is not exhaustive, but includes the major crops cultivated in Egypt. Some crops, however, can be viewed as a group or representative of a crop group. Vegetables and other legumes, for example, are composites of different vegetable and legume crops, and the cotton aggregation into staple length encompasses several varieties

in each category. In the same manner, tomatoes and onions represent other exportable vegetables, and citrus represents other fruit crops.

Some crops, like maize and rice, are distinguished by variety or technology. Maize varieties are categorized as traditional (open-pollinated) and hybrid, while rice varieties are classified as *japonica* and *philippine* (or IRRI). Other crops are classified by seasons: winter, summer and nili crops.

In addition, technology choices include three levels of water application (low, medium, high) and, except for perennials, three planting dates (recommended date, one month earlier and one month later than recommended date) with corresponding changes in yield levels. This gives a total of 315 cropping choices. And yet, the model is flexible enough to accommodate new crops and technology in the future if the needed coefficients become available.

Crop Rotation

The model solves for the optimum cropping pattern for the whole year. This means that it compares the growing of perennial crops (sugarcane, citrus and alfalfa) with growing one, two or three other shorter duration crops in rotation with each other. To allow for this choice, monthly land requirements and planting dates are defined such that different cropping combinations are possible. Examples are: short berseem and cotton rotation, wheat and rice, wheat and maize and beans and maize. With more flexibility in the choice of planting dates, the model can also choose a longer berseem crop (up to three cuts) and late cotton planting. The only restrictions on crop rotations are on cotton and rice. For technical reasons, cotton should be grown on a two-year rotation in Upper and

Middle Egypt and on a three-year rotation in the Delta, while rice area is limited to a total of 1.2 million feddans due to the limitation of the irrigation delivery system.

Land Area

The model divides Egypt into eight agricultural regions. These are the lands along the Nile valley: Upper Egypt, Middle Egypt, the three Delta regions (East, Middle and West Deltas) and the `New Lands' development ; sandy-soil/canal-irrigated region (SCNLAND), clay/calcareous-soil/canal-irrigated region (CCNLAND), and sandy-soil/groundwater-irrigated region (SGNLAND). These regions accounted for 7.7 million feddans of land available for agriculture, and another one million feddans of potential area for further land reclamation. The regional breakdown of land areas for agriculture is given in Table B.1.

Water Resources

The 1959 agreement between Egypt and Sudan determined Egypt's share of the Nile water to be 55.5 billion cubic meters a year. Approximately 90% of this is allocated for agriculture annually. This is equivalent to 50 billion cubic meters before delivery and irrigation losses or, given an overall delivery efficiency rate of 70%, to 35 billion cubic meters for crop consumptive use.

Accordingly, it is assumed that 50 billion cubic meters of water from the Aswan Dam is available for agriculture every year, with the following combined irrigation efficiency (canal and field level) for the regions:

Table B.1--Existing and potential area for agriculture, by region

	(feddans)
Existing area	
Upper Egypt	1,066,475
Middle Egypt	1,136,291
East Delta	722,813
Middle Delta	2,032,598
West Delta	870,751
New Lands	
Sandy, canal fed	787,000
Clay, canal fed	1,031,000
Sandy, groundwater fed	82,000
Potential area	
New Lands	
Sandy, canal fed	1,064,200
Clay, canal fed	156,500

	Percent
Upper and Middle Egypt, and the Deltas	70
Sandy-canal irrig. new land (SCNLAND)	60
Clay-canal irrig. new land (CCNLAND)	70
Sandy-groundwater irrig. new land (SGNLAND)	80

Irrigation in the SGNLAND region is from groundwater and does not compete with other regions for Nile water. In this region, no predetermined water supply constraint is set, but the cost of pumping groundwater for irrigation is added to the production costs.

For the other regions, the water balance constraint is determined by the crop water requirements in the field (evapo-transpiration), irrigation efficiency, and the water supply at the Aswan Dam. The water constraint is specified on an annual basis in the present model due to lack of reliable data on monthly crop water requirements, monthly water

supply at the Aswan Dam and the delivery system's monthly capacity by region. Ideally, if such data were available, a monthly water balance should be included in the model.

Labor

Labor demand for crop and livestock production is satisfied from two labor sources: family and temporary (hired) labor. It is assumed that each farm family has, on the average, 1.5 full-time workers available for its own farm at a reservation wage equal to half the market wage rate. Additional labor requirements are satisfied through temporary labor whose supply is assumed to be perfectly elastic at a given market wage rate for the region.

The number of farmer households for the Nile valley regions was taken from the 1993 Statistical Yearbook. For the New Lands, estimates were based on an average farm size of 5 feddans for clay or calcareous lands and 20 feddans for sandy lands. For each region, Table B.2 presents the estimated number of farm households.

From the above figures, monthly available labor was estimated by multiplying the number of households by 1.5 (full-time labor) and 30 days (working days for month).

The wage rates (LE per day) by month used in the model are shown in Table B.3.

Table B.2--Number of farm households by region

Upper Egypt	981,071		
Middle Egypt		830,610	
East Delta		392,953	
Middle Delta	1,382,504		
West Delta	312,620		
SCNLAND	39,350		
CCNLAND	206,200		
SGNLAND	4,100		

Table B.3--Monthly agricultural wage rates by region

Regions	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Egypt 5.1	4.5	4.5	4.6	4.6	4.6	5.0	5.2	5.2	5.1	4.9	5.1	
Middle Egypt 5.1	4.5	4.5	4.6	4.6	4.6	5.0	5.2	5.2	5.1	4.9	5.1	
East Delta	6.0	5.7	5.7	5.2	5.2	5.2	5.2	6.0	6.0	6.0	5.7	6.0
Middle Delta 6.0	5.7	5.7	5.2	5.2	5.2	5.2	6.0	6.0	6.0	5.7	6.0	
West Delta 6.0	5.7	5.7	5.2	5.2	5.2	5.2	6.0	6.0	6.0	5.7	6.0	

Note: Wage rates in the New Lands are assumed to be 10% higher than that of West Delta region. The same wage rates apply for both crop and livestock production.

Other Expenses

Other production expenses in the model include: fertilizers and manures, seeds, pesticides, draft animal and tractor use, and miscellaneous. These costs are specified for each crop and region. However, available data from the Ministry of Agriculture only differentiates these costs by agricultural zones (Upper Egypt, Middle Egypt and Delta). In the absence of similar cost data for the new lands, it was assumed that their production costs are similar to those of the delta rather than those of Upper or Middle Egypt. For two crops, maize and rice, the input costs used are adapted from farm surveys conducted by the Center for Agricultural Economic Studies of Cairo University.

Yield Levels

Yield levels are regional averages for 1990, except for rice and maize. Yields differ by region and by technology. As mentioned earlier, water application and planting dates were treated as technology alternatives. From CROPWAT, an irrigation requirement computer software developed by FAO, a generic yield response function to water application that holds for all crops was adapted. This function is given as:

$$Y = 0.8X + 1.3X^2 - 1.1X^3,$$

where Y = yield deviation from the optimum (no water stress),

X = reduced water application compared to optimum (ET) requirement.

From this function, three water treatments were included in the model: low (30% less water than ET requirement), medium (15% less water than ET requirement) and high (equal to ET requirement), with corresponding 18%, 6%, and 0% yield losses.

Except for perennials, three planting dates were also included: recommended date, one month early, and one month late, with corresponding yield reduction of 0, 5, and 10%.

Processing

The final demands for several commodities in the model are necessarily expressed in processed form. These are wheat flour, sugar, cotton, rice, and vegetable oils. Except for wheat, the model incorporates processing activities, with assumptions about their conversion rates and costs, and where applicable, their by-products for livestock consumption. Due to lack of data on wheat processing costs and conversion rates to

flour, wheat flour is specified in wheat grain equivalents, both on the supply and consumption sides.

Demand Data

To estimate domestic demand curves, consumer (retail) prices, 1990 domestic consumption and price elasticities were used. For internationally traded commodities, border prices for imports were computed at c.i.f. Alexandria plus an estimated transport cost to wholesale market (average Egypt). For exports, border prices were estimated as the world market prices (at the major world market for each commodity) minus 80% of shipping costs from Egypt. Border prices for pulses (legumes), flax, cotton, rice, sesame, soybean, maize, sorghum, sugar, citrus, and vegetable oils using were based on average 1989-1991 world prices. For potatoes, onions and tomatoes, the average 1990 Egyptian unit export prices of these commodities were used.

Price elasticities of demand were adapted from EASM88. Table B.4 summarizes the key information and the 1990 trade activities available in the model.

LIVESTOCK SUBSECTOR

The livestock subsector, which was treated as fixed or exogenous in previous versions of the model, has been added on an endogenous basis in the current EASM version. Livestock included are buffalo, cattle, sheep and goat, chicken (broiler and layer) and draft animal (camel, horses, mules and donkey). For the Year 2000 scenarios, an exotic breed of cattle was also included. Except for the draft animals, which are still exogenously fixed and allocated to the regions, livestock populations are endogenously

solved and allocated according to the regions' resources and cropping patterns which support the animal population.

Two types of sheep are included in the model: one is treated as endogenous, another as exogenous. It is assumed that around 30 percent of the 1990 sheep population is of nomadic (range) type, and is treated as exogenous to the model, while 70 percent is raised on agricultural land. It is also assumed that a feddan of old land (four feddans of new lands) can supply a head of sheep/goat's nutritional requirements through natural grass growth on the fringes and canals/dikes. Up to this limit, sheep/goat production does not compete with other livestock, but beyond the natural grass holding capacity, addition sheep/goat production do compete with other livestock for feeds.

Table B.4--Demand data for various commodities, 1990

Commodity	Base Price	Import Quantity	Import Price	Export Quantity	Export Price	Domestic Consump.	Price Elasticity
	(LE/mt)	(1,000 mt)	(LE/mt)	(1,000 mt)	(LE/mt)	(1,000 mt)	
Wheat	763	6,439	735	0	438	10,987	-0.55
Barley	221					101	-0.20
Fava bean	1,350					394	-0.63
Lentil	2,630					12	-0.80
Legumes	1,350	73	1,792	4	1,433	37	-0.63
Flax	600			10	1,417	86	-1.00
Cotton (mls)	3,000	60	6,771			68	-3.50
Cotton (ls)	5,160		26	11,933	187	-3.00	
Cotton (els)	5635		13	16,441	33	-2.50	
Rice	801	3	1,201	76	866	2,173	-0.74
Sesame	3,450	15	4,260	2	3,408	32	-1.00
Groundnut	565			3	2,687	20	-1.00
Soybeans	375	25	1,022		708	6	-1.00
Onions	549		60	666	668	-0.64	
Potato	494			136	513	1,835	-0.77
Tomato	408			20	717	4,824	-0.75
Vegetables	526					3,232	-0.76
Maize	610	1,900	577	0	264	4,056	-0.68
Sorghum	532		563		250	260	-0.64
Citrus	350			150	1,423	2,351	-1.64
Sugar	500	812	1,160	2	812	1,684	-0.57
Vegetable-oil	800	672	1,729		1,156	846	-1.20

"0" - means less than 0.5.

Animal Units

Buffalo and cattle are divided into breeding and fattening units. The breeding units produce milk and calves which can be sold for veal or fattened into eight, sixteen, or twenty-four month-old animals. Fattening Modules 1, 2, and 3 involve fattening periods of four months, one year, and twenty months after weaning. For the exotic breeds, fattening modules are defined by six, ten and fourteen month periods. The assumptions for the breeding units used in the model are given in Table B.5.

Each breeding unit, therefore, is composed of a bull, a cow, and their replacements. In terms of animal heads, each breeding unit consists of:

	Cow	Bull
Buffalo	1.235	0.015
Cattle	1.266	0.020
Sheep/goat	1.200	0.300

Livestock and poultry products include beef, milk and milk products, poultry meat, sheep and goat meat, and eggs. Beef and milk come from buffalo and cattle. There are quality differences between buffalo and cattle products, e.g., buffalo milk has higher butterfat, so to make them comparable, their products were weighted by their prices. Veal prices are 20% higher than regular beef, and buffalo meat is 10% cheaper. On the other hand, buffalo milk is 39% more expensive than cattle milk.

Table B.5--Breeding coefficients for livestock

Items		Buffalo	Cattle (Native)	Cattle (Exotic)	Sheep/ Goat
Weaned calves per year	0.695	0.720	0.825	0.80	
Bull-cow ratio		1:67	1:50	1:20	1:33
Culling rate (%)					
Bulls		20.0	20.0	20.0	50.0
Cow		16.4	20.0	20.0	21.4
Breeder mortality rate (%)					
Bull		5	4	4	5
Cow		7	5	4	5
Stock replacement (per unit per year)					
Bull		0.005	0.005	0.016	0.012
Cow		0.234	0.250	0.254	0.250
Calf yield net of replacement		0.457	0.465	0.559	0.533

The model distinguishes between breeding and fattening activities. As mentioned above, cattle and buffalo breeding units produce milk and calves, which can be sold as veal or fattened further. There are four meat production choices for cattle and buffalo. One is veal production. In this case calves are sold for veal immediately after weaning.

The other choices are fattening to one, two, or three year old animals. If calves are fattened, the weaning period is extended from 2 months to 4 months, which in effect reduces the amount of milk available for human consumption. And because the model solution is on equilibrium one, each three-year fattening unit is composed of a one-year old, a two-year old, and a three-year old animal, and a two-year fattening unit consists of a one-year old and a two-year old animal.

Table B.6 presents the carcass weights (kg) of different animals, and Table B.7 gives the annual yields (weighted for buffalo and cattle) of livestock products from each unit or each technology choice.

Livestock Demand

Demand data for livestock products for 1990 were taken from FAO (1992) and Soliman (1992). They are summarized in Table B.8.

Labor Requirements

Labor requirements for livestock and draft animals were adapted from Soliman (1992), based on 1977, 1983, 1987, and 1991 farm surveys of livestock activities. Table B.9 lists livestock labor requirements by type of labor (man, woman, child) and by season (summer, winter).

Since the available supply of family labor is by month and does not distinguish by type, the labor requirements were converted to equivalent man labor using the assumption that woman labor is equivalent to 0.7 man labor, and child labor to 0.5 man labor. The monthly labor requirements for livestock were estimated by setting a manday equal to eight hours and then dividing the seasons' labor requirement by six months.

Other Production Costs

Other livestock production costs in the model are veterinary and breeding services, and the costs of pullets and chicks. They are presented in Table B.10.

Table B.6--Carcass weight by type animal

Animal Type	Buffalo	Cattle (Native)	Cattle (Exotic)	Sheep/ Goat
			(kilograms)	
Culled bull	275	234	360	40
Culled cow	250	208	318	35
Weaned calves	40	47	67	
Fatteners				
Module 1	75	83	161	20
Module 2	151	165	225	
Module 3	195	208	285	

Table B.7--Annual yields from livestock activities

Animal Type	Milk	Meat/ Eggs
		(metric ton/unit)
Breeders		
Buffalo		0.038
calf for veal	1.904	
calf fattened	1.360	
Cattle (Native)		0.047
calf for veal	0.473	
calf fattened	0.312	
Cattle (Exotic)	0.072	
calf for veal	5.089	
calf fattened	3.635	
Fatteners		
Buffalo		
Veal		0.040
Module 1		0.067
Module 2		0.136
Module 3		0.175
Cattle (Native)		
Veal		0.056
Module 1		0.083
Module 2		0.165
Module 3		0.208
Cattle (Exotic)		
Veal		0.080
Module 1		0.161
Module 2		0.225
Module 3		0.285
Sheep/Goat		0.025
Chicken (1000 broilers)	1.000	
Chicken (1000 layers)	12.000	

Table B.8--Livestock demand data for 1990

Livestock Products	Retail Price	Import Price	Export Price	Import Quantity	Export Quantity	Consump-tion	Price Elasticity
	---------- (LE/mt) ----------				---------- (000 mt) ----------		
Beef	9,800	10,808	6,741	115	4	523	-2.44
Sheep/goat meat	10,980	10,155	7,429	2	1	99	-1.75
Milk	1,008	1,019	815	113	2	2,694	-0.90
Poultry meat	6,760	5,105	3,544	3	2	203	-2.18
Eggs	4,000					156	-1.13

Table B.9--Labor requirement by labor type per livestock unit

Livestock	Man		Woman		Child	
Type	Winter	Summer	Winter	Summer	Winter	Summer
			(hours/season)			
Buffalo	390.1	269.0	226.8	122.2	42.0	27.5
Cattle	389.2	269.0	195.1	109.7	41.8	27.5
Sheep/goat 53.9	38.4	13.9	9.5	5.9	3.9	
Chicken (broiler)	132	132				
Chicken (layer)	1,525	1,525				
Camel	377.1	269.0	97.3	66.2	41.3	27.5
Horse	377.1	269.0	97.3	66.2	41.2	27.5
Mule/donkey	377.1	269.0	97.3	66.2	41.2	27.5

Table B.10--Other input costs

Livestock Type	Veterinary service	Breeding service	
		(LE/unit)	
Breeding unit			
Buffalo	15.63	24.00	
Cattle (native)	12.41	19.00	
Cattle (exotic)	12.41	19.00	
Sheep/goat	2.00	7.00	
Fattening units			
Cattle (native)			
Veal	6.21		
Module 1	9.93		
Module 2	14.89		
Module 3	19.86		
Cattle (exotic)			
Veal	6.21		
Module 1	9.93		
Module 2	18.62		
Module 3	24.82		
Buffalo			
Veal		7.82	
Module 1	12.50		
Module 2	18.76		
Module 3	25.61		
Chicken (layer)	708	5,180	(pullets)
Chicken (broiler)	92	454	(chicks)
Camel	14.40	21.50	
Horse	14.40	21.50	
Mule/donkey	14.40	21.50	

FEEDS SUBSECTOR

Livestock feeds can be differentiated into three types: feedcrops, processing byproducts, and crop byproducts. Feedcrops include those crops grown specifically for livestock consumption (berseem, alfalfa and fodder maize) and those that can be consumed both as food (for human consumption) or feeds (maize, sorghum, barley, fava beans and soybean). Processing byproducts (or co-products) include ricebran and wheatbran, molasses, soybean meal, and seedcakes from cotton and flax seeds. Crop byproducts are basically hay, straw or fodder from various crops (rice, wheat, barley, fava beans, lentil, legumes, ground nuts, maize, sorghum, and sugarcane). The value, therefore, of an agricultural crop or commodity includes the value of its byproducts to, and for some crops the alternative consumption in, the livestock subsector.

The model assumes interregional movements for processing byproducts and grain feedcrops but not for fodder crops (berseem, alfalfa and fodder maize) and crop byproducts. This means that consumption of processing byproducts and grain feedcrops are constrained at the national level and are not limited by the regions' cropping patterns. Fodder consumption, however, is constrained at the regional level by the regions' cropping activities. It should be noted that fodder availability is seasonal due to the seasonal nature of the cropping activities. And because of this, the feed demand schedules given below were estimated on a seasonal basis.

The nutritional value of feedstuffs is based on their dry matter (DM) content, digestible protein (DP) content and starch equivalent (SE) or energy content. Livestock have a minimum set of requirements for these nutrients, and the model has to balance the

supply and demand for these nutrients which it does on a least-cost basis. Table B.11 summarizes the nutrient contents of the different feedstuff included in the model.

On the demand side, livestock and poultry have separate sets of feed requirements. For livestock, nutrient requirements are given in terms of DM, DP and SE, while for poultry (broilers and layers) feed rations are given in fixed amounts of maize, soybean meal, and feed concentrates. Feed concentrates in the model are not locally produced and do not represent any burden upon the regions' cropping activities. Tables B.12 and B.13 present the feed requirements for livestock and poultry.

Table B.11--Nutrient content of different feedstuffs

Feeds	Dry Matter	Digestive Protein	Starch Equivalent
		(percent)	
Feedcrops			
Berseem	0.24	0.020	0.10
Fodder maize	0.25	0.040	0.11
Alfalfa	0.24	0.020	0.10
Sorghum	0.82	0.043	0.82
Fava beans	0.91	0.205	0.69
Maize	0.82	0.059	0.82
Soybean	0.82	0.200	0.69
Barley	0.89	0.098	0.83
Processed feeds			
Soybean meal	0.89	0.390	0.72
Seed cake	0.91	0.173	0.50
Molasses	0.05	0.000	0.91
Wheat bran	0.89	0.090	0.65
Rice bran	0.89	0.090	0.71
Hay, straw, fodder from			
Wheat	0.91	0.000	0.23
Barley	0.89	0.098	0.83
Fava beans	0.89	0.000	0.25
Lentil	0.20	0.016	0.24
Legume crops	0.89	0.000	0.25
Rice	0.90	0.000	0.22
Ground nut	0.89	0.000	0.25
Maize	0.20	0.040	0.11
Sorghum	0.40	0.021	0.21
Sugarcane	0.20	0.006	0.12
Feed concentrates	0.60	0.130	0.51

Table B.12--Livestock nutrient requirement per season

Livestock Type	Dry Matter		Digestible Protein		Starch Equivalent	
	Summer	Winter	Summer	Winter	Summer	Winter
	(metric tons/unit)					
Breeding units						
Buffalo	2.847	2.847	0.072	0.072	0.893	0.893
Cattle (native)	2.239	2.239	0.036	0.036	0.655	0.655
Cattle (exotic)	3.226	3.226	0.233	0.233	1.567	1.567
Fattening units						
Cattle (native)						
Module 1	0.120	0.120	0.016	0.016	0.113	0.113
Module 2	0.811	0.811	0.089	0.089	0.674	0.674
Module 3	1.743	1.743	0.180	0.180	1.295	1.295
Cattle (exotic)						
Module 1	0.441	0.441	0.039	0.039	0.316	0.316
Module 2	0.892	0.892	0.085	0.085	0.790	0.790
Module 3	1.456	1.456	0.144	0.144	1.383	1.383
Buffalo						
Module 1	0.120	0.120	0.015	0.015	0.110	0.110
Module 2	0.772	0.772	0.094	0.094	0.632	0.632
Module 3	1.663	1.663	0.185	0.185	1.270	1.270
Sheep/goat	0.629	0.629	0.016	0.016	0.113	0.113
Draft animals						
Camel	2.168	2.168	0.195	0.195	0.729	0.729
Horse	1.712	1.712	0.153	0.153	0.576	0.576
Mule/donkey	0.912	0.912	0.082	0.082	0.307	0.307

Table B.13--Poultry feed requirements

Feedstuff		Layers	Broilers
	(metric tons/year/1,000 head)		
Soybean meal	7.20	0.90	
Maize		23.40	2.93
Feed concentrates	5.40	0.68	

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