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M.I.T./CAIRO UNIVERSITY

TECHNOLOGICAL PLANNING PROGRAM

PROJECT PROGRESS REPORTS

6/1/77 - 9/1/77

Appendix V to the

Evaluation Report

A.I.D.
Reference Center
Room 1656 NS

V.1 STOCHASTIC MODEL OF NILE INFLOWS TO LAKE NASSER

Progress Report

June 1, 1977 - August 31, 1977

Personnel

Since the last project report there have been some additions to the list of project participants.

M.I.T.

Mr. Kevin Curry, Research Assistant
and Masters degree candidate was formally incoporated into the project, as scheduled, on June 15, 1977

Cairo University

Dr. Hassan Dorrah, Professor of Electrical Engineering
Dr. Dorrah has considerable interest in stochastic processes and control theory application to hydrology. He is also knowledgeable and a frequent user of Cairo University computer facilities.

Dr. Ibrahim Assuiti
is being partially funded to do work in using the stochastic simulation results in system modelling exercises.

Eng. Mohamed Osama Masef

Eng. Boyoumi Bayou Attia

Eng. Reda M. Aly

Eng. Ismail El-dimary

The above are graduate students working for Masters and Ph.D. degrees in Cairo University

Minstry

Dr. Hassan Ibrahim, Head, Institute for Water Utilization
Dr. Ibrahim is now the main ministry participant and liaison officer.

Dr. Fouad El Shibini, Deputy Director, Institute of Water Resources
Dr. El Shibini is also a ministry representative in the program.

Quarterly Activities

Travel to Egypt

There were two major visits to Egypt during this past quarter. Professor Eagleson and Mr. Cordova visited Egypt during the period of June 8-23, 1977 as scheduled. That trip had two main objectives:

1) Implementation of multivariate Markov monthly streamflow generator and

and train Cairo University participants on its operation; 2) Identify areas of future work for project continuation of interest to the Ministry, Cairo University and M.I.T. All tasks were accomplished and will be discussed later.

Also as scheduled, Professor Bras and Mr. Kevin Curry visited Egypt from August 1 to August 11, 1977. Goals of this trip were to 1) implement a Broken Line Process annual streamflow generator and explain its use and logic; 2) implement a Streamflow Disaggregation Model and train Cairo University Participants on its use; 3) review progress on tasks outlined by Professor Eagleson and Cordova on previous trip; and 4) finalize topics of future work and common interest. Again all goals were accomplished.

Completed Tasks

Data Collection is completed for 10 identified stations. Data is available on a monthly basis for the following stations and the period shown. All data is coded for computer use and available to all participants.

Mongalla	1905 - 1975
Malakal	1905 - 1976
Sennar	1912 - 1975
Khartoum	1900 - 1975
Atbara	1903 - 1967
Tamaniat	1911 - 1976
Wadi-Halfa (Dongolla)	1890 - 1976
Roseires	1912 - 1973
Aswan	1871 - 1976
Bahr Zaraf	1908 - 1963

Data has been check for errors and consistency using a double mass analysis program. Results were satisfactory. A chi square discrimination program was prepared to select between normal and log-normal distributions for the above stations. Results again, are available and indicated particular distributions for some of the stations. In others both distributions passed the test.

Difficulties have been encountered in securing operating rules of dams in Aswan, Sennar, Gabel Aulia and Roseires. Some of them have been obtained and studied. All are needed to deregulate flow at points of interest. A commitment from the ministry for furnishing the data was obtained.

Travel times at different locations, in particular between Gabel Aulia and Khartoum, are needed to make mass balance checks at the junction of the White and Blue Nile rivers. Again, this data was promised by the ministry.

Three different computer models are now operational at Cairo University and M.I.T. During the June visit by M.I.T. participants, a Multivariate Markov model for the generation of monthly streamflows at various locations was implemented. The model is built to preserve auto-correlations between months, cross correlations between stations, means and variances of historical data. Documentation and extensive description of the model was presented orally and in written documents to Cairo University and ministry participants. Documents are available. Attachment A summarizes results of the operational model.

As an exercise in the theory behind this model, Cairo University participants have built a univariate monthly generator.

A limitation of the above model is that it does not preserve annual auto-correlations and the, so called, Hurst phenomena which influences the occurrence of extremes. Due to the success of the Markov Model implementation, we were able to provide two other models beyond what was promised in the original proposal and which attempt to address the limitations of the Markov-Autoregressive model as previously discussed.

The Broken Line Generator was implemented in the trip to Cairo on August 1 after development at M.I.T. This model generates, at different locations, annual values of streamflow preserving the annual autocorrelation, cross correlations, means, variances, skewness and Hurst coefficients. Again, documentation and explanations were presented orally and in written form and are available.

The model is operational both at Cairo and M.I.T. facilities. During implementation some theoretical errors and difficulties were discovered in the traditional Broken Line formulation. This constitutes an interesting modification to a supposedly accepted technique that has been used

extensively throughout the world. It was the unique properties of the large Nile river system which pointed out the inconsistencies. Solutions to the problem have only partially been formulated. Further work is still necessary. Attachment B presents and discusses some of the Broken Line Generator results.

Coincidentally with the Broken Line Model, a Disaggregation Model was developed and made operational at Cairo and M.I.T. This model takes annual discharges generated from the Broken Line process (or any other source) and breaks them into statistically consistent monthly values. These monthly values would preserve correlation between them and between stations.

The model was extensively discussed. Again, documentation on theory and use is available. Attachment C also gives some results of this model with relevant discussions.

For training purposes Cairo University participants will develop an autoregressive multivariate model of annual streamflow values to be used together with the disaggregation model.

Results from the above three models have been used by a sub-group of the Water Resources Program to study and simulate the behavior of the Aswan dam system including the implications to the proposed Toshka depression spillway. Progress in this is reported elsewhere. As the reader can see, the results are rapidly becoming useful in studies of large investment programs.

During the past quarter arrangements have been finalized for visits of Drs. Ibrahim and Shibini to M.I.T. for a two week period starting October 1.

Plans for continuing projects were agreed on. They appear later in this report.

Goals for the next quarter were set. A following section deals with this topic.

Few problems have been encountered throughout the project. Computer facilities at Cairo University are limited in capacity which have somewhat restrained our goals. Accessibility to the machine has been hard sometimes, due to apparently extremely busy periods. Breakdowns of facilities occur relatively frequently. Problems with scientific subroutines, in particular random number generators, are common.

Data acquisition has proceeded reasonably well, although badly needed operating rules and times of travel are still not available as previously mentioned. Diversion schedules in barrages must also be obtained.

Most participants in Egypt, from the Ministry and the University, must still get familiar with existing computing facilities and extensively use them.

In general, though, the project has achieved more objectives than it intended, and as such, we expect no delays or problems in completing this first phase as scheduled.

Next Quarter Activities

By November 15, 1977 the following goals should be accomplished by Cairo and M.I.T. participants.

Cairo Participants:

1. By the beginning of October data needs for continuation projects (see Future Projects sections) must be assessed.
2. By the first week of September, all missing operating rules, diversion schedules and travel times are to be provided by the ministry.
3. Deregularization of flows will be completed as well as the continuity-mass balance check.
4. Reports on the chi square tests and double mass analysis should be furnished and provided to participants.
5. A multivariate annual streamflow generator based on auto-regressive theory is to be prepared to be used with available Disaggregation Model.
6. Get familiarized with available models. Hold seminars and workshops.
7. Implement Frequency analysis program to obtain discharge-frequency curves from generated streamflow.
8. Train Ministry personnel on use of models.

M.I.T. Participants:

1. Finalize versions of documentation and of implemented programs.
2. Find a solution of previously discussed problems with the Broken Line Process.
3. Make final runs with models, carry on study and comparison of behavior.

4. Prepare proposal for continuing work.
5. Start preparation of first phase final report.

It was agreed that Cairo and M.I.T. groups will exchange bi-weekly progress memoranda.

Comments on Activities in Relation to Ministry Involvement and Interest

Although many offices in the Ministry will use the results of this first phase of the study, our principal interactions have been with Dr. Hassan Ibrahim, Head, Institute of Water Utilization, and Dr. Fouad El Shibini, Deputy Director, Institute of Water Resources. Unfortunately, we have had limited contact with Ministry personnel at the lower levels. Contacts have only occurred in some of the open seminars. It is expected that this will change, particularly in continuing projects. Part of the reason for this limited contact with lower level Ministry staff members is due to the physical separation between Cairo University headquarters and facilities and Ministry centers.

Drs. Ibrahim and El Shibini are well aware of the techniques we are employing. The essential data base being utilized is the Ministry's information. Our mechanized approach differs from their usually manual analysis. The ministry has no computer facilities.

The concept of streamflow synthesis is completely new to the ministry operational framework. Usually, their analysis relies exclusively on historical series. We are providing and introducing to them the concept of extracting a maximum amount of information from their available historical data by using time series analysis and synthesis techniques. The generated series provided by the models will be used in frequency analysis and simulation studies. This is already being done in the simulation of the Toshka depression spillway operation. Such simulation will provide design and reliability information not available from exclusive reliance on the historical streamflow series.

The compilation and analysis of data is a major contribution to the Ministry. Data has been checked for consistency and is available for computerized analysis. Deregulation of the data is a major source of information and insight on the extent of river controls. No deregulated series presently exist.

Statistical analysis of the data, necessary for the generation models, has provided information as to the behavior of the Nile, many times corroborating previously observed physical behavior, and many times suggesting previously ignored behavior. For example, on a yearly and monthly basis it is observed that serial correlations in the White Nile are a lot higher than in the Blue Nile and the main stem of the Nile. This corroborates that the White Nile has a smooth filtered behavior due to the swampy regions. It also says that the Blue Nile is a lot more variable, erratic and more responsive to rainfall input. Clearly, also, the Blue Nile behavior dominates the main stem statistics. It is also, unexpectedly, observed that skewness is a lot higher in the White Nile. This implies that the swamps tend to regulate and eliminate the low flow situations while being unable to control high flow conditions. This has implications on projects in the area, like the Jonglei Canal.

By the end of this first phase, Ministry staff members should be able to use the available models with the cooperation of the Cairo University participants.

Future Research Topics

After extensive discussions between the Ministry, Cairo University participants and M.I.T. members two main areas of work were clearly defined as priorities. It is expected that work in these areas will extend for the next three years.

The first area is the physical hydrologic understanding of the Bahr El Gazal, Gebel and Zaraf regions in the White Nile which include the area of the Jonglei Canal project. The objective is to develop a rainfall-runoff deterministic simulation capability, including a routing component. This model will allow analysis of effects resulting from the Jonglei Canal and of future plans for draining large swamp areas. Rainfall-runoff simulation will not only lead to a better understanding of the region, but will provide a valuable tool for studying the most promising possibilities of increasing the Nile River yield. Results from this simulation will indicate induced statistics which will be necessary for our stochastic simulation models which in turn are used to study necessary changes in reservoir operation as well as the operation of the proposed Toshka depression canal and spillway.

The second area will rely extensively on our present statistical and probabilistic studies as well as on the deterministic rainfall-runoff studies. The goal of this parallel development will be the on-line streamflow forecasting capability at various points in the Nile system. This forecasting is to be done using observed streamflow values in a feedback loop through the use of modern control and estimation theory techniques. This methodology will account for the many times that available information is inaccurate and incomplete. Such streamflow forecasting is necessary to tie with water demand forecasting models like the one presently being developed by a U.N.D.P. team in Egypt. The joint use of this supply and demand forecast, taking into account the uncertain nature of the series, will ultimately lead to the concept of optimal on-line operating policies for dams and other diversion structures. This must be the final goal of all the water studies.

Attachments

A - Results of the Multivariate Markov Generator Test Runs

B - Results of the Broken Line Streamflow Generator Test Runs

C - Results of the Disaggregation Model Test Runs

Attachment A: Stochastic Model of Nile Inflows to Lake Nasser

Results of the Multivariate Markov Generator Test Runs

The multivariate Markov Generator was run to produce the simulation model inputs to be tested in the Nile Basin. Four Gaging Stations were selected, using the selection criterion to cover all the main streams in the basin including all the possible sites that could be used in the simulation of the systems. Those gaging stations were:

Station Number	Name
1	River Nile at Wadi Halfa
2	Blue Nile at Roseires
3	White Nile at Malakal
4	Bahr el Jibel at Mongalla

The period of available historical records was from 1912 to 1952 (41 years) of monthly data. Five hundred years of monthly data were generated for each of the four gaging stations, in five traces of 100 years each.

The statistics of the historical data and the statistics of one of these 100 year synthetic traces are shown in Table 1, 2, 3 and 4 (one for each gaging station).

The statistics computed were monthly mean, standard deviation, auto-correlation, cross-correlation lag zero and cross-correlation lag one coefficients, and skewness coefficients.

The synthetic data preserved all the historical statistics except skewness, because this model only preserves the skewness of the normal distribution or the skewness of the two parameters log normal distribution.

TABLE 1. GAGING STATION 1: WADI HALFA

MONTH	H(MCM)		S(MCM)		$\rho_1(0)$		$\rho_0(1)$		$\rho_1(1)$		γ	
	H	S	H	S	H	S	H	S	H	S	H	S
J	3545	3554	685	681	0.91	0.92	0.83	0.81	0.81	0.81	0.27	0.16
F	2399	2438	614	605	0.72	0.67	0.76	0.77	0.60	0.56	1.21	0.80
M	2182	2190	671	604	0.91	0.88	0.55	0.46	0.32	0.28	1.59	1.19
A	1838	1817	651	599	0.88	0.87	0.35	0.26	-0.02	-0.03	1.74	0.87
M	1703	1643	602	487	0.63	0.59	0.16	0.14	0.18	0.20	2.24	0.81
J	1906	1855	593	517	0.58	0.65	0.59	0.62	0.41	0.47	1.15	0.83
J	4975	5035	1593	1578	0.63	0.62	0.86	0.88	0.56	0.48	0.86	0.84
A	18996	19167	3933	3740	0.74	0.79	0.85	0.80	0.58	0.65	-0.26	-0.07
S	21830	22031	3853	4197	0.81	0.82	0.84	0.87	0.57	0.55	0.43	0.35
O	14608	14663	3191	3381	0.85	0.87	0.82	0.81	0.73	0.77	0.86	0.65
N	7244	7289	1738	1794	0.93	0.94	0.89	0.94	0.84	0.84	0.72	1.03
D	4592	4267	836	848	0.94	0.90	0.77	0.78	-0.02	0.26	0.66	0.40

H = Mean $\rho_1(0)$ = autocorrelation coefficient $\rho_0(1)$ = crosscorrelation coefficient (lag one) with Gaging Station 2 (Roseires)

S = standard deviation $\rho_1(1)$ = crosscorrelation coeff. (lag zero) with Gaging Station 2 (Roseires)

H = Historical S = Synthetic γ = skewness coefficient

TABLE 2. GAGING STATION 2: ROSEIRES

MONTH	M(MCM) H	M(MCM) S	S(MCM) H	S(MCM) S	$\rho_1(0)$ H	$\rho_1(0)$ S	$\rho_0(1)(*)$ H	$\rho_0(1)(*)$ S	$\rho_1(1)(*)$ H	$\rho_1(1)(*)$ S	γ H	γ S
J	773	763	179	176	0.[illegible]3	0.95	0.67	0.68	0.59	0.59	-0.27	0.49
F	456	445	113	100	0.66	0.63	0.62	0.61	0.53	0.52	0.42	0.29
M	359	349	107	97	0.52	0.33	0.52	0.41	0.50	0.35	1.09	0.64
A	305	296	125	103	0.32	0.30	0.43	0.34	0.48	0.48	1.12	0.85
M	639	632	387	342	0.64	0.66	0.49	0.54	0.51	0.59	1.76	1.27
J	1666	1648	603	549	0.71	0.75	0.47	0.54	0.41	0.46	1.50	0.71
J	6562	6737	1852	1707	0.72	0.64	0.36	0.42	0.26	0.27	0.29	-0.38
A	15375	15735	3140	2934	0.69	0.73	0.17	0.11	0.32	0.26	0.02	-0.11
S	12731	12880	2780	2849	0.70	0.68	0.30	0.26	0.51	0.51	0.32	-0.03
O	6601	6602	2013	1960	0.87	0.92	0.36	0.42	0.56	0.59	0.26	0.74
N	2617	2609	769	761	0.90	0.90	0.52	0.61	0.67	0.75	0.45	1.26
D	1348	1334	351	356	0.96	0.94	0.76	0.81	0.10	0.23	-0.17	0.82

(*) Crosscorrelation coefficient with Gaging Station 3 (Malakal)

TABLE 3. GAGING STATION 3: MALAKAL

MONTH	M(MCM)		S(MCM)		$\rho_1(0)$		$\rho_0(1)$(*)		$\rho_1(1)$(*)		γ	
	H	S	H	S	H	S	H	S	H	S	H	S
J	2198	2263	794	766	0.88	0.88	0.66	0.59	0.67	0.61	1.69	0.98
F	1536	1556	618	559	0.93	0.92	0.82	0.77	0.82	0.78	3.54	1.08
M	1477	1461	574	495	0.95	0.93	0.85	0.82	0.83	0.79	4.92	0.78
A	1346	1349	295	258	0.85	0.82	0.86	0.84	0.73	0.63	3.39	0.38
M	1531	1544	252	223	0.89	0.88	0.74	0.72	0.59	0.65	1.11	0.[illegible]1
J	1923	1937	252	222	0.94	0.95	0.60	0.68	0.58	0.63	1.49	0.15
J	2407	2424	228	205	0.88	0.86	0.65	0.63	0.45	0.45	1.83	0.10
A	2760	2793	258	237	0.93	0.92	0.54	0.54	0.51	0.42	1.64	0.17
S	2946	2989	317	279	0.94	0.91	0.62	0.56	0.56	0.52	1.07	0.03
O	3241	3284	354	327	0.93	0.95	0.68	0.69	0.66	0.62	0.70	0.28
N	3134	3175	409	395	0.92	0.89	0.70	0.66	0.67	0.63	0.78	0.59
D	2945	2979	613	588	0.91	0.90	0.58	0.53	0.23	0.33	0.50	0.102

(*) Crosscorrelation Coefficient with Gaging Station 4 (Mongalla)

TABLE 4. GAGING STATION 4: MONGALLA

MONTH	M(MCM) H	M(MCM) S	S(MCM) H	S(MCM) S	$\rho_1(0)$ H	$\rho_1(0)$ S	$\rho_0(1)(*)$ H	$\rho_0(1)(*)$ S	$\rho_1(1)(*)$ H	$\rho_1(1)(*)$ S	γ H	γ S
J	1926	1903	654	553	0.99	0.99	0.50	0.43	0.62	0.53	2.23	0.78
F	1647	1633	561	473	0.99	0.99	0.64	0.55	0.66	0.59	2.07	0.74
M	1748	1740	605	500	0.98	0.97	0.67	0.61	0.57	0.51	2.16	0.81
A	1804	1811	551	456	0.88	0.80	0.55	0.46	0.56	0.57	1.76	0.64
M	2243	2275	675	626	0.89	0.91	0.40	0.40	0.41	0.54	1.46	0.95
J	2148	2198	690	729	0.91	0.90	0.24	0.47	0.22	0.41	1.79	1.94
J	2388	2427	679	675	0.88	0.86	0.12	0.26	0.03	0.15	1.45	1.41
A	2767	2802	774	697	0.91	0.88	0.24	0.30	0.48	0.43	0.95	0.92
S	2688	2739	957	927	0.94	0.93	0.55	0.55	0.57	0.58	1.82	1.75
O	2629	2636	1012	939	0.93	0.93	0.58	0.66	0.52	0.65	2.62	1.83
N	2297	2296	723	645	0.97	0.96	0.56	0.61	0.59	0.59	2.00	1.19
D	2112	2128	654	577	0.99	0.98	0.51	0.46	0.33	0.22	1.89	0.03

(*) Crosscorrelation Coefficient with Gaging Station 1 (Wadi Halfa)

Attachment B: Stochastic Model of Nile Inflows to Lake Nasser

Results of the Broken Line Streamflow Generator Test Runs

The model was used to produce 500 year synthetic annual flow records for the four gaging stations used in the markov multivariate generator test runs. These four gaging stations cover the main streams in the Nile Basin and have historical flow records for the peroid 1912 to 1952 that are linearly independent (not the case for some of the excluded gaging stations). Also, each historical record has an associated nonnegative lag-one autocorrelation coefficient, an operational requirement of the model (Sennar has a small negative $\rho_1(0)$).

For each gaging station Table 5 gives the mean, standard deviation, skewness, lag-one autocorrelation and Hurst coefficient for the historical and simulated flow records. The Hurst coefficient for the historical case was not computed but is the desired value for the simulation case. The means, standard deviations, lag-one autocorrelation and Hurst coefficients compare favorably. The large difference in historical skewness coefficients (.02 to 2.4) make them difficult to preserve and this is reflected in the comparison of values. The problem will be the focus of further work. Table 6 gives the lag-zero cross correlation matrices for the historical and simulated records and shows that the structure is preserved.

TABLE 5. BROKEN LINE.

STATION		M	S	γ	$\rho_1(0)$	HURST
WADI HALFA	H	85800	12900	0.36	.18	.70
	S	84400	13900	0.76	.06	.72
ROSEIRES	H	49400	9400	0.02	.09	.70
	S	49300	10000	0.45	.04	.77
MALAKAL	H	27400	4000	2.36	.60	.70
	S	27700	4300	0.79	.65	.67
MONGALLA	H	26400	7400	1.90	.67	.70
	S	26700	7800	1.34	.62	.69

TABLE 6. BROKEN LINE LAG-ZERO CROSS CORRELATION

STATION	H				S			
WADI HALFA	1.000	.893	.524	.436	1.000	.914	.489	.471
ROSEIRES	.893	1.000	.310	.281	.914	1.000	.315	.339
MALAKAL	.524	.310	1.000	.799	489	.315	1.000	.928
MONGALLA	.436	.281	.799	1.000	.471	.339	.928	1.000

Attachment C: Stochastic Model of Nile Inflows to Lake Nasser

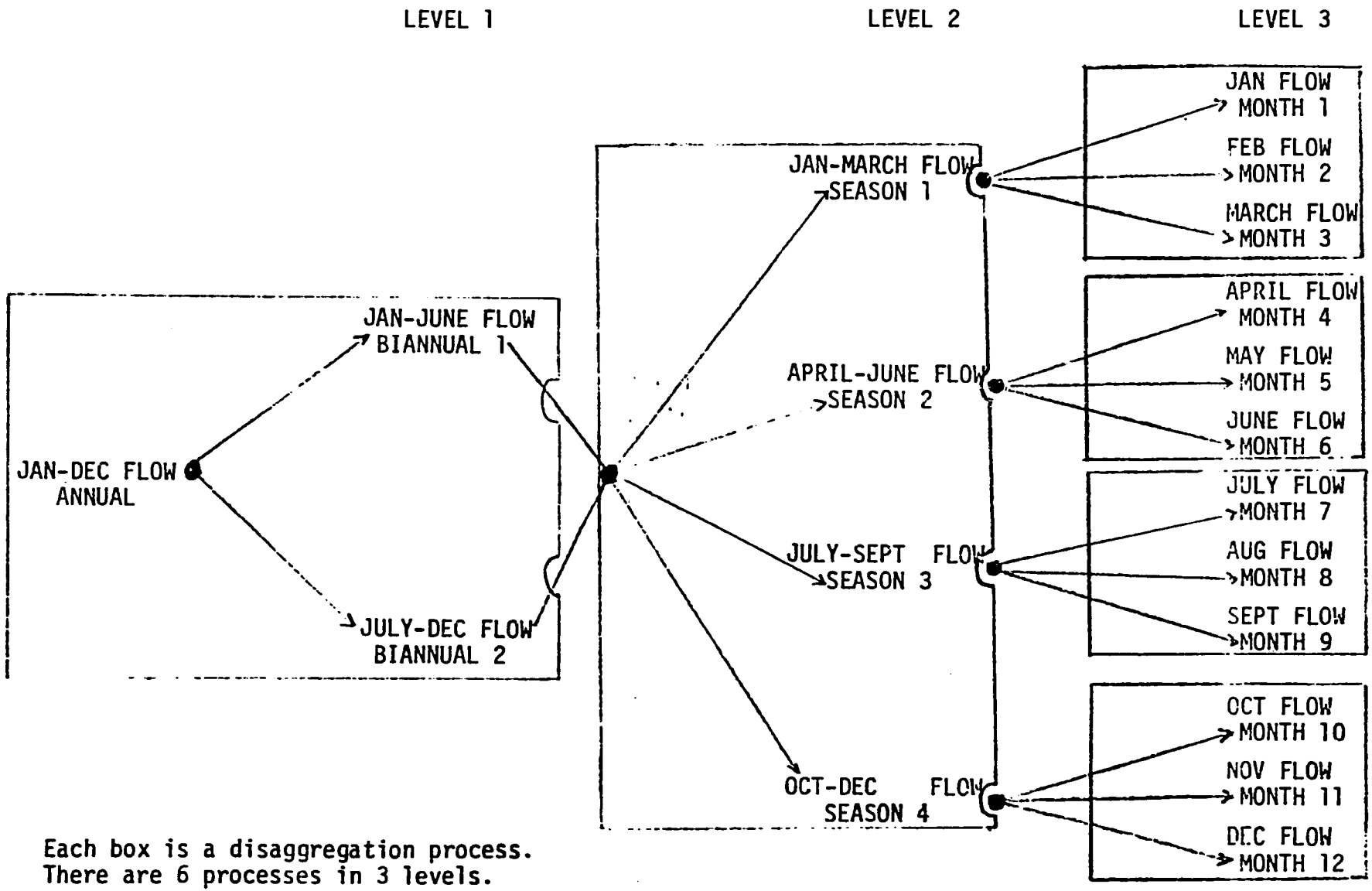
Results of the Disaggregation Model Test Runs

The model was used to disaggregate 41 years of annual flows from the same 4 gaging stations used in the broken line streamflow generator. The disaggregation scheme is shown in figure 1. Annual values are disaggregated into biannual values, biannual values are disaggregated into seasonal values, and each season is disaggregated into 3 monthly values; a total of 6 disaggregation processes. Instead of using synthetic flows generated by the broken line model, historical flows were disaggregated so that results could be judged independently of an external model.

Results of the test are summarized in the following tables 7 to 15. For each disaggregation level, historical mean, standard deviation and skewness is compared to resulting values for each station and the historical cross correlation matrix is compared to the matrix computed from disaggregated values.

Means, standard deviations and cross correlations were preserved. Skewness was preserved in most cases although there is no explicit mechanism for the preservation programmed.

FIGURE 1. DISAGGREGATION SCHEME



Each box is a disaggregation process.
There are 6 processes in 3 levels.

TABLE 7. DISAGGREGATION MODEL

STATISTICS OF BIANNUAL VALUES

STATION	SEASON		M	S	γ
WADI HALFA	JAN-JUNE	H	13600	3000	2.05
		S	13600	2500	2.18
	JULY-DEC	H	72200	12600	0.38
		S	72100	13200	0.19
ROSEIRES	JAN-JUNE	H	4200	1000	0.92
		S	4300	800	0.04
	JULY-DEC	H	45200	9000	-0.02
		S	44500	8900	0.19
MALAKAL	JAN-JUNE	H	10000	2500	3.35
		S	10000	2400	2.71
	JULY-DEC	H	17400	1900	0.76
		S	17400	1900	1.39
MONGALLA	JAN-JUNE	H	11500	3500	1.93
		S	11500	3500	1.97
	JULY-DEC	H	14900	4500	2.13
		S	14900	4300	1.96

TABLE 8. DISAGGREGATION MODEL

HISTORICAL BIANNUAL VALUE CROSS CORRELATION MATRIX

STATION	SEASON								
WADI HALFA	JAN-JUNE	1.00	-.01	.49	.04	.92	.46	.65	.40
	JULY-DEC		1.00	.32	.90	.06	.63	.10	.44
ROSEIRES	JAN-JUNE			1.00	.37	.41	.28	.20	.04
	JULY-DEC				1.00	.01	.56	.07	.41
MALAKAL	JAN-JUNE					1.00	.59	.82	.52
	JULY-DEC						1.00	.59	.74
MONGALLA	JAN-JUNE							1.00	.71
	JULY-DEC								1.00

TABLE 9. DISAGGREGATION MODEL

CROSS CORRELATION MATRIX OF SIMULATED BIANNUAL VALUES

STATION	SEASON								
WADI HALFA	JAN-JUNE	1.00	.03	.50	.01	.95	.65	.70	.43
	JULY-DEC		1.00	.53	.84	.11	.68	.22	.42
ROSEIRES	JAN-JUNE			1.00	.43	.42	.54	.17	.05
	JULY-DEC				1.00	.00	.58	.12	.42
MALAKAL	JAN-JUNE					1.00	.69	.81	.52
	JULY-DEC						1.00	.75	.73
MONGALLA	JAN-JUNE							1.00	.79
	JULY-DEC								1.00

TABLE 10. DISAGGREGATION MODEL

STATISTICS OF SEASONAL VALUES

STATION			M	S	γ
WADI HALFA	SEASON 1	H	8100	1700	1.55
		S	8000	1700	2.66
	2	H	5400	1600	1.94
		S	5600	1200	0.29
	3	H	45800	8200	-0.01
		S	45900	8800	-0.05
	4	H	26400	5500	0.94
		S	26300	5400	0.61
ROSEIRES	1	H	1600	400	-0.00
		S	1600	300	1.81
	2	H	2600	900	1.75
		S	2700	800	-0.01
	3	H	34700	6800	-0.02
		S	34400	7200	0.03
	4	H	10600	3000	0.19
		S	10200	2800	0.25
MALAKAL	1	H	5200	1900	3.32
		S	5200	1800	2.43
	2	H	4800	700	2.33
		S	4800	700	2.44
	3	H	8100	800	1.61
		S	8100	800	2.15
	4	H	9300	1300	0.76
		S	9300	1200	1.18
MONGALLA	1	H	5300	1800	2.27
		S	5300	1800	2.16
	2	H	6200	1800	1.65
		S	6200	1800	1.62
	3	H	7800	2300	1.60
		S	7900	2200	2.06
	4	H	7000	2300	2.45
		S	7000	2200	1.51

TABLE 11. DISAGGREGATION MODEL

HISTORICAL SEASONAL VALUE CROSS CORRELATION MATRIX

STATION																	
WADI HALFA	SEASON 1	1.00	.66	.00	.08	.83	.09	.03	-.06	.90	.72	.63	.33	.67	.61	.49	.45
	2		1.00	.01	-.14	.56	.41	.13	-.07	.78	.75	.57	.21	.53	.48	.28	.19
	3			1.00	.68	.14	.38	.91	.54	-.02	.10	.33	.60	-.01	.08	.33	.30
	4				1.00	-.05	.20	.63	.87	.11	.11	.35	.76	.13	.21	.47	.57
ROSEIRES	1					1.00	.19	.16	-.18	.67	.54	.40	.12	.43	.38	.33	.28
	2						1.00	.42	.23	.12	.43	.30	.16	.03	.09	-.10	-.04
	3							1.00	.61	-.01	.12	.29	.62	-.01	.12	.37	.33
	4								1.00	-.03	-.04	.11	.62	.02	.13	.35	.47
MALAKAL	1									1.00	.84	.76	.40	.81	.72	.54	.51
	2										1.00	.82	.37	.80	.77	.46	.43
	3											1.00	.70	.71	.69	.62	.55
	4												1.00	.39	.48	.73	.71
MONGALLA	1													1.00	.89	.64	.57
	2														1.00	.77	.74
	3															1.00	.92
	4																1.00

TABLE 12. DISAGGREGATION MODEL

CROSS CORRELATION MATRIX OF SIMULATED SEASONAL VALUES

STATION																	
WADI HALFA	SEASON 1	1.00	.56	-.01	.24	.81	.07	-.04	.01	.94	.87	.81	.59	.81	.75	.51	.54
	2		1.00	-.06	-.10	.48	.44	.09	-.07	.66	.73	.55	.28	.42	.32	.22	.11
	3			1.00	.70	.24	.42	.84	.51	-.03	.13	.45	.63	.11	.12	.37	.26
	4				1.00	.25	.36	.48	.84	.25	.25	.48	.74	.30	.35	.44	.54
ROSEIRES	1					1.00	.12	.14	-.02	.76	.68	.71	.54	.58	.51	.47	.49
	2						1.00	.29	.30	.13	.29	.33	.27	-.01	-.05	-.13	-.19
	3							1.00	.52	-.10	.11	.33	.56	.04	.11	.40	.25
	4								1.00	.03	.06	.19	.59	.10	.20	.36	.49
MALAKAL	1									1.00	.89	.80	.54	.80	.70	.47	.51
	2										1.00	.88	.55	.85	.76	.50	.47
	3											1.00	.81	.84	.77	.65	.55
	4												1.00	.62	.65	.75	.69
MONGALLA	1													1.00	.92	.74	.67
	2														1.00	.81	.78
	3															1.00	.89
	4																1.00

TABLE 13. DISAGGREGATION MODEL

STATISTICS OF MONTHLY VALUES

STATION			M	S	γ
WADI HALFA	MONTH 1	H	3500	700	0.28
		S	3500	600	1.82
	2	H	2400	600	1.26
		S	2300	600	2.46
	3	H	2200	700	1.65
		S	2200	700	1.59
ROSEIRES	1	H	800	200	-0.29
		S	800	100	1.81
	2	H	500	100	0.43
		S	500	100	1.97
	3	H	400	100	1.13
		S	300	100	0.55
MALAKAL	1	H	2200	800	1.75
		S	2100	800	1.87
	2	H	1500	600	3.67
		S	1600	600	2.18
	3	H	1500	600	5.11
		S	1500	500	2.08
MONGALLA	1	H	1900	600	2.32
		S	1900	600	2.21
	2	H	1600	600	2.15
		S	1600	500	2.09
		H	1700	600	2.24
		S	1700	600	2.07

TABLE 14. DISAGGREGATION MODEL

HISTORICAL MONTHLY VALUE CROSS CORRELATION MATRIX

STATION													
WADI HALFA	MONTH 1	1.00	.91	.50	.83	.81	.57	.77	.69	.58	.50	.50	.50
	2		1.00	.71	.77	.76	.60	.92	.82	.69	.62	.64	.65
	3			1.00	.59	.55	.55	.79	.83	.75	.65	.66	.67
ROSEIRES	1				1.00	.92	.63	.67	.59	.47	.36	.38	.38
	2					1.00	.65	.61	.62	.53	.39	.40	.40
	3						1.00	.58	.56	.52	.40	.42	.44
MALAKAL	1							1.00	.88	.74	.66	.67	.68
	2								1.00	.93	.81	.82	.82
	3									1.00	.85	.84	.85
MONGALLA	1										1.00	.99	.98
	2											1.00	.99
	3												1.00

TABLE 15. DISAGGREGATION MODEL

CROSS CORRELATION MATRIX OF SIMULATED MONTHLY VALUES

STATION													
WADI HALFA	MONTH 1	1.00	.90	.59	.80	.75	.24	.81	.79	.71	.73	.72	.71
	2		1.00	.78	.78	.70	.35	.94	.88	.77	.82	.83	.83
	3			1.00	.70	.66	.40	.79	.83	.76	.65	.66	.67
ROSEIRES	1				1.00	.88	.39	.75	.71	.59	.57	.58	.57
	2					1.00	.24	.66	.75	.70	.57	.56	.53
	3						1.00	.45	.32	.25	.24	.25	.29
HALAKAL	1							1.00	.89	.72	.72	.72	.72
	2								1.00	.93	.78	.77	.77
	3									1.00	.81	.79	.79
MONGALLA	1										1.00	.99	.98
	2											1.00	.99
	3												1.00

V.2 NILE DELTA GROUNDWATER STUDY

Progress Report

June 1, 1977 - August 31, 1977

Project Objectives.

1. Develop a numerical model for the prediction of seawater intrusion and piezometric head in coastal aquifers involving irregular coastline.
2. Apply an existing aquifer model AQUIFEM and, later, the seawater intrusion to the Nile Delta aquifer to evaluate aquifer water supply capacity (safe yield), aquifer cyclic storage capability, and irrigation and drainage effects.
3. Study the details of seawater intrusion in the Delta aquifer in order to formulate boundary conditions for the model and to evaluate model results.
4. Evaluate the need for more sophisticated model studies in the future, due to the complexity of the seawater intrusion problem.
5. Transfer modern groundwater modeling techniques to Ministry of Irrigation staff and Cairo University faculty.
6. Study the conjunctive use of surface water and groundwater in the Nile Basin.

The first year of the study will concentrate on AQUIFEM application, model development, data preparation, and a detailed analysis of the seawater intrusion process. The application of the seawater intrusion model to the Delta aquifer is scheduled for the second year of the project, to be proposed at a later time.

Progress During Report Period: 1 June - 31 August, 1977.

At the beginning of the report period, Professor John Wilson and Mr. Kenneth Strzepek visited Cairo for three weeks. A great deal was accomplished during the short stay in Egypt. Two formal seminars were given to an audience of Ministry of Irrigation and Cairo University staffs. The seminars were entitled, "Simulation Modelling an Analytical Technique" and "Guidelines for Simulation Analysis." Additional informal seminars were held on the topic of seawater intrusion in coastal aquifers and in the Delta aquifer in particular. A meeting was held with His Excellency Abul El Atta, Minister of Irrigation. He was pleased that our project was being undertaken and gave his support by stating that all the data that we needed would be provided.

A series of meetings were held with Dr. Kamal Hefny and his staff at the Groundwater Research Institute, to discuss existing data for the Delta aquifer and the program of analysis planned for the coming six months. A report containing compiled data was presented by Dr. Hefny's staff. Primary attention will be given to collecting additional information on the hydraulic conductivity of the aquifer and the clay cap. Because AQUIFEM (Aquifer Finite Element Model) is probably too large for long-term use on the University Computer, a finite difference model, called NILAQC, will be developed to replace it for the preliminary analyses.

Professor Sherif M. Makian Ebeid, of the Electrical Engineering Department, Cairo University, joined the project during our visit. He helped implement AQUIFEM on the University computer, and during August updated it with the latest code. He is an excellent addition to the staff because of his familiarity with computer models and with the Delta hydrology.

Professor Abdelwahab Amer of the University devoted his full time to the project during our visit. A training program for university students in groundwater modeling is under his direction with the help of Dr. Makian.

Professor Amer travelled to M.I.T. at the beginning of August. While here, he helped develop a finite element grid for the entire Delta aquifer and saw it implemented for the central portion of the Delta. Since then the model has been used to revise estimates of vertical recharge and discharge due to leakage through the clay cap. Professor Amer also studied basic elements of numerical models and collected literature on seawater intrusion to be used in the training program.

Professor Ebeid has applied NILAQC to the Delta aquifer to evaluate parameters and boundary conditions. The approach has been to first calibrate the model using the relatively steady state piezometric heads of current conditions, then to calibrate for transient conditions using observed heads for years prior to the High Dam. This technique should provide an indication of seawater interface movement. Then the model will be available for preliminary evaluation of steady state safe yield.

Several new analytical seawater intrusion models have been developed to account for the conditions observed in the data obtained during the June visit. These models are oriented toward providing mix regions of recharge/discharge through the clay cap, depending on the distance from the coastline.

Part of the Delta aquifer study is oriented toward a preliminary application of MITSIM, the river basin simulation model and the evaluation of future opportunities for systems analysis. A series of meetings were held with Sarwat Fahmy of the Ministry of Irrigation who is the Egyptian director of the Office of the Water Master Plan. We were given the utmost cooperation and all the data we requested that was available was supplied promptly. Additionally, a great deal of time was spent working with Dr. Elassiouti, Head of the Irrigation and Hydraulics Division of the Faculty of Engineering, Cairo University to introduce the concepts of system analysis. A training program in "System Analysis in Water Resources Planning" was begun for the Cairo University staff expected to participate in the official project. Many contacts were made that will be useful in the future as this project becomes full scale. Among them was a visit to the Hydraulics Research Center at the Deltaic Barrage.

After arrival back in the United States the existing MITSIM was modified to meet the needs of the Nile Basin. The data obtained in Egypt was analyzed and a simulation analysis was performed to analyze the operation of High Dam and the Toska Spillway. These preliminary results will be sent to the Ministry staff for comments and suggestions. Also theoretical work is being conducted to establish statistical confidence in the results obtained from the simulation analysis.

Future Activities, Travel and Seminars for Next Period.

The goals for the fall period of the project are:

1. Complete preliminary NILAQC and AQUIFEM calibrations and safe yield analyses of the Delta aquifer.
2. Compile and organize the steady state analytical seawater intrusion studies with applications.
3. To complete the transient analytical models of seawater intrusion.
4. To make the final choice of approach for the numerical seawater intrusion model.
5. To continue data collection and preparation efforts for Nile Delta.
6. To continue background studies for the use of simulation and other systems analysis techniques in the Nile River Basin and complete the preliminary evaluation of the High Dam and Toska Spillway.

7. Additional training of staff by Professors Amer and Ebeid of staff in the use of groundwater models and in groundwater hydrology.

In late December Professor Wilson and Professor David Marks will visit Cairo to:

1. Give formal seminars of groundwater modeling and seawater intrusion in aquifers.
2. Continue liaison regarding data for Nile Delta and River Basin Simulation Models: data, results, coordination.
3. Explore grounds for water resources systems analysis project connected to the Water Master Plan.

This trip will be proceeded by Dr. Hefny's visit to M.I.T., in late October. Dr. Hefny will spend one week at M.I.T. and a second week with the Water Resources Department of the State of California studying their seawater intrusion control barrier plans and groundwater management.

Difficulties Encountered

It has been discovered that the Cairo University Computer System will be inadequate to meet the needs of running MITSIM. MITSIM requires approximately 400 K words of storage and the Cairo University facility has approximately 250 K. A program overlay is possible; however, overlays have never been performed at Cairo University before. The seawater intrusion model to be built will also require relatively large core, unless it is designed from the outset to be disc-oriented. AQUIFEM fits on the computer, but is not an efficient program for the ILC logic. Some alternative arrangements should be made that will meet our needs as well as be acceptable to Cairo University.

Another problem is that in the Division of Irrigation and Hydraulics no one has a knowledge of numerical modeling and system analysis techniques. A large part of our effort must be to educate the staff in these modern techniques. This, however, does take a great deal of their time, slowing the analysis process.

There is inadequate data describing the location of the seawater wedge. Deep cores were drilled many years and then abandoned, for a one time measurement. Several deep wells are currently being drilled in the Eastern Delta. However, there are numerous measurements in shallow wells which accurately locate the intersection of the interface with the clay cap. This lack of information of the interface may greatly increase the uncertainty of development alternatives and slow down the analysis phase of the project.

A.I.D. Investment Opportunities.

There are significant investment opportunities in the deep exploration of the Delta aquifer. The purpose would be to better define the spatial and temporal characteristics of the seawater interface and its zone of transition, and to locate the basement or bottom of the aquifer. Secondary benefits would be derived in the form of estimates of vertical hydraulic gradients and vertical variation of hydraulic conductivity. A series of longitudinal and lateral boring would be required.

Supplemental Progress Report - August 30, 1977.

Summary for River Basin Simulation Study.

1. The Ministry of Irrigation is currently addressing the problem of developing an overall systems plan of Egyptian Water Resources. This plan is being carried out by the Office of the Water Master Plan and the UNDP. It is to include Egyptian as well as expatriate staff. They wish to employ modern water resources system analysis techniques, but at present have no ability to do so. The first phase of the project is devoted to data collection. The present data set is rather limited or found in another Ministry.

2. The current project is very well suited to fit into the Ministry's planning process. The need for analytical techniques can be provided by the project especially with M.I.T.'s experiences in international River Basin Planning. The project can also help with more efficient data collection by providing a focus for the data collection. By introducing these techniques there will be a need to train Ministry personnel in these techniques.

3. The future direction is seen in reviewing the requirements of the planning process and designing methodologies and implementation of planning tools to design a Master Plan for Water in Egypt. These topics will be discussed during Professors Marks' and Wilson's December trip.

Summary for Nile Delta Study

1. The Ministry of Irrigation currently has limited capability for employing modern techniques of groundwater analysis, particularly numerical models. Until recently all modeling was done by expatriate staff on U.N. projects. Now, Dr. Ebeid of the University has become involved in modeling, including one other project prior to this. However, he is a consultant

to the Ministry rather than a staff member. The data base collected by the Ministry is not oriented toward those items of most interest in resource evaluation. This is typical where the data has not been drawn together in a systematic analysis of the resource. There are also gaps in the data, attributable to lack of funds rather than approach. The sparse information available for the deep portion of the Delta aquifer is an example.

2. The current project can strengthen the Ministry by improving analytical capabilities, and through these capabilities demonstrating the importance of various types of data.

3. Near term future research in this project will primarily be directed toward the development of a numerical model of seawater intrusion in the Nile Delta. Additional topics being considered include an evaluation of the New Valley Development, the use of systems techniques to improve data collection and analysis, and a detailed level study of river aquifer interaction in Upper Egypt. It would be particularly valuable to the Ministry to enhance the data collection program. It is anticipated that the seawater intrusion study will take an additional two years from the date of this report. Additional studies will be for at least a two-year period.

V.3 HOUSING AND THE CONSTRUCTION INDUSTRY

Progress Report

June 1, 1977 - September 1, 1977

I. SYNOPSIS OF PROJECT. (See initial project proposal and progress report of June 1 for detailed description.): The project includes three subprojects with each covering a particular aspect of the housing situation in Egypt. The work program for the projects is essentially in three phases: Phase 1) familiarization with situation of Egypt, identification of data required, initiating collaborative contacts with appropriate government agencies, and detailed structuring of research; 2) collection of required data through field surveys, published reports, discussions with the various ministries, and outlining tentative areas of conclusions and recommendations; and 3) evaluation and analysis of data, preparation of recommendations, discussions of preliminary conclusions with informed officials and professionals, preparation of final report, and identification of areas/issues which require further detailed research.

The subproject "Housing and Public Policy" is concerned with national housing policy with the objective of developing a model for evaluation of public policy options. A basic model of the housing market has been developed based on extensive discussions with ministry experts, previous studies, and field research. Sufficient specific data which are required to test alternatives have been collected to allow initial limited computer runs to test the model as well as to suggest preliminary recommendations. The final phase of the work will focus on calibration of the parameters of the computer model through inputs of more refined detailed data. Various alternative scenarios will be tested for consideration of the ministries concerned with housing.

The goal of the subproject "Housing Construction Industry and Materials Supply" is to determine priorities for the allocation of resources and investments to increase the availability of building materials. The focus is on resources, production, distribution, and consumption of selected materials, both conventional and non-conventional. Extensive data have been collected on cement, bricks, steel, glass, and gypsum, and

data are almost complete for lumber, floor tiles, and sanitary fixtures. Consumption data are still being prepared. The data will give some indication of housings' share in production and consumption of major building materials and allow the determination of alternative scenarios of materials usage in housing. Recommendations will be developed in the final phase for maximizing the efficiency of use of both traditional and alternative materials.

The final subproject, "Housing Construction Systems and Design Norms," is concerned with developing guidelines/references for appropriate housing and physical planning. There are two primary areas: 1) a study of the industrialized building systems in Egypt with focus at the dwelling scale; and 2) a study of the larger scale aspects of the planning of settlements. In gathering data for both areas, particular stress has been given to a field survey undertaken in six selected low-income areas. These surveys are intended to be the prime source for determination of user needs, physical characteristics of dwellings, existing space standards and costs, and income correlations. Close collaboration has been established with one of the plants producing prefabricated panels and the study of industrialized building systems which allows direct applicability in recommendations and possible testing of modified designs in future research. Also, direct working collaboration has been initiated with the group concerned with settlement patterns/standards and the General Organization for Physical Planning which is responsible, among other tasks, to assist towns throughout Egypt in preparing master plans and housing subdivisions. The planning group intends to develop alternative planning models for low-income areas based on existing and proposed codes, existing settlement realities, and developer/financing mechanisms in the last phase of the work.

Joint recommendations will be prepared combining inputs from all subproject areas for the final phase of the work.

II. STATUS OF PROJECTS: All of the subprojects are now in the final phase of analysis/evaluation of data, and preparing conclusions and recommendations.

A. Activities completed: Most of the data have been collected by the subprojects, and several field trips have been undertaken directed toward securing the required data.

Data collection - all subprojects have essentially gathered the bulk of data required as support for their interest areas. The Housing Economy group has gathered information in two areas: a) material for determining the structure of the housing model; b) data for the calibration of the parameters of the model. This information has allowed the initial structuring of the model and the testing of the computer program. The Materials group has nearly completed its data collection for cement, steel, brick, gypsum and glass, particularly in the production area. Sanitary fixtures, lumber, and floor tiles are in the process of being surveyed and should be completed in September. The study on Industrialized Systems has been focusing its efforts on only one of the pre-fab systems imported from East Germany as a test case. Intensive meetings have been held with both the company's technical experts as well as with the designers of the first buildings with that system. The Site Planning group has focused its data collection efforts on reference case studies of existing settlements, existing and proposed standards for housing and planning, and utility intrastructure standards and costs. Only the utility information is not yet complete at this point.

Field trips - All subprojects have had several working trips to Cairo. The emphasis was for M.I.T. team members to work in Cairo during the summer to participate in the data collection efforts. Cairo members will meet with counterparts at M.I.T. during the fall during the preparation of the initial summary report.

B. Activities planned: The focus of the last phase of the work is on the preparation of specific, clear recommendations for the use of the various ministries. The "product" from each of the subprojects will be as follows:

From Economy Study: a model of the Egyptian housing economy with various public policy alternatives tested through a computer analog.

From Materials Study: a) detailed data on specific materials including production, distribution, and consumption. b) specific recommendations as to possible causes of shortages and inefficiencies, and potential means to alleviate such constraints in building materials for housing.

From Industrialized Systems Study: a) development of an evaluation system for prefabrication systems in Egypt. b) analysis and redesign of specific system in Egypt as pilot study to serve as model for other systems to be analyzed in future.

From Site Planning Study: a) documentation of 6 selected low income areas studied through field surveys carried out during the summer 1977 b) a comparative evaluation of old Cairo, a public housing project, and an informal sector areas as a basis for developing alternative physical planning models for future large scale housing developments.

Field trips: Field trips are planned by Cairo University personnel to M.I.T. to discuss/prepare the final report as well as to bring remaining data which were collected.

Conference on Construction in Developing Countries: Members from both M.I.T. and Cairo University are planning to attend a 4 day conference sponsored by the World Association for Element Building and Prefabrication. Presentations will be made by industrialized housing experts who have experience in developing country situations. In addition factory visits will be made to several of the parent companies whose panel factories are now being imported into Egypt.

Joint M.I.T./Cairo University Meeting: Working sessions are planned to be held at M.I.T. during the 2 week period of September 26 through October 7. The purpose of the sessions is to discuss the progress/status of the research up to this point, to make plans for the completion of the initial phase of the research, and to investigate alternatives for future long term proposals. Participants from Cairo University will be a member from the Materials group and all members of the Economy, Industrialized Systems, and Site Planning groups. Three ministry officials from the General Organization for Physical Planning, Ministry of Housing

and Reconstruction, have also been invited to attend. Aside from the specific seminars devoted to present and future phases of the work, group meetings will be devoted toward discussions of specific housing issues critical to the Egyptian situation. Side trips would also be arranged to specific housing interest areas in Boston including a pre-casting factory, on-going housing projects, and meetings with various experts from area universities.

C. Initial Preliminary Conclusions: Tentative recommendations which will be made at the end of the initial phase of the work can already be narrowed down into several areas: 1) Particular emphasis/study should be directed toward the informal sector of housing. This group, roughly estimated at 50-75% of all new construction, must be considered in any future development plans of Egypt; 2) The demand for several building materials is already exceeding the present actual production and emphasis must be placed on more efficient use of existing materials/methods and investigation of alternative, non-conventional materials; 3) The prefabricated housing systems imported into Egypt must undergo extensive modifications, both in the design of prefabricated elements and in the design of the dwelling unit in order for them to be acceptable for low income housing; 4) The problem of low income housing is not with the individual dwelling itself, but one of government provided services/utilities. Government efforts should be directed toward providing basic infrastructure, services, and more appropriate land distribution and subdivision, and should focus on larger scale issues at the settlement scale instead of the individual dwelling.

III. APPLICABILITY OF WORK TO GOVERNMENT MINISTRIES. The research of all of the three subprojects is intended to assist the various ministries in their work. The Housing Economy group's result should be of particular use to the Ministry of Planning as well as the Ministry of Housing and Reconstruction. The model being developed should allow experimentation with various public policy options before actual implementation. Specific policy changes could be tested, for example, relaxation of rent control, and their impact on other sectors of the economy could be ascertained.

The work of the Materials group should be of direct use for the Mininstry of Housing and Reconstruction, the Ministry of Planning and the Ministry of Industry. Priorities of investments, areas of shortages for the specific building materials and realistic alternatives with non-conventional materials will be included in some of the recommendations of the work of the initial phase.

The work of the Industrialized Housing group should be of direct use to the various government owned companies charged with using the imported prefabricated systems. Appropriate policies of use as well as specific recommendations for modifications should be of interest to each company.

The Site Planning group is focusing its work for specific use of the General Organization for Physical Planning (GOPP) in the Ministry of Housing and Reconstruction. Use of the work is for government housing investment policies to emphasis land control and provision of infrastructure. The work would be directly used in that the strong ties established include 2 full time architects/planners from the Ministry to assist in the work.

IV. FUTURE DIRECTIONS/TOPICS. Specific areas considered for future research included the following:

From Housing Economy study: further refinement of model with the addition of more specific data.

From Materials study: further research in new uses of conventional and non-conventional materials with the testing of new materials in real applications; further research into productivity of building materials production and use: evaluation of the efficiency of materials themselves as now used as well as that of labor, capital (equipment) and other materials used in production and installation; research into other non-material constraints on housing production: manpower, construction equipment, and capital.

From Industrialized Systems study: expansion of study to include the other large panel systems now being erected in Egypt; testing of actual redesign of panel systems with full size prototypes.

From Site Planning study: three areas were identified as appropriate to both MIT and GOPP interests: teaching, research, and practical applications.

teaching: discussions centered around offering a seminar in the GOPP during March of next year; participants would be approximately 10 people from the GOPP in an intensive 10 day session evaluating a specific project as a vehicle for discussion and as a means of presenting planning issues. Also, possibilities were discussed, where an outstanding junior member of the GOPP could attend M.I.T. as a student in the Master of Architecture program.

research: continued development of basic documentation of reference areas of land/dwelling systems; development of planning models of new areas considering staging, low income people, and cultural and economic situation.

practical: demonstration of principles in a specific site, both in a desert area of development, and in an expansion area in the agricultural region.

A brief summary of the status of each of the three subprojects follows. Each includes Synopsis of Project; Status, including activities completed and planned; Applicability of work to ministries; and Future directions/topics.

Subproject:

HOUSING ECONOMY AND PUBLIC POLICY

I. SYNOPSIS OF PROJECT. The subproject represents an attempt to develop a working simulation model of the Egyptian housing economy, and to use this model in establishing and evaluating Egyptian housing policy. The proposed model departs from traditional modeling efforts in developing countries in several respects. The first and most important is that the model is not a direct normative or planning model. It contains no objective function which is either directly or implicitly maximized. Instead the model is a positive forecasting tool, although unlike those developed before. This is the unique feature of the model -- it directly models the institutions that characterize Egyptian housing. These include severe rent control, partial public control over investment and prices, and an extensive black market. The model takes these institutions as given and tries to predict individual behaviour within them. This raises the third advantage of the model -- it contains a wide range of policy parameters. In the short run these include government set housing rents and material prices, public housing investment and factor supplies. In the longer run, the model can be adopted to study the consequences of institutional changes such as the elimination of rent control.

A model so structured offers a number of advantages as a tool in public policy making. Because it is set within the local institutional framework,it cannot be discarded as "unrealistic". Secondly, it in principle can provide policy makers with rough estimates about the long run consequences of alternative policies. As such, the Housing Economy Subproject intends to try to develop a local, Egyptian capacity to run and modify the model--and to integrate it into portions of the housing decision making process.

II. STATUS OF PROJECT. During the first 9 months of the subproject, four tasks or goals were identified. To date two of the tasks have been successfully completed.

1. The first task involved developing an "understanding" of the Egyptian housing economy: How it works, public-private responsibilities, regulation, etc. Such "knowledge" was acquired through several trips and extensive talks with contractors, builders, academics, and government officials. At this point, project staff feel that they have a good understanding of the logic and structure of Egypt's housing economy.

2. The second task involves translating this understanding into a specific computer-based model. Over the last serveral months, the project staff have been designing and programming such a model, in Fortran, on MIT's IBM360 series computer. The model is still being tested and debugged now, but the staff feels this portion of the project is progressing well. This final model will be operable on several Egyptian computers. A more detailed discussion of the model is found in Attachment A.

3. The third task is to develop close working relations with academics at Cairo University and government policy makers in various ministries, who would aid in the development of the model and be likely candidates to later use it. The project staff feel to date that we have not been very successful in accomplishing this. So far, no economists have been found with sufficient experience in housing problems, and no architects or planners seem to have experience in economic modeling. Our only successful academic contact to date is Professor M.A. Barrada. Things are not appreciably better at the ministerial level. The Ministry of Housing and Reconstruction is a very "administrative" organization, with few planning functions. As such, their responsiveness to some of our overtures has been weak. The Ministry of Planning offers a potentially greater link, but we are only now beginning to explore this.

4. The final task is to assemble, from various sources, data needed to calibrate the model. The project is fully aware of what data are and are not available, but to date we have been only moderately successful in acquiring them. We currently have data requests in at the Ministries of Housing and Planning, and at the official census agency, CAPMAS.

III. FUTURE DIRECTIONS. The housing economy subproject currently envisions an extension through the summer of 1978. It is felt that the time is necessary to finish the model, acquire data, expand the Egyptian contacts and actually begin using the model to analyze policy. The following timetable is suggested for these tasks:

-Finish model: Sep. '77 - Dec. '77

-Expand Egyptian contacts: Sep. '77 - Feb. '78

-Acquire data: Sep. '77 - Feb. '78

-Model simulations and policy analysis: Feb. '78 - July '78.

We feel this framework is quite reasonable and anticipate preparing a formal proposal for extending the project.

Attachment A:

MODELING THE EGYPTIAN HOUSING ECONOMY

Any attempt to develop a model of the Egyptian housing economy must recognize two important constraints. First, the government plays a major role in regulating the private sector as well as operating a separate public sector. Secondly, there is insufficient data for the application of sophisticated econometric techniques. Both of these constraints are discussed below, and each suggests that an algorithmic simulation approach is the correct and most realistic mode of modeling. A proposed model is then described along with a tentative system of equations.

I. Egypt's housing economy is clearly divided into a public and a private sector, each with its own set of institutions and behavioral parameters. The public sector currently builds essentially a single kind of middle class housing and rents these at approximately 1/5 of cost. Naturally there is excess demand, and waiting lines are long. There appears to be no monetary arbitrage in this market, despite occasional statements in the press that some units are illegally sublet at higher rents. Most local housing offices seem to enforce the law and so it may be assumed that the excess demand is semi-permanent.

Egypt's private sector operates in quite a unique manner. To begin with, one may imagine three submarkets existing within it: one for luxury housing, the other for standard middle class housing, and the third for lower class or "informal" housing. Within each submarket, the standing stock of housing has rents set by law. Units built before 1968 have fairly uniform and extremely low rents. Units built since 1968 have rents set ostensibly at marginal production costs (generally several time higher than old units). For each category of housing, therefore, there is a distribution of official rents.

The important institution that holds this system together is a strong tenents' rights law that prevents a tenant from being evicted as long as he meets the official rent. Landlords, therefore, cannot raise rents (even with a lease) because tenants will simply refuse to pay. The landlord response is to charge a one time entrance fee. Although this is illegal, as are rents above the prescribed level, it occurs only once, as a cash transaction, and is impossible to police. A landlord letting an apartment, therefore, is

essentially selling it or permanently leasing it for an initial fee plus the official rent.

Such a system severely discourages turnover and locks a landlord into a one-time opportunity to cover the lifetime "costs" of his unit. Individuals rarely leave an apartment because they can at best split the new "key money" with the old landlord and will be forced to pay full key money for a new apartment. Each year a few old units do turn over, however, and these plus new units constitute the supply of housing available for occupancy. The "price" such units command is determined by demand, and once rented (effectively sold), that price becomes part of the distribution of prices observed in the standing stock. There is thus a substantial current divergence between the average price of units within a submarket and the marginal price of new or turnover units. Consumer decisions over whether to seek a new unit are based on a comparison of the average-vs.-marginal price. Supplier decisions are based purely on the marginal price.

This system has a number of interesting features to it. For example, if the marginal price of housing is not rising, eventually, as units turn over, the average price will equal the marginal. As this happens, more and more people enter the market since old housing is no longer cheaper than new. In short, the existence of key money eliminates rent control in the long run. The continued existence of units with depressed rents is due more to tenants' rights in conjunction with the steady inflation of housing costs and prices. In such a situation average and marginal prices continue to be different although each moves upward over time.

The system also results in some dead weight efficiency loss. The lump sum fee which is lost if a unit is vacated prevents individuals from freely trading with others, and thus units may be unoptimally distributed to families. The net distributive effect of the system is difficult to ascertain. A great many poor people benefit by probably living in units they could not now afford. At the same time, those poor people who are forced to seek housing at the margin are much worse off paying fixed key money rather than rent. Wealth among the poor is scarcer than income.

A final escape valve is the opportunity to double up with relatives. If the number of households vacating units plus new family formation exceeds the units vacated plus new construction, prices rise until the excess demand is temporarily forced to seek shelter with others. Families who have doubled up represent a continual pool of those looking for final homes.

II. In any economy which is characterized by multiple sectors -- some of which have permanent excess demand -- supply and demand curves are discontinous and difficult at best to identify. Such features are hard to capture with a system of econometric equations. Thus even if adequate data were available, an algorithmic simulation model might more realistically portray the features of Egypt's housing market.

Reinforcing this methodological approach is the fact that a usable time series on housing production, consumption, price and so forth simply does not exist. Scattered pieces of information are available for selected years and there is a wealth of small-sample or impressionistic information, but these are clearly inadequate for econometric work. An algorithmic simulation with "guestimated" parameters appears to be about the best that could be expected.

III. The model will begin by taking the current period distribution of people into houses (N_{ij}), the previous period's set of factor prices and rents (P_ℓ, R_i, $\bar{R}_i$) and the growth in urban families (ΔH_j). Based on previous prices some households do decide to improve their housing and others are forced to vacate for random reasons. The closer average rents are to marginal ones, the more this occurs (III. A., B., C.). This group, plus new families and those in group quarters, constitutes each period's demand. The supply of units for occupancy in each period is composed of those units vacated plus new construction (CI_i^T). New construction depends on profits which in turn are estimated by the previous period's price of housing and the current prices of materials. It is assumed that suppliers pay black market prices for factors, either directly or implicitly with waiting costs (in the case of queues). Official government prices for materials set a floor, but not a ceiling on factor costs. Given construction intentions, factor demands are developed (II. A., B.).

Factor supplies are fixed in the short run since they are determined by previous prices (if the factor is private) or by government action (if public) (II., C.). The allocation of factors to contractors is determined by a short-run market equilibrium in which prices adjust to distribute to those contractors willing to pay the most (based on expected profits) (II., D.). Construction proceeds (II., E.) and the new units are added to vacated ones for "sale" (IV., D.).

The pool of demanders is then allocated to the available stock with a logit choice model (III., D.). Since most people will seek to locate in the few public units that are available, this excess demand must be re-allocated to the private sectors (IV., A.). Short-run housing prices, in this marginal market, are then adjusted to clear the market (IV., B.). Again, excess demands are eliminated through doubling up.

The pattern of allocation that results in this marginal market is then used to update the overall configuration of families in units (IV., C.), and the housing prices that were necessary to clear the marginal market get averaged in with those of the standing, non-active stock (V., A.). Finally, of course, these marginal housing prices form the basis of consumer and developer decisions in the next period. Similarly, prices established in factor markets are used to establish the next period's factor supplies (II. A., C.; III. A., B.).

This forms the tentative structure of the model. The lag structures are certainly subject to change and numerous values of the various parameters (I. E.) will have to be estimated. Our current view is that this will be done from ad hoc data -- and then evaluating model forecasts in light of recent actual market behavior.

EGYPTIAN HOUSING MODEL OUTLINE August 1977

I. Notation

A. Subscripts

1. $i = 1,m$ categories of housing supply

(Example: $i = 1,5$, #5 is doubling up, 4 is public housing, 1-3 are various private types.)

2. $j = 1,n$ classes of families

(Example: $j = 1,3$ low, medium, high income)

3. t = time period

4. ℓ = type of factor $\ell = 1,p$

B. Prefixes

S = supply

D = demand

C = consumption (ex post)

C. Variables

ΔH = increase in number of families

M = units of factor

F = units of housing (stock)

I = units of housing investment

R = housing rents

N = number of families living in standing stock

r = rate of return on capital

P = factor prices

D. Variables with a ^ over them (e.g. $\hat{I}$) are exogeneous.

E. Behavioral Parameters

α_j = utility parameter = share of income spent on non-housing items

$\beta_{i\ell}$ = prod. coefficients

$\pi(\ )$ = profit function

$m_\ell(\ )$ = supply function for non-public factors

γ_i = short-run adjustment coefficients for rents (prices)

d_i = exogenous rate of annual unit vacancies

δ_ℓ = short-run factor price adjustment coefficients

II. New Construction

A. Desired construction of new units as a function of expected profits

$$\pi_i^T = \frac{R_i^{T-1} - \sum_\ell \beta_{i\ell} P_\ell^T}{\sum_\ell \beta_{i\ell} P_\ell^T} \qquad i = 1,3$$

$$DI_i^T = \pi(\pi_i^T) \qquad i = 1,3$$

B. Factor demand as a function of desired construction

$$DM_{i\ell}^T = DI_i^T \beta_{i\ell} \qquad \begin{array}{l} i = 1,3 \\ \ell = 1,p \end{array}$$

C. Factor supplies as a function of factor prices and government usage for public sector construction

$$SM_\ell^T = \hat{M}_\ell^T - CI_4^T \beta_{4\ell} \qquad \text{if } \ell \text{ is public factor}$$

$$SM_\ell^T = M_\ell^T(P_\ell^{T-1}) - CI_4^T \beta_{4\ell} \qquad \text{if } \ell \text{ is private factor}$$

D. Determine current period market factor prices to equilibriate demand with fixed factor supply (based on previous period prices).

$$\Delta P_\ell^T = P_\ell^T \delta_\ell \left[\sum_{i=1,3} DM_{i\ell}^T - SM_\ell^T \right] \qquad \ell = 1,p$$

E. Final factor consumption and unit construction

$$CM_{i\ell}^T = DM_{i\ell}^T \qquad \begin{array}{l} i = 1,3 \\ \ell = 1,p \end{array}$$

$$CM_{4\ell}^T = CI_4^T \beta_{4\ell}$$

$$CI_i^T = \min_\ell [\beta_{i\ell} CM_{i\ell}^T] \qquad i = 1,3$$

$$CI_4^T = \hat{CI}_4^T$$

VII. Final Housing Demand

A. Utility to families of renting new units at competitive private "rents R_i^{T-1}:

$$U_{ij}^T = U_j(y_j - R_i^{T-1}, Q_i) \qquad i = 1,3 \quad j = 1,3$$

$$UMAX_j^T = \max_{i=1,3} [U_{ij}^T]$$

B. Utility to families of continuing to live in units at controlled rents $\bar{R}_i^T$:

$$\bar{U}_{ij}^T = U_j(y_j - \bar{R}_i^{T-1}, Q_i) \qquad i = 1,5 \quad j = 1,3$$

C. Determine what proportion of families living in the standing stock will seek relocation in any period:

$$H_{ij}^T = d_j N_{ij}^T \qquad \text{if } \bar{U}_{ij}^T > UMAX_j^T \qquad i = 1,4 \quad j = 1,3$$

$$= N_{ij}^T \qquad \text{if } \bar{U}_{ij}^T < UMAX_j^T$$

$$H_{5j}^T = N_{4j}^T$$

$$H_j^T = \sum_{i=1,5} H_{ij}^T + \Delta\hat{H}_j^T$$

D. Determine the pattern of housing demand from this "pool" of families

$$DF_{ij}^T = \frac{e^{U_{ij}}}{\sum_i e^{U_{ij}}} H_j^T \qquad j = 1,3 \quad i = 1,5$$

where $U_{ij} = U_{ij}^T \qquad j = 1,3 \quad i = 1,3$

$U_{ij} = \bar{U}_{ij}^T \qquad j = 1,3 \quad i = 4,5$

IV. Short-Run Equilibrium

A. Distribute excess demand from public sector to private sectors

$$\text{If} \quad \sum_j DF_{4j}^T > SF_4^T \qquad j = 1,3 \quad i = 1,3,5$$

$$\text{recompute} \quad DF_{ij}^T = \frac{e^{U_{ij}}}{\sum_{i=1,3,5} e^{U_{ij}}} (H_j^T - SF_4^T)$$

B. Adjust private prices so that excess demands are zero

$$\Delta P_i^T = \gamma_i [\sum_j DF_{ij}^T - SF_i^T] P_i^T \qquad i = 1,3$$

C. Final consumption of new and vacant houses in period T is added to those remaining in standing stock

$$N_{ij}^{T+1} = N_{ij}^T - H_{ij}^T + DF_{ij}^T \qquad i = 1,5 \quad j = 1,3$$

D. Available housing supply in each period equals vacated units plus new construction

$$SF_i^T = \sum_j H_{ij}^T + CI_i^T \qquad i = 1,4 \quad j = 1,3$$

V. Long-Run Equilibrium

A. Price of new and turnover units gets averaged into current stock

$$\bar{R}_i^T = \bar{R}_i^{T-1} \frac{[\sum_j (N_{ij}^T - H_{ij}^T)] + P_i^T (\sum_j DF_{ij}^T)}{\sum_j (N_{ij}^T - H_{ij}^T + DF_{ij}^T)} \qquad i = 1,3$$

Subproject:

HOUSING CONSTRUCTION INDUSTRY AND MATERIALS SUPPLY

I. SYNOPSIS OF PROJECT (see the initial project proposal for a detailed description): The focus of the study is materials as an input to construction and the technology and economics of their production, distribution, and use. Products after the first year are to be in three areas: (1) a survey of the availability and utilization of major construction materials in Egypt; (2) tentative recommendations pertaining to the alleviation of the constraints imposed on housing production by particular materials; and (3) suggestions as to directions for future investigations. Concentration is to be on conventional as well as non-conventional materials, assessed as to their future potential in Egypt.

Research activities for the first year have been divided into three general phases. The initial phase consists of overall structuring of the research, identification of the materials traditionally used in housing construction in Egypt and those which might be used, and data identification. The second phase is detailed data collection and compilation. These phases are anticipated to extend through September or longer if necessary. The third and final phase, identification of apparent materials shortages and inefficiencies in their use in housing construction and the underlying causes and formulation of recommendations to alleviate these difficulties, is to proceed through November, with some preliminary findings and tentative conclusions by September. December is reserved for the preparation of the first year report.

II. STATUS OF PROJECT: At this point, Phase 1 activities have been completed, Phase 2 is well underway particularly in the traditional materials area, and Phase 3 is just beginning. All activities are expected to be completed, as scheduled, during the coming period. Three trips to Cairo have been made to date, with at least one trip to MIT scheduled for the remaining quarter as well as perhaps another trip to Cairo.

A. Activities Completed: Phase 1 activities were finalized in July when the Egyptian and MIT teams met in Cairo. The type of data to be collected for the traditional materials is basically in line with that in the initial data list presented in the June progress report, with a few modifications, particularly in the consumption area, as indicated below. It was agreed that data collection efforts would continue to be focused on cement (used in concrete work, mortars, and plastering), steel (reinforcing bars), and bricks (red, sand-lime, cellular concrete, and new clay bricks), proceeding to glass, lumber (used in both the final structure and in its construction), sanitary fixtures, and floor tiles (primarily cement tiles) as time permits. As for the non-conventional materials, some preliminary work had been done on plastics, gypsum, and other materials, and it was agreed to focus future activities on stabilized earth, gypsum, and lightweight concrete, among others.

The status, present and future, of Phase 2 activities, data collection and compilation, is summarized below with respect to, first, traditional materials and, then, non-conventional materials. A list of the tables and figures summarizing much of the data gathered to date on (1) general information, (2) cement, (3) steel, (4) bricks, (5) glass, and (6) gypsum is included as Attachment A. The sources of information were recorded for each type of data for reference purposes and are noted below in the discussion of the data collected and that remaining to be collected on the various materials. Lumber, sanitary fixtures, and floor tiles remain to be surveyed as time permits. In gathering the necessary information, certain guidelines were set forth, including: (1) recording, whenever available, the same type of data from more than one source, leaving the judgment of reliability to the data analysis stage; (2) avoiding, as much as possible, the duplication of any data that was included in the on-going Ministry of Industry studies of the building materials sector (referred to as the Booz, Allen, Hamilton study) and of the metallic products sector (referred to as the Atkins Planning Study), unless there was a necessity for comparison; and (3) concentrating, whenever possible, on the consumption and trade data compared with local production and on production cost against official and current sales prices with time. Activities in gathering data have also included monitoring and translating articles from local newspapers, dealing with the housing

problem and with suggestions by authorities for its solution, which are of help not only to the materials group, but to the entire housing project.

Much of the basic production, trade, and planned investment information per the data list in the June progress report has been gathered for cement, steel, bricks, and glass. The major sources have been visits to the four cement plants as well as other materials plants, a Ministry of Planning report on steel, and updating of the Building Research Institute's study of bricks, as well as a few other sources like the Central Agency for Public Mobilization and Statistics' Statistical Yearbook, Federation of Egyptian Industries' Yearbook, Ministry of Housing and Reconstruction's Programme of Reconstruction and Development, Joint Housing Team's (MOHR, MOP, A.R.E. and Office of Housing, US AID) Immediate Action Proposals for Housing in Egypt and Housing and Community Upgrading for Low Income Egyptians, and various tables and figures collected from the Ministries of Housing and Reconstruction (MOHR), Industry (MOI), and Planning (MOP). The Booz, Allen, Hamilton and Atkins Planning reports have been particularly useful sources. In the case of the red bricks produced mainly by private sector factories, a special approach was adopted for collecting data on production, whereby data was based both on official records for brick factories (from General Organization for Industrialization) and on selective field surveys of the factories themselves. In some cases, the full time series remains to be completed; for example, volume of production and imports/exports of materials in quantity terms will, if possible, cover the years 1960, 1966, and 1970-1976. Furthermore, planned expansion of production capacity up to 1985, with an indication of the status of the project (e.g., under construction, financed, or planning stage), is still missing in some cases. These particular items are needed for the housing economy model subproject as well as for our own work. Various other items of information, such as an indication of inputs into production, have been collected for some materials and are of primary interest to the materials project.

An item of information which we had thought was not available, but which we found at least for cement in the Booz, Allen, Hamilton report, is the sale of materials to housing as well as to other sectors. This gives us the share of production legally going to housing. With it and our estimates of housing's consumption of materials, we can get some estimate of the quantity of materials

flowing into the housing sector from other sectors via the black market. The sales distribution offices are probably the best sources for this information for the regulated materials, cement, steel, glass, and lumber; the unregulated materials are unlikely to have such central offices. The Booz, Allen, Hamilton and Atkins Planning reports are also possibilities. If these fail, it should be possible to estimate sales of at least structural materials on the basis of cement sales to housing. These data will be obtained for 1960, 1966, and 1970-1976 where possible.

The collection of consumption information is more difficult but very important, as this sets our study apart from the other on-going materials studies. That is, we agreed we should focus on materials usage in housing, and how it might be made more efficient by, for example, using traditional or alternative materials in new ways. The list of data pertaining to consumption in the data list in the June progress report needs some revision in light of our findings. As for consumption of materials on an aggregate basis, some information has been collected for cement, steel, bricks, and glass, and more is available in a report, entitled Consumption Estimates of Some Building Materials in A.R.E. up to the Year 1982, prepared by Dr. Yousri Khedr Ismail of the Faculty of Commerce at Cairo University, for the General Egyptian Organization for Building Materials and Ceramics. The Booz, Allen, Hamilton and Atkins Planning reports also have some such figures. The difficulty with this type of data is that the basis for such figures is generally not made clear in the published source.

For aggregate consumption of the seven materials for 1960, 1966, and 1970-1976, it is probably best just to use production plus imports minus exports plus any change in inventories as an estimate (local sales might alternatively be used). Projections to 1985 can be done on an investment basis using the MOHR's and MOP's figures on materials use per LE of investment and planned investment in various industry categories; the Booz, Allen, Hamilton report used this as one approach for estimating future cement consumption, but then estimated other materials on the basis of their cement figures. We have some data on this from MOHR and MOP, but they are inconsistent with each other and incomplete; we are presently trying to clear up these questions and get further information.

Most important is consumption of materials by housing. This is best estimated on a disaggregate basis using technical coefficients (i.e., volume of materials per square meter of housing) and volume of housing production. This should be done for a couple different types of housing, such as 3 or so kinds of formal housing (i.e., public/private, low/medium/high income level, load-bearing/skeleton-frame construction), 1 or 2 kinds of informal housing, and 1 prefabricated model. The housing economy model subproject is trying to obtain estimates of housing production on this disaggregate basis for 1960, 1966, and 1970-1976 through the MOHR, and their model will project housing demand to 1985.

As for the technical coefficients, several possible sources exist. For formal housing, these include: (1) the Joint Housing Team's Immediate Action Proposals for Housing in Egypt; (2) an estimating book, prepared by the General Organization of Building Contractors, available in the library of the Building Research Institute; (3) the work which Mr. Ahmed Gharib's group at the MOHR is doing; and (4) data used at the governorate level for their allocation of materials (obtainable by visiting one or two governorates). The 1962 and 1977 (not yet passed) building code and specifications law and 1969 modification of the law might also be helpful. The suggestion was also made by the Egyptian team that we develop our own technical estimates based on typical plans which can be obtained from the MOHR; this has been done for brick usage in low-cost housing, and could be expanded to include various types of housing and various materials. As for informal housing, the Joint Housing Team's Housing and Community Upgrading for Low Income Egyptians has some information. Secondly, the informal sector survey of the housing project is to produce the raw data on materials usage (e.g., structural type, internal and external wall thicknesses, wall height, and dimensions of rooms for units surveyed -- from this brick usage can be estimated) and to develop typical housing types with materials usage indicated; some of these figures have already been developed. Finally, we also had an interview with a small contractor who detailed, in price and quantity terms, the materials used in very low-cost (though not specifically informal) housing. One thing which needs further investigation still is what percent of these materials in the informal sector are recycled. As for prefabricated housing, we have some figures on cement and steel use in the shell from Dr. Adel Fareed of Prefabricated Houses

Company and a table from the MOHR giving cement requirements for production and erection of the units by various plants. This should be sufficient for getting at least a rough estimate of the technical coefficients for such housing; the architectural component of the housing team may be able to give us some further information as their project progresses.

One last item falling under the consumption category in our initial data list is official and black market prices of the seven materials for 1960, 1966, and 1970-1976. Some information has been collected on this. Sources we have include the Joint Housing Team's Immediate Action Proposals for Housing in Egypt and Housing and Community Upgrading for Low Income Egyptians and Battelle's Egypte Resume and Egypte: Statistiques de la Construction. Additional sources pursued or being pursued in Egypt include the sales distribution offices, the ministries, the Central Organization for Prices in Nasr City, and talking to some contractors who purchase materials regularly.

In summary, these various data will give us an indication of housing's share in production and consumption of major building materials, as well as a clear picture of alternative scenarios of materials usage in housing. Based on this and our knowledge of materials availability in Egypt, we can begin to develop recommendations for maximizing the efficiency of use of both traditional and alternative materials in housing.

Phase 2 activities of data collection and compilation in the area of non-conventional materials have also been progressing. In order to start discussions respecting possible non- or under-utilized materials for housing, preliminary exploratory reports were prepared, respecting: (1) plastics, (2) gypsum, and (3) other materials. The rationale behind the plastics and composites report was that, with the growing petrochemicals industry in the Middle East, polymeric materials and the composite materials employing them are at le[illegible] of potential interest in housing. They have exhibited rapid growth in the United States, Europe, and Japan, particularly in the form of composites. Whether or not this is a potential source for the future depends upon the growth of the industry, particularly in Egypt. Prospects look somewhat promising though in that it has been learned that plastics are to be locally produced by a joint venture company for the petrochemicals industry, providing Egypt with nearly 300,000 tons yearly of plastics such as PVC, polyethylene, polystyrene, and polypropylene, and that a limited amount of

melamine resin is already being produced by a public sector company at Mansoura City.

With respect to gypsum, Egypt has large deposits and a long history of use, but its potential appears not to be attained. This is particularly true of some of the newer developments in gypsum such as fiber reinforcement, which greatly increases its strength and resistance to impact. Others are newer plasters and hard cements derived from gypsum. As indicated by the list of tables and figures in Attachment A, much data has already been gathered regarding the availability and use of gypsum in Egypt.

Among the materials briefly noted in the third paper are: stabilized earth, surface-bonded block, sulfur, high-strength mortars, bamboo, high-speed paint spraying, and lightweight wall and partition construction. Stabilized earth is of great interest as a low-cost, widely-available material, particularly for single-storey or low-rise housing in towns, villages, and rural areas. A great deal has been done in other parts of the world that should be examined preparatory to possible development in Egypt. In surface-bonded block, masonry units such as concrete block and brick are laid up rapidly without mortar, and fiber-reinforced mortar is then plastered to the surface, bonding the wall and providing a weather and wear-resistant surface. Although glass fiber has been used most, natural fibers available in Egypt may perform satisfactorily. Sulfur is becoming available in many parts of the world as a by-product of oil extraction. It has been shown that building blocks and mass concrete bonded with sulfur rather than portland cement can be achieved at low cost. If sulfur is available in Egypt at low cost, as it appears it might be, it may help to ease the cement problem for concrete and concrete block. The promising work at the Building Research Institute respecting the new and improved clay bricks brings up the question of improved mortars. The incorporation of polymeric materials can greatly increase the tensile and shear strengths of mortars, as well as their adhesion to brick and block. Other additives and replacements for cement and lime may also result in improvements, leading to improved quality and more efficient methods of construction with masonry. Bamboo has already been well-studied in Egypt as well as elsewhere; its potential and problems are well known. Methods of painting entire rooms by power spraying have been developed which greatly reduce the time and materials involved in finishing buildings. This might be

particularly appropriate for the new prefabricated housing soon to be erected in Egypt. Wall and partition construction, involving light metal framing and a variety of wallboards, including gypsum, and making provision for utilities such as electrical lines, greatly reduce the weight of buildings and accelerate the construction process.

As a consequence of these three preliminary reports and the joint meetings in Cairo in July, it was decided that stabilized earth, gypsum, and lightweight concrete would receive special emphasis in the immediate future. In addition, consideration is also to be given to sulfur, high-speed spray painting, surface-bonded block, improved bonding of masonry, plastics as adjuncts to other materials, and sandwich construction. In search of further information in these areas, letters have been written to various agencies, such as the East-West Center in Hawaii, United Nations, Bandung Institute of Technology in Indonesia, and CENAC at Ciudad Universitaria in Colombia, and some replies received, as well as a review of the available literature begun. Investigation of the availability of the requisite materials, in both raw and manufactured forms (e.g., gypsum, materials for lightweight aggregate, sulfur, water glass, and flue ash) is underway in Cairo, with much data already collected on gypsum as indicated in Attachment A.

Phase 3 activities are just beginning. Tentative conclusions and recommendations concerning each building material studied, leading to a developed technical and economic basis for a national housing policy, will be included in the final report ending the initial year's work. According to the preliminary analysis of the data gathered to date, however, two very general observations can be made: (1) the demand for building materials in many cases is already exceeding present actual production; moreover, the rate of increase in the demands in coming years is expected to widen the gap between production and consumption, unless serious and active solutions are taken for alleviating building materials shortages and/or inefficiencies; and (2) the need is essential, therefore, for the improvement of the efficiency of locally produced building materials as well as for the introduction of new concepts for the utilization of locally available raw materials. The following sorts of issues will be taken into consideration in developing our final recommendations: (1) defining any shortage or inefficiency in use of raw materials needed for building materials processing, and the amount of their reserves on short and

long-term bases; (2) identifying, if possible, any obstacles hindering building materials production to establish means for their alleviation; (3) determining local production through time and planned investments, and comparing these with actual consumption to determine needed expansions or new projects; (4) establishing production costs against sale prices through time to detect any exaggerated profits; (5) studying the flow of materials distribution from producing plants to the consumer to locate transportation problems/distribution gaps; (6) determining materials allocation to the housing sector compared with actual materials consumption by that sector to locate any attraction to or from competing sectors; and (7) estimating the technical coefficients upon which the allocation of building materials to housing is based and the actual coefficients for formal and informal housing to locate any waste or shortage in materials usage or distribution.

As for travel in this quarter, in late June/early July, Professor Dietz and Dr. Rossow, along with several other members of the housing team from MIT, went to Cairo for the purpose of conferring and planning with their counterparts. In the course of his week-long visit, aside from meetings at the university, Professor Dietz met with Dr. Moustafa El Hifnawi, Chairman, and others at the Building Research Institute and toured the facility; visited a traditional brickyard and a modern asbestos-cement plant; met with Mr. Ahmed S. Mourad, President, and Dr. Adel Fareed, Project Manager, of Prefabricated Houses Company and with them visited their new plant, one of eleven such plants being erected in Egypt, and a housing site where domed and vaulted roof units on concrete molds were being precast; and, on the last day, went to Suez with several other members of the housing group to see the King Faisal housing development and general reconstruction efforts in Suez, as well as the new vehicular tunnel under the Canal. A major portion of Professor Dietz's time in Cairo was spent in discussions with Dr. Mahmoud Reda, Professor Hassan Fahmid Imam, Dr. Mohamed Ramez, and Professor Ahmed El Erian regarding the three preliminary reports he had prepared and the direction of activities and division of responsibilities for the remainder of the year in the area of non-conventional materials. On his return to Boston, Professor Dietz stopped in London to visit the Building Research Establishment Laboratories at Watford; there, he discussed their work in fiber-reinforced gypsum and its possible application in Egypt and the subject of stabilized earth, as well as obtaining pertinent literature.

Dr. Rossow's two-week visit overlapped with the last couple of days of that of Professor Dietz, during which time meetings with their counterparts and the trip to Suez were the major activities. Most of the rest of Dr. Rossow's first week was also spent at the university. In the course of our various meetings, the materials group reviewed the data on traditional materials that had been gathered, identified the gaps remaining and potential means of filling them, and discussed some preliminary findings and conclusions, as well as confirming our work schedule for the rest of the year. A couple of meetings with the housing group as a whole were also held during the first week in order to bring everyone up to date on the status of the various subprojects. Collaboration among the subprojects is particularly important with regard to the survey of the informal sector. In the course of our general meetings, the details of the survey were discussed and changes incorporated as necessary; meetings with the students actually doing the survey were also held, and trips were made by the MIT team to two formal and two informal areas to be surveyed.

During the second week more of Dr. Rossow's time was spent in the ministries and in meeting with a couple of industry people, although a final wrap-up meeting was held on the last day at the university with the materials group. It was during this week that she had a chance to review the Booz, Allen, Hamilton and Atkins Planning Phase 1 reports (market studies basically). The general feeling was that they have good data on the production side, but focus less on the consumption side. Moreover, they are aimed at total consumption, and are not so concerned with housing's share and how materials are used in housing, whether or not their use is efficient, etc. In the Booz, Allen, Hamilton report, for example, consumption of all materials appears to be based on cement consumption, which might be reasonable if one is considering a particular type or mix of construction and structural materials, but seems less reasonable if one is looking at aggregate consumption with a potentially changing product mix and all materials including finish items. Also, consideration of the informal sector in housing construction appears to be rather vague; in the case of the Booz, Allen, Hamilton report, for example, a figure of 12 percent is added to the official consumption figures to cover repairs, minor works, and other. It was at this point, then, that we decided our efforts should be focused more on the usage side, both in formal and informal housing.

B. Activities Planned: Activities required to complete this first year's effort fall into three categories: Phase 2, Phase 3, and final report writing activities. As indicated in Section II.A, certain data, particularly that pertaining to consumption, remain to be collected on cement, steel, bricks, and glass, while the full set of data is yet to be gathered for lumber, sanitary fixtures, and floor tiles. To the extent possible in this first year, these Phase 2 activities will be completed by the end of September, before the visit of Egyptian team members to MIT. Phase 2 activities pertaining to non-conventional materials will continue through the end of October. Activities at MIT will focus on the collection and review of available literature and other sources of information on the technical and economic aspects of developing/adapting for use and actually using stabilized earth, gypsum, and lightweight concrete, among other less conventional materials, in housing construction; activities in Cairo will be more concerned with investigation of the availability of the requisite raw materials and suitability of such materials for use in Egypt. Phase 3 activities, formulation of our tentative conclusions and recommendations regarding building materials and their use in housing construction in Egypt, on the basis of our first year's findings, will continue through mid-November. The joint meetings to be held at MIT in late September/early October will be an especially important time for development and discussion of these ideas. It is at this time also that the final report will be outlined and responsibility for its writing allocated among the team members, such that it can be completed by mid-December.

As for planning next year's work, a proposal concerning our research activities for next year and beyond will be prepared by mid-October. Possible directions and topics for this research are noted below in Section IV. This will be another major activity to be undertaken in our joint meeting in the early fall.

The last item is travel planned for the remainder of this first year. In late September/early October, Dr. Reda, along with several other members of the housing team from Cairo, is to visit MIT for nearly two weeks. Aside from making it possible for the materials and housing groups as a whole to meet in numerous working sessions, this also gives the Egyptian team members an opportunity to observe and utilize the facilities and resources available in

the vicinity of MIT. In the course of the above discussions, several activities have been noted which are expected to be accomplished at this time, including: final gathering of Phase 2 inputs on conventional materials, discussion of Phase 2 findings to generate Phase 3 outputs, discussion and writing of the proposal for next year and beyond, and finally, outlining and allocating responsibility for the writing of the final report for this initial year. A visit to Cairo by Dr. Rossow in late November has tentatively been scheduled to wrap up Phase 3 activities and the final report.

III. APPLICABILITY OF WORK TO MINISTRIES: Concern over building materials availability and utilization is spread among three ministries, the MOHR, MOI, and MOP, whose activities often seem to overlap and sometimes even conflict. The MOHR, for example, regulates the supply of cement, mainly, it appears, through the Egyptian Cement Office. Through Mr. Mesalamy's office (Under Secretary of Supply and Procurement), the MOHR appears to be involved in trade in all controlled materials, combining planned investment in various sectors with their respective technical coefficients to arrive at materials needed which, when compared with materials locally produced, yields trade figures. Allocation of controlled materials to local governorates for housing construction also seems to be handled through Mr. Mesalamy's office; at the governorate level, then, materials permits are issued for particular types of housing and materials quantities. The MOI regulates the supply of other controlled materials, including steel, lumber, and glass, also, it appears, through distribution offices. Licenses for materials production are issued through the General Organization for Industrialization (GOFI) within the MOI at the time a firm commences operation. The MOP plans investment in various sectors; based on this, then, and their respective technical coefficients, it estimates materials needs much as the MOHR does, except that the two sets of numbers appear to conflict. The MOP also appears to plan investment in expansion of materials production, although it is not clear whether the MOP or the MOI/MOHR initiates this.

Several studies involving building materials to varying degrees, aside from ours, are going on in conjunction with these three ministries. Joint MOHR-AID teams are investigating various housing issues: (1) first, in a rather general context in their initial report, Immediate Action Proposals

for Housing in Egypt, where some issues pertaining to materials in housing are raised and some statistics given; and (2) second, in the more specific contexts of their three more recent reports, one each on finance, urban land use, and low-cost housing, where only the latter gets into the subject of building materials, identifying their use in informal housing to some extent and updating some of the statistics presented in the first report. A study just beginning, under the direction of Mr. Gharib in the MOHR, is the development of new technical coefficients for materials use in different types of housing construction; as this is directly relevant to our work, we are presently trying to contact Mr. Gharib. The GOFI, within the MOI, under the financing of the IBRD, is carrying out six sector studies with in-house people as well as Egyptian and foreign consultants. Two have been repeatedly mentioned as being of particular interest to our project: (1) building materials sector study (excludes lumber and metal products) using Booz, Allen, Hamilton as foreign consultants; and (2) metallic products sector study using Atkins Planning as their foreign consultants. These we have found to be largely focused on the production end, with estimates of consumption on a rather aggregate basis; we are thus relying on them for some of the more production-type data and trying to focus our efforts on identifying housing's share of production and its usage of materials and efficiency thereof. As of July, the MOP was very actively involved in developing its next five-year plan.

With this understanding of the concerns of the three ministries regarding the availability and utilization of building materials, it is clear that the findings of our study are of potential importance and interest to each of them in their future planning activities. They need to know, for example, whether apparent shortages in the supply of particular materials reflect true shortages (i.e., supply is less than demand perhaps because of certain long-term problems, like insufficient capacity, or more short-term ones, like pricing or unusual sector demands)or whether they actually reflect problems in materials distribution or utilization, among other conditions. On the basis of our findings, then, we can begin to recommend actions whereby government and industry might begin to alleviate some of the constraints imposed on housing production by construction materials; these might include, for example, expansion of production of particular materials, development/adaptation of

new materials, setting/lifting of price controls, and adjusting the utilization of particular materials. We further believe that the current project can play a positive role by assisting the ministries in the development of improved data compilation and usage techniques.

Our interactions with all three ministries to date have been reasonably extensive in an effort: (1) to gain understanding of and insight into how the housing and building materials sectors operate and interact, and what problems they face; and (2) to collect data, as the ministries are the source of much accumulated information. A list of some of our ministry contacts to date, as well as an indication of the nature of the exchange, is given in Attachment B. It might also be noted that Mr. Tarek Selim of the Minister's Technical Office in the MOHR will be coming to MIT this fall to participate in the Center for Advanced Engineering Studies program for a year or so, perhaps ultimately entering a graduate degree program in engineering at MIT. As for the future, we need to make our ministry contacts more solid -- to more firmly enlist the support of under secretaries in the MOHR, MOI, and MOP, with the result that personnel under them begin working more directly with us, as has been more the case in the other ministry-related studies noted above. We need to strengthen our three-way team of MIT-Cairo University-Ministry participants. This is of critical importance if we are to continue to gain the active support and endorsement of the ministries and potential implementation of recommendations we might make, because this is the only way we, and they, can continue to be assured that our activities are relevant to and in the interests of the ministries.

IV. FUTURE DIRECTIONS/TOPICS: Potential directions for work beyond this first year lie in three areas, two involving further research in the building materials field and one involving research into the other resources constraining housing construction. The first topic entails expansion of our work done this year in the area of conventional and non-conventional materials along somewhat more technical lines. Some specific items to be researched might include: improvement of the quality of certain traditional building materials through the utilization of plastics, resins, sulfur, water glass, and fiberglass; stabilization of earth; studying the various aspects of utilizing gypsum in the building industry; production of lightweight aggregates from clayey

deposits and their utilization in the building industry; and determination of optimum use of available limestone deposits in building materials production (e.g., in lime production, as an aggregate for concrete, and as regularly shaped bricks). This program of research would be directed toward studying and utilizing locally available raw materials in the building industry in Egypt, materials which are already largely known and applied elsewhere, although they might be relatively new or untried in Egypt. Research activities thus fall into three basic areas: (1) information search on the particular materials (e.g., their use in other countries, resource availability in Egypt, and so forth); (2) development, as necessary, to adapt the materials to Egyptian conditions; and (3) most importantly, application of the materials in actual production and construction. Dr. Adel Fareed, of Prefabricated Houses Company, might be particularly helpful in such efforts, as he is interested in testing new materials and techniques, such as high-speed paint spraying, alternatives to cement floor tiles, and lightweight aggregates, in conjunction with prefabrication.

Further research into the productivity of building materials production and utilization is a second area of potential interest for work beyond this first year. The productivity and efficiency of particular materials as they are now used in Egypt and how this might be improved warrant further investigation. Moreover, the utilization of labor, capital (equipment), and other materials in the production and installation of these materials is also of concern. Given the greater availability of time and better knowledge of the data base, existing and potential, some of the more sophisticated analytic tools, such as production functions and input-output analysis, may be appropriate for investigation of these issues in the future years of our project.

A third direction for research for next year and beyond is to extend the study to include the remaining resources affecting housing production, so as to complete our picture of resource availability and utilization in housing and construction in Egypt. Probably the next most important resource to study is manpower in the form of skilled and unskilled labor, contractors, and professionals; skilled labor for housing construction appears to be in particular short supply, due to its high rate of temporary migration to other Arab countries where wages are much higher. Construction equipment and capital as needed by contractors for equipment purchase and working capital might also be considered. Land and capital for financing represent still two

more resources impacting housing, resources which the MOHR-AID studies have recently been investigating. In any case, it seems clear that more in-depth analysis of these resource problems constraining housing production in Egypt is needed in the near future.

Attachment A:
List of Tables and Figures Summarizing Data Gathered to Date

1. General Information

Number of buildings and housing units in Egypt (May 1966 census)
Units built for urban and rural housing (1969-74)
Quarry production of building materials (1952, 1969-74)
Local production of building materials (1952, 1968-74)
Private sector production of building materials during the years 1975 and 1976
Values of building material industries output (1952, 1969-74)
Development of production in construction and housing sectors at current prices (1969-73)
Development of labor in construction and housing sectors (1969-73)
Development of wages in construction and housing sectors at current prices
Development of income in construction and housing sectors at current prices (1969-73)
Annual increase in prices of building materials (1961-74)
Proportionate cost of materials per 100 £E of residential construction (March 1974)
Technical parameters and coefficients of informal sectors (1977)
Annual increase in construction costs (1961-74)
Cost changes of items encountered in housing jobs during years 1962 to 1965
Official and unofficial market prices of building materials in 1976
Public expenditure by housing and utilities sector as related to total expenditure by all sectors (1969-74)
Investments in construction and housing sectors at current prices (1969-73)
Building materials demands for 1977 based on an investment plan of 1300 million £E of which 715 million £E specified for building and construction sector
Imports demand estimate for building materials in 1977 based on a 715 million £E investment plan
Building materials demands for 1977 by private and public sectors based on an alternative investment plan 600 million £E for building and construction sector
Five-year plan of investment in building materials for years 1976 to 1980
Exports and imports of stone, plaster, cement, asbestos and glass (1969-74)
Building materials imports (1975 and 1976)
Imported building materials during the years 1975-77

2. Cement

Cement producing companies and their production capacities
Raw materials quantities and chemical composition utilized in cement producing companies during 1976
Development of total local cement production from 1961 to 1976
Cement production during years of 1970 to 1976 distributed among producing companies
Production of clinker and different types of cement by different companies in 1976
Additional and total production capacities expected from 1975 to 1984
Projects for cement production under execution
Predicted total production capacities of cement up to year 1982
Means of transportation of cement within the period of 1970 to 1973
Sales and production costs of locally produced types of cements in 1973 and 1974
Price changes of locally produced types of cement (1973-77)
Production versus consumption of cement from 1970 to 1974
Cement consumption of various sectors during years of 1970 to 1974
Quantities of cement allocated to various sectors from 1960 to 1976
Estimated demands for cement from 1974 to 1984
Exports, quantity and value, within the period 1964 through 1974
Exports and imports of cement compared with local production during 1971 to 1976

3. Steel

Reserves of Egyptian iron ore
Iron ore production (1952, 1969-74)
Comparison of working efficiencies of steel producing companies
Weight percentages of basic materials needed for producing a ton of steel
Reinforcing steel production (1952, 1969-74)
Production of steel rebars 37 and 52 by public sector companies (1968-73)
Production capacities and actual production of steel rebars by existing companies in 1973
Expected steel production from expansion projects 1976-1985
New production capacities according to planned expansion projects
Total planned production capacities until year 1984
Steel rebars production and production costs through years 1973, 1974, and 1975 by public sector companies
Price changes of steel rebars during the period of 1963 through September 19, 1973
Steel prices to consumer for the steel 37 and 52 during the period from September 20, 1973 to May 24, 1977
Steel prices to consumer for steel 37 and 52 starting May 24, 1977
Means of transportation of steel during 1973
Diagram of the distribution process of steel reinforcement

Allocation of locally produced and imported steel rebars to various sectors in 1973
Steel actual consumption and demands estimate until year 1984
Actual and minimum demands for steel 37 and 52 through 1974-84
Variation in factors influencing steel demands with time
Quantity and value of imported steel during 1960-73
Quantity and value of exported steel during 1960-72
Total production and imports of steel compared with distributed quantities to give inventories (1967-77)
Prediction of surplus production for export (based on steel 37)

4. Bricks

Development of brick production from 1963 to 1980
Red brick production (1963-75)
Sand-lime brick production (1965-78)
Estimation of rate of brick consumption per ton of cement (1970-80)
Development of red brick prices from 1970 to 1977
Total number of bricks used for housing construction within period 1970-75 and estimated demands within period 1976-80
Average number of housing units constructed within period 1970-75 and estimated demands to be constructed within period 1976-80
Total shortage in housing units estimated at three different years
Average number of housing units constructed within three time periods
Distribution of housing units constructed between public and private sectors within three time periods

5. Glass

Demand of glass sand up to 1982 for El Nasr Company for glass and mirrors
Glass and founderies sand total demand (1975-82)
Relative weights of production of different thicknesses of glass sheets (1970-74, 75, 76)
Production of transparent flat glass sheets within the years of 1971 to 1976, estimated by area and value
Production of transparent glass sheets, estimated by weight (1971-76)
Development of production cost of transparent flat glass within the period form 1971 to 1976
Factory and consumer prices of different types of glass
Development of the consumption of glass utilized for building purposes in Egypt during the period from 1966 to 1972
Development of consumption of transparent glass sheets given by local sales and imports (1971-76)
Estimates of glass consumption by using the rate consumed per one thousand tons of cement
Demands estimate for glass consumption (1973-82)

6. Gypsum

Resources data
Chemical analysis of different types of gypsum
Location of gypsum quarries and factories in Egypt
Processing data
Production data
Development of consumption in Egypt during the period from 1966 to 1977
Development of gypsum production for 1969/70 up to 1974
Gypsum consumption related to cement consumption
Present market of gypsum products
Expected total demand of gypsum in 1982
Activity chart of the Egyptian Gypsum, Marble and Quarries Company (GYMCO)
Company's activities development from 1969/70 up to 1974
Company percentages production in tons for the various activities during 1974
Company percentages sales in pounds for various activities during 1974
Development of company production and sales from 1966/67 up to 1974
Development of expected production of the company during 1974-1982
Development of labor and wages from 1966/67 up to 1974
Production capacity of projects
Geographic location of expected production
Geographic location of required investments 1976/80
Market needs for gypsum products
Development of expected production of gypsum up to 1982

Adel El Zorghby, Samir Naggar	Trying to collect data on and explanation of materials requirements of various sectors for various years and projected materials needed to 1985
Michel Rafael, Ramzy Shenouda Morcos	Discussion of materials for housing and explanation/expansion of table of technical coefficients in MOHR-AID's Immediate Action Proposals...Egypt

2. Ministry of Industry

Kamel Maksoud	Undersecretary of Supply--discussion of information available in MOI on materials for housing and introduction to Mr. Fahmy
A.M. Fahmy	GOFI liaison on building materials sector study--discussion of study and introduction to people doing study
Rob Voight, Jean-Yves Maillet, Tony Mayo, Paul Haskell	Booz, Allen, Hamilton consultants to GOFI on materials study--discussion of study and possibility of getting copy of Phase I report
Munir	GOFI--trying to get or at least see Phase I reports of Atkins Planning and Booz, Allen, Hamilton sector studies

3. Ministry of Planning

Dr. Saad Hanafi	Undersecretary--discussion of what information MOP might have that would be useful

Saleih Gobran	Trying to collect MOP's data on materials requirements of various sectors, investment in construction in these sectors, and associated materials needs to 1985 as well as planned investment in materials production to 1985

Subproject:

HOUSING CONSTRUCTION SYSTEMS AND DESIGN NORMS

I. SYNOPSIS OF PROJECT. (See initial project proposals and June 1 Progress Report for detailed description.): The overall goal is to develop guidelines/references for appropriate housing and physical planning derived from physical and socio-economic realities. There are two primary areas of concern: a) the industrialized buildings systems being developed in Egypt; and b) the planning of settlements, with focus on the provision of housing for the low income groups and larger scale land subdivision issues.

The initial phase of the project included identification of basic land/dwelling categories for evaluation of industrialized systems and determination of design criteria in the settlement studies. Initial contacts were made with appropriate ministries in order to initiate long term collaborative efforts. The data gathering phase took place during July-August, where specific information was required, and field surveys were scheduled. The final phase of the work was intended to include recommendations/conclusions which could be discussed with appropriate officials. Also, areas/issues would be identified for future detailed research.

The expected product at the end of the final phase includes the development of an evaluation system for industrialized housing in Egypt, and the analysis and redesign of a specific industrialized system in Egypt as a pilot study to serve as a model for other systems being developed. The site planning study would prepare alternative physical planning models for low income areas which are intended to be used by government agencies for future large scale housing developments. A descriptive report would also be prepared on the low income areas surveyed in detail during the summer.

II. STATUS OF PROJECT: The project is now in the final phase of analysis and evaluation of the data.

A. Activities completed: The group has concentrated on the collection of data from the ministries and continued familiarization with the housing situation through meetings with government officials, field trips to selected housing areas, and interviews with users, suppliers, and contractors. Project goals and the conceptual outline for the work was further refined. Several field trips were undertaken by the MIT members to Cairo to assist in data collection and continue joint coordination of the work. Close working contacts were initiated within the housing ministry to allow direct application/transfer of the work.

Field trips were carried out during July-August by MIT members to Cairo. The initial joint trip by the two members during the first week in July had the following goals: a) Review/collaborate with Cairo University counterparts on progress of informal sector user survey, and industrialized housing evaluation. b) Initiate/develop contacts within Ministry of Housing and Reconstruction. c) Determine specific areas of contribution of subprojects on housing to on-going work in Ministries. d) Outline specific tasks for completion of work during initial phase. e) Collect data from Ministries and continue familiarization with housing situation through meetings with government officials, field trips to selected housing areas, and interviews with users, suppliers, and contractors.

An additional field trip in August was made by one of the MIT members to Cairo to continue data collection and preparation of field survey information.

Meetings were also held in Washington with Dr. Fareed of the Prefabricated Housing Company of Cairo to further discuss the project.

Field survey: (See attached summary of areas surveyed.) Six selected low-income areas of Cairo were surveyed with the objective of providing "real" data as well as to check data gathered from other sources. It was not possible to undertake a very large or detailed survey because of time and budget restrictions. Therefore, precise statistical results were not

expected. The objective was to get indications and directions in supporting or refuting various hypotheses proposed in the subprojects.

The survey was intended to collect data for the clearly specified objectives of the subprojects, as well as to allow extraction of additional information to correlate more factors if required in the future. The survey was divided into two general parts:

1) Physical planning survey of the selected areas. The information to be collected included densities, land use, type of housing, systems of layout, etc. The information would be correlated to income categories, family size, and other social and economic factors gathered from a family questionnaire. The physical survey also provided the base from which the household samples were selected to be interviewed.

2) Questionnaire and direct observation for the households in the selected area.

The results of the questionnaire are intended to provide a reference for the following: testing of hypotheses on low income social grouping; determination of mechanisms for site development; establishment of site layout criteria, demands on public facilities, expected use of areas, etc.; determination of priorities of infrastructure by user in site development; identification of issues requiring further detailed study.

The areas selected were based on the following variables:

1) The resident's socio-economic group/housing categories (see previous working paper in June 1 Progress Report): very low unstable; low stable; low unstable; middle stable; middle unstable; high. 2) Formal or informal development. 3) Age of area: recent (last 5 years); established (5 to 20 years); old (20 to 35 years). 4) Type of housing: "Emirates" (blocks of flats); houses; buildings developed on small plots. 5) Privately or publicly developed. Some types were excluded as they fall outside the focus of the projects, for example the high income group. Other groups were excluded because they have been covered in other research: the low-stable and middle-stable residents in public housing. Faculty, students, and GOPP personnel were involved in the surveys.

A descriptive report was prepared documenting the areas studied at several levels of information: overall locality scale, block scale, typical dwelling, and typical family profile.

Refined conceptual framework for industrialized housing study. Owing to the limited time available and to constraints imposed by the complexity and scope of the subject, it was decided to develop a more focussed strategy, by retaining the initial aim of evaluating and assessing the relationship between existing prefabrication technology in Egypt and design. This can be achieved by: a) Constructing an evaluation system for all prefabrication systems in Egypt, based on a complete knowledge of their technical, economic, and design characteristics. b) Relating generic design standards, which are specific to well defined housing categories, to a "typical" prefabrication system.

The second strategy was chosen for the following reasons: 1) The methodology remains valid for all systems, thus allowing a more thorough examination of each either concurrently or in the next phase. 2) Design and performance in terms of specific income groups and site choices can be better matched to their built counterparts on a system to system basis, rather than being applied to all. 3) Elements common to all systems can be defined by comparing each singular case study of each prefabrication system matched to specific target populations and sites. Conversely, dependent as well as independent factors may be specified and/or defined for the whole industry 4) The conclusions of the study will become immediately applicable in the real world, and can be tested for validity, before jumping to unsubstantiated conclusions concerning all systems.

Thus, the current study is intended as a pilot study for application to other systems, either already existing or planned.

The study will focus on a "typical" simple large concrete panel system of the "closed" category (Helwan) in order to investigate its capability to widen the range in terms of: layout modification; element or component diversification; ability to contribute to other, more "open" systems, both in conventional construction and in prefabrication (industrialized sector); and possible diversification into other building categories (other than housing).

The decision to limit the study to the evaluation and analysis of a "prototypical" large concrete panel prefabrication system during the first year of the project is based on the following considerations:

1) The East German system (Helwan) is the first prefab factory to be put into actual operation this year or early next year, and will be the first one to produce large series. 2) The system is prototypical in all its technical and design aspects of a whole generic range of large concrete panel systems of other origin. It is essentially a "closed" system (i.e., only type-specific floor plans can be produced) and thus may create problems in terms of social and developmental upgrading in the future. 3) Recommendations for greater adaptability, flexibility, and variability in terms of a more "open" system approach can be applied to other systems later, but at the same time may be tested by using the East erman system as the first "case study".

B. Activities planned. The final phase of the first year's work focus on the preparation of tentative recommendations for the ministries. The expected product from the industrialized housing study includes two parts: a) the development of an evaluation system for prefabrication systems in Egypt; and b) analysis and redesign of a specific system in Egypt as a pilot study to serve as a model for other systems to be analyzed in the future. The site planning study will develop: 1) alternative planning models for new low income areas based on existing and newly proposed codes, existing settlement realities, and developer/financing mechanisms; and 2) documentation/analysis of the selected low income areas studied in the field surveys carried out during the summer.

Joint MIT/Cairo University Conference. A meeting is planned during September 26 - October 7, 1) to discuss the status of the research to date; 2) to outline tasks for the completion of the initial phase of the work; and 3) to prepare future proposals for a long term research program. Personnel from the Ministry have also been invited to attend. The main activities would be working sessions on various topics of concern to the group; some suggested areas are: housing problems focused on the informal sector of Egypt; physical-social-economic surveys, methods, analysis of data, problems; industrialized technology in developing areas considering cultural and economic realities.

Hamburg Conference on Construction in Developing Countries: A member of the MIT group and two members from Cairo University are planning to attend the conference sponsored by the World Association for Element Building and Prefabrication. The conference represents a unique and timely opportunity to gather up-to-date information and data in the field of housing systems, particularly in view of the fact that most of the systems planned or used in Egypt are of European origin. In addition, specific visits will be made to several of the parent companies whose factories are now being imported into Egypt.

Field trips: An additional meeting in Cairo or Boston is planned for November to discuss/coordinate final preparation of the report for the completion of the first phase.

III. APPLICABILITY OF WORK TO MINISTRIES. Direct working collaboration has been established for both the study of the industrialized building systems and the study on site planning.

Contacts with the Prefabricated Houses Company: Mr. A. S. Mourad, President, and Dr. Adel Fareed, Technical Director, have enthusiastically joined with the study on industrialized building systems. Full cooperation has been pledged as noted in "Future Directions" of the work. Weekly meetings have been held with Cairo University counterparts to discuss various technical features of the proposed systems.

Contacts with Ministry of Housing for site planning study: Direct working collaboration has been set up with the CU/MIT team working in the area of settlement patterns/standards and the General Organization for Physical Planning (GOPP). Mr. Hafez Ali, Chairman of GOPP, pledged full cooperation with our group and assigned Michael Fouad, vice-President of Research and Regional Planning, and Ramzy-Ezzat Constantin, Director of Planning, and two junior architect/planners, to work with our group. The two junior architects would serve as direct liaison

and assist us in data collection; they are assigned to work with us on a full-time basis as needed. Letters have been sent to Hafez Ali from the Cairo University executive committee reaffirming the offered collaboration. Among other tasks, the GOPP has overall responsibility to assist towns and villages in Egypt in preparing master plans, newly mandated by law, as well as having advisory powers on housing subdivision in the governorates. A strong continuing influence could be achieved with a successful initial project. Immediate interest and use of the work could be as a reference for the World Bank "site and services" projects now being developed under the responsibility of the GOPP. Further "site and services" projects are also being planned for AID funding.

The specific contribution of the subproject on settlement patterns and standards may be identified in three areas: a) redirection of the focus/emphasis of government funds/efforts from involvement/provision of individual houses to larger scale issues: land subdivision and infrastructure; b) development of land subdivision/infrastructure models as alternatives to costly and wasteful large scale planned housing developments currently favored; c) development of a methodology of survey/data techniques to provide a base for future urban planning. The study provides a complement to the other housing subprojects in that both the larger scale settlement implications as well as the individual dwelling would be represented.

IV. FUTURE DIRECTIONS/TOPICS: Several areas are being considered for future more detailed study as a possible continuation of the work.

The study on industrialized systems may readily be expanded into the following areas: 1) further detailed study of the other nine systems being imported into Egypt; 2) testing of actual redesign/modifications of the panel systems with full size prototypes. Dr. Adel Fareed of the Prefabricated Houses Company (the firm handling the East European system being developed in Helwan) expressed full cooperation and interest in terms of time, expertise, and facilities in the fabrication and testing of prototypes.

Various possibilities exist for future work on larger scale site planning issues. Several areas of collaboration are apparent from the General Organization for Physical Planning (Ministry of Housing) which could be developed into long-term projects. Three areas have been identified as follows:

- teaching: discussions centered around offering a seminar in the GOPP during March of next year; participants would be approximately 10 people from the GOPP in an intensive 10 day session evaluating a specific project as a vehicle for discussion and as a means of presenting planning issues. Also, possibilities were discussed, where an outstanding junior member of the GOPP could attend MIT as a student in the Master of Architecture program.
- research: continued development of basic documentation of reference areas of land/dwelling systems; development of planning models of new areas considering staging, low income poeple, and cultural and economic situation.
- practical applications: demonstration of principles in a specific site, both in a desert area of development, and in an expansion area in the agricultural region.

Attachment B

SUMMARY OF LOW INCOME SURVEYS

Dr. Barrada, Dr. Zakia Shafie, Dr. Nasamat

August 1977

From the preliminary evaluation of the data available for the subprojects, it became clear that there was much information which was not available; therefore, a field survey was initiated. It was not possible to undertake a very large or detailed survey because of time and budget restrictions. Therefore, precise statistical results were not expected. The objective was to get indications and directions in supporting or refuting various hypothesis proposed in the subprojects.

The team approved of carrying out this survey not only to achieve the above objectives but also because it was felt that it could give the following benefits:

1) to initiate a quick interest and involvement of students and faculty in the research through a tangible "product";
2) to help establish a general background for all members of the team with a common vocabulary and concepts;
3) to quickly establish a working relationship between members of the team and start the communication mechanism.
4) to enable all members of the team to get a direct contact, "feeling", and first hand information of part of the housing problem in Egypt, particularly those members from MIT and Cairo University who are new to these problems.

OBJECTIVES

The survey was intended to collect data for the clearly specified objectives of the subprojects, as well as to allow extraction of additional information to correlate more factors if required in the future. The survey was divided into two general parts:

1) Physical planning survey of the selected areas. The information to be collected included densities, land use, type of housing, systems of layout, etc. The information would be correlated to income categories, family size, and other social and economic factors gathered from a family questionnaire. The physical survey also provided the base from which the household samples were selected to be interviewed.
2) Questionnaire and direct observation for the households in the selected area.

The results of the questionnaire are intended to provide a reference for the following:

- testing of hypothesis on low income social grouping
- establishment of prototypes/models of dwelling designs
- determination of mechanisms for site development

- establishment of site layout criteria; demands on public facilities, expected use of areas, etc.
- determination of priorities of infrastructure by user in site development
- identification of issues requiring further detailed study.

THE SURVEY TEAM

Twenty two students from the Department of Architecture formed three survey groups (8, 8, and 6). Each group was headed by one teaching assistant. Each group was allocated two residential areas (Group 1: two informal; Group 2: two formal; Group 3: one informal and one formal). A member of the staff of Cairo University team accompanied selected students and the teaching assistants in a preliminary identification of the areas.

SURVEY PERIOD

The surveys started on July 10, and lasted for approximately 2 weeks. An additional 2 weeks were then required to prepare the plans at the dwelling scale and to complete the site plans.

INITIAL PILOT SURVEY

An initial pilot survey was prepared in Cairo for testing before preparation of the final form. The joint team then met in Cairo at the beginning of July for a review of this pilot survey. Based on the pilot survey and comments from joint team discussions, the survey was revised into its final form. Also, it was found that in most cases the areas chosen did not contain enough dwellings from which to select the desired survey sample (40 to 50). Accordingly, the areas were increased to include 120 to 150 buildings in each of the cases.

The purpose of the test/survey that was carried out in late June was to:
- a) familiarize the students with the areas selected for research;
- b) testing of survey format;
- c) determine the approximate time necessary to complete the questionnaire in each area;
- d) prepare a site plan for each area with the buildings, streets, utilities, etc.

The results were encouraging with both student interviewers and the people surveyed enthusiasm.

SELECTION OF AREAS

The types of localities in Egypt were identified according to the following main variables:

1) The resident's socio-economic group/housing categories (see previous working paper in June 1, Progress Report): very low unstable; low stable; low unstable; middle stable; middle unstable; high.
2) Formal or informal development.
3) Age of area: recent (last 5 years); established (5 to 20 years); old (20 to 35 years).
4) Type of housing: "Emirates" (blocks of flats); houses; buildings developed on small plots.
5) Privately or publicly developed.

Some types were excluded as they fall outside the focus of the projects, for example the high income group. Other groups were excluded because they have been covered in other research: the low-stable and middle-stable residents in public housing.

The six areas chosen are representative of a type of category. There are many other similar areas in Cairo.

Locality	*Housing Category*	*Type of Development*	*Age of Area*	*Type of Housing*	*Type of Developer*
El Haram	Low-stable and unstable	Informal	Recent	Small plots	Private
Meet Okba	Low-stable and unstable	Informal	Old and established	Small plots, emirates	Private
Mataria	Low-stable and unstable	Informal	Recent	Small Plots	Private
Helwan	Low/medium stable	Formal and informal	Established and recent	Houses, small plots	Private and public
Shoubra	Middle-stable	Formal	Established	Emirates	Private
Abbasayia	Middle-stabl:	Formal	Old	Emirates	Private

SELECTION OF SAMPLE FAMILIES

The families to be interviewed were determined from the site plan prepared from the pilot survey. The procedure of selection was as follows: The height of each building was marked on the site plan for each area. The total number of buildings of various heights were recorded, and a percentage of each category (equal to the percentage of category to total) was allocated; i.e., if the total number of four-story buildings was a third of the total number (30) then 10 samples would be selected from these 30. The necessary number of each category was chosen at random by each teaching assistant and marked on the site plan, taking into consideration a choice which includes a variety of building locations, i.e., corner, end of street, etc. If the building chosen contained several floors and apartments, the students were left free to choose any of these for the interview. The number of samples selected for each area are as follows: Al Haram 35; Meet Okba 47; Mataria 47; Helwan 43; Shoubra 45; Abbasayia 24.

LIMITATIONS OF SURVEY DATA

Precise statistical results were not expected from the survey. The objective was to get some indication and directions on specific issues related to the low income sector. Specific comments pertaining to the data are as follows:

1) Some of the survey questions were left blank without mentioning the reason, which may be explained by: a) refusal to answer; b) error by interviewer; c) a negative answer and not recorded.
2) Most of the chosen residential units from the informal sector were on the ground floor. The residents of the ground floor intercepted the students and wanted to know the reason for entering the house. Therefore, the tendency was to interview them while explaining.
3) Some of the answers did not indicate a pattern because they were not answered by all of the people interviewed. This might have been due to: a) failure to grasp the meaning of the question; b) desire of the student to finish the interview quickly; c) answer did not fit in the format, and the student failed to record it as a general remark.
4) The questions omitted in all of the samples formed a uniform pattern in the 6 areas, except for the question about income in Shoubra which was not answered in any sample.
5) The people were sometimes suspicious when the students wanted to draw the dwelling unit and refused completely. This occurred primarily in the formal areas. In the informal areas the people were quite hospitable and helpful as soon as they were reassured that the interviewers were really students. (Some of them even offered tea or cold drinks!)

Attachment C
WORKING PAPER: NOTES ON EGYPTIAN HOUSING SITUATION
Reinhard Goethert, 1 September 1977

Context:

1) The population of Egypt will double by the year 2000.

2) The annual population growth is 2.4% for the country. Urban growth is approximately 4%, of which half is from immigration and half is from natural growth. In 1960, 38% of the population was urban; in 1970, 44% was urban (World Bank study, 1972).

3) The largest percentage of population is the low income; which is also the sector growing most rapidly.

4) Rapid, undirected urbanization is having deteriorating effects on the cities of Egypt. Focus of work on Cairo allows immediate, direct use of the results of the study and, secondly, it is inevitable that Cairo will continue to grow in the immediate future despite efforts intended to retard population inflow. The most severe impact is on Cairo, and perhaps is a forerunner of what will happen in other cities in Egypt.

5) Rapid urbanization is also continuing on the limited scarce agricultural land, despite best efforts to stop expansion.

Housing:

1) According to various studies (including MOHR/AID "immediate action proposals for housing in Egypt"), there exists an acute housing "shortage", which was approximately 1.5 millions in 1975.

2) There is a shortage of vital construction materials, in particular cement. There is a shortage of skilled labor due to the attraction of higher salaries in other Middle Eastern countries.

3) Under present approaches, including industrialized systems, there exists no way for the government to provide sufficient housing for expected demand. (Within 10 years they could feasibly only produce 172,000 units; AID report.)

4) Middle and higher incomes are sufficiently able to acquire and afford housing.

5) Cost of existing minimum housing built by the government is around LE 2,800, which is beyond the economic capacity of 76% of the urban population. One consequence is that up to 70% of all urban housing currently built is by the lower income "informal sector" which constructs dwellings illegally outside of the formal housing market.

Government regulations:

1) It is estimated that 50% of subdivisions and 60% of dwelling activity are in violation of existing legislation.

2) Certain conditions are clear: a) building codes, and b) land subdivision regulations, are not compiled with. This is not confined to the low income areas (the so called "informal sector") but also prevalent throughout the income spectrum: middle, as well as high income dwelling construction. The middle and high income builders tend to comply with land subdivision regulations but deviations from the building permits are common. No data/studies are available on the percentage of non-compliance but estimates range very high.

3) What is then the purpose of the codes and laws? The promulgation of additional laws, however reasonably intended, generally means more laws are ignored, and the general cynicism of the public toward government efforts is increased.

4) A reasonable objective is to identify a minimum acceptable set of rules which must be followed for health, safety reasons. The criteria for the rules involve layout efficiency to minimize present and future costs.

5) It may be more appropriate to concentrate efforts on aspects within the direct control/responsibility of the government, i.e., the provision of infrastructure.

Socio/ cultural:

1) Supremacy of the family unit remains the primary social/ cultural attribute.

2) Lower income and rural people tend to follow and <u>require</u> traditional living patterns. Middle and higher income people tend to emulate/desire European living patterns.

3) The traditional village organization has been around the family clan. Several generations from a common descendent often inhabit a specific section of a village known as "Hamula". The traditional rural house is composed of a number of rooms grouped around an open courtyard with high windowless stone or brick walls. The courtyard serves functional purposes of keeping chickens, etc., and suited to the cultural traditions of the family.

Planning:

1) "Traditional" neighborhoods offer direct pedestrian access to markets, employment, family, and related to climate/ cultural/social values with an unequaled vitality. They are rich in social interaction and participation. However, they tend to lack water, proper sewage disposal, and refuse collection services which the city is unable to provide because of limited finances, skills, and materials. Also, there are few recreational open spaces for people to go and sit with families in the evenings as is the custom throughout the urban areas. Coffee shops, which spill into the streets, become the prime neighborhood focus in these areas.

2) "Non-traditionally" developed areas (often higher income, but not necessarily) have complete services but require automobile use, and have poor land utilization resulting in higher public costs disproportionate to population served.

3) New public and private developments generally follow imported European patterns which do not relate to Egyptian culture, social structure, nor climate. Most of the large scale planning concepts are direct imports from these European models -discrete land uses, low densities, "garden city" illusions, automobile orientation.

4) The European "garden city", approach of apartment slabs set in a green common space, is nonsense in reality, particularly in the context of the lower income majority of the population in Egypt.

Large scale housing developments:

1) Government and private intervention is required and large scale developments must continue to be implemented. However, the physical product must change.

2) Both new developments in desert areas and expansion of existing urban areas will have basic requirements of cost efficiency in layout, encouragement of high densities, and compact planning.

3) Large projects imply large numbers of people with varied interests and backgrounds. Large housing projects tend to provide a few restricted dwelling unit types for design/administrative simplicity, stratifying the areas into a narrow spectrum of a social group. However, although redesign of the dwelling unit itself may better accommodate each family's needs, the end result will be the same as seen in the older housing projects for the lower income groups throughout Egypt. For example, they will approach the deteriorated conditions as in the Ain El Sira, Zeitum projects in Cairo. The problem lies in the site planning.

4) Although site planning is perhaps in a narrow field of specialization, it has broad implications on urban areas in terms of financial health, physical efficiency, and culture, both present and future.

5) The current planning of housing projects has reinforced a bad situation -the excessive amount of undefined open areas/circulation space and unnecessary streets, which exacerbate the lack of maintenance, no refuse collection, etc. These open spaces, "green areas", are under the direct responsibility and control of the city which is the least able to maintain it in terms of finances and interest/motivation for maintenance.

6) The change of the arrangement or shape of the apartment slabs is not the issue. The key is the responsibility/ control, ownership and use of the land; the building is secondary.

7) In housing projects, particularly for the low income, it is contrary to separate commercial facilities/small shops from the dwelling structures. Daily food requirements demand easy access to allow small purchases of perishable food stables. It is a burden to the people to isolate the shops as is found in traditional western planning areas who are dependent on the automobile induced sprawl areas. Shops will develop despite best efforts of authorities to control their development.

8) Areas should not be planned for exclusive use of the automobile, with its land wastage and burdens to urban transportation, particularly to the old and the young. The traditional pedestrian methods of planning should be encouragedand continuedin new developments.

9) Primary issues should not be obscured by purely visual attributes: texture, scale, patterns, decorations, which are only one but immediately obvious aspect of an area's "character". Many of the mentioned characteristics which architects, etc., consider in defining an area, cannot be artificially, instantaneously created, but are subconsciously created over a long period of time.

Individual dwelling units:

1) The image that one gets from public housing projects is worse than the actual individual family situation. Dwellings (from observation) generally tend to be clean, well-maintained, and reflect high family pride and investment: fancy light-fixtures, decorated interior, flowers, and fine furniture quite extravagant considering the family's income. The exterior also shows/reflects pride as well as attempts to individualize units in the uniform mass of a project.

2) Dwelling construction and the provision of dwellings appear not to be a problem from the physical sense. Evidence through case studies clearly shows that the low income can finance and construct their own 4-5 story dwellings suited to their financial, physical, and social requirements. (This is not to say, however, that financial and technical assistance programs by the government would not allow perhaps quicker, better designed buildings.)

3) Dwellings clearly develop into 4-5 story structures, regardless of initial design, income group, or area. Often even in the larger established housing projects, extensions can be seen encouraging onto obviously public land initially intended for public "green" areas. In some cases, people have even added whole rooms illegally on the ground floors. It is clear that planning must consider this transformation into a higher density with its increased demands on schools, utilities, transportation.

4) Recommendations for reducing a unit size to 60-80m^2 and smaller should be carefully considered in light of the cultural situation and long term effects. Although initially there may occur savings which lower costs to the individual household (although studies have indicated that this would still not be within reach of the majority), the size is not tailored to the Egyptian culture, as in most traditional cultures, with larger, extended families. Smaller units either force "overcrowding" as families attempt to continue their traditional lifestyles, or families are forced to adopt nuclear family patterns with resultant breakdown of large family groups and long term social deterioration/change.

Informal sector housing:

1) The provision of housing by the informal sector should be encouraged and supported by the government. This is perhaps the most effective in terms of cost and within the reach of a greater number of population.

2) The progressive nature of informal sector construction spreads the demand for building materials over a longer period of time. There would be no direct, immediate surge in demand on the already over-burdened materials industry.

3) Families must be encouraged and allowed to continue to construct their own dwellings. Aside from providing a shelter for a single family there is a clear trend and incentive for expanding to 4 stories which provides shelter for 4 to 5 additional families while, at the same time:
a) improving the financial position of the family;
b) providing additional housing units onto the market.

4) A possible government policy is to speed up the informally produced dwellings by building a single story unit <u>only</u> (either prefabricated or conventional; whichever cheaper, quicker) and to encourage the owner to expand on own resources. Government costs would be for only one unit, with a net gain of five units.

Focus of policies:

1) The primary focus of the government should be: a) how to provide maximum benefit to most people; and b) how to address the problems which the people are not able to solve/handle themselves and which require a larger scale of organization.

2) Policies should concentrate on the urban areas because of the limited agricultural land and the resultant inevitable urbanization process.

3) Particular consideration should be given to the low income majority currently outside of the formal housing market.

4) The focus should be on larger scale settlements instead of single dwellings.

5) The problem clearly lies in the realm of government provided services: water supply, sewage disposal, street lighting, street paving, refuse collection, and electricity supply. Government efforts should be directed toward providing basic infrastructure, services, and more appropriate land distribution and subdivision. The subdivision of land must be assumed by the government to control direction, areas to be used, and to a large extent, to assure future, economically feasible, provision of utilities.

6) Planning models should be determined through the study of selected urban areas to determine realistic land policies including land uses, densities, circulation, and dwelling needs.

V.4 URBAN TRANSPORTATION IN METROPOLITAN CAIRO

Progress Report

March 15, 1977 - September 1, 1977

Administrative Organization.

In the M.I.T. group, the principal investigator is Ralph Gakenheimer and the project manager is Thomas Brigham. There are two assistants, Martin Michael of the Department of Urban Studies and Planning who is specializing in transport project development and programming, and Donald Keller of the Department of Civil Engineering, who is specializing in technical aspects of programming. In addition, there has been part time help from Atul Sharma on the economics of auto ownership, and from Moustafa Amar on travel demand modelling. Travel survey and travel demand aspects of the research are directed to Tom Brigham, who also participates in the other parts of the research.

Coordinator of the research in Egypt is Mr. Ali El-Daghistany, Vice Minister of Transportation. Director of research for the counterpart team is Dr. Mohamed El-Hawary of Cairo University. Participation of the Transportation Planning Authority of the Ministry of Transport is led by Mr. Abdel-Aal Salmawy, Technical Director. The project also includes Dr. Farouk El-Beri (Cairo University) and Dr. Mohamed Owais (Assyut University), and Mr. Mokhtar Hassan of the Transportation Planning Authority of the Ministry of Transportation. Student assistants include Ahmed Badazvi and Hamdi Ismail. This group has planned and executed the travel survey (including a pilot survey followed by the full survey). It has processed the data and prepared all the necessary inputs to computer analysis of the data. It has hosted the visiting members of the M.I.T. team and facilitated all aspects of data gathering. It has independently collected a large amount of data on auto ownership and transportation project development. In short, the performance of the counterpart team under Dr. El Hawary's direction in all aspects of this research has been very successful.

Following initial exploratory visits to Cairo to select objectives of research and means of accomplishing it, the following phases of work have taken place: (1) Layout of the general strategy of research, (2) Planning and executing of the travel survey and data processing in Cairo, with a visit to Cairo by Brigham to participate in the planning of both elements, (3) A

three week visit to Cairo by Gakenheimer and Michael to collect data on project development, (4) The rest of the summer in Cambridge preparing materials on programming, the analysis of auto ownership, and the preparation of project development information toward a paper on the project development experience, (5) During the rest of the summer the Cairo team has completed the survey coding and data processing, and has collected materials on project development, (6) In August and September, members of the Cairo Team are arriving in Cambridge for the blending of these materials and the consolidation of the research effort.

Activities to the Present Time.

Element I: Travel Analysis.

Summary - The first element of the urban transportation project as outlined in the project proposal of March 3, 1977 is 90% complete. Traffic volumes and travel behavior in the greater Cairo metropolitan area have been monitored, and standard survey procedures and documents have been developed to allow repetition of the surveys by responsible governmental agencies. Consistent data collected over time will provide an essential tool for diagnosis of urban transportation problems, the planning of solutions to the problems and the monitoring of the effectiveness of the solutions implemented.

Members of the project team from Cairo University, the Cairo Transport Authority and M.I.T. agreed that development of analytical models and planning methodologies to demonstrate use of the collected data would aid not only the adoption of the project work by governmental agencies, but also in the progress of elements IV and III of the project itself. Hence, the scope of the work was expanded to include development and application of a traffic assignment model, which could predict traffic flows and speeds given alternate forms of the Cairo street network, and in conjunction, speed and delay studies for arterial and collector streets forming the segments of the network.

In addition, it was agreed that the transit portion of the travel behavior surveys will be excluded from this year's program, due to the fact that the number of stations which would have been employed in the survey given the resources available would not have provided sufficiently

comprehensive data. This exclusion allowed the expansion of the private vehicular travel behavior portion of the survey and a corresponding increase in its eventual usefulness.

Traffic Volume and Travel Behavior Surveys -- Criteria for the surveys were developed and applied to the actual survey effort in the form of the following steps. First, a preliminary traffic volume and O-D survey was performed in order to train supervisory personnel for the larger survey, and also to obtain data with which to analyze the 6th of October/Tahrir/Galaa bridge traffic flow problem. The analysis of the resulting data allowed the staff to gain familiarity with the analytical tasks which were largely computer-performed during the processing of the comprehensive survey data. (See "A Study of Traffic Flows on the 6th of October and Tahrir Bridges Axes" by El-Hawary, Owais and Abdel-Bary, May 1977.) Second, the main survey was conducted utilizing 267 counting stations, roughly 96 percent of which were also travel behavior survey stations. Third, since the main survey occurred on a single day and covered the 10 busiest hours of the day, traffic fluctuation surveys were undertaken to measure traffic volumes in central city, peripheral, and suburban areas over the entire 24-hour day for one week. These data were used to estimate total daily volumes, hourly fluctuations and weekly fluctuations in traffic of various common vehicle types. Fourth, in order to calibrate a traffic assignment model accurately enough to allow it to be used in Egypt, relationships between traffic capacity, volume and speed over the network needed to be determined. Hence, speed and delay surveys were conducted on sufficient numbers of streets and intersections to develop Cairo-specific parameters for relationships between link speed and traffic volume for streets of various widths, and for various types of adjacent land use.

Considerable effort was devoted to survey area delineation, origin-destination zone selection and location of the survey station so as to maximize survey data output. Three different survey forms were developed, which are as follows:

a) Traffic Volume - designed to allow counting of all the major types of vehicles, and in addition to provide distinction between private and public transit buses, among the three principal types of public transit vehicles (trams, buses, and trolley buses), and between private autos and taxis.

b) On-Route Interview - origin/destination and trip purpose were the key data elements desired. In addition, vehicle type, occupancy governate of registration and over-night parking location were also asked.

c) Speed and Delay - designed to allow the timing of traffic flow speeds along arterial and collector streets and delays encountered at intersections and traffic circles. The surveys are conducted in a floating car moving in traffic at roughly average speed.

Following collection of the data, the Cairo University computer facility was employed to sort and tabulate the results. Key data elements include traffic volumes, vehicle occupancy, trip purpose, trip origin and desintation, governate of registration and overall indices of vehicle flows within, into and out of the metropolitan area.

Documentation of preparation and execution of the surveys is complete. Preparation of a traffic volume/travel behavior survey manual for future, and hopefully regular use at the Transport Planning Authority and related governmental agencies is well underway and is expected to be completed by the end of September. The manual will allow the surveys and data tabulation methods to be replicated with a minimum of effort and technical expertise.

The selection and implementation of the traffic assignment program in Cairo is approximately 40% complete. An assignment program is currently being set up at M.I.T., which will provide a pilot system to demonstrate program implementation, application of the model to the Cairo situation, and provide a framework for further street and highway network analysis on-site in Cairo. The work at M.I.T. is being performed jointly by M.I.T. team members, and visiting project team members from Cairo University and the Cairo Transport Planning Authority.

It is anticipated that a parallel system will be set up in Cairo, preferably at Cairo University, and that a number of potential solutions to either localized or general traffic congestion will be tested and documented by the end of December, 1977.

Element II: Project Programming

As a first step in the adaptation of project programming technology to meet Egyptian needs, a study of current transportation project implementation procedures was undertaken jointly by the Cairo counterpart team and members of the M.I.T. team in Cairo during June. Following the initial review of U.S.

programming literature which began during the Spring in Cambridge, and after discussion between the M.I.T. and Cairo teams in Egypt, it was determined that this study should be based on a review of the historical development and current status of a number of transportation projects in the Cairo area. For this purpose, a "project status" package was written, designed to assist in the collection of information in four project-characteristic areas: (1) project description and component/element breakdown; (2) source of funding; (3) identification of the organizations which developed the project idea, as well as the project designers, constructors, and those responsible for implementation; and (4) identification of problems which arose (and the non-problems which didn't) in the course of project development and implementation. Utilizing this guideline, an extensive series of interviews and general discussions were held in Cairo, first to identify the current set of proposed and on-going transportation projects, and then to gather information on each project in the four previously mentioned areas. Sources of information included individuals associated with Cairo University, the Transportation Planning Authority of the Ministry of Transportation, the Ministry of Housing and Reconstruction - General Office of Physical Planning, and the Gize and Cairo Governorates, as well as private firms involved in the design and construction of projects. The results of this data gathering effort are currently being analyzed by the M.I.T. team in Cambridge (with the participation of visiting Cairo University team members), while the counterpart team in Cairo continues to assemble more refined data on the various projects. This analysis is enabling the research teams to develop an overall picture of the manner in which urban transporavion projects are currently developed and implemented in Cairo, as well as identifying specific project-implementation problems. It will conclude with a paper, commenting on this assembled information, "The Project Development Experience in Transportation in Cairo."

Concurrent with these activities, the review of U.S. programming methodologies is continuing in Cambridge. Specific examples of past programming efforts, as well as proposed-but-untried techniques, are being examined. The intent here is to generalize the programming experience of the U.S., and then, in conjunction with the research concerning project implementation in Egypt, to identify those techniques which might be useful

and adaptable in the Egyptian context. Special attention is being given to the definition and understanding of uncertainty in project development. The principal objective is to prepare a programming method which fits the institutional realities and other requirements.

Element III: Auto Ownership

Beginning in May, and continuing through June and July, an M.I.T. team member in Cambridge has been assembling and reviewing information pertaining to auto ownership, both in developing and developed nations. Particular emphasis has been placed on pinpointing the particular factors which appear to influence the level and pattern of distribution of ownership. The work of identifying these factors in the specific case of Egypt was initiated in Cairo during June, when M.I.T. team members, together with the Cairo University counterpart team, began to assemble a broad range of basic information pertaining to the ownership of automobiles in that country. This information includes data specifically concerning "who owns automobiles," the cost of purchasing and maintaining autos (including the problems of delay and high cost in auto purchasing, and fuel and insurance costs), the importation of automobiles and their components (foreign capital requirements, foreign sources of autos and parts, and tariff structures), domestic production and assembly of automobiles (historic patterns; planned production levels for the future; and manpower, materials and capital requirements and availability); information concerning alternatives to private auto ownership (taxis, remis, and public transportation services); and basic demographic data.

Remainder of the Contract Period

Element I: Travel Analysis.

During the next three and a half months we will put the UTPS package of the USDOT into operation on the IBM computing machinery at M.I.T. This will be done with the assistance of Mokhtar Hassan, visiting member of the Cairo team. When the programs are operating we will examine specific alternatives in Cairo transportation system development as introductory exercises of interest to transport officials in Cairo and as preparation for the incorporation of these programs into our programming method.

At the same time, we will finalize the choice of a traffic assignment program for Cairo. This includes working through certain obstacles caused by the differences in computer equipment between the U.S. and Cairo. Before the end of the contract year, exercises with project alternatives will also be done in Cairo.

Element II: Project Programming

During the remainder of the contract year, most of our available person-months will be put to this task. We will complete the project review paper, as a distillation of experience in project implementation toward selecting features of our programming method. In addition, an introductory memorandum on the programming process is in the final stages of preparation, a memorandum of the technical aspects of programming will soon be ready, and a memo on uncertainty will be completed. The latter reflects our thought that differences in the uncertainties of phenomena, and different views of uncertainties may be a key to understanding the Cairo situation. From this work we expect to advance to a general paper for discussion on programming method for transportation improvements in Cairo by the end of the contract year.

Element III: Auto Ownership

This element will not receive further work before the end of this contract period, (except through informal sources, such as work by students in related courses).

The Next Contract Year

Proposed activities for next year include continuation of some of the on-going activities and the beginning of some new ones. It is convenient to mention them in three elements.

1. Refinement and application of the programming method. Since we will only reach the completion of the component parts of the programming method by the end of the current contract year, we will be left during the coming year to consider its operability as a complete method, to apply it to a series of test cases, and to further refine it for use as a tool of decisionmaking. The emphasis is on application of the method developed during the first contract year, and on generating the improvements resulting from applications.

2. Auto Ownership. We hope to have means for the extension of the analysis of auto ownership. The purpose would be to work toward a model which relates auto ownership to (a) import tariffs, (b) manufacturing policy, (c) user costs, and the many administrative decisions affecting these factors. This work is based on our belief that auto ownership is the aspect of urban transportation which is the most significantly manageable by policy. Changes in the import tariffs on automobiles, for example, could have a great impact on traffic in the streets of Cairo within a short time--no doubt a much greater impact than any feasible action on transportation within the city itself. At the same time, since this policy lever does not exist in the U.S. and most other post-industrialized countries, there is no background of analytical technique with which to study the subject. Our objective is to develop a perspective on auto ownership which will bring the attention of the Egyptian government to it as a means of transportation planning, and suggest the consequences of government action on the subject.

3. Transit. The principal new element of next year's research would be our entry into the subject of mass transit. There are many reasons for doing this. While traffic on the street is the immediate basis for expanding the capacity of the transportation system, it is a fact that well over 90 percent of the trips made to Cairo are by public transit. In terms of its social role and its significance to the economy in general, public transit is much the more important mode. In Cairo it suffers severe problems of under-investment and overcrowding.

Our project experience up to the present time includes substantial preparation for transit sector research. We have had a number of contacts with the Cairo Transit Authority, the operating agency. We have annual reports of the agency, describing operating performance, conditions of the fleet, and so forth. We have information relevant to transit in the set of projects reviewed for study of projec programming activity. We have information on transit vehicles as traffic in the travel surveys. We will have the UTPS package mounted, at least in Cambridge, offering an array of programs for the analysis of mass transit. Hopefully, the programs to be put into operation in Cairo will also have transit analysis features.

Our purpose is to prepare to examine project alternatives in mass transit as well as in street traffic, and to add the methods for doing this to our programming capability. This will extend our programming capability

to include means of examining the efficiency of scheduling and headways, measuring needs for transit equipment, and, generally, evaluating proposed improvements to transit effectiveness.

V.5 HIGHWAY TRANSPORT PLANNING IN EGYPT

Progress Report

June 1, 1977 - September 1, 1977

OBJECTIVE

The primary objective of this cooperative effort continues to be the strengthening of Egyptian institutional capabilities for the analysis, planning, and programming of highway investments. This will be accomplished by establishing a data collection and inventory methodology reflecting the parameters appropriate for upgrading and maintenance decisions in Egypt, by applying and calibrating an existing evaluation framework—the Road Investment Analysis Model—for use in these decisions, and by the training of Transport Planning Authority and Cairo University personnel in the use of these data collection and analysis techniques. Emphasis has been placed on the identification, and resolution of the major issues confronting the establishment of appropriate maintenance and upgrading standards and schedulings for Egypt.

Specifically the work will build upon the existing MIT effort in Ethiopia by applying the developed framework and methodology to the following issues:

1) Economic evaluation of proposed projects (both new construction and upgrading of existing links)
2) Economic evaluation of design and maintenance standards in the context of the larger road network
3) Development of projections of future maintenance requirements and traffic patterns
4) Recommendation of equipment required to develop and maintain the data inventory of the network condition and maintenance activities.

To demonstrate the methodology, the team is concentrating on data collection and analyses for a single maintenance zone, through the involvement of Cairo University graduate and undergraduate students, and collaboration with Transport Planning Authority officials and Cairo University on the development and use of this evaluation framework on Egyptian maintenance and upgrading situations of immediate interest. The calibra-

tion aspect of the project involves adapting to Egyptian conditions empirical relationships of pavement deterioration and maintenance effects which have been developed by MIT and applied in Ethiopia, and is expected to proceed over the longer term.

PROGRAM OF WORK

The research activities for the first year have been divided into four general phases. The initial phase is coordination of the research effort, identification of an area of study, and identification of data requirements and availabilities. The second phase is installation of the computer model at the Cairo University Scientific Computation Center, and training of Egyptian personnel in its theory, use, and data requirements and formats. The third phase is detailed data collection and compilation. These phases overlap and are expected to extended through September. The last phase, the analysis of the specific cases chosen by the team, and sensitivity analyses on them, along with tentative conclusions and recommendations derived from them, will proceed concurrently from July through November. December is reserved for preparation of the final report.

PROGRESS TO DATE

The overall program is running close to the original schedule, despite the computer implementation difficulties discussed below. Responsibilities for the various data items required have been distributed among the team members according to their field of expertise, and appropriate data sources within the ministry identified. The zone of study has been reduced from the original zone due to data requirements and limitations imposed by the model on allowable network size. The new zone is bounded on the west and south by the roads on the west bank of the Rosetta Branch of the Nile between the cities of Tawfikieh, Tamalay, Khatatba, and Kanater, and on the east and north by the Cairo-Alexandria Agricultural Road, between the cities of Qalub (just north of Cairo) and Tawfikieh (where the Agricultural Road crosses the Rosetta Branch). The included network, comprising 32 links and 21 nodes (not all of which are traffic generators), is close to the maximum the model is capable at present of analyzing. A map of this study zone is attached.

The required data and methods of collection and processing were demonstrated by Mr. Brian Brademeyer through a series of seminars on the User

Manual, covering each of the data areas in turn. Two links from the study zone were selected as initial case studies to demonstrate the model and data collection and processing, with the data being generated and structured by various Egyptian team members, depending on field of expertise. One link connects the towns of Kafr El-Dauwar and Abu Hiummus via the Cairo-Alexandria Agricultural Road; the other is a new road linking Shibin El Kom to the Rosetta Branch of the Nile at Tamalay. The former has been analyzed at MIT for three construction and two maintenance options, and the results reviewed in Cairo while the latter was used to demonstrate various data collection requirements and options. Data collection forms were also developed for the major data blocks.

The second phase, implementation of the computer model and instruction on its use and data requirements has been successfully concluded, with the Kafr El-Dauwar--Abu Hiummus link being run as an example at the CAPMAS National Computation Center. Implementation on the Cairo University facilities is proceeding, and should be completed shortly. Considerable difficulties were encountered in converting the Road Investment Analysis Model (RIAM) from IBM to ICL hardware facilities, involving: (1) the inability of ICL to read an IBM source tape, which required programmer Ms. Dorria El-Aggon to create an assembler language program to read the IBM tape and pack it in the form used by ICL; (2) the different length of words between the two machines and the unavailability of real variable comparisons for equality on ICL, which required Dr. Sherif Ebeid and Ms. Dorria to scan the program line by line and convert the 92 alphameric comparisons used in the program into the form acceptable to ICL; and (3) the program size reduction necessary for the Egyptian computers, which required that Mr. Brademeyer and Dr. Ebeid devise an efficient ICL-overlay structure. Of minor annoyance were the hardware problems at the ICL of Cairo Unviersity, which caused repated delays.

The third phase, detailed data collection and processing, required a distillation of currently available sources, and implementation of new surveys where the necessary data base was weak or non-existent.

Transport Planning Authority personnel have gathered all data required for the link characteristics and proposed construction projects and maintenance policies (by Engr. Sayed Khalil, Director of Geometric Design) along with data on existing link traffic volumes, (by Engr. Mohammed Khalil,

Director of Traffic Division) and prepared in tabular form, with coding and card punching currently underway . The vehicle characteristics and costs data were collected, on a preliminary basis, by Dr. Abdel Fathy Lashine from available Transport Planning Authority records and the Egypt National Transport Study, Phase I, Interim Report. From these, data deficiencies were identified and are discussed below. A report on the data collection prepared by Engr. Mohammed Khalil, is attached as Appendix I.

The Kafr El-Dauwar--Abu Hiummus example that was run at MIT, and later at CAPMAS, indicated excessive cost savings for intercity taxicabs with reductions in pavement roughness (up to a factor of 5 to 6). The Egyptian team members suspected these values as unrealistic; as they were derived from data in the Interim Report and the Transport and Road Research Laboratory Kenya equations (which were presumably being used outside their calibrated range in this instance). Dr. Lashine of the Transport Planning Authority arranged for an interview survey of intercity taxicab drivers, with the data gathered as well as the differences with the Phase I Interim Report presented in Appendix II to this report. Due to the magnitude of the discrepancies and their implications for the reliability of operating cost predictions, additional surveys on bus and truck costs are now anticipated by the ministry. These new volumes will be used in revised case studies run at MIT and Cairo University.

Traffic counts have been made on all links in the study area. However, origin-destination data was not available, as the zones used in the Egypt National Transport Study, Phase I, Interim Report were too aggregate for our purposes; nor was there information on route choice behavior. To remedy this situation, an O-D interview survey was performed in the study zone on August 8 under the direction of Dr. El-Hawary and Dr. Owais. The interview stations were taken as the stations used for the traffic counts. Fifty-four students and forty-two patrolmen were employed in the one-day survey. The forms were developed by Dr. Mohamed Owais and Mr. Brademeyer, with the finalization done by the entire project group.

Of the questions, two were directed to O-D flows (where are you coming from, where are you going) and the remainder were aimed at determining route choice behavior. Questions asked were: what are the major cities in your route; will you stop at any city enroute; if so, for how long; do you normally take this route; if so, why; if not, why this time; and

what is your estimate of your travel time. The intent of the interview was to get as much information about the route actually used as possible, and an indication of knowledge of available alternatives. This data will be analyzed at MIT after it has been processed by Dr. Owais. A map indicating the survey stations is attached.

Based on Mr. Michael J. Markow's review of available sources (Appendix III), the project team determined the pieces of equipment desired to conduct the tests for the network condition inventory, and their specifications; these were prepared by Engr. Abd El Maksoud Sadek, General Director for Design and Laboratory Section, and are attached as Appendix IV. A preliminary meeting was arranged between Mr. Brademeyer, Dr. Lashine, Mr. James Norris, and Mr. Richard L. Aitken of the USAID Commodity Import Program to discuss the procedural aspects of obtaining the equipment, and further negotiations between the ministry and AID are currently underway.

Priority has been given to analysis at the network level, as indicated by the objectives. The present link evaluation model is currently being modified at MIT to incorporate these network aspects, with completion expected by mid-September. The data required by the new model has already been collected by the Egyptian team members, and is currently being processed in Cairo.

PLANS FOR THE COMING PERIOD

The work for the coming period (September through December) will be in three areas: calibration of traffic assignment parameters; analysis of the network study zone; and preparation of the final report.

Calibration of the assignment parameters (value of time and diversion intensity) will be performed at MIT once the O-D survey route preference data has been processed by the Egyptian team members. Since all of the study zone lies inside the agricultural area, no attempt will be made at present to determine the effects of the desert on route choice, although this will be addressed in the future. A small computer program will be developed at MIT to convert the data gathered in Cairo into the form acceptable to the LOGIT calibration program. The predicted values of the behavioral parameters will then be used in the network analysis phase.

The network will be preliminarily analyzed to determine the operating

costs and travel times for the various links, providing the cost data necessary for performing the route choice calibration discussed above. Once these behavioral parameters have been determined, the study network will be analyzed under the proposed maintenance policies and construction schedules, and projections of traffic flows and maintenance expenditures developed. Several perturbations around the proposed investment program will also be analyzed for sensitivity.

To accomplish the above tasks and prepare for the final report, Dr. Mohammed Owais will travel to MIT from the period of September 5 to October 5 (or thereabouts). His participation will include the case study analysis, the writing of the final report, and the preparation of a detailed program for the next year. In addition, Dr. Mohammed El-Hawary will visit Boston periodically between late August and mid-October, to Cairo, to monitor project progress.

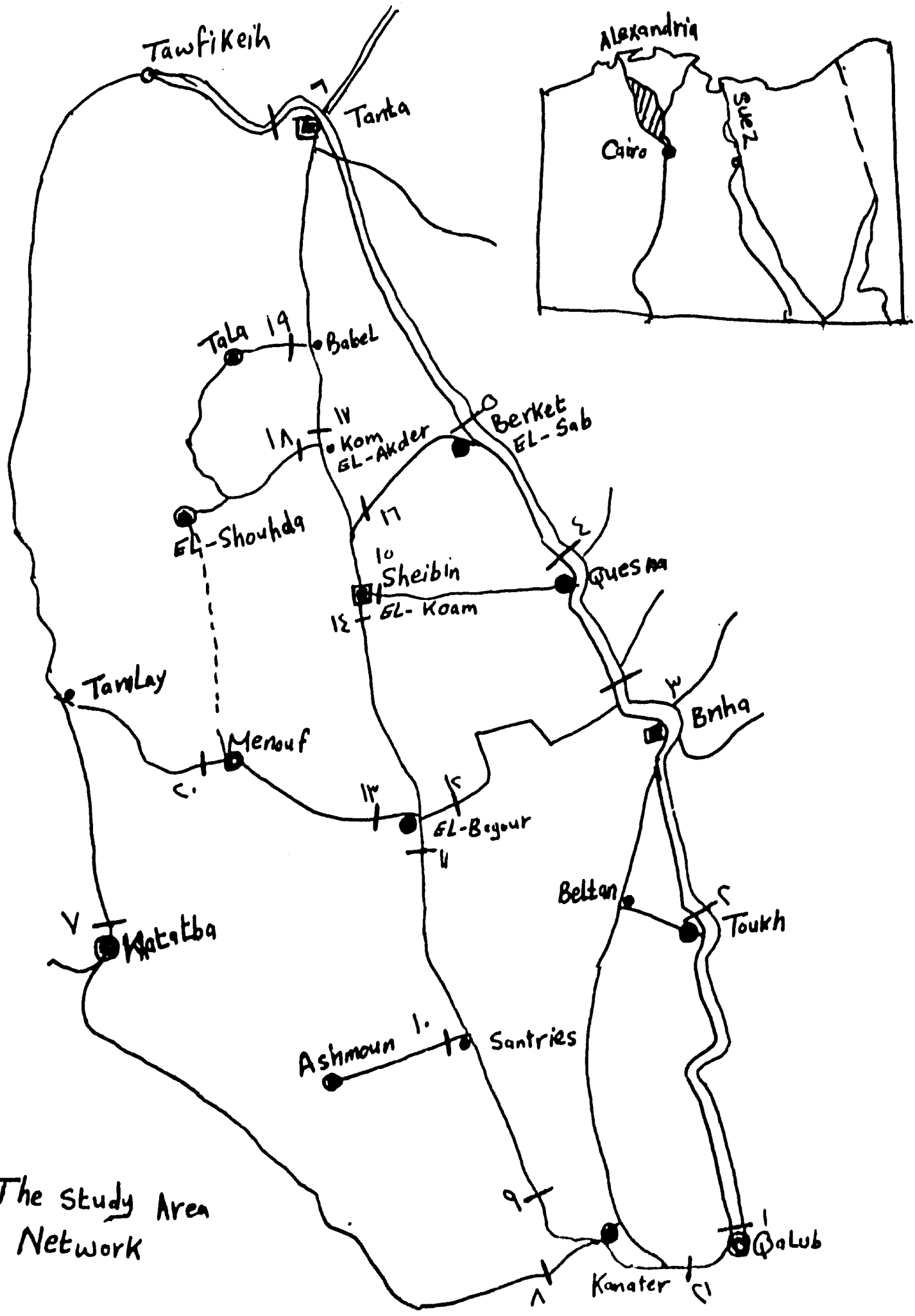
FUTURE DIRECTIONS AND TOPICS OF RESEARCH

In the longer term outlook, we plan to address three interrelated and hierarchical extensions of the current program. The network planning, implementation, and evaluation effort will be expanded to include the rest of the Egyptian network, maintenance organization and capacity constraints, and calibration of the empirical relationships to the Egyptian environment. Capital budgeting and programming techniques will be devised to consider the "optimal" timing and scale of future road investments, and to consider economic, materials, capacity, and institutional constraints to program implementation. Multi-modal models will be developed to consider the intermodal impacts of intercity transport investments, and to address sector improvements in a unified manner, using simplified models of non-road transport.

Concurrently and complimentarily, specific shorter term goals of more modest scale would consider the following items: more sophisticated assignment models which are based on attraction-generation techniques which free the user from O-D demands and path enumeration data requirements; calibration of the environmental factors peculiar to Egypt; expansion of the behaviroal parameters to include the effects of desert travel on route choice, giving planners an indication of what policies should be followed to encourage utilization of desert roads; development of congestion models which reflect the traffic mix and behavioral patterns in

Egypt; and the effects of water table height on road deterioration; among others. Also of interest would be the expansion and updating of the data base relevant to transport investment, and analysis of the organizational and institutional constraints on investment policy.

Other investment opportunities which AID may be interested in funding separately from the present program include improvements in maintenance organization; purchase of additional construction and maintenance equipment; studies of the impacts of transport regulations; and inventory and data base development, such as Phase II of the Egypt National Transport Study.



The Study Area Network

Attachment A: HIGHWAY TRANSPORT PLANNING IN EGYPT

Road Evaluation Equipment

This memo updates an earlier listing of road evaluation equipment for Egypt. It is correlated whereever possible to entries in a set of manufacturer catalogs that have been enclosed. Prices include estimated shipping costs to Cairo.

It appears that manufacturers of pavement evaluation equipment are limited to the firms listed. There are, however, many potential suppliers in the categories of vehicle weighing and traffic counting. Catalog cuts from a sample of these firms have been included to illustrate the range of products available. Lists of other potential suppliers, taken from the Thomas Register and the Industrial Product Director, are appended to the end of the memo.

1. <u>Pavement Roughness Measurements</u>

A. BPR Roughometer: Soiltest, Inc., CT444 or equivalent

Estimated price: $30,000

Manufacturers or Suppliers:

Soiltest, Inc.
2205 Lee Street
Evanston, IL 60202
(312)869-5500

James Cox and Cons, Inc.
PO Box 674
Colfax, CA 95713
(916)346-8322

K.J. Law Engineers, Inc.
23660 Research Drive
Farmington Hills, Michigan 48024
(313)478-3150

Reese Maintenance Corporation
Napolean, OH 43545

B. Road Meter

Estimated price: $2000 - 5000

Manufacturers or Suppliers:

PCA Roadometer
Soiltest, Inc., Model ML-500B or equivalent

Potential Suppliers:

Soiltest, Inc.
2205 Lee Street
Evanston, IL 60202
(312)869-5500

James Cox & Sons, Inc.
PO Box 674
Colfax, CA 95713
(916)346-8322

Mays Ride Meter
Catalog #890: $2000

Rainhart Co.
PO Box 4533
600-608 Williams Street
Austin, TX 73751
(512)452-8848

2. Pavement Deflection Measurements

A. Recordable Benkelman beam, Soiltest HT300 and HT320 or equivalent, 2 required

Estimated price: $1000

Potential Manufacturers or Suppliers:

Soiltest, Inc.
2205 Lee Street
Evanston, IL 60202
(312)869-5500

James Cox and Sons, Inc.
PO Box 674
Colfax, CA 95713
(916)346-8322

K.J. Law Engineers, Inc.
23660 Research Drive
Farmington Hills, Michigan 48024
(313)478-3150

Reese Maintenance Corporation
Napolean, OH 43545

B. Dynaflect

Estimated price: $20,000 plus 2,000 training

Manufacturers:

Radiation Engineering and Manufacturing Co.
Box 214, Rt. 5
Fort Worth, Texas 76126

Lane-Wells, Inc.

C. Road Rater

Estimated price: $60,000

Manufacturer or Supplier:

Foundation Mechanics, Inc.
c/o Wyle Laboratories
1128 Maryland Street
El Segundo, CA 90245
(213)678-4251

3. Skid Resistance

Portable Skid Tester, 2 required

Estimated price: $2000

Manufacturer or Supplier:

Soiltest, Inc. Model HT120
2205 Lee Street
Evanston, IL 60202
(312)869-5500

4. Pavement Coring

4-inch and 6-inch core diameter thin-wall diamond bits to operate with Soiltest DR 705A rig, 60 of each required

Estimated price:

4" core--$400 each
6" core--$600 each

Manufacturer:

Soiltest, Inc.
4"--DR1360 or DR1460
6"--DR1348 or DR1448

5. Axle Loads

A. Weigh-in Motion device--40 pad location required

Weighing and Weighing-in-Motion Systems
Weighwrite In-Motion Weighing
(Requires Trucks to Reduce Speed to 3-4 kph)
Price: $18,000
Smiths Industries
PO Box 209
Industrial Way
Wilmington, MA 01887

Treadle Scale Weighing System
(for static of 3-4 kph weighing)
BLH Electronics
42 Fourth Avenue
Waltham, MA 02154
(617)890-6700

Unitech Dynamic Weighing System
(weighs, counts, and records speed of traveling vehicles)
Price: $35,000 - 50,000
Unitech, Inc.
1005 East St. Elmo Road
Austin, TX 78745
(512)444-0541

Streeter Amet Highspeed Highway Weighing System
Streeter Amet Corp.
Grayslake, IL 60030
(312)223-4801

B. Semi-Stationary or Portable Weigh Scales: 5 required

ELDEC model 3040 with 3410 printer:
Price: $11,000 per pair with printer
LOADOMETER "Hi-Way" scales (no recorders)
Price: $1000 per scale
Loadometer Corporation
1700 Union Avenue
Baltimore, MD 21211

6. Traffic Recording

Streeter Amet Corporation Traffic Classifer
(Model 401) or MR 112/114 Counters

Surveyor Series
Price: $950 - 1700 each
DEPCO
117 East Helena Street
Dayton, Ohio 45404
(513)461-5898

Stevens print-punch recorders
Leupold and Stevens, Inc.
PO Box 688
Beaverton, Oregon 97005

Fisher and Porter punched tape counters
Price $1000
Fisher & Porter Co.
Warminster, PA 18974
(215)674-6000

TRAFFIC COUNTERS

COUNTERS: TRAFFIC
(see also Counters (Electronic))

CONN: EAST NORWALK
LFE TRAFFIC CONTROL DIV., AUTOMATIC SIGNAL
Regent St. (Automatic Vehicle Detectors & Counters) (203—838-4791) ..... AAAA
(See Our Catalog In Thomas Under LFE Fluids Control Div.)

CONN: NORTH BRANFORD
Multi-Counter Mfg. Co. Stroud Rd. ..... B

CONN: OLD SAYBROOK
Conrac Corp., Cramer Division Mill Rock Rd. ..... AAAA

CONN: WOODBURY
DENOMINATOR COMPANY, INC., THE (Single & Multiple For Classification, Directional & Volume Counts, Traffic Counting Boards) (203—263-3216) ..... B

IL: CHICAGO
De-Tec-Tronic Corp. 2508 N. Halsted St. ..... AA
S W [illegible] COMPANY 5360 Northwest Hwy. (312—775-[illegible]) X
Mangood Corp. 105 W. Adams ..... AAAA

IL: CHAMPLAIN
Sprecher Amor Div. Slusser & Wiche (Automatic, Repeating Portable & Permanent) ..... AAAA

IL: OAK BROOK
Tri-Tronics Co., Inc. 821 Enterprise Dr. ..... A

IL: ST. CHARLES
Rocera Company, Inc. Powis Rd. at U.S. 64 (Vehicle & Pedestrian Counters & Detectors) ..... A

MO: KANSAS CITY
Drive In Theatre Mfg. Co. 709 No. 6th St. (Car Counters & Speakers For Drive-In Theatres) ..... A

MO: [illegible]
[illegible] 126 Jackson St. N.
[illegible] (Instruments & Controls) ..... A

THERMAL FLEET [illegible]

NH: BEDFORD
Sprecher Amor & Divide [illegible]
Mass. ..... AAAA

OHIO: CLEVELAND HEIGHTS
SERVICE SEQUENCE SYSTEMS INC. 1625 Lee Rd. (Take-A-Number System) (216—321-7255) X

OHIO: DAYTON
DAYTON ELECTRONIC PRODUCTS COMPANY 115 Helena St. (513—461-4661) ..... AA

SURVEYOR
TRAFFIC COUNTING SYSTEMS
by DEPCO

- Lightweight & Rugged
- Temp. Range −30°F to +150°F
- Compatible with loop or road tube
- Solid-State Circuitry & Pressure Switch
- Safe and Accurate Operation in any Position
- Automated Translation

Specialists in State-of-the-Art Traffic Counting Systems

Dayton Electronic Products Co.
115 East Helena St. • Dayton, Ohio 45404
(513) 461-4661 461-5899

OHIO: DUBLIN
Gammatronic, Inc. 86 S. High (Vehicle) ..... AA

OHIO: UHRICHSVILLE
K-HILL SIGNAL COMPANY, INC. 328 W. 3rd St. (Portable For Highway Total Flow & Directional) (614—922-6421) ..... A

K-HILL "SOLID STATE"

We make Totalizer Traffic Counters; Two Way Directional Traffic Counters; One Way Directional Traffic Counters; Pedestrian & Wildlife Traffic Counters; Counters for Drive-In Theatres, Banks, Shopping Malls, Airports, Gas Station Parking Lots and Wash Racks.
Counters operate from rubber road tube or special treadles. All counters available with solid state circuits. If you have a counting problem, contact us (614) 922-6421.

Bill Hall

K-HILL SIGNAL CO., INC.
328 W. Third St. • Uhrichsville, Ohio 44683

ORE: BEAVERTON
LEUPOLD & STEVENS, INC. P.O. Box 688-T (Single & Dual Recorders. Print & Punch Tape Record. Teletypewriter Processable) (503—646-9171) .. AAAA

STEVENS
PRINT-PUNCH
TRAFFIC
RECORDERS

Recorder prints and punches on 8 channel tape for in-field reading or teletypewriter processing. Resets to zero after each punch cycle. Dual recording for directional counts or two lanes, and other features. Standard 16 channel recorders and tape readers also available. Write for literature.

STEVENS TRAFFIC PRODUCTS
Leupold & Stevens, Inc.
P.O. Box 688T, Beaverton, Oregon 97005 U.S.A.

PA: SPRING CITY
Micro-Strain, Inc. Stone Run Rd. (Loop Detectors For Traffic Count And Control-Plug-In) ..... A

PA: WARMINSTER
Fischer & Porter Company 51 Warminster Rd. .. AAAA

TC: [illegible]
Sprecher [illegible] Inc. Dept. T, P.O. Box [illegible] X

WASH: [illegible]
Opeco Inc. Dept. T, 720 [illegible] St. S.W. ..... AA

COUNTERS-Traffic
[illegible] Co. 8335 Northwest Highway, Chicago, IL 60630 (312-[illegible])
[illegible] Co., Inc. 2336 Melwood Ave., Toledo, OH 43611 (419-[illegible])
[illegible] Company, NY 14445
[illegible] Co., Inc., Lancaster, PA 17604
[illegible] Co., Inc., Lancaster, OH 43065
[illegible] Co., Inc., Syracuse, NY 13211
[illegible] Mfg. Co. Inc., Stamford, CT 06471
[illegible] Co., St. Charles, IL 60174
[illegible] Amor Div., Mangood Corp., Grayslake, IL 60030

476 [illegible]

COUNTERS, Traffic: *See also Counters, Hand Tally*

[illegible] Co., Inc., Main St., Woodbury, CT 06798 (Schematic Processing Equipment) ..... (I)
[illegible] Corp., 31-40 Park Rd., Totowa Boro, NJ 07724 ..... (IR)
[illegible] Signal Co., Inc., 328 W. Third St., Uhrichsville, OH 44683 ..... (K)
Leupold & Stevens, Inc., Box 688, Beaverton, Or 97005 ..... (LS)
[illegible] Inc., 720 [illegible] St., S. W., Bremerton, Wa 98310
[illegible] Amor, Div. of Mangood Corp., Sluser & Wiche, Grayslake, IL 60030 ..... (S)
[illegible] Co., 70 [illegible] St., New Haven, CT 06510 ..... (TC)

VEHICLE WEIGHING

CAL: BELMONT
HOMS, DOUGLAS CORP. 1642 Industrial Weigh (415—592-1616) ..... AA
CONN: STAMFORD
METRODYNE CORP. 22 Acosta St. (203—437-4376) X
IND: TERRE HAUTE
WINSLOW SCALE CO. 25th & Haythorne, P.O. ox 1523 (812—466-1231) ..... AAA
MD: BALTIMORE
LOADOMETER CORP. 1700 Union Ave. (Portable Vehicle Scales For Over-the-Road & Off-Highway Wheel Load Weighing) (301—366-1711) ..... A
MASS: WALTHAM
BCH ELECTRONICS 42-T Fourth Ave. (617—890-6760) ..... AAAA
MICH: SOUTHFIELD
STERLING SCALE CO. INC. 20952 Boening Dr. (Truck) (313—358-0890) ..... AAA
MO: WEBB CITY
WEBB CORPORATION, THE 406 E. Broadway (417—673-4646) ..... AA
NJ: BOUND BROOK
INTEC INC. 416-T Vosseller Ave. (201—356-8112) .. AA
NJ: CLIFTON
HOWE RICHARDSON SCALE COMPANY 680 Van Houten Ave. (201—471-3400) ..... AAAA
OHIO: COLUMBUS
THURMAN SCALE CO. 1937 Refugee Rd. (614—445-8361) ..... AAA
VT: ST. JOHNSBURY
FAIRBANKS WEIGHING DIV. COLT INDUSTRIES 700 E. St. Johnsbury Rd. (802—748-2371) ..... AAAA
WASH: LYNNWOOD
ELDEC CORPORATION 10700 - 13th Ave. W. (On Vehicle) (206—743-1313) ..... AAAA
WIS: RICE LAKE
RICE LAKE BEARING INC. 231 W. Coleman St. (Replacement Scale Parts, Pivots, Bearings) (715—234-9171) ..... AAA

Attachment B: Road Evaluation Equipment Required for Highway Transport Planning in Egypt

A. Pavement Roughness Measurements:

1. One BPR Roughometer: Soiltest, Inc. CT444 or equivalent. This piece of equipment works at an operating speed of 10 miles/hr and it will be used only for calibrating the Portland Cement Association Roadometer which works at an operating speed of 50 miles/hr
2. Four units of PCA Roadometer: Soiltest, Inc., Model ML-500B or equivalent. Also as it is explained in HRB Special Report No. 133, some types of automobiles cannot work with the apparatus for unknown reasons, it is required that the apparatus be supplied with a reliable automobile such as a Ford Custom 500.

B. Pavement Deflection Measurements

1. Recordable Benkelman beam, Soiltest HT300 and HT320 or equivalent, two are required. They will be used to calibrate the Dynaflect.
2. Dynaflect, four are required.

C. Skid Resistance

Portable Skid Tester, Soiltest Model HT120, 2 are required.

D. Pavement Coring

4-inch and 6 inch core diameter thin-wall diamond bits to operate with Soiltest DR 705 rig, 60 of each required.

E. Training

It is required that three young engineers attend a 3-month training course in the United States on using the equipment and on PSI measurements. If it is possible, we would like an expert from the United States to joint the Egyptian team during their first measurements for PSI.

TRAFFIC

A. Weigh in Motion Equipment

Required 5 Streeter Amet Weigh in motion device Model 4500/3

B. Traffic Recording Equipment

a) Required 50 Streeter Amet Corporation Model MR-112 for two lane vehicle counter

b) Required 20 Streeter Amet Corporation Model MR-114 for four lane counter

c) Required 10 Streeter Amet Classifier Model 401

N.B. All equipment has to be supplied complete with all necessary accessories, and spare parts for 10 years.

Training

It is required that three engineers each attend a one month training course in the United States on using and repairing the equipment.

ATTACHMENT C

HIGHWAY TRANSPORT PLANNING

PROGRAM

REPORT

for

INVENTORY: CONSTRUCTIONS, STANDARDS

SCHEDULED, STANDARDS RESPONSIVE & MAINTENANCE

COLLECTED DATA

Ministry of Transport
Egyptian Highway and Water
Authority

TABLE OF CONTENTS

	Page
INTRODUCTION	1
THE ROAD NETWORK	2
PAVED DESIGN ADOPTED	3
SOURCES OF DATA	7
EXAMPLE OF CALCULATION SHEETS	9

INTRODUCTION

According to the agreement held by:

--THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

--FACULTY OF ENGINEERING CAIRO UNIVERSITY.

--MINISTRY OF TRANSPORT AND COMMUNICATIONS.

a) TRANSPORT PLANNING AUTHORITY.

b) ROADS AND WATERWAY EGYPTIAN AUTHORITY.

For adopting the Massachusetts Institute of Technology Road Investment Analysis Model for use in evaluating alternative design, construction and maintenance strategies for the Egyptian Road Network:

The Faculty of Engineering and the Ministry of Transport personnel have cooperated to begin to study the Monofia and Qalubia governates Road network.

The data collected here for the road conditions, Road inventory, geometric standard, traffic counts, vehicle characteristics depend on:

a) The actual information taken from the field survey, traffic survey, and laboratory tests.

b) Adoptation the AASHO Interim Guide methods for calculation of both the total EQUIVALENT SINGLE AXLE LOAD per lane and the Structural Number.

c) AASHO ROAD TEST RESULTS Applied to pavement design in Illinois: H.R.R.--No. 90 (1965).

The road network studied consists of the following links.

1.	SHOUBRA/QALUB	Double	Direction	road	length	7.0 km
2.	QALUB/BANHA	"	"	"	"	35.0 km
3.	BANHA/TANTA	"	"	"	"	44.0 km
4.	TANTA/KAFR EL ZIAT		"	"	"	18.0 km
5.	KAFR EL ZIAT/TOFICIA		"	"	"	8.0 km
6.	QALUB/KANATER	"	road	"	"	9.6 km
7.	KANATER/SANTRISS		"		"	18.0 km
8.	SANTRISS/BAGOR	"	"	"	"	14.0 km
9.	BAGOR/SHEBIN EL KOM		"	"	"	13.0 km
10.	SHEBIN EL KOM/KOM EL AKDER		road	"	"	5.0 km
11.	KOM EL AKDER/BABEL		"	"	"	9.0 km
12.	BABEL/TANTA		road	"	"	11.0 km
13.	KANATER/KATATBA		"	"	"	39.0 km
14.	KHATATBA/TAWFICIA		"	"	"	53.0 km
15.	ASHMON/SANTRISS		"	"	"	9.0 km
16.	BANHA/BAGOR		"	"	"	18.0 km
17.	BAGOR/TAMALAY		"	"	"	23.0 km
18.	BERKT SABEH/SHEBEN EL KOM		"	"	"	12.0 km
19.	QUESSINA/SHEBIN EL KOM		"	"	"	12.0 km
20.	SHOHADA/TALLA/BABEL		"	"	"	17.0 km
21.	SHOHDA/MONOF		"	"	"	km
22.	KANATER/BILTAN		"	"	"	21.9 km
23.	BILTAN/TOKH		"	"	"	4.0 km
24.	BILTAN/BANHA		"	"	"	9.1 km

PAVEMENT DESIGN ADOPTED

FOR THE STRUCTURAL NUMBER

In determining the structural number, the following equations were used:

$$Dt \text{ (or) } SN = a_1D_1 + a_2D_2 + a_3D_3$$

Where a_1, a_2, a_3 are coefficients of relative strength of the surface, base and subbase respectively.

and D_1, D_2, D_3 are thickness in inches of the surface, base and subbase respectively for the composite pavement.

For the coefficients a_1, a_2, a_3 we have used both the following tables:

--AASHO Interim guide coefficients Table 1.

--AASHO Road Test Results applied to Pavement Design in Illinois H.R.R. No. 90 1965 (Table 2).

TABLE 1

COEFFICIENTS OF RELATIVE STRENGTH OF PAVEMENT COMPONENTS

PAVEMENT COMPONENT	COEFFICIENT (3) a_1	a_2	a_3
Surface course:			
Road mix (low stability)	0.20		
Plantmix (high stability)	0.44 (4) *		
Sand asphalt	0.40		
Base course:			
Sandy gravel		0.07 (2)	
Crushed stone		0.14	
Cement treated (no. soil cement):			
650 psi or more (1)		0.23 (2)	
400 psi to 650 psi		0.20	
400 psi or less		0.15	
Bituminous treated:			
Course graded		0.34 (2)	
Sand asphalt		0.30	
Lime treated		0.15 - 0.30	
Subbase:			
Sandy gravel			0.11 (4)*
Sand or sandy-clay			0.5 - 0.10

1. Compressive strength at 7 days
2. This value has been estimated from AASHO Road Test data, but not to the accuracy of those factors marked with an asterisk.
3. It is expected that each state will study these coefficients and make such changes as their experience indicates necessary. (Sources AASHO 127, P, 22)
4. After AASHO ROAD TEST Equation.

TABLE 2

MINIMUM COEFFICIENTS FOR PAVEMENT STRUCTURE MATERIALS

MATERIALS	Min. Strength Requirements			Coefficients		
	MS	CBR	PSI	a_1	a_2	a_3
Bituminous surface subclass						
B-1, B-2; B-3, and B-4	300			0.2		
B-5 and I-1	900			0.3		
I-11	1,700			0.4		
Base Course						
Granular						
Gravel, Grade 7		50			0.10	
Gravel, Grade 9		70			0.12	
Crushed stone, Grade 8		90			0.13	
Water bound macadam		110			0.14	
Selected soil stabilized W/P6			300[c]		0.15	
Granular material stabilized			1450[c]		0.20	
W/PC plant mix			650[c]		0.23	
Granular material stabilized			450[c]		0.20	
W/lime flyash			650[c]		0.23	
Granular material stabilized W/bit materials						
Emulsified asphalts	300				0.16	
Liquid asphalts	400				0.18	
Paving asphalts	600				0.20	
	900				0.24	
PC concrete (new	1,[illegible]		2,500[c]		0.50	
Subbase						
Gravel						
Grade 11		30				0.11
Grade 7		50				0.12
Grade 4		70				0.13
Crushed stone						
Grade 8		90				0.14

--For calculating the traffic count and data in terms of equivalent 18--kip single--axle load applications we have used the following tables:

AVERAGE EQUIVALENCE FACTORS FOR THE DESIGN OF FLEXIBLE PAVEMENT STRUCTURE AASHO INTERIM GUIDE

Serviceability index expected to be reached at the end of the design period: 2.0

TABLE 3

AXLELOAD	EQUIVALENT FACTORS	
	SINGLE AXLES	TANDEM AXLES
2000 - 8000	0.006	---
8000 - 16000	0.18	0.02
16000 - 20000	1.00	0.08
20000 - 20000	2.35	0.17
24000 - 30000	5.80	0.42
30000 - 34000	12.00	0.83
34000 - 38000	20.00	1.38
38000 - 44000	33.00	2.40
44000 - 48000	---	3.50
Passenger Cars	0.0002	

Source: AASHO (127, p. 19a)

SOURCES OF DATA

1. For the location, geometric and traffic count data:

   a) Field survey has been carried out under observation of Eng. Mohamed Khalil Hassen

      --the survey crew consists of 2 groups:

      each group consists of six men and a driver.

      --collecting geometric data was done by two engineers.

   b) The equipment for the survey consists of 20 Traffic counters and two cars.

2. Other Data and Calculation have been carried out by Eng. Abdel Maksoud Sadek, Road Laboratory Department

   Eng. Sayed Ali Khalil, Road Laboratory Department

   Eng. Mohamed Shaker, Road Laboratory Department

   Eng. Ibrahim Nusser, Faculty of Engineering

   Eng. Sayed Abd El Azem, Faculty of Engineering

3. SOIL DATA (subgrade CBR) have been from previous tests carried during execution of the construction of the Roads.

4. The WEATHER (ANNUALRAIN Fall, Dry and wet season length).

   DATA Have been taken from the Meteorology Department Information.

4. For PAVEMENT DATA (surface type, shoulder, carriageway thickness): Pavement field borings have been carried out to determine pavement thicknesses in addition to visual inspections of the pavement surface (deformation, wearing, cracking).
5. For the FINANCIAL COST, Prices and UNIT COSTS have been taken from the up-to-date construction costs of the highway projects items.

EXAMPLE FOR CALCULATION SHEETS

We mention here after an example for the data collected for the link QALUB/BANHA.

--The QALUB/BANHA link consists of 3 sections which run from

Kilo 15.0 - 26.0

26.0 - 35.0

and from Kilo 35.0 - 50.0

---

1. The Pavement of which consists of

   1. <u>SECTION (1) from Kilo 15 - Kilo 26</u>

      The first pavement of this section was constructed in 1958, consisting of:

      a) A layer of pitran gravel of thickness 25cm = 10".

      b) Portland cement concrete layer (without shrinkage or expansion joints) of thickness 17.5 cm = 7".

      c) Hot mix asphalt concrete of thickness 5.0 cm = 2".

--Then first reinforced repavement of this section was constructed in 1962, with the layers as follows:

d) A layer of pit run gravel of thickness 25 cm = 10".

e) Asphalt concrete binder course of thickness 5 cm = 2".

--And in 1972

f) The last surfacing of hot mix asphalt of thickness 5 cm = 2".

2. <u>Section (2) from Kilo 26 - 35</u>

a) Consisting of an old layer of limestone of thickness 25 cm = 10".

--In 1955

b) A layer of 15 cm = 6" or pitrum gravel.

d) A layer of hot mix surface course f 5 cm = 2"

--In 1962

e) A layer of hot mix asphalt concrete f 5 cm = 2"

--In 1972

f) A layer of open graded (premix) hot mix asphalt concrete 6cm = 2.4.

11

--In 1962

e) A layer of 5 cm = 2" hot mix ashpalt concrete and then in 1972.

f) 6 cm = 2.4" open graded (premix) hot mix asphalt concrete.

g) 4 cm = 1.6 hot mix asphalt concrete surface course.

TABLE 4

CALCULATION OF STRUCTURAL NUMBER (SN OR DT) FOR LINK: QALUB/BANHA

Year of Const.	Type of Material Used in Layer constructed	Section 1 From kilo 15 - 26 layer cms	layer inches	Coeff	ΣSN	Section 2 From kilo 26 - 35 layer cms	layer inches	Coeff.	ΣSN	Section 3 From kilo 35 - 50 layer cms	layer inches	Coeff.	ΣSN
1955	Macdam calcarous stone.					15.0	10"	0.14	1.40				
	Stab. sandy clay									15.0	6"	0.05	0.30
	Pit run gravel base	10.0	4"	0.07	0.28	15.0	6"	0.07	0.42	25.0	10"	0.07	0.70
	Port. concrete slab	17.5	7"	0.5	3.50								
	Hot mix asphalt concrete	5.0	2"	0.4	0.80	5.0	2"	0.4	0.80	5.0	2"	0.4	0.80
						5.0	2"	0.44	0.88	5.0	2	0.44	0.88
1962	Pit run gravel	25.0	10"	0.07	0.70								
	Hot mix asphalt concrete binder	5.0	2"	0.40	0.80								
	Hot mix asphalt concrete surface					5.0	2"	0.44	0.88	5.0	2"	0.44	0.88
1970	Hot mix asphalt concrete surface	5.0	2"	0.44	0.88								
1972	Hot mix open graded. (premix)					6.0	2.4	0.34	0.816	6.0	2.4	0.34	0.816
	Hot mix asphalt concrete surface					4.0	1.6	0.44	0.704	4.0	1.6	0.44	0.704
	Total Structural Number				6.96				5.900				5.080
	Total Thickness of Pavement in MM.	675				650				650			

13

CALCULATION OF STRUCTURAL NUMBER FOR PROJECT (OVERLAY 1)

--Layer suggested to be constructed:

Hot mix open-graded (premix) of 6cm = 2.4"

S.N. for OVL 1 } 2.4 x 0.34 coeff. = 0.800

For Project (OVERLAY 2)

--Layers suggested to be constructed:

a) Hot mix open graded (premix) of

6 cm = 2.4".

SN = 2.4 x 0.34 = 0.800

b) Hot mix asphalt concrete surface course of 5.0 cm = 2".

SN = 2.0X 0.44 = 0.88

ΣSN = 1.680

for Ovl2

14

TOTAL STRUCTURAL NUMBER OF SECTIONS AFTER PROPOSED OVERLAY

For OVL 1

Section 1 = 6.96 + 0.8 = 7.76

Section 2 = 5.90 + 0.8 = 6.70

Section 3 = 5.08 + 0.8 = 5.88

* * * * * * * *

For OVL 2

Section 1 = 6.96 + 1.68 = 8.64

Section 2 = 5.90 + 1.68 = 7.58

Section 3 = 5.08 + 1.68 = 6.76

* * * * * * * *

CALCULATION FOR EQUIVALENT

SINGLE AXLES PER LANE

SINCE OVERLAY AND SINCE SEALING

FOR QALUB/BANHA LINK

Years since last overlay = 4

Years since last sealing = 2

VEHICLE TYPE	NUMBER/DAY/LANE	NUMBER OF AXLES	COEFF. FACTOR	N'ESAC/LANE/DAY
Private	4803	2	0.006	57.5
Lorry	1060	2	0.18	381.5
Lorry with Truck	457	2 single 2 dual	0.18 0.42	547
Bus	252	2	0.18	90.5
				1076.5

Equiv. Singel Axles/lane/ 4 year = 1076.5 x 4 x 36 = 2.153 M.11

Calculation for total FINANCIAL COST:

For Project: OV1 1:

Price of Premix course of 6.0 cm	= 50000 x 15 x 2.0 =	1,500,000 LE
Price of Patching for 1cm average	= 50000 x 15 x 4 =	300,000
Sealing or tack coat	= 50000 x 15 x 0.2 =	150,000
Shoulder paving		
3 cm premix course	= 2 x 50000 x 1 x 10 =	100,000
18.5 cm wear course	= 2 x 5000 x 1.25 x =	125,000
Miscellaneous	=	400
		2,575,000 LE

For project OVL 2

The same items above + Surface course of 5 cm thickness =

50000 x 15 x 2.4 = 1,800,000

Total 4,375,000 LE

ATTACHMENT D

INTERCITY TAXICAB OPERATING COSTS

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INTERCITY TAXICAB OPERATING COSTS

1. INTRODUCTION

The vehicle operating cost is considered to be one of the essential items to be taken into consideration in the economic analysis of projects related to road construction and maintenance. Chapter 4 of the draft report of the Highway Cost Model (HCM) examines this item in detail and illustrates upon the input data required for the Model.

During the first run of the computer program for the link of the Cairo-Alexandria Highway between Kafer El-Dawar and Abou-Hoomos, and due to the preliminary nature of such investigation, it was decided to use any available data without going into detail of their precise accuracy. The Berger-Dorsch Egypt National Transport Study, Phase I, interim report, provided these necessary basic data.

2. VEHICLE CLASSIFICATION

The vehicle classification scheme of the HCM proposes five different types of Vehicles:

Motor Cars

Light Goods

Buses

Medium Goods

Heavy Goods

In view of the nature of the different types of vehicles operating on the Highway network in Egypt, some alterations on this classification was introducted.

A. Motor Cars

The motorcars under the HCM proposed scheme include passenger vehicles

seating not more than nine passengers. Estate cars, taxis and hired cars are also included, but not "land-rover" or "mini-bus" types of vehicles.

The data provided by the Berger-Dorsch report, however, illustrates upon some basic differences between the operating characteristics of both private cars and intercity taxicabs (ICTC). This is primarily due to the annual milcage of each type which was estimated to be over 100,000 km for ICTC, whereas for private cars this would normally not exceed 15,000 km. Hence it was considered more appropriate to introduce in the HCM two types for the motorcars.

i. Private Cars

This includes all passenger vehicles having a plate number with "P" registration.

ii. Intercity Taxi Cabs (ICTC)

This includes non-meter taxis operating outside urban areas.

B. Light Goods

The Berger-Dorsch report indicates that this category of vehicles does not represent any appreciable percentage among the different types of vehicles on the road. This type was not, therefore, considered in the present study.

C. Buses, Medium Goods and Heavy Goods

These types were studied in accordance with the requirements mentioned in the HCM classification.

3. OPERATING COSTS

As mentioned before the preliminary data concerning the operating costs

were taken directly from the Berger-Dorsch report. The next step was to carry out a detailed study with the objective of achieving realistic figures concerning the operating costs of the different types of vehicles. The first phase of this investigation was directed towards the operating costs of ICTC.

4. STATIONS FOR THE SURVEY

These were designed to cover the main corridors along which the ICTC operate over the Delta and Upper Egypt as follows:

a. Cairo Zone

There are three main stations in the Cairo area:

1. Cairo--Delta: Destinations for ICTC are: Alexandria; Damanhour, Tanta; El-Mansoura Damietta; El-Mahalla; Shebin El-Kome; Menouf; Desouk; Quesna; Benha.

2. Cairo--Upper Egypt: Destination: Beni-Swaif; El-Menia; Assiut; Sohag, Safaga; El-Fayoum.

3. Cairo--Suez Canal Zone

Destination: Port Said; Ismaillia; Suez; Zagazig.

b. Alexandria Zone

Destination: Mersa-Matrah; Dananhour; Tanta, El-Mahalla; Rasetta; El-Mansoura, Kafer El-Dawar, Zagzig, Cairo.

c. Tanta Zone

Destination: Cairo; Alexandria, Damanhour; Ismailla; Kafer El Sheikh; El-Mansoura, Port Said, Ismaillia.

d. Port Said Zone

Destination: Cairo; Suez; Ismaillia; Tanta; Mahalla; Damietta; Mansoura; Alexandria; Zagazig

e. Ismaillia Zone

Destination: Cairo; Prot Said; Suez; Mansoura; Zagazig.

5. INTERVIEW FORMS

These were prepared with the objective getting a true picture about the operating costs of this type of vehicle, a copy of these forms is attached with this report.

6. EXECUTION OF SURVEY

This task was undertaken by interviewing the drivers at the stations. Two engineers and their assistants spent eight working days on that job. As expected there was at the beginning of the interviewing a reluctancy on the drivers' side to answer them, thinking that the survey might be connected with the Income Tax authority. Other drivers tried to give the impression that they are loosing heavily. Later when they were assured that there was nothing in this interview related to the income tax authority, the forms themselves were the primary support for this view as they contained nothing about their names or their licensing number, a more positive and accurate response was achieved. On the other hand there was some sort of a cross-checking in the forms themselves which would indicate those who might grossly under- or over-estimate any item.

During the interview it was noticed that most of the drivers do not

own their cars. There eixst several private companies who own and operate these services employing the drivers. Data from those who operate these companies were also included in the survey.

Altogether there were about 320 completed interview forms. Twenty of them were rejected as being completely outside the normal range. The rest of the forms were grouped and analyzed to give the answers required.

7. RESULTS

The results were obtained by getting the mean value of each item.

A. Annual Mileage = 70,180 km.

It might be of interest to know that the results indicate that there is a direct relation between the annual mileage of ICTC and the distance between the two cities along which the car operates. The longer the distance between the two cities the larger the annual mileage. The range varied between 36,000 up to 100,000 km/year.

B. Type of Car

The Peugeot 504 GL Estate car dominates the fleet of the ICTC operating on the Egyptian highway. This type, with 7 passengers, presents about 62% of the total number interviewed. One would expect roughly the same percentage would apply for the car s which were in operation during the interview. It might be of interest to know that second to this type of car in percentage is the preceeding Peugeot 404 Estate car.

Characteristics of Peugeot 504 GL Estate

Max towing capacity = 1500 kg

Max power, DIN 93 bhp

Max road speed = 160 km/hr

Engine 4 cylinder, super gasoline

C. Average Present AGE of the Cars

It is noticeable that the average ICTC is relatively new.

Average Age = 4.00 Years

D. Fuel Consumption

Type of fuel: super gasoline

Basic Consumption = 7.67 km/Lt

Basic Cost = 0.08 LE/Lt

Annual Cost = $70180 \times \frac{1}{7.67} \times 0.08$

= 732.02 LE

E. Engine Oil

Basic Consumption = 0.0007 Lt/km

Basic Cost = 0.27 LE/Lt

Annual Cost = 70180 x 0.0007 x 0.27

= 13.40 LE

F. Lubrication

A total sum of 28.00 LE/year

G. Tires

Lifetime = 22,500 km/tire

Cost/tire = 25.0 LE (official price) 52.00 (Actual Price)

Annual Cost = $4 \times 25 \times \frac{70180}{22500}$ = 311.92 LE

H, Maintenance

a. Parts = 250.0 LE/yr

b. Labor = 332.0 LE/yr

I. Driver Cost

As explained before most of the drivers work for several companies. In general the driver receives 20% of the gross revenue earned by the ICTC.

Therefore total cost of driver/year $= 0.20 \times \frac{0.54}{100} \times 6.6 \times 70180$

$= 500.26$ LE

J. Annual Registration

LE 120

K. Fines (for committing any offense against traffic law)/year

LE 48/year

L. Garage

LE 60/year

M. Parking (Fees for the use of the public station)

LE 208.8/year

N. Administrative Overheads

154.8 LE/year

O. Insurance

Due to the high rate of accidents of this type of cars, public insurance companies refuse to make any insurance policy with their operators

GENERAL INFORMATION

Average Speed = 70.18 km/hr (from any city center to city center)

Occupancy Rate = 6.6 passenger/ICTC

Average Fares = 5.4×10^{-3} LE/km

ATTACHMENT E

O-D TRAFFIC SURVEY ON RURAL NETWORK

Dr. Mohamed Owais

1. Objectives

Traffic assignment methods deal with the problem of allocating fixed traffice demands between origin-destination (O-D) paris to an existing or hypothetical transportation network made up of links connecting nodes.

The Logit Diversion Model adopted for traffic assigned on Delta Rural Highway Network in Egypt formulation is:

$$V_i = V \frac{\exp(-\theta \cdot GP_i)}{\sum_{j=1}^{m} \exp(-\theta \cdot GP_j)}$$

where

V_i = volume of a certain vehicle type in a certain year assigned to path i between a certain origin and destination;

V = total demand of this vehicle type in this year between this origin and destination;

θ = intensity of diversion parameter for this vehicle type;

M = number of paths between this origin and destination; and

GP_i = generalized price of path i for this year and this vehicle type.

The generalized pri e formulation is:

$$GP = VOC_i + VALTIM \cdot TT_i$$

where

VOC_i = vehicle operating costs over path i for this year and this vehicle type,

$VALTIM$ = value of time for this vehicle type, and

TT_i = travel time over path i for this year and this vehicle type.

The model's parameters, VALTIM the θ, are vehicle type specific, and will be estimated using disaggregate data concerning route choice.

For the purpose of calibrating both parameters, VALTIM and θ, a survey was conducted on the 8th of August 1977.

2. Design of interview sheet

The interview sheet was designed to collect information about vehicle type, O-D pair route choice. For the O-D pair route choice, three criteria were considered in designing the form: previous knowledge about O-D route alternatives, perception of travel time, and pre-trip route decision. A typical form sheet is included in this report.

3. Selection of interview stations

The interview stations were selected so as to interview traffic in both directions on each link of study area network. Twenty-one interview stations were selected. These stations were located near traffic police check points. Steel barriers were located at interview points for safety precautions. In the following table a list is given for station number and location, and a diagramatic sketch shows the locations.

Station Number	Location
1	Kalama
2	Touck
3	Kafer El-Gazar
4	Quesna
5	Defra
6	El-Tadreib
7	Katatba
8	Nicla
9	Abou-Yoesf
10	Sanries
11	Kafr-El-Gonami
12	Angahs
13	Sars El-Layar
14	Shenwan
15	Meet Abou Sheah
16	El-Kased
17	Betebs
18	El-Batanon
19	Kafer-El-Arab
20	El-Kamsean
21	El-Hadsah

4. Organization

4.1 Interviewing Crews

The Cairo-Alexandria agricultural expressway carries a heavy traffic volume, much more than any other link in the network. For this reason, six interviewers were allocated for each of stations 1 and 2 to interview vehicle drivers in each direction. For stations 3 to 6 four interviewers were allocated for each station. For the rest of the stations, 7-21, two interviewers were allocated; bringing the interview team to 54 members. Also, another 5 interviewers were listed for reserve. At each interview station two traffic policemen were allocated to stop traffic in both directions. Also, patrols in cars were organized to check the progress of the interviewers. Before the survey day, a lengthy meeting was held at Cairo University between the supervising team of the survey and the graduate students from the Civil Engineering Department taking part in the interview. In this meeting, the interview questionaire was discussed and questions raised from the students were answered.

4.2 Timing of Survey

A typical weekday representative of average traffic volumes was chosen for conduting the survey: Monday, the 8th of August, 1977. Traffic driver interviews were conducted from 7:00 a.m. until 19:00 p.m., with a break from 13:00-14:00 p.m.

4.3 Distribution of interviewers to allocated stations

During the meeting held at Cairo University it was decided that all the persons participating in the survey would gather at Cairo University main entrance at 5:00 a.m. on the survey day. Six routes were selected to distribute the interviewers at their interview stations before 7:00 a.m. A bus conveyed the interviewers of stations 1-6 using route number 1. Five Peugeot 6-seat intercity taxis covered the rest of the stations, with stations number 21, 8 and 7 as route 2, stations 9, 10 and 11 as route 3, stations 12, 13 and 20 as route 4, stations 14, 15 and 16 as route 5, and stations 17, 18 and 19 as route 6.

5. Results

5.1 Zoning

The study area was divided into a number of zones. The zone boundary is the governorate boundary of the Markaz which was also considered as zone centroid. The external area surrounding the study area was divided into 11 zones. These boundaries of the external zones were chosen as a natural barrier, such as a canal, and as each zone generated or attracted traffic using a major highway crossing the study area.

5.2 O-D Matrix for each interview station

After the data had been collected, manual processing was carried out. Since five vehicle types were interviewed (private cars, intercity taxis, bus, trucks and trucks with trailers) there are five O-D matrix sheets for every interview station. As the sample size interviewed for each vehichle type was considered as representative of the daily traffic, the O-D matrix was expanded by a factor which is the Average Daily Traffic (ADT) divided by the sample size. Each cell in the O-D matrix was then multiplied by this factor.

5.3 Master O-D Matrix

The master O-D matrix was obtained by adding together the enlarged O-D cells for each vehicle type at each interview station for the 21 stations, producing 5 master O-D matrices for the 5 vehicle types. A typical form of the data analysis is given.

STATION NO.

VEHICLE TYPE

TOTAL SAMPLE SIZE =

A.D.T. =

E.F. =

O \ D	CAIRO	QLUB	TOKH	BNHA	QSNA	BR-SB	TANTA	KAFR ZIAT	KOM HAMADA	BADR	TALA	EL-SHOUDA	SH. EL KOM	MONOUF	BAGOUR	ASHMON	KANATER	1	2	3	4	5	6	7	8	9	10	11
CAIRO																												
QLUB																												
TOKH																												
BNHA																												
QSNA																												
BR-SB																												
TNTA																												
KAFR ZIAT																												
KOM HAMADA																												
BADR																												
TALA																												
EL-SHOUDA																												
SH. EL KOM																												
MONOUF																												
BAGOUR																												
ASHMON																												
KANATER																												
1																												
2																												
3																												
4																												
5																												
6																												
7																												
8																												
9																												
10																												
11																												

وزارة الداخلية - وزارة النقل
جامعة القاهرة -

صحيفة الاستقصاء الشخصي على الطريق
نموذج الطرق الاقتصادى

توقيت البدء فى الاستقبال: دقيقة ساعة

توقيت الانتهاء من الاستقبال

رقم الصحيفة ☐☐☐☐ محطة رقم ☐☐ التاريخ: يوم شهر

١	٢	٣	٤	٥	٦				٧	٨		٩
رقم مسلسل	نوع المركبة	مكان بدء الرحلة المحافظة - مركز أو قسم	مكان انتهاء الرحلة المحافظة - مركز أو قسم	اسماء المدن التى تمر عليها خلال الرحلة	هل تتوقف فى اى من هذه المدن خلال الرحلة				الزمن الذى تستغرقه الرحلة	هل تستخدم هذا الطريق باستمرار		اسباب استخدام أو عدم استخدام الطريق
					لا	تمر				نعم	لا	
						اسم المدينة	الطريق المتوقف	مدة التوقف				

V.6 GOVERNMENT IMPACT ON SMALL-SCALE INDUSTRY

Progress Report

March 15, 1977 - September 1, 1977

This report covers activities carried out in the period of March 15 - September 1st, 1977 under the project on the impact of governmental policy on small-scale industrial development in Egypt. The principal objective of this study is to analyze the ways that government encourages or discourages innovation and expansion in small industrial firms by examining the impact of governmental policies, bureaucratic practices, and organizational structures on the behavior of small entrepreneurs. On the basis of this analysis, recommendations can be developed for policy and organizational changes to increase incentives for expansion in the small-scale industrial sector. Project activities fall into three categories: (1) Data collection and analysis of small-scale industry; (2) Data collection on governmental activities in the small-scale sector and analysis of the interactions between small firms and government; and (3) Recommendations. Because the project is to be completed in a short period (March 15, 1977 - December 15, 1977), we chose to study one industry in depth: shoemaking. This industry was selected because of its export potential, its high labor-capital ratios, and its weight within the private sector.

1. Data collection and analysis of small-scale industry

In this study, small-scale industry has been defined as firms employing under 100 workers. Data on such firms is scattered throughout government ministries; and little of it is current: the last comprehensive census of industrial production was taken in 1966.

The major data bases available for the project are the 1977 GOFI study of the private sector, a 1974 census of firms employing 1-9 workers and a 1972 survey of shoemaking firms. Project activities in the period March - June focused on the discovery, collection, and translation of these sources and on planning the collection of two new sets of data: the first, data on shoemaking firms that have applied for loans from the Development Industrial Bank; and the second, survey data on a stratified sample of 200 shoemaking firms in the Cairo governorate. With the assistance of the Development Industrial Bank, data was collected from the dossiers of shoe

firms that applied for loans on firm characteristics (assets, number of workers, indebtedness, investment projects) and on success in loan repayment. The survey of 200 shoemaking firms is presently underway under the supervision of Dr. Mustapha Kamel El-Said Ibrahim and will be completed by October, 1977. The sample has been stratified by firm assets; this information has been provided by the tax inspectorate for animal wealth. We seek information on firm characteristics (ownership, assets, number of workers, equipment), firm histories, and the contacts between various governmental agents (tax inspectors, social security inspectors, cooperative officials, and so forth) and small firms. We also seek to understand the entrepreneurs' perceptions of their chances for growth and to determine under what circumstances (lower interest rates? no interest-profit-sharing? more flexibility in firing and hiring? increased demand? more secure demand?) small industrialists might decide to invest and expand.

2. Data collection on governmental activities in the small-scale sector and analysis of industry-government interactions

Responsibility for the small-scale private industrial sector is divided between the Ministry for Local Governments and the Ministry of Industry. The former deals with firms employing 1-9 workers; under its aegis is organized the Handicrafts Industries and Productive Cooperative Organization whose member organizations provide some of the raw materials for artisanal producers, market some of their production, provide some social services, and in a few cases, organize joint production. The Ministry of Industry deals with firms employing over 9 and is responsible for licensing the expansion or creation of new productive facilities and for controlling the quality of production. In addition to these two ministries with direct responsibility for the private small-scale sector, other government agencies take decisions with significant impact on small firms. For example, the tax reform currently proposed by the Ministry of Finance, which would lower taxes for all firms in the small-size category that agreed to keep books, would clearly alter the structure of incentives for small entrepreneurs. Regulations on hiring, firing, wages, apprenticeships and social benefits payments are determined by the Ministries of Labor and Social Welfare. The policies and procedures of the Development Industrial Bank and the Nasr Social Bank affect the likelihood of investment by small entrepreneurs.

The principal sources of data on the activities of government in small-scale sector and on the impact of various policies and procedures on expansion in the sector are extended interviews in the ministries and agencies, on the one hand, and interviews with industrialists, on the other. The work in the ministries was begun in a pre-study visit to Cairo in January, 1977, continued during a two-week stay in June, and will be completed in a two-week period in the winter of 1977-8. Site visits to about twenty small firms and cooperatives provided the opportunity for preliminary discussions of the impact of governmental policies and procedures. On the basis of these open-ended discussions, questions were designed for the shoe industry survey described above that will systematically explore the industrialists' perceptions of governmental impact.

Given the uneven quality of the economic data we have and can hope to obtain, it is illusory to expect any rigorous measures of the impact of policy on production and investment decisions. And yet, even from the "soft" data obtained in the preliminary round of interviews, certain trends emerged which are illuminating clues to government-industry relationships. For example, we learned from government officials about new efforts to develop the marketing services of the cooperatives; also, that when cooperatives sell the merchandise of a member, they subtract a sum to be applied at the end of each year against the member's taxes. We learned from the tax inspectors of the extremely high rates of tax evasion among the very firms that are the target group of the cooperatives: typically, these small firms are inspected every four to six years. Virtually no penalties are ever levied against them. We learned from industrialists about their distrust of the apparently arbitrary and erratic interventions of the tax authorities. It comes as no surprise, then, to learn that even in a period of surplus shoe production, members are reluctant to let the cooperatives market their goods, for fear of enmeshing themselves in negotiations with tax inspectors whose notice they might otherwise hope to escape, if not indefinitely, at least for four or five years. In brief, two bureaucracies -- the tax authorities and the cooperatives -- are working at cross purposes. Using the cooperatives as tax collectors is weakening the cooperatives without producing substantial improvement in the collection of taxes. On the basis of data from our

interviews and from the survey we hope to build on cases like the example just cited to develop a fuller picture of the way the policies and procedures of various government agencies work either to provide incentives for industrial growth or, conversely, as in the example, to persuade the industrialist that the prudent course is remaining within old routines and avoiding risks.

3. Recommendations

Although it will be impossible to spell-out recommendations before the study described above is completed, several tentative conclusions are already emerging. First, with respect to measures that the Egyptian government might take within existing budgetary constraints to promote development of small-scale industry, our observations of the interactions between government and business suggest that policies which require considerable bureaucratic intervention and expertise are less likely to be successful than policies that provide across-the-board incentives to which any industrialist might respond. An example of the first kind of policies are technical assistance programs, which presuppose that managers and workers are so deficient in necessary skill that no significant advance is possible without remedying these deficiencies and that this is best accomplished by using experts, administrative agencies (whether Egyptian governmental or international), and a structured program of government interventions to provide training. The World Bank Mission that studied small-scale industry in Egypt (report of June, 1977) has proposed such an approach. An example of the second kind of approach would be reform of the tax system in order to eliminate those features that discourage expansion. Such a reform might be implemented without the creation of new bureaucracies; its success would be far less dependent on administrative competence and far more dependent on appropriate structuring of tax incentives. To achieve this, the Egyptian government would need much better information on the sectors it is trying to tax, regulate, and stimulate than it currently possesses. Though the two approaches are not mutually exclusive, choices must be made; and in our final recommendations we foresee suggesting steps that might be taken to implement reforms of the second type.

Secondly, with respect to measures that foreign funding agencies might take to promote the development of small-scale industry in Egypt, we hope to be able to propose criteria and procedures for financing that would substitute for those currently applied in evaluating loans to large enterprises.

Mustapha Kamal El-Said Ibrahim (Cairo University) has primary responsibility for the completion of part (1); Suzanne Berger (M.I.T.) has primary responsibility for (2); they will jointly prepare part (3). John Potter (M.I.T.) and Judith Chubb (M.I.T.) are associated with the research.

Attachment A: Government Impact on Small-Scale Industry

QUESTIONNAIRE

Introduction: Interviewer explains: In our country in the past we have been interested in big firms and public sector firms. Now we realize that we need to know about small firms, for they are important to the country. We are from Cairo University and we are doing research on this question. After the open door policies, it is clear that this is very important, and we ask your help. What we need is to understand how your business works and what its problems are. Everything you say to me is confidential. We do not record your name. We do not give information on particular individuals to government or to anyone. We are interviewing 200 people and in our report, all the comments and figures from all 200 firms will be combined, so it will be impossible to identify your particular firm.

First, some facts we need to know about your firm:

1. How old is it? _____

2. Is there one owner or more? (Specify) _____

2A. How many workshops? _____

3. To understand how your firm works, could you answer (here insert Arak questionnaire, p. 22-23)

4. This place of work -- do you own it or rent it? _____

   Estimated size _____

5. What are the places you buy raw materials? (Interviewer: take each place and ask for each the following questions:)

   a/ Is it a cooperative or what? _____

   b/ How often do you go there? _____

   c/ Do you pay cash everytime? _____

   d/ If not, what are the conditions of purchase? _____

   e/ Do they always have what you need? _____

QUESTIONNAIRE - Page 2

6. How many regular workers do you have here? (exclude trainees and boys) _____

7. How long have they been here? (Interviewer: In small firms go through individual cases; in firms over ten, get average time in firm and range of time in firm.)

8. How old were the workers when they came to the firm? _____

9. How many trainees and boys help here? _____

10. Did you have more workers or fewer workers three years ago? _____

11. How many hour per day do workers work this month on average? _____

How many did they work three years ago? _____

12. What is the total number of pairs of shoes you made this month?

_____ How many did you make in a month three years ago? _____

13. If you had the opportunity to sell more shoes that you are making now, what would you do? _____

(If he says, 'hire more workers,' ask:
What do you have to offer a worker to get him to come? _____

How do you get rid of the worker when you don't need him any more? _____)

(If he says 'buy more machines,' ask:
What type of machines? _____

Where, how, did you learn about the machines? _____)

(If he says subcontract, ask:
Will he subcontract all or part of the shoes needed? _____

How will he divide profits with the subcontractor? _____)

14. If you need to borrow money to operate or expand, how do you get it? (List all sources) If he says family and friends, ask if they earned it by work abroad)

QUESTIONNAIRE - Page 3

15. If you had the opportunity to borrow money at 2-3% interest to buy machines, would you? _____

(If he says no, ask: Would you consider a new machine if offered, like the Nasr bank offers taxis, with monthly repayment? _____

If no, Or would you agree to get money be a profit-sharing arrangement? _____)

(If he answers yes to Question 15, ask:

What kind of machines would you buy? _____

What kind of guarantee could you offer to the bank? _____

16. Do you produce only when you have orders? _____

(If yes, ask: How do you get orders? _____)

(If no, ask: How do you decide how much to produce? _____

and then ask:

17. How do you sell what you produce? (Interviewer asks: local market? _____ Export market? _____)

18. Sometimes opportunities exist to expand a business, either with more machines or more workers. But owners hesitate. Have you ever been in this situation? _____

(If yes, ask:) Why did you hesitate? _____)

(If he mentions hisgher taxes, follow up with questions. If not, ask directly, Would you hesitate because tax inspectors would look at new machines and more benches and increase your taxes too much? _____ (Explore)

(If he mentions social insurance, follow up with questions. If not ask directly, If you hired new workers, might you have troubles with social insurance? _____ (Explore)

QUESTIONNAIRE - 4

18A. How often do you change your models? _____

Where do you get the new ideas? _____

19. Some people say that government interferes too much; others say that government does not do enough. We would like to know your experiences.

a/ Have you ever gone to the local government? For What? What happened?

b/ Have you ever gone to the government to get raw materials? What happened?

c/ What government officials have come to see you in your shop? What happened? Determine department.

20. What about the cooperatives? What is your experience with them?

21. Many things changed after the October war in 1973. Are things better for you now, worse, or the same? _____ (Explore)

22. When you think about the future, do you think in 2 or 3 years your situation will be better or worse? or same? Do you think your firm will be bigger?

23. Finally, would you like your son to follow you in your business? (If not, why not)

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1977-2[illegible]

V.7 DEVELOPMENT OF IMPROVED MACROECONOMIC AND SECTORAL PLANNING METHODS

Progress Report

June 1, 1977 - August 31, 1977

1. Introduction

Progress continues to be made on this project whose purpose is to improve methods of macroeconomic and sectoral planning which can be applied effectively by Egyptian economic authorities. The emphasis so far continues to be on the assembly and preparation of data necessary for implementing consistent sectoral planning methods. During the period since the last project report some major changes in organization were necessary. However, these have resulted in improved effectiveness in preparation of the data. These changes have also strengthened ties with the Ministry of Planning.

Data preparation has proceeded far enough to begin testing the consistency of the national income accounts for 1973, classified sectorally, with the input-output table for that year. That has yielded experience with the types of problems to be encountered in working with the most recent data. Subsequent data preparation work has also been planned in more detail and is underway. In addition a paper evaluating more current macroeconomic conditions in the Egyptian economy was prepared with Professor Nazli Choucri in conjunction with the project on Egyptian Labor Migration.

2. Changes in personnel and institutional arrangements

The previous Minister of Planning has suggested that the connection of this project with the Ministry of Planning be established through the Institute of National Planning. Therefore extensive discussions were held with the Director of the INP, Mr. Sabry Abdullah, to make arrangements for the cooperation of two members of his staff, Mr. Ibrahim Issawy and Mr. Ali Nassar, on the project. It was believed that definite arrangements had, in fact, been made. However, subsequently, the INP asked for formal subcontracting arrangements and a lump sum payment. Since it was not possible for the project to enter into arrangements of this type, and not deemed desirable even if it were possible, the potential connection with the INP had to be abandoned.

However, with assistance of the present Minister of Planning direct association was established with two other members of the Ministry

Mahmoud Saleh and Morris Farid. These have been the most active and responsible persons in the Ministry in the preparation of input-output tables and other sectoral information which is essential for the multi-sectoral planning methods proposed for development.

Active direction of the project in Cairo continues to be under the supervision of Dr. Amr Mohie-Eldin who has given a wide range of assistance in other projects as well. Mr. Esam Montasser of the Ministry of Planning and Dr. Gouda Abdul Khalik continue to participate actively in the research. The participation of Dr. Ahmad El Safty has been less active and is expected to terminate shortly as he takes up a position in Kuwait.

Professor Lance Taylor of M.I.T. spent a week in Cairo at the beginning of August working actively with members of the project there. Professor Eckaus also spent a week in Cairo in August working on the project.

3. Research Accomplished

The first objective was to gain experience in testing the consistency of the national income accounts and the input-output tables are available for the Egyptian economy. This was done for the year 1973 by estimating a sectorally disaggregated set of final demands for that year. These vectors were summed and multiplied by the $(I-A)^{-1}$ matrix, computed from the input-output table. The resulting set of outputs is now being compared, sector by sector, with output data for the economy. There are a number of discrepancies, some of which are being corrected by re-examination of the national income accounts and some of which may require revision of the input-output tables flows.

However, it is expected that a somewhat more current input-output table will become available in the near future. Therefore, the emphasis on establishing consistency of the input-output table and the national income accounts will shift to this new table.

In addition, detailed plans were made for the estimation of the other sets of data necessary for the implementation of a multisectoral planning model.

Dr. Amr Mohie-Eldin continues his research on the structure of prices and prepared a paper on price and wage policy in Egypt. Dr. Gouda Abdul Khalik has prepared a first draft of a study of the detailed composition of exports

and imports. Dr. Esam Montasser's work on the detailed composition of private and government consumption has also progressed. The contributions of both were necessary in order to make the computations previously described.

During the week which Professor Taylor spent in Cairo, he helped in the programming and final steps of the computation of the technical coefficients matrix associated with the 1973 input-output table and the $(I-A)^{-1}$ inverse matrix and the test of the consistency of the table with the income and output data for 1973. Professor Eckaus continued work on the comparison of the actual and computed output estimates and assessed with Dr. Amr Mohie-Eldin the status of the project and the program of future work.

Another paper was prepared jointly by Professor Nazli Choucri and Professor Eckaus, combining the insights gained in the Egyptian Labor Migration project and the project on Improved Macroeconomic and Sectoral Planning Methods. This paper has been circulated in draft form for comments.

Attachment A: Development of Improved Macroeconomic and Sectoral Planning Methods

A NEW VIEW OF THE EGYPTIAN ECONOMY

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PLANNING PROGRAM

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May 26, 1977

A New View of the Egyptian Economy

1. Introduction

There is a conventional view of the Egyptian economy which argues that the current situation is not a viable one and emphasizes the magnitude of the social and economic problems which must be overcome in order to generate sustained development. To mention only a few of the difficulties which are stressed in this view: the overall rate of economic growth is low, especially as compared to the growth in population; there is an unusually high proportion of consumption of the national income and correspondingly low levels of saving; there is a high rate of inflation, extensive domestic price distortions and production and distribution inefficiencies which arise from that and bureaucratic sources; the economic decision making machinery of the government is slow and cumbersome and there is an apparent absence of cogently planned policies in a number of critical areas.

The pessimists predict that Egypt will become "the Bangladesh of the Middle East." The optimists say that, if the country can only "hold on" for a few years, conveying the image of hanging from a great height by one's fingernails, then revenues from Suez Canal, new oil discoveries and unspecified foreign investments will finally bring some respite to the country. Even in this optimistic view it is believed that the basic problems will not be overcome, but the favorable developments will make it possible to live with the problems and to grow in spite of them.

Yet there are inconsistencies among both "optimists" and "pessimists" holding the conventional view which should create some doubts as to its full accuracy. First, there is the question of how the apparent high rate of growth consumption is being maintained.

That type of phenomenon is usually associated with a high rather than a low income growth. Second, it is also true that imports have risen rapidly, contributing to the balance of payments difficulties, but an inspection of the composition of imports indicates that there is a substantial part which is not final consumption goods but rather inputs into new capital formation. Secondly, looking more widely, the massive migration of Egyptian manpower, while creating local shortages, is also generating substantial incomes earned abroad, a part of which are returning as remittances. Moreover, the common complaints about shortages of domestic construction labor are only partially explained by migration; such shortages could also be counted as evidence of a construction boom. These are only examples of other inconsistencies as well.

Thus, there is evidence that the conventional view of the Egyptian economy is, at least, not fully correct and should be re-examined to determine the extent to which it corresponds to the current realities. It may reflect a stereotyped opinion which though widely held, and having important elements of truth, is not completely accurate. Such a re-examination is the object of this brief note. In the space of only a few pages, a full investigation of the conventional and revisionist views cannot be presented. However, the issues are too important to wait for the full development of the alternative positions but should be raised as soon as possible for broader discussion.

II. The Conventional View of the Current State of the Egyptian Economy

In the interests of brevity - and because the intended readers of this note are already familiar with the situation - this review of the conventional view of the current state of the Egyptian economy will be presented in outline. The economy is commonly characterized as follows:

- low overall rates of growth associated with low rates of investment and saving, and domestic savings in the aggregate being negative;
- relatively high rates of consumption, due to subsidization of important components of expenditures particularly of low income groups as well as control of some consumer prices;
- large balance of payments deficits due to a relatively low growth of exports, and a rapid expansion of imports, again largely because of consumption growth;
- a high rate of inflation, partly "imported" but partly due to domestic pressures;
- rapid growth in the government deficit due to expenditures far outrunning tax receipts;
- growing social and economic inequities represented by unregulated importation of conspicuous luxury imports, ineffective income taxation and subsidies to consumption of middle income groups;
- low labor productivity, particularly in the public sectors due to compulsory hiring requirements and other administrative factors;
- distortions in the price system, including an overvalued exchange rate and price controls and/or subsidies on major intermediate and final goods and services;
- a bureaucratic and control-ridden system of approvals and allocations for major primary and intermediate products;

- open unemployment in urban areas combined with scarcity of particular types of skilled workers;
- a lack of clarity in economic policy which has its effects domestically in unwillingness to accept major policy changes and abroad in discouragement of foreign investment.

The list could undoubtedly be expanded and made more explicit in a number of directions and dimensions. It is also somewhat unfair in that for each generalized complaint there are undoubtedly important exceptions. However, it should be emphasized that it is not being argued here that all of these complaints are, in fact, correct descriptions of the Egyptian economy. Rather the purpose of the listing is simply to characterize the conventional views, widely held both in Egypt and abroad, of the current state of the Egyptian economy.

III. A Revisionist View of the Egyptian Economy

While some of the unfavorable characterizations of the Egyptian economy are undoubtedly correct to some degree, the conventional view is inadequate, if not erroneous, in important respects. Again for the sake of brevity, it will not be possible to provide an exhaustive treatment of this thesis here, but some important qualifications can be pointed out.

A. The Significance of Migrant Labor in Evaluating the Current State of the Egyptian Economy

Everyone agrees that the phenomenon of the rapid increase in the migration of Egyptian labor to other countries of the Mid-East must be quite significant for Egypt as well as for the countries receiving that labor. The migration includes professionals, skilled and unskilled labor. It appears to be mainly short term in nature, rather than permanent, and is already making a substantial contribution to the Egyptian economy via the remittances which are sent back to Egypt.

In Egypt, as in other countries, a careful accounting of the contributions of migrant labor to the economy is not attempted in the national income accounts. However, the principles of proper national income accounting are clear. The earnings of Egyptian migrants who retain their citizenship and plan to return are part of the national income and product of Egypt, though not a part of the domestically produced income. The consumption abroad of Egyptian nationals should be counted like imports or tourist expenditures abroad; a subtraction from the national product. So the net addition to the national product of Egypt, due to Egyptian nationals and permanent residents who are working abroad, is the savings of those persons. It should be emphasized that these savings are not necessarily the same as emigrant remittances. Remittances are just those funds, from savings or other

sources, which happen to be sent back to Egypt in any year. The remittances can be used for any purpose as any other type of funds but a considerable part of them are undoubtedly used to finance domestic consumption in Egypt.

It is understandable that in Egypt, as in other countries, the difficulties of estimating net wage income earned abroad after foreign consumption should lead to the omission of this item. Yet the failure to do the accounting correctly does distort the view of the current state of the Egyptian economy.

Consider the following national income and product identity in which taxes and depreciation are neglected:

National Income = Wages + Rent + Interest + Profits = Gross National Product = Private Consumption + Saving + Government Consumption Expenditures + Exports - Imports.

In this identity, saving, being identically equal to investment, is substituted for investment in the sum of the total uses of the national product. Private consumption naturally appears in the uses of the national product, and, of course, that part of total consumption financed by remittances cannot be distinguished from any other consumption. So the effects on consumption of the earnings of migrant labor which are sent home do appear in the national income accounts. Following the national income accounting principles described above, the savings by migrant labor ought also to appear in the national income accounts. But, as noted, that estimation is never attempted. Only the effects on consumption appear in these calculations. The result is to increase the ratio of consumption to gross national product above what the ratio would be if both the consumption and savings by migrant workers were taken into account.

Although the direction of the effect of neglecting migrant labor income and saving is clear, the previous argument does not, itself, establish the magnitude of the effect. That requires more careful estimation than can be done here, but some rough calculations will indicate orders of magnitude. These will reveal the potential effect of migrant earnings.

The total number of Egyptian migrants working abroad has been estimated in the range from 500,000 to 1,000,000, that is, from roughly five percent to ten percent of the labor force. The income differentials between migrant workers, as compared to domestic wage incomes, has, in turn, been estimated from five to ten times. Thus, the total wage income of migrant workers may be from 25 percent to 100 percent of domestic wage incomes.

But the consumption abroad by migrant workers must be subtracted to obtain the net additions to the national product. If consumption abroad is 80 percent of migrant incomes, perhaps a high figure, so that savings were only 20 percent, the net addition to Egyptian national wage income would be 5 percent to 20 percent. If the consumption rate by migrants were 60 percent of their income and the savings rate 40 percent, the net addition to wage income would be 10 percent to 40 percent.

Suppose now that wage income, in turn, was 60 percent of national income. Then the net addition to national income by migrant workers abroad might range from 3 percent to 12 percent or from 6 percent to 24 percent. This is a substantial amount to be omitted from the national income accounts. It should be noted that as long as the number of non-permanent migrants is growing, this underestimate will, in turn, grow, and will continue to give an erroneous view of the state of the economy.

It was noted previously that remittances need not be associated with current saving

but rather are flows from accumulated funds. These flows may well lag behind savings abroad, if reports are correct that there is some accumulation of funds which is repatriated only when workers return home. If we assume that migrant workers do send back two-thirds of their current saving, that adds 2-4 percent to domestic purchasing power, at the low end of the estimate range. At the high end of the estimate range, remittances add 8-16 percent to domestic purchasing.

If, in turn, the entire amount of remittances are spent on consumption, the additions to consumption range from 2 to 16 percent according to the above calculations. The consumption levels are raised and, since saving is calculated as a residual, subtracting those higher levels of consumption from an unchanged national income, means lower apparent saving. Thus adding percentages such as those to domestic consumption without adding current migrant saving to the national product implies an important distortion of the national accounts. The mistake in national accounting - which, again, is not unique to Egypt - could be in part responsible for the prevailing view of a high consumption-low savings economy. Correcting the mistake revises this conventional view.

It should be emphasized that high private consumption is not the only element in the conventional view of Egypt as a high consumption-low savings and investment economy. The rapid increase in public consumption is partly responsible for this view. Yet government subsidies to private consumption have risen even more rapidly. Those subsidies, while adding to the government deficit, of course, are essentially supports to private consumption. They permit private saving to be more substantial while reducing public saving. Of course, a pound spent to subsidize consumption does not become a pound of private saving.

There are a number of other important effects of large scale migration of workers on the Egyptian economy. These will be followed up in subsequent papers. The preceding calculations, rough as they are, make the point that Egyptian migration of workers to other countries of the Middle East is not a marginal phenomenon of recent years, but a central feature of current economic conditions.

B. A Revisionist View: Egypt as a Booming Economy

The emphasis in the conventional view of the Egyptian economy on the rapid growth in consumption tends to suggest that this is the source of the pressure on the Egyptian economy that is manifest in increasing prices and balance of payments deficits. Correspondingly, the implication is that the levels of investment are relatively low. Yet an examination of both the national accounts and the data on physical production and use of essential components of investment suggest that there has, in fact, been a rapid growth in investment in recent years.

Investment was stagnant, or even declined, for a number of years during the 1960's. In the aggregate in some years it was twelve percent or less of gross national product. Since there were some major net investment projects being undertaken which would account for a large part of the total, this means that there may actually have been disinvestment in some sectors of the economy.

By comparison, in 1974 total investment appears to have grown by roughly 45 percent over 1973 in value terms and in 1975, the increase may have been almost 60 percent as compared to 1974, again in current values. Even when deflated these represent impressive increases.

The national account estimates tend to be verified by real data on production and use of major components of fixed investment. For example, cement production runs from 3,300 roughly to 3,500 thousand tons per year. But in recent years exports, which were about one million tons, have virtually halted and cement was imported at a rate of over 1,300 thousand tons in 1976. Similarly, the import of steel reinforcing bars which had

been negligible in the early 1970's has grown substantially. Domestic production of these bars runs about 220-260 thousand tons per year. In 1976, there were imports of 350 thousand tons.

Investment is reported to have been constrained in 1976 due to growing balance of payments deficits which were controlled by limiting investment. But this again is evidence of the strong stimulus for new investment which exists.

An inspection of the commodity composition of imports also tends to confirm the other data on investments. The machinery and equipment imports rose by 60 percent in 1974 over 1973 and base metals and manufactures rose by almost 150 percent in the same period. Thus, while there can be little doubt that consumption growth is providing a substantial impetus to the Egyptian economy, similarly there can be little doubt that investment growth is also pushing hard on available resources.

Unfortunately, data on the division of investment between the private and public sector is not available in detail. There are some suggestions that private sector investment responded with special vigor to the new policies enunciated in 1973. For example, the value of approvals of private investment undertakings by the General Organization for Industry almost tripled from 1971/72 to 1973, though they subsequently leveled off.

The growth and vigor of the private sector is also shown by the 80 percent increase in its exports of manufactured goods from 1973 to 1974 as compared to a roughly 45 percent increase in public sector manufactured exports. In 1975, exports of manufactures by both sectors declined, with private sector exports falling most.

Finally, the balance of payments deficits and high levels of consumption are, in themselves, circumstantial evidence of a booming economy. The income which is

being used to purchase foreign and domestic consumption goods is not being generated by government transfers alone, nor do those account for the high proportion of investment goods among imports. It is more plausible that high levels of investment are, in turn, pushing consumption.

Thus, again, a conventional stereotype of the Egyptian economy appears to be less than fully accurate. That stereotype emphasizes the inefficiencies, the distortions, the bureaucratic obstacles and lack of initiative in the economy. Yet, however, serious as those impediments might be, the economy appears to have advanced rather rapidly since the new policy directives of 1973. Whether those advances can be sustained and accelerated is another question which can only be touched upon here.

C. A Revisionist Perspective on the Characteristics of Public Administration and Policy Formulation

As noted, the conventional view of Egyptian administration with respect to the economy and other aspects of society is that it is a heavily bureaucratic and control-ridden system. While it is not the purpose of this section to deny this aspect of Egyptian society, it is useful to put it in perspective. And that perspective does create a new view. Again, only a brief outline of the argument will be presented.

There are significant new elements in Egyptian administration and policy formulation. These are:

- domestic political liberalization as evidenced in the greater scope given to public media, the formation of new political groupings, the greater openness and vigor of parliamentary debates;
- wider role in policy-making given to political groups and parliamentary committees as indicated by their active review of government programs;
- impetus to rationalization of economic policy not only in response to pressures from international institutions and sources of economic assistance, but from internal sources;
- the growting emphasis on domestic economic, educational and cultural developments in Egypt, providing a new basis for regional leadership.

These and other changes are hardly sweeping away cleanly and swiftly all the previous patterns of administrative behavior. Rather there is disjuncture between established patterns and new trends and, as a result, new stresses which, on occasion, break out in dramatic forms. Yet, it is clear that the greater participation in political

processes is being encouraged. This is having effects which are not being fully anticipated and which are being dealt with in ad hoc ways. Sometimes steps backward are taken after steps forward. Yet the trends persist. And the domestic political trends are, to some degree, contributing to the entrepreneurship and vitality which is showing in the economy.

IV. The Significance of the Revisionist View of the Current Situation in Egypt

There are many old problems to be overcome in the course of the further political and economic modernization of Egypt. The conventional view emphasizes these problems and, in doing so, fails to appreciate both the strong positive trends which exist and the new problems which are emerging.

The Egyptian economy gives many signs of a system under pressure, struggling with old bureaucratic rigidities and inadequate methods of policy formation and in some ways trying to do too much too quickly. The result is disappointed expectations, inefficiencies and "living beyond its means." But consider what is not true - though often implied: the system is not bogged down by its old rules; liberalization of the economy has not failed to generate entrepreneurship; the labor force has not failed to respond to economic incentives. In the political and administrative areas, liberalization nas not been followed by repression; bureaucratic patterns have not been unchanged; public enterprise has not been content simply to maintain its output positions and private enterprise has not been timid.

Thus, the social and economic problems of Egypt do not have their source in a lack of initiative and ferment. The problems are those of managing growth and change from many sources. Internal investment and foreign migration, domestic liberalization and new patterns of regional leadership, are transforming the country. The problems are difficult ones in their own right and, if not resolved, could frustrate development by generating social inequities and unfulfilled expectations at home and abroad, and could impose unnecessarily high costs through inefficiencies. But the problems of dealing with growth are still easier than those of stagnation and, in their character, more encouraging. The new news of the Egyptian economy is one of hope.

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ISN=2[illegible]

V.8 EGYPTIAN LABOR MIGRATION

Progress Report

June 1, 1977 - September 1, 1977

Progress to Date:

The major effort during this past phase was a continuation of data collection with a view to writing an initial report on the implications of labor migration for the construction industry in Egypt. This paper is to be authored jointly by Professors Mohie-Eldin, Choucri, and Eckaus. Attached is an outline of the paper which indicates the directions of the analysis, the type of data that would be required, and the scope of the analysis.

We focus on the construction industry because it is critical to the economy as a whole, because there is strong evidence of outward migration among construction workers, and because the Ministry of Labor has been concerned with developing procedures for regulating that migration.

During this past period, we have also contributed a paper written with Professor Eckaus, entitled "Interactions of Political and Economic Change: The Case of Egypt" (August, 1977), and prepared two other papers that bear directly on labor migration in Egypt. The first, by a research associate for this project, Ijaz Gilani, is entitled "International Migration: Some Lessons for an Egyptian Migration Policy." This paper reviews the policy experience of Turkey and Yugoslavia (both countries export labor to Europe), and draws some appropriate inferences for the Egyptian case. The second paper, by Professor Choucri, is entitled "Migration Processes Among Developing Countries: The Middle East," and seeks to develop the conceptual basis for systematic analysis of the migration process and of the policy interventions that could affect this process.

Next Phase:

We expect, first, to complete our analysis of migration in the construction industry and draw the implications for the economy as a whole, "clean" the data, and begin more systematic and quantitative analysis of the dimensions of labor migration in Egypt, with the view of generating a comprehensive perspective that would assist in identifying appropriate policy interventions and evaluating current policies.

Difficulties Encountered:

The major difficulties involve obtaining consistent and complete data series on many aspects of labor migration. An enormous amount of time and effort is going into the data gathering and "cleaning."

R. S. Eckaus
A. Mohie-Eldin

Attachment A: Egyptian Labor Migration

Suggested Title:

Migration and Employment in Construction:

Critical Factors in Development

I. **Introduction**

RSE AM This will be a brief statement of the issues and the content of the paper.

II. Employment and development patterns in Egypt: overall and in construction sector

AM A. Overall patterns of employment in Egypt

AM RSE B. Patterns of investment and their significance for construction activity

III. The relations of construction activity to the rest of the Egyptian economy.

AM-RSE A. Input-output and capital forming interrelations of construction with the rest of the economy.

AM B. Distribution of construction in the Egyptian economy

1. Sectoral
2. Relative importance of major projects
3. Geographic

AM IV. Materials, capacity and foreign exchange as constraints on construction activity

NC V. Labor force availabilities in construction

A. Characteristics of labor force in construction and growth

1. Size
2. Age
3. Occupational structure
4. Origins

B. Patterns of recruitment into domestic labor force

NC VI. Emigration of construction workers

A. Overall patterns of emigration

B. Emigration of construction workers

1. Overall patterns

2. Recruitment

3. Returnees

C. Relative wages and effects on migration

NC VII. Special Policies Affecting Migration and Returnees
AM

A. Domestic

Labor permits, political environment

Secondment practices

B. Foreign

1. Saudi Arabia

2. Libya — Work permits

3. Kuwait and Gulf — Laws of nationality

4. Iraq — Residence permits

VIII. Social Costs of Construction Labor Migration

(Note restriction of discussion to unique features of construction labor movement)

RSE A. Emigration and wage increases in construction as a means of adjustment by Egyptian economy to international demands and prices - effects of pushing so much of the adjustment through a single sector

1. On wage costs in the sector

2. On relative costs of investment

3. On stability of labor force and planning problems

4. On gestation periods in construction

AM B. Other social costs

1. On income distribution

2. On rural-urban population movements

3. Relative social versus private marginal products of construction labor

RSE IX. Social Benefits of Construction Labor Migration

A. Improvements in individual-family welfare

B. Social value of remittances in the form of funds - nominal versus shadow price of foreign exchange

C. Savings patterns and the capture of savings

NC X. Conclusion
RSE
AM

A. Distinctive features of construction migration in relation to total labor migration

B. Implications of migration policies and patterns for Egyptian development

V.9 HEALTH CARE DELIVERY SYSTEMS

Progress Report

June 1, 1977 - September 1, 1977

Progress To Date:

During this past phase in our project, we have focused largely on four tasks: (1) delineating the interrelationship between demographic and malnutrition indicators on the one hand, and developmental indicators, on the other; (2) developing a questionnaire to be administered through the Ministry of Health field offices to obtain systematic information on the administration of health services and approaches to malnutrition; (3) planning the subsequent phases of this project; and (4) establishing and formalizing a working relationship between the Cairo University/M.I.T. team and the representatives from the Ministry of Health.

A. Relationship between Malnutrition Indicators and Development

The first major task involved developing means for unravelling the relationship between malnutrition and development. This was done in two phases. First, developing the correlation between infant mortality (as a demographic indicator of malnutrition) and various development indicators; and second, describing the interrelationships using regression analysis. In each phase, the governorate was used as the unit of analysis. Governorate-wide data are highly revealing in indicating the differences among various regions of Egypt with respect to child mortality and to development. Although we have also found that the correlation between both sets of variables were generally low, closer investigations revealed high interconnections among the development variables and close relationships to infant mortality. Indeed governorate data are sufficiently refined to enable an initial untangling of major relationships. The correlation and regression analyses are described in project memoranda prepared by Dr. Field and by George Ropes.[1]

Throughout this analysis, the Sinai was excluded from all calculations, on the grounds that it was anomalous in several responses. Thus there were

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[1] John O. Field, "Correlation: Infant Mortality and Selected Variables by Governorates," (July 19, 1977), and George Ropes, "A Report on Correlation and Regression Analysis of the Egyptian Health Care Data," (M.I.T., August 23, 1977).

24 cases each representing a governorate. The development variables employed were the following: % women in the paid labor force, crude birth rate, % total illiteracy, % femal illiteracy, % urban, % households with electricity, % households with pure water in the dwelling and % households with pure water in the building.

Two major dependent variables were examined: infant mortality and crude birth rate. The most important results to date include the following: first, there are significant differences among regions of the country in terms of the relationship of demographic and malnutrition variables to developmental ones. Egypt cannot be treated as a single entity if the factors affecting infant mortality in various regions of the country are to be understood.

Second, the results indicate that development is not a simple or direct path to reduced infant mortality. For example, illiteracy alone has little impact on infant mortality ($R^2 = .05$) and female illiteracy has even less impact. Similarly, reduction of birth rate alone has only a limited impact. For urban governorates $R^2 = .23$. However, when the effects of total illiteracy and birth rate <u>together</u> are examined, they account for 50% of the observed variance in infant mortality (i.e., R^2 increases to .50). Neither a reduction in the birth rate alone, nor an increase in literacy alone has a direct impact on reducing infant mortality. But together, their combined effect is to reduce infant mortality.

Third, for some regions of the country, other developmental variables, such as urbanization and total illiteracy have important effects on reducing infant mortality. By the same token, the most significant determinants of the birth rate are delineated when the data are disaggregated by governorate. Urbanization is consistently an important factor in reducing the birth rate and, again, there are marked differences among the governorates.

These results are still tentative, pending further analysis and refinement, but point to the importance of focusing on the governorates in order to obtain a more disaggregated, and more accurate, perspective on the relationship between demographic and development variables in Egypt.

B. Developing a Questionnaire on Health Delivery

The second major task undertaken during this past period was the development of a questionnaire to be administered through the bureaucracy and agencies of the Ministry of Health to obtain systematic information on the perspective from the periphery, and on assessments of malnutrition by those who are responsible for administering the Ministry's policies on these issues. The draft questionnaire was prepared initially at M.I.T., and revised following discussions with the Cairo University team and representatives from the Ministry of Health.

The major thrust of the questionnaire is two-fold: (a) to elicit information on the Ministry's perspective on health delivery and malnutrition problems; and (b) to request systematic data from the Ministry's own files, both at the center and at the periphery.

C. Planning Subsequent Phases of the Project

The next phases of this project include:

(a) the final completion of the questionnaire and its dissemination through the Ministry of Health's own administration;

(b) two papers: one by the Cairo University team; the second with the collaboration of the Ministry of Health. Drs. Shafika Nasser and Mervat El Rafie will complete their review of the malnutrition problem in Egypt and the Ministry's approaches to that problem; Dr. Salah Shahbander and Motaz Mobarak of the Ministry of Health will complete their analysis of the history of the health service in Egypt;

(c) a sample survey to be tested on two governorates, one in Upper Egypt and one in Lower Egypt, in order to obtain more systematic data on health status and malnutrition. The pilot will be undertaken in the fall and a large scale survey at a later stage; and

(d) the inclusion of a two week period of weighing children and attendant training of personnel built into the survey activity.

D. Regularizing Working Relationships with the Ministry of Health

Under the direction of Dr. Salah Shahbander, a weekly meeting between the Cairo University group and the Ministry of Health representatives is held to assure coordination of activities and collaboration. The major effect of these meetings is to enable various participants to present to the entire group their own work, obtain assistance, and develop cohesion

among the group. The meetings are in the form of a seminar to which visitors from M.I.T. and elsewhere are invited to address the group and, in turn, to share some of the methodological and substantive problems.

Problems At This Stage

So far, the major problems involved collection and analysis of health related data. There appear to be strong inconsistencies in observations for the same variables reported in different years, which draw attention to potentially serious data problems. We have developed some hypotheses about the nature of the difficulties. However, despite the data problems, some patterns emerge in the regression analysis that point to major differences among the governorates with respect to the relationship between infant mortality and developmental indicators.

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Attachment A: Health Care Delivery Systems

MEMORANDUM

To: Shafica S. Nasser
Mervat El-Rafie
Salah Shahbandar

From: John O. Field

Date: July 19, 1977

CORRELATIONS: INFANT MORTALITY AND SELECTED VARIABLES, BY GOVERNORATE

You will recall that, while in Cairo in June, I attempted a number of correlations using governorate-level data. The idea was to establish some simple empirical relationships between malnutrition and other features of Egyptian life. This memorandum summarizes my findings and includes both the raw data that I employed and the statistical results derived.

The Data

Most of the data analyzed were drawn from "The Preliminary Results of the General Population and Housing Census, 22/23 November 1976 in Egypt," Central Agency for Public Mobilisation and Statistics, mimeo , 1977, 57pp. Included are the following, all broken down by governorate.

- Women in the paid labor force (percent of "economically active" women six years and older)
- Percent illiterate in the population aged ten years and above
- Percent illiterate among females aged ten and above (calculated from the actual numbers; the percentage figures understate the rate of female illiteracy since the population totals include all ages.)
- Percent urban
- Percentage of households with electricity
- Percentage of households without purified drinking water

- Percentage of households with purified drinking water: tap in dwelling
- Percentage of households with purified drinking water: tap in dwelling or inside building

These variables were each correlated with infant mortality rates for 1973 given to me by the Ministry of Health. In addition, infant mortality rates for 1972 documented by CAPMAS were used to test consistency in the correlations given occasionally major differences in the mortality figures for the two years. Of necessity, infant mortality must serve as a proxy for the incidence and seriousness of basic protein-caloric malnutrition. Regrettably, I was not able to screen out mortality for newly born children under four months of age so as to strengthen the mortality-malnutrition connection. This is something that would be worth doing if the data are available in that form. It would also make sense to do similar runs with toddler mortality rates.*

The final variable included in the correlations is the crude birth rate for 1973, also provided by the Ministry of Health.

These variables are all plausibly linked with infant mortality, especially when arranged by governorate for purposes of capturing variation within the country and the extent to which mortality is, in fact, associated with other conditions.

Conspicuous by their absence are data on per capita income by governorate. Please send these data to me, if they are available, along with anything else that you would like me to work on.

Theory

In the main, infant mortality should be correlated with variables such as these. One would also expect the associations to be visible at the governorate level. That is, governorates high in infant mortality might be expected to show high birth rates, high illiteracy, and low indices of development, whereas governorates with low mortality rates would be expected to show relatively low birth rates, less illiteracy, and higher levels of development.

More specifically, as women enter the labor force in increasing numbers, it would be reasonable to hypothesize that infant mortality will decline in response to the greater income earned by the family and the improved wellbeing made possible by this added income. On the other hand, a number of analysts (Hart, Reutlinger-Selowsky, etc.) have posited the opposite effect: decreased child welfare resulting from reduced maternal attention generally and lessened opportunity for breast feeding in particular. Reutlinger and Selowsky, on the strength of data

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* For the country as a whole, it would be useful to portray infant mortality by monthly age for at least the first year of life and, preferably, for the first three years of life.

from Calcutta, refer to a "negative income effect" for these reasons (Shlomo Reutlinger and Marcello Selowsky, Malnutrition and Poverty: Magnitude and Policy Options, World Bank Staff Occasional Papers, No. 23, Baltimore: The Johns Hopkins University Press, 1976, p. 35).

If the "child survival hypothesis" (Wray, Taylor et al., Brewer, etc.) is correct, higher rates of infant mortality should contribute to higher birth rates as parents replace their losses and compensate for anticipated losses, all the while maintaining a high norm of desired family size. Similarly, if what is true elsewhere is true in Egypt, later children in a family will be more vulnerable to malnutrition, health hazards, and mortality than earlier children, again suggesting a positive correlation between birth rates and infant mortality.

Illiteracy and mortality are thought to go together for at least two reasons. First, illiteracy is an indicator of low development conceived as improvement in population attributes and capabilities. Compared with the educated, illiterates are "backward" and less able to cope with changes taking place around them. Second, illiteracy - maternal illiteracy in particular - is sometimes (Kerala studies, etc.) viewed as a direct barrier to appropriate child care. The illiterate mother is bound by traditional beliefs and practices deemed harmful to her vulnerable child, and she is less adept as well as less inclined to seek proper care when necessary.

Urbanization has long been regarded as a prime indicator of development, more urban societies being, presumably, more developed in a whole variety of ways. On the other hand, social deprivation is often accentuated by economic development, notably in the burgeoning of urban slums and in the multiple insults that afflict people living there. According to several studies (Wray, etc.), malnutrition is a more serious problem among the urban poor than among the rural poor. We might, therefore, expect a positive correlation between percent urban and infant mortality in Egypt, although the reverse might also be true to the extent that urbanization entails higher incomes, greater amenities, improved sanitation and water, and easier access to services, including health care. In such cases, greater urbanity would be accompanied by lower infant mortality.

Electrification is another development indicator which, in the present instance, represents a direct benefit to people in their homes. Appropriately, the distributional quality of development is taken into account. While it would require fairly tortuous reasoning to claim that electrification, as such, should reduce mortality, household electrification may, in fact, be a form of disseminated development which alters people's life-styles enough to trigger other changes that are more directly relevant to mortality (such as whether farm animals are kept in the dwelling, or independently housed). In general, one would expect infant mortality to be lower in places where household electrification is most advanced.

If any indice of disseminated development should have a direct bearing on malnutrition/morbidity/mortality, it is the availability of purified drinking water. With the possible exception of environmental sanitation, no other infrastructural change is more likely to make a difference to this cluster of variables. Households without purified drinking water reasonably accessible to them are prime candidates for high infant mortality rates. Households with purified water in their homes are distinctly advantaged in Egypt, and one would expect a markedly lower incidence of infant mortality in such households than elsewhere, unless a tap in the same building constitutes a functional equivalent.

With the data provided by CAPMAS and the Ministry of Health, I have tested these propositions in the most rudimentary way, making simple linear correlations between infant mortality and the other conditions mentioned, with the data broken down by governorate in order to capture intra-country variation. Primary reliance was on the Pearson r (product moment correlation coefficient), supplemented occasionally by the Spearman r (rank correlation coefficient) as a hedge against possibly faulty data. The Spearman test, normally reserved for ordinal data, makes sense on the assumption that the actual figures being correlated are not always accurate but that the relative positioning of governorates is. All relationships excluded the Sinai, a political anomaly. The other three Frontier governorates were also excluded when the lack of matching data made this necessary.

Findings

The raw distributions (see attachments) support the proposition linking higher infant mortality to lower levels of development in that, regionally, mortality tends to be highest in Upper Egypt, where development has typically lagged behind the rest of the country. So a regional pattern is apparent in the data.

On the other hand, at the governorate level the correlations-with near uniformity-are disappointing substantively and insignificant statistically. Although in the predicted direction, for the most part, they are generally quite low, and little confidence can be placed in them.

SEE TABLE ON THE
NEXT PAGE

That infant mortality is not meaningfully related to women in the paid labor force is perhaps explained by the fact that most Egyptian women are in the labor force, albeit without pay. That is, the difference between the two types of labor implied - one traditional and the other in the modern, organized sector - may not be all that relevant to child welfare. On the other hand, the negative sign suggests that the added income derived from a women's working for pay does not contribute to child welfare either, at least as reflected in mortality data. Something on the

CORRELATIONS: INFANT MORTALITY AND SELECTED VARIABLES, BY GOVERNORATE

	Pearson r		Spearman r_{rho}	
	INFANT MORTALITY 1973	INFANT MORTALITY 1972	INFANT MORTALITY 1973	INFANT MORTALITY 1972
WOMEN IN THE PAID LABOR FORCE *	-.203 n.s.	-.187 n.s.	-.04 n.s.	
CRUDE BIRTH RATE *	.352 Sig.at .05 (one tailed test)	.471 Sig.at .01 (one tailed test) Sig.at .02 (two tailed test)	.299 n.s.	.357 Sig.at .05 (one tailed test)
PERCENT ILLITERATE #	-.079 n.s.			
PERCENT FEMALE ILLITERATE *	-.212 n.s.			
PERCENT URBAN *	.106 n.s.	NOTE: this correlation is reduced by fact that four governorates are 100% urban.		
PERCENT HOUSEHOLDS WITH ELECTRICITY #	-.019 n.s.			
PERCENT HOUSEHOLDS WITHOUT PURIFIED DRINKING WATER #	.199 n.s.		.166 n.s.	
PERCENT HOUSEHOLDS WITH PURIFIED DRINKING WATER: TAP IN DWELLING #	-.174 n.s.			
PERCENT HOUSEHOLDS WITH PURIFIED DRINKING WATER: TAP IN DWELLING OR INSIDE BUILDING #	-.136 n.s.			

* minus Sinai

\# minus - Frontier governorates for lack of matching data

NOTE: Pearson r is the standard linear correlation coefficient measuring the extent to which the same units occupy the same relative position on two variables. Spearman r_{rho} is a rank order coefficient used here as a hedge against possibly faulty data.

order of a "negative income effect" is apparent but mild. Viewed nutritionally, the proportion of women in the paid labor force is not (yet) a positive development indicator.

The one relationship achieving statistical significance is that between infant mortality and the crude birth rate. Moreover, the fact that the correlation is positive supports a linkage made in the literature (Levinson-Abbott, etc.) uniting nutrition policy and family planning. Either existing children must survive for parents to have fewer of them, later children are more likely to die than earlier children, or some combination of the two. Whatever the case, this is a finding which suggests the need for direct health sector attention to malnutrition/mortality, expecially since development - even disseminated development - has such limited impact on the problem.

That infant mortality is not significantly correlated with illiteracy is a case in point. Education to the level of literacy does not seem to result in better child care. In fact, the relationship is slightly inverse. It is even more inverse when female literacy is considered alone. Governorates with lower levels of infant mortality tend to be governorates with higher proportions of illiterate women, Kafr-El-Sheik being a notable example and Kena being another. Still, the correlations are insignificant, and an element of ecological fallacy may be involved.

The remaining results can be summarized quickly. Urbanity and mortality are very weakly related, and again the direction of the relationship is the opposite of what conventional development theory would predict. Household electrification has almost no discernible impact on mortality. The availability of purified drinking water, theoretically an important factor, turns out to be both insignificant and negative in the correlations.

In sum, the message of this exercise -insofar as there is one - is simple and somewhat unexpected. Mortality and fertility are significantly correlated. Mortality and development, variously defined, are not. The former comes as no surprise; the latter does. The two together suggest that direct nutrition - health interventions will be necessary if infant mortality is to be reduced substantially. Reliance on food subsidies and on economic development, the current "policy" in Egypt, is likely to prove disappointing or at least disappointingly slow.*

Possible Explanations

Lest any of this be taken too seriously, there are several reasons why the correlations are so poor aside from the reality of the situation.

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* As if to verify this observation, the Ministry of Health's own calculations show a net decrease in infant mortality of only 11 per thousand between 1952 and 1972, "Basic Statistical Information of Health Services," Ministry of Health, January 1975, p.2

- Infant mortality is an inadequate indicator of malnutrition. Not only is a fair amount of mortality not nutrition related, much malnutrition does not end in mortality. Infant mortality alone does not capture the dynamics imputed by the propositions mentioned above, at least some of which dynamics have delayed effects and may not be fully manifest until data are available for older age cohorts. It is also possible, of course, that the propositions are themselves weak.

- The data may not be sufficiently accurate for the correlations to portray reality. Conceivably, genuine differences among the governorates are not being picked up, resulting in washed out correlations. Moreover, since mortality is generally considered the dependent variable in the relationships under review, ideally one would want to lag mortality or, barring that, maintain time parity. Unfortunately, the mortality data precede the other data by three to four years. This is a likely source of distortion.

- Another possibility is that the hypothesized relationships exist but are not linear. Linear testing, as in the results reported here, would then understate the degree of association.

- It is also possible that the thrust of the propositions mentioned is correct but that other things are going on, intervening between the one-to-one relationships tested with the effect of washing them out. Many of the linkages imputed between mortality rates and other conditions are quite indirect, and the nature of the associations involved may be missed for lack of more complete data. (Needless to say, were there more complete data and were this more than a vaguely suggestive exercise, we would want to go well beyond simple correlations in our analysis.)

- Finally, in a substantive vein it bears noting that the data convey lots of anomalies, correctly or otherwise, from the standpoint of the theoretical expectations advanced above.

  - Cairo and Alexandria, despite their being centers of modernity, reveal fairly high rates of infant mortality. Illiteracy, however, is quite low - comparatively, as is the proportion of households lacking electricity and purified drinking water. Curiously enough, the crude birth rate is also low in Cairo and Alexandria. In terms of the correlations, none of this "makes sense."

  - Aswan suffers from a very high rate of infant mortality but is otherwise nondescript. Matrouh had the lowest mortality rate of any governorate in 1973 (39/1,000) while at the same time manifesting a birth rate that was well above average. Matrouh is also low on illiteracy and average on urbanity. Assyut, average concerning mortality, has a higher-than-average crude birth rate but is low on purified drinking water. And so on. Patterns such as these are death on significant correlations.

The data for Port Said, Suez, and Ismailia show the effects of their being in or close to the war zone, a possible source of additional anomalies.

The Bottom Line

No analysis resting solely on correlations deserves to be paid serious attention, and the data at my disposal may be unequal even to such simple (and simple-minded) treatment.

On the other hand, the exercise has brought to light two distinct possibilities, both of which are important to policy. First, a significant relationship does seem to exist in Egypt between infant mortality and the birth rate. One may infer from this, and with fairly solid theoretical grounding, that family planning objectives would be furthered by investments in better nutrition and health among the very young. The case for nutrition's becoming a higher priority concern of the Ministry of Health is, thereby, strengthened considerably.

Second, the correlations suggest a very weak - and often inverse - relationship between mortality and development. The implication of this is that development is not its own cure, at least in the short run, for the multiple insults underlying infant (and, we may presume, toddler) mortality. Malnutrition may not be a medical problem, as Dr. Bindary claims;* but as a socio-economic problem, which he also claims, it appears to be remarkably resistant to socio-economic development. Health policy, therefore, becomes one of several ways in which the Government of Egypt can impact the problem by means of direct interventions without waiting for "development," finally, to perform its presumed magic.

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* Conversation with John O. Field, June 1977, in Cairo.

cc Wafik Hassouna
George Ropes
Eckaus/Taylor
Nevin Scrimshaw

Y-196

$Y-\bar{Y} = -23.5$
w/o Sinai

REGION	GOVERNORATE	INFANT MORTALITY RATE	Rank	1972 CAPMAS	WOMEN IN THE PMD LABOR FORCE	Rank	CRUDE BIRTH RATE	Rank
Urban					10.8			
N = 4	Cairo	128	3	152	11.0	3	27.4	21
	Alexandria	103	4	125	10.7	4	29.2	20
	Port Said	48	war zone	23 47	10.3	6	3.8 war	23
	Suez	60	war zone	21 56	5.8	18	2.1 war	24
Lower					10.2			
N = 9	Damietta	85	16	85	7.4	13	39.2	9
	Dakahlia	79	17	84	9.7	9	37.0	15
	Sharkia	49	14	103	5.5	20	38.1	12
	Kalyubia	118	4	144	10.2	8	42.3	4
	Kafr-El-Sheik	55	20	12 67	18.3	1	35.0	17 16
	Gharbia	99	11	111	9.2	11	34.5	14 17
	Menoufia	115	5	137	9.7	9	40.1	8
	Behera	71	19	20 82	13.0	2	37.4	13
	Ismailia	74	war zone 18	19 69	8.7	12	16.5 war	22
Upper					7.3			
N = 8	Gizeh	109	6	139	10.4	5	41.8	5
	Beni-Suef	106	8	128	7.4	13	43.4	2
	Fayoum	97	13	128	6.1	17	43.2	3
	Minya	103	9	127	5.8	18	40.8	7
	Assyout	98	12	119	6.2	16	41.1	6
	Sowhag	88	15	101	10.3	6	38.4	10
	Kena	75	18	98	5.2	21	38.4	10
	Asswan	132	2	140	6.3	15	33.9	19
Frontier					2.3			
	Red Sea	180	1	190	3.0	22	34.2	18
	El-Wadi El Gedid	107	7	117	1.9	24	44.5	1
	Matrouh	39	21	24 57	2.2	23	37.4	13
	Sinai	11	war zone	25 57	1.8	25	1.3 war	
EGYPT		98		116	9.2		35.4	
	Excluding Sinai, $X-\bar{X} = -94$				% economically active population (6 years & over) to the total population		1974 preliminary = 35.7 1975, preliminary = 36.0	
		MOH, 1973			CAPMAS 1976		MOH, 1973	

REGION	GOVERNORATE	PERCENT ILLITERATE	Rank	FEMALE ILLITERACY %	PERCENT URBAN	Rank	
Urban		35.7			100%		
	Cairo	34.6	23	35.8	100	1	
	Alexandria	37.4	22	37.4	100	2	
	Port Said	31.9	21	35.2	100	3	
	Suez	44.4	20	42.9	100	4	
Lower		59.4			26.8		
	Damietta	49.4	19	42.4	25.6	15	
	Dakahlia	56.3	11	53.7	24.0	18	
	Sharkia	62.6	9	57.2	20.2	24	
	Kalyubia	53.7	14	49.6	40.9	10	
	Kafr-El-Sheik	70.1	5	61.0	20.8	23	
	Gharbia	54.9	13	52.8	33.4	12	
	Menoufia	56.9	10	56.1	14.7	25	
	Behera	66.2	8	54.7	26.8	14	
	Ismailia	50.8	17	48.3	47.1	8	
Upper		66.7			30.46		
	Giza	53.0	15	50.0	57.0	7	
	Beni-Suef	68.0	7	60.6	24.9	16	
	Fayoum	73.6	1	60.2	24.2	17	
	Minya	70.1	4	60.4	21.0	22	
	Assyut	68.5	6	60.8	27.7	13	
	Sohag	72.8	2	63.9	21.1	21	
	Kena	71.2	3	62.4	22.9	19	
	Asswan	56.0	12	53.9	37.0	11	
Frontier		60.9	41.8*		51.7		
	Red Sea	31.2	25	41.0	84.9	6	
	El Wadi-El Gedid	32.9	24	47.7	22.9	19	
	Matrouh	50.9	16	58.6	45.3	4	
	Sinai (Liberated)	49.6	18	61.4	100	5	
EGYPT		56.5	also	71.0	43.9		
		*any literacy Age 10 and above CAPMAS 1976 Table 20		male = 43.2 NOTE: These figures are not directly comparable because different denominators for age 10+, without pop. totals [illegible]	calculated from CAPMAS 1976 figures		Table 12 pp 5-8

	REGION	GOVERNORATE	1 HOUSEHOLDS WITH ELECTRICITY (%)		2	3 HOUSEHOLDS W/O PURIFIED DRINKING WATER (%)		4	5 HOUSEHOLDS WITH PURIFIED WATER TAP IN DWELLING (%)		6 HOUSEHOLDS WITH (5) OR TAP INSIDE BUILDING (%)	
1	Urban		84.4			1.4			72.5		83.1	
2		Cairo	82.1	3		1.6	20		70.1	3	80.7	3
3		Alexandria	89.6	1		1.2	22		77.8	2	89.6	1
4		Port Said	89.3	2		2.0	19		83.8	1	86.9	2
5		Suez	78.6	4		1.3	21		54.4	4	64.9	4
6												
7	Lower		38.1			26.7			19.3		22.4	
8		Damietta	60.8	6		2.4	18		45.1	5	49.6	5
9		Dakhalia	34.0	13		16.6	16		25.1	8	28.8	8
10		Sharkia	30.0	15		30.4	11		14.5	13	16.2	15
11		Kalyubia	55.5	7		38.5	4		16.2	12	19.8	12
12		Kafr-El-Sheik	23.2	16		23.2	14		14.1	14	16.9	13
13		Gharbia	43.7	9		21.3	15		24.2	9	28.5	9
14		Menufia	39.0	10		41.3	6		4.8	18	12.5	18
15		Behera	33.3	14		25.0	13		17.5	11	20.0	11
16		Ismailia	44.3	8		44.5	4		27.2	7	29.9	7
17												
18	Upper		29.3			38.3			15.2		18.6	
19		Giza	63.1	5		41.6	5		33.8	6	39.7	6
20		Beni-Suef	21.0	19		26.8	12		4.6	19	14.6	21
21		Fayoum	21.5	18		8.0	17		4.6	19	12.2	19
22		Minya	19.8	21		40.4	7		9.0	21	11.4	22
23		Assyiut	23.2	16		37.3	9		13.0	15	16.8	14
24		Sohag	16.0	22		47.3	3		10.0	16	13.7	17
25		Kena	20.2	20		51.8	2		9.9	17	12.3	20
26		Asswan	38.6	11		32.9	10		20.0	10	21.8	10
27												
28	Frontier	Red Sea	37.3	12		57.3	1		14.8		16.1	16
29		El Wadi El Gedid										
30		Matrouh										
31		Sinai (liberated)										
32												
33												
34												
35	EGYPT		45.7			25.2			30.2		35.1	
36												
37											Calculated from	
38												
39			CAPMAS, 1976			CAPMAS, 1976			CAPMAS, 1976		CAPMAS 1976	
40			Table 23 p. 52			Table 26 p. 54			Table 25 p. 54		Table 25 p. 54	

OF SELECTED VARIABLES, BY GOVERNORATE

7/18/77

V-199

	MEAN	VARIANCE	STANDARD DEVIATION	conditions
INFANT MORTALITY				
a) 1973 data (MOH)	94.1 91.9	884.9 503.7	30.4 22.9	minus Sinai minus 4 Frontier governorates
b) 1972 data (CAPMAS)	109.1	1142.4	34.5	minus Sinai
WOMEN IN THE PAID LABOR FORCE (CAPMAS, 1976 Table 18, p.47)	8.0	13.4	3.7	minus Sinai
CRUDE BIRTH RATE (1973 data, MOH)	34.2	123.5	11.4	minus Sinai
PERCENT ILLITERATE (CAPMAS, 1976 Table 20, p.49)	57.7	138.9	12.1	minus 4 Frontier governorates
PERCENT FEMALE ILLITERATE (CAPMAS, 1976)* *age 10 yrs +	52.1	77.9	9.0	minus Sinai
PERCENT URBAN (CAPMAS, 1976 Table 12, pp.36-8)	43.6	884.2	29.7	minus Sinai
PERCENT HOUSEHOLDS WITH ELECTRICITY (CAPMAS, 1976 Table 23, p.52)	44.2	556.6	24.4	minus 4 Frontier governorates
PERCENT HOUSEHOLDS W/O PURIFIED DRINING WATER (CAPMAS, 1976 Table 25, p.54)	25.49	280.4	17.2	minus 4 Frontier governorates

(over)

		MEAN	VARIANCE	STANDARD DEVIATION	conditions
PERCENT HOUSEHOLDS WITH PURIFIED DRINKING WATER: TAP IN DWELLING (CAPMAS, 1976 Table 25, p.54)		28.6	553.8	24.1	minus 4 Frontier governorates
PERCENT HOUSEHOLDS WITH PURIFIED DRINKING WATER: TAP IN DWELLING OR INSIDE BUILDING (CAPMAS, 1976 Table 25, p.54)		32.6	648.4	26.1	minus 4 Frontier governorates

DRAFT

Attachment B: Health Care Delivery Systems

Progress Report on Correlation and Regression Analysis of Egyptian Health Care Data

Submitted by George Ropes, August 23,1977

The results obtained from John O. Field's correlation analysis of data provided by CAPMAS and the Ministry of Health (see JOF memorandum of July 19,1977) prompted further analysis of those data. Accordingly, at Prof. Field's request I have been engaged for the past several weeks in submitting the data to more complex statistical scrutiny, utilizing MIT's excellent computer facilities. I employed the Statistical Package for the Social Sciences (SPSS).

The data were punched on IBM cards and entered into the computer. Each governorate was considered a case. Sinai was excluded from all calculations, on the grounds that it was anomalous in several respects. There were thus 24 cases. Data were available on a total of eleven variables:

1) Infant Mortality Rate 1973 (Mort73)
2) Infant Mortality Rate 1972 (Mort72)
3) Percent Women in the Paid Labor Force (Pdlabor)
4) Crude Birth Rate (Birth)
5) Percent Total Illiteracy (Totillit)
6) Percent Female Illiteracy (Femillit)
7) Percent Urban (Urban)
8) Percent Households with Electricity (Elec)
9) Percent Households without Pure Water (Nowater)
10) Percent Households with Pure Water in the Dwelling (Watrdwel)
11) Percent Households with Pure Water in the Building (watrbldg)

Twenty-one cases had values for all eleven variables. The Frontier governorates were missing values for Variables 8-11.

The first procedure followed was to reconfirm and extend Prof. Field's correlation computations, employing somewhat refined data. (Female illiteracy rates were recalculated from the CAPMAS data, as were total illiteracy rates for the Frontier governorates.) Means and standard deviations were obtained for all variables. Pearson correlation coefficients were obtained for Mort73 and Mort72 against all the other variables, both for Egypt as a whole, and for the various regions. See the appended table for a summary of the significant correlations. The aggregate data for All Egypt is shown to be masking significant relationships that only become apparent when the data are disaggregated.

Scattergrams were also produced for Mort73, Mort72, and Birth, against all other variables, in order to provide a visual representation of the distribution of the data. These plots tended to confirm the observation that the regions were distinctly different.

Multiple regression is a statistical technique which indicates the combined effect that several independent variables may have in explaining the variance in a given dependent variable. Regression may be used either descriptively or inferentially to predict values from an observed sample. In this case, we were primarily concerned with describing the relationships among our set of demographic and developmental variables. Three different dependent variables were examined: Mort73, Mort72, and Birth.

A large number of computer runs were made, for Egypt as a whole and different regions separately and together, in order to clarify as much as possible our understanding of the interactions among the variables.

In our first runs, four variations were tested, involving all combinations of Totillit and Femillit, and Watrdwel and Watrbldg. The combination of Totillit and Watrbldg proved to be the most descriptive of the four possibilities.

In the course of our proceedings, we became concerned that our R^2 values were being artificially inflated by multicolinearity among the independent variables. Therefore, each independent variable was successively regressed against all the other independent variables. High F values for these equations were taken to indicate multicolinearity. On the basis of these runs and an examination of the individual F values for the variables in these equations, Elec and Watrbldg were excluded from the final series of runs. The independent variables which were included were: Pdlabor,Birth,Totillit,Urban,Nowater. Parameters were established which caused only those variables which were significant at the 0.1 level and which had at least 25% of their variance not explained by the variables already in the equation to be entered. A summary of results is appended.

Residual plots were also generated. No glaring problems were evident from an examination of these plots.

Discussion:

Substatively, the relationships elucidated by this exercise are extremely informative.

The first point worth of note is the importance, even necessity, of disaggregating the data. Egypt cannot be treated as a single entity if the factors affecting infant mortality in the various regions of the country are to be understood.

Second, the importance of collecting complete and accurate data is underlined. The differences between the results for Mort73 and Mort72 highlight this point. Given good data, one would expect less variability in the relationships from year to year, and from region to region.

Third, it is apparent that development is not, at least directly, the path to reduced infant mortality. For example, total illiteracy alone has little effect on infant mortality (All Egypt: R^2=.05, F=2.27 n.s.). Female illiteracy has even less impact (R^2= -.01, F=0.63 n.s.). Reducing the crude birth rate likewise has only limited impact (Urban/Lower/Upper: R^2=.23, F=7.18). When both are entered, however, Totillit and Birth together account for 50% of the observed variance in Mort73 rates. Most of Totillit's impact on Mort73 is thus indirect, through the Birth variable. Further path analysis of this type will be pursued.

Correlations: MORT73

Region	Significant at .01	Significant at .05
All Egypt	-----	Birth
Urban Lower Upper	Birth	-----
Urban Lower	-----	Birth
Lower Upper	-----	-----
Urban	-----	Birth
Lower	-----	-----
Upper	-----	Totillit Femillit
Frontier	-----	Femillit

Correlations: MORT72

Region	Significant at .01	Significant at .05
All Egypt	Birth	-----
Urban Lower Upper	Birth	-----
Urban Lower	-----	Birth
Lower Upper	Birth	-----
Urban	-----	Birth
Lower	-----	-----
Upper	-----	Totillit Femillit Urban Elec
Frontier	-----	Femillit

MORT73

Urban[1] Lower Upper	Mort73 = 104.778 + 1.827 Birth - 1.283 Totillit (4.663)[c] (3.320)[b]	[R^2=.50, F=10.99 (.001)]
Urban[2] Lower	Mort73 = 148.438 + 1.721 Birth - 2.415 Totillit + 0.688 Nowater (5.987)[c] (5.817)[c] (2.706)[a]	[R^2=.80, F =17.21 (.001)]
Lower[3] Upper	No variables entered at 0.1 level (F)	
Lower[4]	No variables entered at 0.1 level (F)	
Upper[5]	Mort73 = 202.833 - 1.526 Totillit (2.549)[a]	[R^2=.43, F=6.49 (.05)]
Lower[6] Upper Frontier	Mort73 = 205.015 - 1.782 Totillit (2.942)[b]	[R^2=.28, F=8.66 (.01)]

1: 21 cases
2: 13 cases
3: 17 cases
4: 9 cases
5: 8 cases
6: 20 cases

Student t statistic in parentheses (DF=N-k-1) (two-tailed)

a = .05
b = .01
c = .001

MORT72

Urban[1] Lower Upper	Mort72 = -34.076 + 3.140 Birth + 0.850 Urban (6.032)[c] (4.122)[c]	[R^2=.63, F=18.42 (.001)]
Urban[2] Lower	Mort72 = -85.122 + 3.337 Birth + 1.288 Urban + 1.025 Nowater (6.601)[c] (5.441)[c] (2.770)[a]	[R^2=.78, F =15.53 (.001)]
Lower[3] Upper	Mort72 = -38.401 + 3.044 Birth + 1.140 Urban (3.783)[b] (2.437)[a]	[R^2=.46, F=7.93 (.005)]
Lower[4]	No variables entered at 0.1 level (F)	
Upper[5]	Mort72 = 249.808 - 1.532 Totillit - 0.700 Nowater (4.275)[b] (3.408)[a]	[R^2=.78, F=13.42 (.01)]
Lower[6] Upper Frontier	Mort72 = -42.108 + 1.252 Urban + 2.982 Birth (3.375)[b] (2.941)[b]	[R^2=.40, F=7.57 (.005)]

1: 21 cases
2: 13 cases
3: 17 cases
4: 9 cases
5: 8 cases
6: 20 cases

Student t statistic in parentheses (DF=N-k-1) (two-tailed)

a = .05
b = .01
c = .001

BIRTH (with MORT73)

Urban[1] Lower Upper	Birth = 23.272 - 0.286 Urban + 0.243 Mort73 (6.693)[c] (4.358)[c]	[R^2=.76, F=34.28 (.001)]
Urban[2] Lower	Birth = 14.647 - 0.355 Urban + o.332 Mort73 - 0.266 Nowater + 0.920 Pdlabor (7.651)[c] (6.665)[c] (2.635)[a] (2.432)[a]	[R^2=.90, F =29.8((.001)]
Lower[3] Upper	No variables entered at 0.1 level (F)	
Lower[4]	No variables entered at 0.1 level (F)	
Upper[5]	No variables entered at 0.1 level (F)	
Lower[6] Upper Frontier	No variables entered at 0.1 level (F)	

t statistic in parentheses (two-tailed)

a = .05
b = .01
c = .001

1: 21 cases
2: 13 cases
3: 17 cases
4: 9 cases
5: 8 cases
6: 20 cases

BIRTH (with MORT72)

Urban[1] Lower Upper	Birth = 22.573 − 0.280 Urban + 0.213 Mort72 (7.950)[c] (6.032)[c]	[R^2=.84, F=54.63 (.001)]
Urban[2] Lower	Birth = 29.386 − 0.376 Urban + 0.248 Mort72 − 0.275 Nowater (7.982)[c] (6.601)[c] (2.680)[a]	[R^2=.90, F=38.16 (.001)]
Lower[3] Upper	Birth = 27.815 + 0.166 Mort72 − 0.285 Urban (3.783)[b] (2.697)[a]	[R^2=.49, F=8.93 (.005)]
Lower[4]	Birth = 33.754 − 0.480 Urban + 0.159 Mort72 (2.805)[a] (2.667)[a]	[R^2=.60, F=7.23 (.05)]
Upper[5]	No variables entered at 0.1 level (F)	

Lower[6] Upper Frontier	No variables entered at 0.1 level (F)

t statistic in parenthesis (two-tailed)
a = .05
b = .01
c = .001

1: 21 cases
2: 13 cases
3: 17 cases
4: 9 cases
5: 8 cases
6: 20 cases

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MEMORANDUM

TO: Shafica Nasser
Mervat El-Rafie
Salah Shahbandar

FROM: John Field

DATE: August 18, 1977

EXPLAINING INFANT MORTALITY AND THE CRUDE BIRTH RATE IN EGYPT: SOME INITIAL REGRESSIONS

This is an interim report on a regression analysis of Egyptian data performed by George Ropes and myself in late July and early August, 1977. Our objective has been to see how much we can learn about the dynamics of infant mortality and the crude birth rate in Egypt from a restricted, if theoretically relevant, body of data organized at the governorate level. The analysis is still in progress, with our current findings (reported here) being tested for possible violation of the assumptions underlying linear regression. Vital additional data will be introduced as they become available. Caution in interpretation is warranted on both counts. On the other hand, the findings so far are sufficiently striking to justify "early" sharing with our colleagues in the Health Care Delivery Systems Project.

Background

The present work is a spin-off from the correlations calculated by hand and discussed in my memo of July 19, 1977. Two things emerged from that effort. First, infant mortality in Egypt appears to be very weakly (and insignificantly) correlated with various types of development despite all sorts of theoretical reasons for expecting the opposite. Second, infant mortality appears to be positively (and significantly) correlated with the crude birth rate. The inference drawn was that development, variously conceived, has little impact on mortality but that mortality probably does influence fertility quite strongly while being itself influenced by fertility in turn.

The Analysis

Regression analysis permits identification of those variables that have an independent influence on the dependent variable while taking other selected variables into account. It also permits specification of the degree of influence exerted by each variable in the equation and at what level of confidence. Finally, it permits a test of significance for the equation as a whole, and it indicates how much of the total variation in the dependent variable is being "explained" by the variables in the equation. All this is pretty heady stuff, particularly when the results are as impressive as ours seem, at first glance, to be.

Regressions were run with infant mortality in 1973, infant mortality in 1972, and the crude birth rate in 1973 serving as the dependent variables. Independent (i.e., causal) variables include the percentage of each governorate's population that is urban; the percentage illiterate (total and female); the proportion of women in the paid labor force; the percentage of households with electricity; and the proportion of households lacking access to purified drinking water, having purified water in the dwelling, or having it at least in the same building. Regressions were run for Egypt as a whole (minus the four Frontier governorates for lack of data) and regionally comparing Upper and Lower Egypt, the latter including and then excluding the four urban governorates of Cairo, Alexandria, Port Said, and Suez.

A quick caveat is in order. Of necessity we are trying to explain 1972 and 1973 "effects" by reference to 1976 "causes". The mortality and birth data precede the development data in time, although the latter are said to "cause" the former. This is not as preposterous as it sounds if one assumes - as we must - that distributions in 1976 reflect realities in 1972-3 or even earlier as well.

Findings

Table 1 shows the "best model" explaining infant mortality in 1973. Beta weights, i.e., standardized regression coefficients, are given for each variable. This model, and those in succeeding tables, were generated by step-wise regression, with the computer entering variables in descending order of significance to a limit of .05.

Several things stand out in this table. First, only two of seven possible variables - birth and % illiterate - emerge as having an independent and significant influence on mortality. The rest are either redundant, insignificant, or both. Illiteracy is, in fact, strongly intercorrelated with urbanity, electrification, and purified water (suggesting a markedly skewed pattern of development in Egypt). With illiteracy "entered" into the model, none of these other correlates is a sufficiently independent influence to justify inclusion. The variables which best explain variation in infant mortality - as revealed in these data - are the birth rate and illiteracy, the latter simply being the strongest developmental influence.

Table 1: Infant Mortality in 1973 - Egypt (minus Frontier)

MORT73 =	0.947 BIRTH	-	0.674 TOTILLIT	
Sig.	.01		.01	

Equation sig.: .001 (F = 10.99)
Adjusted R^2 : .500

MORT73 = infant mortality in 1973
BIRTH = crude birth rate
TOTILLIT = total illiteracy (%)

Second, whereas the influence of the birth rate is in the predicted direction, that of illiteracy is not. Higher birth rates are conducive to higher mortality rates. This is either a function of more complete reporting of both phenomena in some governorates as against others, or it is a function of the oft-noted tendency for later children to be especially vulnerable to malnutrition, disease, and resulting mortality. Whichever, the beta indicates that 99 times out of 100, a 1% increase (or decrease) in the birth rate will - on the average - produce almost the same change (.9%) in the rate of infant mortality when the effects of illiteracy are held constant. By comparison, the impact of illiteracy is both weaker and inverse, although still highly significant. A 1% decrease in illiteracy will actually increase the incidence of infant mortality by an average of .67% when the effects of the birth rate are taken into account. We shall see this pattern repeated for mortality in 1972.

Third, not only is the equation as a whole significant at .001, it explains a remarkable 50% of the total variation in infant mortality in 1973. That is, two variables - the birth rate and the prevalence of illiteracy - by themselves and in relation to each other - account for half of the variation observed in infant mortality from one governorate to another! Such power from such parsimony is rare.

In sum, we can assert with considerable confidence that infant mortality in 1973 was influenced principally by the birth rate that year, and, to a somewhat lesser extent, by the degree of illiteracy. Other factors were also at work - we simply did not have measures of them,whatever they are; but we can say that several prominent variables available to us failed to show an independent influence. With birth and illiteracy rates known, urbanity, electrification, the absence or presence of purified water, and the like have very little explanatory power of their own. It is even conceivable that, had data for birth rates been a year or two earlier than those for infant mortality, the impact would be greater still.

Table 2 shows the "best model" explaining infant mortality in 1972. A number of similarities and differences are apparent.

Table 2: Infant Mortality in 1972 - Egypt (minus Frontier)

MORT72 =	1.291 BIRTH +	1.679 URBAN -	1.414 WATRBLDG -	0.615 TOTILLIT
Sig.	.01	.01	.01	.01

Equation Sig.: .001 (F = 24.52)
Adjusted R^2 : .824

MORT72 = infant mortality in 1972
BIRTH = crude birth rate
URBAN = urban population (%)
WATRBLDG = households with purified drinking water in the same building (%)
TOTILLIT = total illiteracy (%)

Principle among the differences is the fact that four independent variables enter the equation, each significant unto itself and each able to improve significantly the total equation's adjusted R^2 as well. That three of the four are stronly intercorrelated measures of development (Urban:Watrbldg, .93; Urban:Totillit, .85; Watrbldg:Totillit, .90) does not - in this instance - obviate their having apparently independent effects. Development, it would seem, comes in different guises and with different implications.

A second difference of note is that the causal strength of the constituent variables in the model is generally greater than before. This reflects both the added number of variables in the model and, presumably, differences in the mortality data for the two years. A 1% decrease (increase) in the birth rate may now be expected to result in an average decrease (increase) in infant mortality of 1.3%, holding the rest of the model constant. Purified water has about the same impact (1%: - 1.4%) inversely. Surprisingly, urbanization emerges as a negative influence. Under the conditions specified in the model, a 1% increase in the urban population yields an increment of infant mortality by a substantial average of 1.7% - evidence once again that some economic development actually accentuates human deprivation. The weaker influence of illiteracy (1%: -.62%) is similar to what it was for mortality in 1973, and again it is inverse. Marginal improvements in literacy will actually add to the mortality rate when the effects of birth rate, urbanity, and purified water are held constant.

The final difference worth mention is that this more complete model improves our explanation for variation in infant mortality. Whereas with the 1973 data we were able to account for "only" 50% of the infant mortality in Egypt, the 1972 data enables us to account for fully 82% of the variation. Only 18% of the variation is not explained by our model, an incredibly low figure when it is realized that this model contains no measures of health services and health status, two fairly direct influences on survival.

In the main, the two models are quite similar in their message. Infant mortality is highly conditioned by the crude birth rate; and development - when represented by heightened literacy or by urbanization - can make the problem worse even while the expansion of purified water to more and more households makes it better. Clearly, different types of development dispose in different directions so far as infant mortality is concerned. The net effect of development may well be felt in its significance for fertility. This effect is shown in Table 3.

Table 3: The Crude Birth Rate in 1973 - Egypt (minus Frontier)

a) With infant mortality in 1973 as candidate for entry...

BIRTH = - 0.721 URBAN + 0.470 MORT73
Sig. .01 .01

Equation sig.: .001 (F = 34.28)
Adjusted R^2 : .769

b) With infant mortality in 1972 as a candidate for entry...

BIRTH = -1.253 URBAN + 0.592 MORT72 + 1.034 WATRBLDG + 0.482 FEMILLIT
Sig. .01 .01 .01 .01

Equation sig.: .001 (F = 58.95)
Adjusted R^2 : .921

BIRTH = crude birth rate
URBAN = urban population (%)
MORT73 = infant mortality in 1973
MORT72 = infant mortality in 1972
WATRBLDG = households with purified drinking water in the same same building (%)
FEMILLIT - female illiteracy

At a glance it is apparent that these models accounting for the crude birth rate are remarkably similar to those accounting for infant mortality. The number and type of variables are the same in each instance, depending on whether one uses mortality data for 1973 or 1972. The overall explanatory power of birth rate models is even greater.

Just as the birth rate has a significant influence on infant mortality, infant mortality has a significant influence on the birth rate. This is an interaction which I suspect is of profound substantive importance, an interaction conditioning the effects (on mortality and fertility) of just about everything else going on in Egypt. Additional work is needed to pursue this notion. Suffice it here to note simply that as mortality increases (decreases) by 1% the birth rate will increase (decrease) by roughly 1/2% when other changes are held constant.

Urbanization, seemingly a foe of reduced infant mortality in Table 2, returns as a friend in Table 3 through its negative influence on the birth rate, which in turn varies positively with mortality. Urbanization consistently diminishes fertility on about a 1%:1% basis, with mortality and other influences partialled. Whether urbanization is, on balance, a positive or negative influence on infant mortality cannot be established on the basis of the analysis to date.

Ambiguity returns again in the second equation of Table 3. Purified water, an effective antidote to infant mortality (1972 data), is a positive influence on fertility. The more water, the more births; and the more births, the more mortality even though more water also means, directly, lessened mortality. The two edges of development are apparent once again.

Similarly, illiteracy among women means higher birth rates, which is what one would expect. However, improved literacy in general has a negative effect on infant mortality (Table 2), which is not what one would expect. Again, the Egyptian situation suggests powerful cross-pressures. Perhaps path analysis can sort out the conflicting tendencies evident in the data.

In the midst of all this confusion, two rather formidable figures stand out. Urbanity and mortality (1973) alone account for 3/4ths of the variation in the birth rate from governorate to governorate. Urbanity and mortality (1972), along with purified water and female illiteracy, account for fully 92% of the variation in fertility. These equations display an explanatory virtuosity rarely seen in cross-sectional analysis.

Regional variation is evident in the data and not merely with regard to levels of mortality, fertility, and the like. The dynamics are different, too, if one can believe regressions in which the number of governorates is quite small (N=13 for Lower Egypt, including the four urban governorates of Cairo, Alexandria, Port Said, and Suez; N=9 for Upper Egypt).

Perhaps the most striking difference between Lower/Urban Egypt when infant mortality is the dependent variable, is the failure of the birth rate to enter the equations for Upper Egypt as against being the first to do so for Lower/Urban Egypt. By the same token, with birth rates as the dependent variable mortality emerges as a strong influence in Lower/Urban Egypt but not in Upper Egypt. The message would seem to be that the mortality-fertility dynamic noted consistently at the national level is pretty much a product of circumstances in Lower/Urban Egypt. In Upper Egypt mortality is most influenced by literacy and the availability of purified water, two aspects of "disseminated development", while variation in the birth rate there is not adequately explained by any of the variables currently in the file.

The only other observation worth making is that for Lower Egypt alone without the four urban governorates, only one model is significant: Urbanity (Beta = -.620) and infant mortality 1972 (Beta = +.590) explain 61% of the variation in the crude birth rate [F = 7.23 (.05)]. Further investigation of the dynamics operating in Lower Egypt are indicated.

Table 4 summarizes the regional findings for infant mortality, and Table 5 does so for the crude birth rate.

Table 4: Infant Mortality by Region

	Lower/Urban Egypt			Upper Egypt		
		(Sig.)			(Sig.)	
MORT73 =	1.104	(.01)	BIRTH	-0.721	(.025)	TOTILLIT
	-1.261	(.01)	TOTILLIT			
	-1.426	(.01)	WATRBLDG			
	1.019	(.01)	URBAN			
Equation Sig.:	.001	(F=41.68)		.05	(F = 6.49)	
Adjusted R^2 :	.931			.439		
MORT72 =	1.357	(.01)	BIRTH	-0.763	(.01)	TOTILLIT
	1.359	(.01)	URBAN	-0.608	(.01)	NOWATER
	0.504	(.025)	NOWATER			
Equation sig.:	.001	(F=15.53)		.01	(F=13.42)	
Adjusted R^2 :	.784			.780		

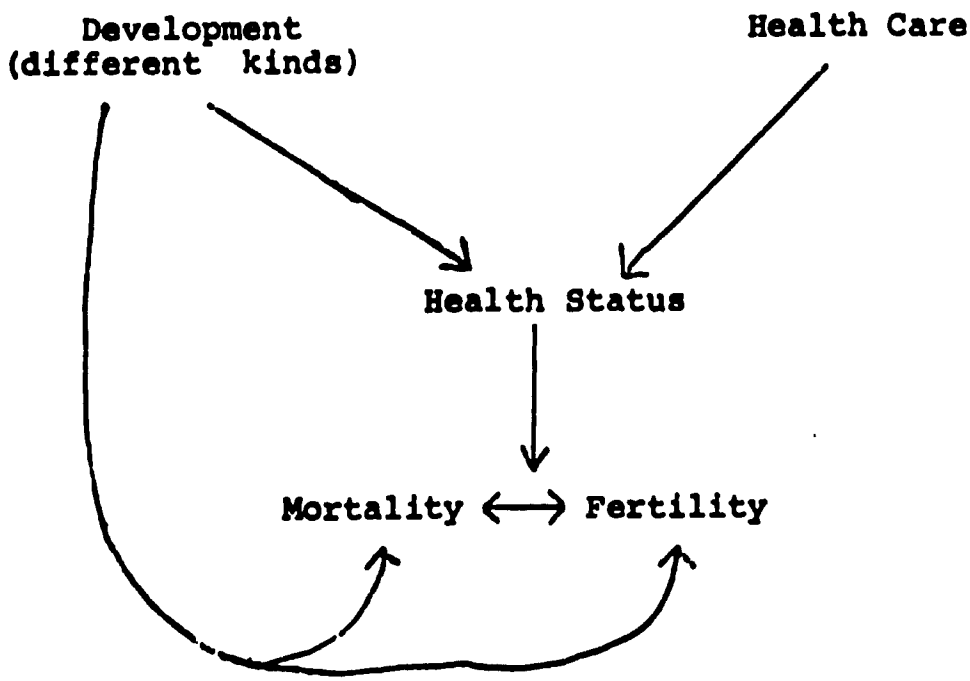
NOWATER = households lacking access to pruified drinking water (%)

Table 5: The Crude Birth Rate by Region

	Lower/Urban Egypt			Upper Egypt
		(Sig.)		
BIRTH =	-0.921	(.01)	URBAN	
	0.616	(.01)	MORT73	
	-0.321	(.025)	NOWATER	
	0.221	(.025)	PDLABOR	
Equation Sig.:	.001	(F=29.80)		
Adjusted R^2 :	.906			
BIRTH =	-0.974	(.01)	URBAN	
	0.611	(.01)	MORT72	
	-0.332	(.025)	NOWATER	
Equation Sig.:	.001	(F=38.17)		
Adjusted R^2 :	.903			

The Next Step

At the same time that we are testing the equations already produced for statistical flaws, we need to add new variables in order to enrich the theoretical value of our models. As discussed in our meetings this week, it would be desirable to have measures both of health services (average population per health center or unit, for example) and of health status (extent of gastroenteritis, schistosomiasis, and the like) at the governorate level. We could then explore the following sets of relationships - an exciting prospect.



+ = positive causal relationship

- = inverse causal relationship

cc: George Ropes
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V.10 ENGINEERING APPLICATIONS FOR THE EGYPTIAN PLASTICS INDUSTRY

Progress Report

June 1, 1977 - September 1, 1977

Objective: To strengthen the area of plastics technology in Egypt.

Progress to Date: The starting date of this project was 1 June, 1977. Since then, the following actions have been taken:

1. Arrangements for technical collaboration have been made with the National Plastics Co., Delta Plastics and El Sharif Plastics, all located in Cairo. Attention will focus on extruded polyvinyl chloride (pvc) pipe and polyethylene (pe) film for fertilizer sacks initially, with some future possibilities which include modified polystyrene (ABS) refrigerator door liners and butane gas tanks of as yet unspecified material.

2. A tensile tester for plastics has been designed by Dr. Bayoumi and reviewed by the people at M.I.T. It should be constructed and in operation by 1 November, 1977.

3. A testing apparatus for pvc pipe will be built and put into operation at Cairo University within the next 1-2 months.

4. A series of tests on sealed joints taken from p.e. film sacks manufactured by National Plastics has been performed. The joints were sound and strong as the base film from which they were made.

5. In response to a request from the Petrochemicals Project, with which a good liaison has been established, work on cross-referencing and comparison of specifications for plastics has begun. This involves identifying the specifications for a particular plastic material or plastic product available from the

American Society for Testing and Materials (ASTM), from the German plastics industry and from Italian sources and comparing them for the purpose of setting Egyptian standards, specifications and operating procedures. Such will be required by the Petrochemicals Project once their production plant comes on-stream.

6. A fairly extensive literature survey on plastic pipe has been completed and copies made for the workers at Cairo University. In addition, subscriptions to several technical journals have been started for them and a library nucleus of 25-30 texts has been ordered.

Activities For the Next Period

During the next period, the following is anticipated:

1. Completion of the construction of the tensile tester.

2. Completion of the pipe testing apparatus.

3. Start of a program of testing fertilizer-filled p.c. sacks to evaluate the seal made at the fertilizer factory, which may be more prone to failure than the one made at the bag factory.

4. Continuation of the work on specifications and standards.

5. Begin a study of the feasibility of replacing welded steel butane gas tanks for home use with tanks made of a suitable plastic. Advantages would include lower weight, corrosion resistance, less noise in handling reduced possibility of explosion in a fire and improved impact resistance.

Project Personnel

Ministry

Dr. Hamid Amer, Head, Petrochemicals Project

Eng. M. El Warrack, Technical Director, Petrochemicals Project

Eng. Mansour Rabid, Manager, National Plastics Company

M.I.T.

Frederick McGarry, Professor of Materials Science

Robert E. Cohen, Associate Professor of Chemical Engineering

John R. Potter, Technical Officer, Technology Adaptation Program

Cairo University

Salah A. Bayoumi, Head, Department of Design & Production Engineering

Mahmoud El Rafei, Associate Professor, Dept. of Chemical Engineering

V.11 LONG-TERM INVESTMENT PLANNING FOR THE EGYPTIAN ELECTRIC POWER SYSTEM

Progress Report

June 1, 1977 - September 1, 1977

The basic objective of this project is to help develop professional skills in applying mathematical economics and operations research to analyze project alternatives for Egyptians concerned with planning electric power projects. The best way to develop autonomous capabilities in this area, as well as the best way to get answers to important investment questions, is to start in right away building simple, practical models, feeding data into them, and analyzing the results. Then, if everything seems to be proceeding smoothly, the models can be made increasingly complex and elaborate, to incorporate more and more features of reality. The emphasis is going to be on developing a hands-on capability for building and analyzing useful, simple, operational models which give answers to some pertinent questions of investment planning.

This basic philosophy has been agreed to by the participants from the Ministry of Electricity, Cairo University and M.I.T. The environment in MOE and Cairo University is favorable for this sort of applied economic analysis because the Egyptian engineers are very able in the technical aspects of their field and are eager to seriously develop their own capabilities in applying operations research and mathematical economics.

In the first weeks of July, several meetings were held in the office of the First Undersecretary of State of the Ministry of Electricity and Energy to discuss implementation of the agreement between M.I.T., Cairo University and the Ministry concerning the study of long-term investment planning for the Egyptian electric power system. The following people attended these meetings: from M.I.T., Prof. Weitzman; from the Ministry of Electricity and Energy, Eng. M. Abaza, Dr. F. Taher, Dr. H. El-Shaer, Dr. E. El-Sharkawi, Dr. M. Sweidan, Eng. El-Gazzar, Eng. K. Yassin, Eng. S. Doss; from Cairo University, Prof. S. Abu-Hassein, Prof. S. El-Sobki, Dr. H. Anis, Eng. H. El-Kolaly, Eng. M. Mahmoud.

At these meetings, a specific simple model of project evaluation was applied to sample data provided by Ministry personnel and some crude sensitivity analysis was performed. Also, we looked at some specific ways of formulating the problem of selecting an optimum combination of steam and gas

turbine generators. Finally, we discussed the general features which would be desirable to include in an expanded model of investment planning.

A research strategy was proposed which consists of the following three projects: (1) a preinvestment survey for investment planning, (2) a study of the optimum mixture of different types of power stations for variable demand, and (3) an expanded model for investment planning.

The first project is concerned with the following set of issues. The Ministry of Electricity is confronted with the task of selecting electricity generating projects from a wide range of options, including hydroelectric, thermal using various fossil fuels, gas turbine, and nuclear. Many of these projects are big relative to the demand being served. In such a situation, it is not clear how to rank projects. Cost per rated kilowatt is not a good measure because there is a fair amount of excess capacity introduced with a large project. We have mathematically formulated the problem of expanding capacity at minimum present discounted cost and, under certain simplifying assumptions, devised a formula for an "equivalent cost per kilowatt" which has a rigorous foundation as the solution to the optimal capacity expansion problem and automatically corrects for the size of a project. This formula can be used to rank various investment alternatives and lends itself very readily to economic analysis whereby the main parameters -- cost of fuel, rate of interest, growth of demand, etc. -- are varied and the effect is noted. We have already applied this methodology to some crude cost figures on various investment alternatives and the results seem to constitute a very useful preinvestment survey. We have agreed on the following execution steps:

- -- data collection for different types of plants;
- -- calculations of the "equivalent cost of capacity" for each type of plant;
- -- ranking the various investment alternatives;
- -- economic analysis (calculating the effects of varying all of the important parameters;
- -- general conclusions and recommendations.

This project is currently underway and it is anticipated that there should be concrete results by November or December. An enclosed paper describes the analytic framework being used. We hope to extend this methodology to a more sophisticated and complicated model. As of September 1st, data collection for six new power plants is almost completed, and preliminary equivalent costs of capacity" have been calculated.

The second project are out of a practical problem suggested by Ministry personnel. The demand for electricity varies -- daily, weekly and seasonally. Some types of plants (steam generators) are relatively cheap per kilowatt provided they are used at near full capacity. At low capacity utilization, they are relatively expensive. Other types of plants (gas turbines) are relatively expensive per peak kilowatt, but the output can be easily and cheaply varied, and they are relatively cheaper per kilowatt at low output. The basic question is this: Given the pattern of demand fluctuations, what is the least cost combination of power station types? We have succeeded in mathematically formulating a very simple version of this problem, but a more sophisticated model should be developed, and it should be applied to real data. The execution steps of this task are:

-- development of a good mathematical model;
-- data collection;
-- model solution on a computer;
-- economic analysis (calculating the effects of varying parameters);
-- general conclusions and recommendations.

This project is underway and we hope to have some results by December. At the present time, a model has been created of fairly general applicability, and a complete computer algorithm to determine the minimum cost plant mixture ratio has been prepared.

The third project area is less well defined than the other two. It involves constructing a much more complicated complete programming model which would determine least cost investment combinations for a very general situation, as contrasted with the piecemeal, partial approaches being undertaken in the other two projects. In principle, such a model could encompass regional effects, investment lumpiness, transmission losses, time variable demand, etc. The drawback is that such a model is hard to formulate, very difficult to solve on a computer, and cumbersome to analyze parametrically because of its large size. We hope to work up to more general formulations of the problem of optimal investment strategies by successively relaxing the constraints in the existing simple models (after we thoroughly understand those models) in directions that seem most fruitful. The third project is not completely defined at this stage, because it depends very much on what we learn from the other two models. As we solve the simpler models, however, we will continually be thinking of how we would like to formulate a more general model.

We are hoping the funding of this project can be expanded in the future because th. project is turning out to be of greater interest and use than was originally suspected and the initial budget underestimated project needs. The original proposal funded sixty (60) hours a month of Egyptian research time, and it now looks as if the project should employ triple that amount if it is to realize its full potential. In addition to developing the third project area, we would to incorporate several new topics in the future.

Attachment A: Long-Term Investment Planning for the Egyptian Electric Power System

Investment Criteria for Lumpy Capacity Expansion

M.L. Weitzman

Summary

Suppose that capacity must be expanded over time in some industry or sector. If all capacity expanding projects are small, it is easy to rank them. The next project to be undertaken should have the lowest cost per unit of capacity. When some investments are large, this simple criterion no longer works. A large project might have low unit costs and yet be undesirable because its huge capacity could only be fully utilized at some future time. The standard approach to investment planning based on an individual evaluation of separate projects doesn't normally work when there are indivisibilities. To determine if and when an individual project should be untertaken, the entire investment strategy must be mapped out in unison. This can be a very messy combinatoric problem, especially if repetitive strategies are disallowed because some ways of increasing capacity are uniquely tied to geographic or other conditions.

Surprisingly enough, it turns out that even when investment projects are big and lumpy, the project analysis approach can be made to work. This is a tremendous simplification, since investment priorities can be ranked by the simple expedient of calculating a single cost-like number for each project. The present paper is concerned with explaining this result, which provides a rigorous theory of investment criteria for choosing among large scale projects.

Introduction

The present paper can be viewed as an exercise in trying to strongly characterize an optimal policy for expanding capacity when investments must be

made in discrete or lumpy projects. Although the theory is developed at an abstract level, perhaps the easiest way to convey its flavor is by starting with a specific example.

Suppose planners are considering the best way to expand electricity generation in some country or region. A more or less steady expansion of the system is contemplated, far into the future. Assume that all electricity must be domestically produced (later we consider the possibilities of exports or imports).

Generating capacity is expanded by investing in individual projects. There may be many alternatives of various sizes. Some projects are repeatable - like thermal or perhaps nuclear power plants of various sizes. Other projects, frequently very large ones, are by their very nature once and for all investments because they are tied to a specific location. Hydro-electric installations readily come to mind. Many of the newer exotic technology projects are also non-repeatable - harnessing tidal flows (Fundy, Britainy), diverting water into natural depressions (Quattara), etc.

The basic question is: which project should be undertaken next? This question is more difficult to answer then might be supposed. Among small projects it would suffice to develop next that generating source offering the lowest (present discounted) cost per rated kilowatt of capacity. But when a project is large, initial excess capacity is almost inevitable. Nor is it clear how to correct the "lowest cost per kilowatt" formula for excess capacity. Indeed, there is no reason to expect that one lumpy investment project may be analyzed in isolation from the alternatives by assigning to it a single number which can meaningfully be compared with the other assigned numbers. In a world of lumpy projects, optimal investment strategies can usually only be

analyzed as an entire (mixed integer) programming problem formulated over some large time horizon. The solution typically involves a complicated interdependence[1] among all the projects which defies any simple analysis. Such problems are combinatoric in nature and they are frequently difficult or expensive to solve.

Of course, if the least cost capacity expansion problem has special features, these may be advantageously utilized in characterizing and finding an optimal solution. Thus, for example, in the Chenery-Manne capacity expansion model,[2] infinite repeatability of all projects and a linearly growing demand limits the strategy space to capacity expansion of one size plant only. An optimal strategy is easily found by locating that size plant which gives lowest present discounted cost when it alone is always expanded to meet new demand. The situation is fundamentally different when non-repetitive projects are considered, and a seemingly messy combinatoric problem immediately emerges.

The basic conclusion of the present paper is that under certain assumptions it is possible to assign each project a "recovery cost" which gives a correct ordinal ranking of when it should be undertaken relative to the other projects. Thus, all the advantages of a single rate of return criterion apply in an unfamiliar context. That project should be next undertaken which has the lowest recovery cost. The formula giving a project's recovery cost is a relatively straightforward adjustment of the cost per kilowatt which takes account of the project's size; it is easy to apply and has an elementary economic interpretation.

While the conclusions of the present paper are based on a simplified model, it is hoped they may be of some use in a wider context. For example,

the notion of recovery cost might prove helpful in providing a rough screening criterion for large projects technically not covered by this paper's formal model.

The Model

We consider a planning situation where the demand for a certain commodity is prescribed at each time and must always be fulfilled. For analytic convenience, the fixed final demand schedule $D(t)$ is taken to be a linear function of time:

$$D(t) = A + Bt. \tag{1}$$

Formula (1) might be defended as a first order approximation holding for at least the near future. It represents a key assumption which greatly simplifies the analysis.

Demand is met by investing in discrete projects which expand capacity. A typical pattern of capacity expansion is depicted in Fig. 1.

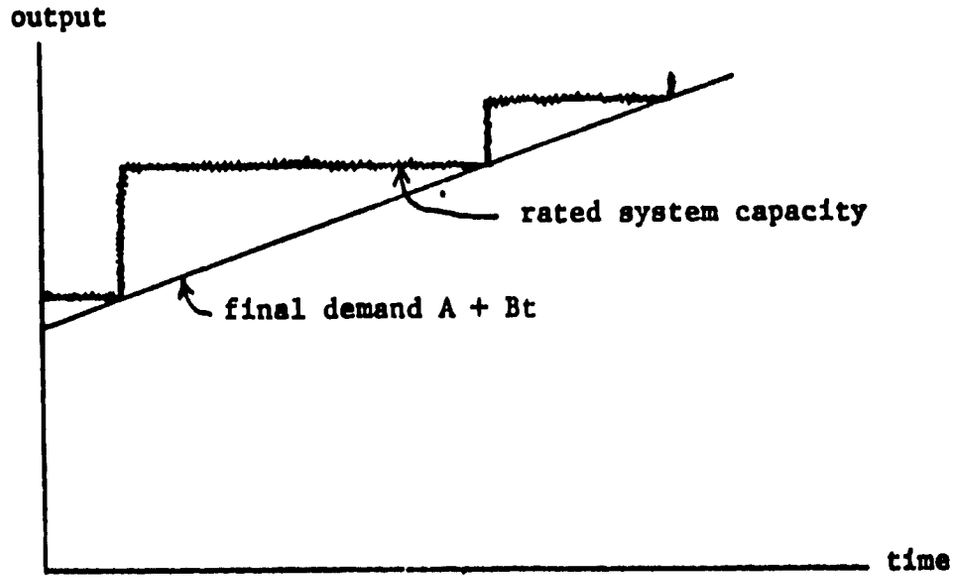


FIGURE 1

Let there be a total of n different projects. The first m of these are unique and non-repeatable. Projects m+1 through n are repeatable and can be invested in over and over again.

Let project i ($1 \leq i \leq n$) have a full capacity output of K_i. Without significant loss of generality, we allow projects to begin producing only when no excess capacity exists in the system (all previous projects are producing at full capacity). If project i is chosen to increase the rated capacity of the system by coming on line at T (a time when there is zero excess capacity in the system), it is restricted to do so according to the following prearranged production schedule. At time t, $T \leq t \leq T + \frac{K_i}{B}$, the output of project i is $B(t-T)$, leaving excess capacity $K_i - B(t-T)$. At time $T + \frac{K_i}{B}$, the output of project i reaches its full rated capacity level, K_i, and it remains there forever (every capacity expanding project is assumed for simplicity to be infinitely durable). Thus, the output stream of project i coming on line at time T would look as follows:

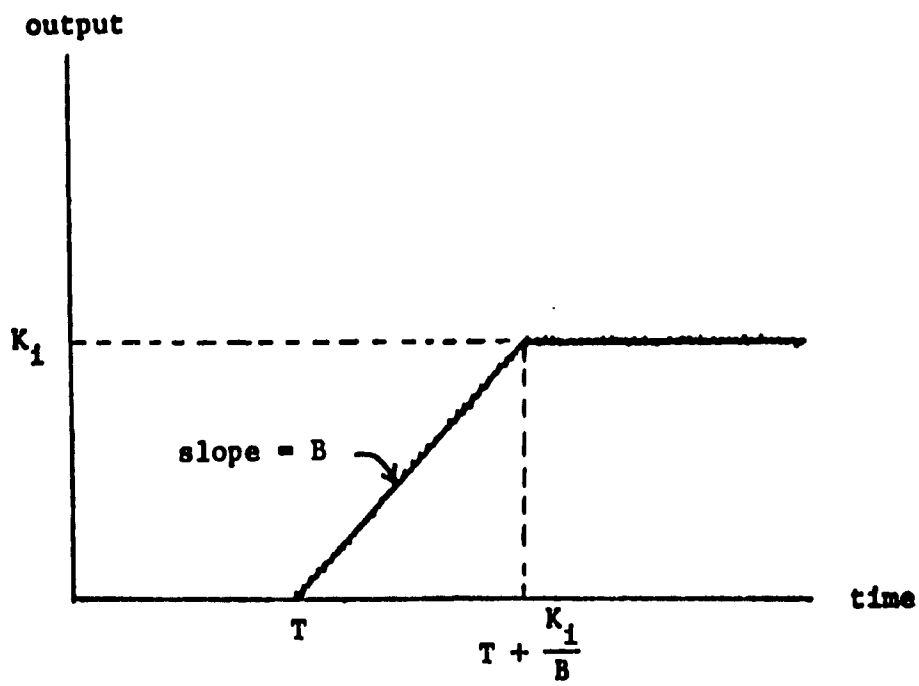


FIGURE 2

If project i is chosen to begin coming on line at T, it forces outlays to be made at time t as given by the project cost function $F_i(t-T)$. When $t<T$, project i is in the primary construction phase. It is during this phase that are incurred the major construction costs associated with creating an installation of size K_i. At times from T to $T + \frac{K_i}{B}$, basic overhead installations have already been completed and secondary capacity is filled in according to the prescribed linear schedule. Finally, for times after $T + \frac{K_i}{B}$, all construction has been completed and the only outlays are variable operating costs.

To use an example from hydro-electric generation, the first phase would be concerned with constructing a dam and creating the basic overhead for a transmission system and other installations. The second phase would involve filling in the existing system with more generators and transmission lines until full capacity is reached. At that time the third phase begins, with full capacity operating costs being the only outlays. For a small thermal plant, the second phase is of minor consequence, the first and third phases being dominant.

Optimal Capacity Expansion

The basic problem is to schedule capacity expanding projects to come on line meeting final demand at minimum present discounted cost. Let the hth plant installed (h=1,2,...) be a project of type j(h) and let it begin operating at time T_h. Mathematically, the problem is to introduce projects in the optimal order j*(1),j*(2),... which minimize

$$\int_0^\infty \sum_{h=1}^{\infty} F_{j(h)}(t-T_h) \quad e^{-rt}\, dt, \tag{2}$$

subject to $$T_1 = \overline{T}_1 \tag{3}$$

$$T_{h+1} = T_h + \frac{K_{j(h)}}{B} \tag{4}$$

for $i=1,\ldots, m$, and $\ell \neq h$, $\quad j(h) = i \Rightarrow j(\ell) \neq i$. (5)

The objective function (2) is the present discounted value of all costs incurred in expanding capacity. Time T_1 ($= \overline{T}_1$, given) is the first time when no excess capacity exists in the system and a new plant must begin operating. Thereafter, as expressed by equation (4), new capacity comes on line at times when the old capacity just exactly covers demand. Condition (5) precludes using any of the non-repeatable projects $i=1,\ldots, m$ more than once. Note that we are implicitely assuming there is enough start up time to complete project $j^*(h)$ before time T_h. So long as there is at least one repeatable project, a solution of (2)-(5) must exist.

Because projects are indivisible, problem (2)-(5) possesses a complicated combinatoric structure which seemingly defies easy solution. Surprisingly, it turns out that the model as it is formulated has enough structure to induce a very simple characterization of an optimal solution. A "recovery cost" is assigned to each project. That project is next undertaken which has the lowest recovery cost among all remaining alternatives. Thus, we have the unexpected result that lumpy projects can be meaningfully ranked as investment priorities.

Many of the underlying assumptions of formulation (2)-(5) -- arithmetic growth of demand, infinite project lifetime, etc. -- may appear to be un-

realistic. Yet the model as a whole captures enough essential aspects of reality that its solution is likely to be relatively robust over the near future. What we are really interested in knowing is not so much the complete solution to an infinite horizon problem, so much as the identification of the next project, or the next few, to be built (after that, the data will change anyway). Identifying the next few projects to be built is easily and quickly done for the model (2)-(5). The optimality of this choice is unlikely to be much sensitive to the shortcomings of the present formulation. In other words, my feeling is that if a more complicated and realistic model were constructed, the investment program for the near future obtained by numerically solving it would not differ appreciably from the present model's recommendations.

Even for complicated investment situations, the project ranking which emerges as a solution to the simplified model (2)-(5) might serve as a rough screening device or as a starting point for more sophisticated analyses, like integer programming.[3] The fact that it is possible to sharply characterize an optimal solution makes problem (2)-(5) a natural preliminary to any more general analysis. And the present model may even be a reasonable description of some situations.

Solving the Problem

Define the recovery cost of a project to be the hypothetical payment per unit of output which would make the project just break even. The recovery cost for project i, C_i, is defined as the solution to:

$$\int_0^{K_i/B} C_i\, Bs\, e^{-rs}\, ds + \int_{K_i/B}^{\infty} C_i\, K_i\, e^{-rs} ds = \int_{-\infty}^{\infty} F_i(s)\, e^{-rs}\, ds. \quad (6)$$

The right hand side of equation (6) is the total cost of project i, discounted back to the time when it first starts coming on line. The left hand side is the hypothetical discounted revenue accumulated by charging a price of C_i per unit of output (the first integral covers the expansion phase and the second full capacity operation).

Integrating out the left hand side of (6) yields the formula

$$C_i = \frac{r^2 \int_{-\infty}^{\infty} F_i(s)\, e^{-rs}\, ds}{B(1-e^{-rK_i/B})} . \tag{7}$$

Although the notion of recovery cost has intuitive appeal, the following theorem gives it a rigorous basis as a criterion for selecting among discrete projects of differing sizes.

Theorem: A necessary and sufficient condition for an optimal solution of problem (2)-(5) is the rule:

<u>always select next the project with lowest recovery cost.</u>

At time T_1, that project i^* (=$j^*(1)$) should come on line which satisfies:

$$C_{i^*} = \min_{i=1,\ldots,n} C_i . \tag{8}$$

If i^* is a non-repeatable project ($1 \le i^* \le m$), it is deleted off the list from which the next project $j^*(2)$ is selected (by the criterion of lowest recovery cost) to come on line at time $T_2 = T_1 + \frac{K_{i^*}}{B}$. Note that once a repeatable project ($i=m+1,\ldots,n$) is selected by the criterion of minimum recovery cost, it will continue to be selected by that same criterion (so

long as a project with lower recovery cost is not added to the list of available projects).

Because it is so easy to calculate recovery costs, sensitivity analysis is made especially simple. The effects on project ranking of changing such parameters as the interest rate, growth of demand, plant capacity or cost estimates is easily determined. It is also easy to say how an optimal investment strategy changes when certain projects are added to or deleted from the list of prospective candidates.

That such an elementary decision rule as (8) is optimal depends more crucially than might be supposed on the simplifying assumptions of the model. There does not seem to be available a sharp characterization of an optimal solution when, for example, demand varies non-linearly with time, projects depreciate, or the discount rate is not constant. About all that might be said of a general character in such situations is that a limiting argument could be used to show the results presented here are valid as an approximation when the stipulated preconditions are close to being met.

Proof of Optimality

For completeness, we prove the optimality of decision rule (8) from first principles. An alternative approach would be to demonstrate that (2)-(5) is a particular example of a resource pool problem and then to apply the general theory developed in Weitzman [1976] to this special case.

The following monotonicity property is important:

In an optimal policy,

$$C_{j(h)} \leq C_{j(h+1)} \tag{9}$$

for all h=1,2,...

proof: Consider an alternative policy that reverses the order of investment in projects j(h) and j(h+1) but leaves unchanged the rest of the program. That is, at time T_h project j(h+1) comes on line and at time $T_h + \frac{K_{j(h+1)}}{B}$ project j(h) comes on line - otherwise everything else remains the same. The difference in present discounted cost between the old policy and the new variation is

$$e^{-rT_h} Y_{j(h)} + e^{-r(T_h+K_{j(h)}/B)} Y_{j(h+1)}$$

$$- (e^{-rT_h} Y_{j(h+1)} + e^{-r(T_h+K_{j(h+1)}/B)} Y_{j(h)})$$

$$= e^{-rT_h}[Y_{j(h)}(1-e^{-rK_{j(h+1)}/B}) - Y_{j(h+1)} (1-e^{-rK_{j(h)}/B})], \tag{10}$$

where

$$Y_i \equiv \int_0^\infty F_i(s)\, e^{-rs}\, ds. \tag{11}$$

Inequality (9) must hold because otherwise, from formulas (7) and (11), expression (10) is positive and the original policy is non-optimal.

The main body of proof now proceeds by contradiction with the selection rule based on (8). Suppose that it is optimal to choose as the first investment some project j(1)(≠i*) satisfying

$$C_{j(1)} > C_{i*} \tag{12}$$

Let the present discounted cost of this allegedly optimal policy be

$$\alpha \equiv \sum_{h=1}^{\infty} Y_{j(h)} e^{-rT_h}. \tag{13}$$

Equation (13) can be rewritten as

$$\alpha = \sum_{h=1}^{\infty} \frac{Y_{j(h)}}{1-e^{-rK_{j(h)}/B}} ((1-e^{-rK_{j(h)}/B}) e^{-rT_h}), \tag{14}$$

where, making use of (4),

$$\sum_{h=1}^{\infty} (1-e^{-rK_{j(h)}/B}) e^{-rT_h} = \sum_{h=1}^{\infty} e^{-rT_h} - \sum_{h=2}^{\infty} e^{-rT_h} = e^{-rT_1}. \tag{15}$$

It follows from the monotonicity property (9) that since project i* satisfying (12) does not come on line at time T_1 in the allegedly optimal policy, it never does. Consider an alternative policy of commencing with project i* and postponing to a starting date of $T_1 + \frac{K_{i*}}{B}$ the allegedly optional policy which had previously begun at T_1. In other words, what was policy over $[T_1,\infty)$ now becomes policy over $[T_1 + \frac{K_{i*}}{B},\infty)$ and project i* now begins at T_1. The present discounted cost of this alternative policy is

$$\alpha' \equiv e^{-rT_1} Y_{i*} + e^{-rK_{i*}/B} \alpha. \tag{16}$$

From (12), (9), (11), and (7),

$$\frac{Y_{i*}}{1-e^{-rK_{i*}/B}} < \frac{Y_{j(h)}}{1-e^{-rK_{j(h)}/B}} \qquad h=1,2,\ldots \tag{17}$$

Combining (17) with (14), (15),

$$\frac{Y_{i*}e^{-rT_1}}{1-e^{-rK_{i*}/B}} < \alpha,$$

which can be rewritten as

$$e^{-rT_1} Y_{i*} + e^{-rK_{i*}/B} \alpha < \alpha .$$

By (16), this implies

$$\alpha' < \alpha.$$

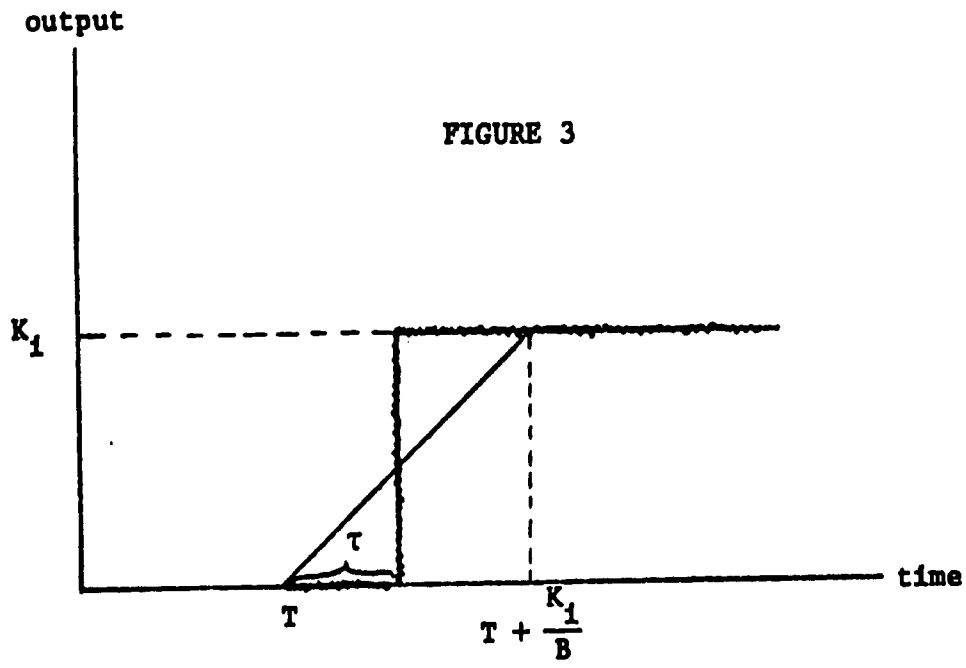
The alternative policy has lower present discounted cost than the proposed optimum, a contradiction. Hence, the surposition (12) is false. The selection rule based on (8) is a necessary condition for an optimum.

This concludes our proof of the form of an optimal policy. Strictly speaking, we have proved the necessity of the selection rule based on (8) for a project coming on line at T_1. The extension to T_h for all h is immediate. The selection rule (8) specifies a unique choice of j*(h) for each h (except in the case of ties, for which it is easy to show that how the tie is broken makes no difference to the value of the objective function). Thus, since an optimum exists, sufficiency of the selection rule based on (8) has also been demonstrated.

A Few Brief Extensions

It is easy to extend the model to cover the case where imports are available at price P and exports can be sold at price $p(<P)$. To make the problem interesting, p should be higher than variable production costs (otherwise there is no exporting) and P should be high enough to ward off a stategy of importing everything and producing nothing domestically.

When imports and exports were disallowed, the output stream of project i coming on line at time T was as depicted in Fig. 2. Now the corresponding output stream would be as depicted in Fig. 3.



For τ periods of time, the commodity is imported to help meet final demand. Then, when plant i comes on line at time $T + \tau$, it immediately produces at full capacity, exporting the excess production over domestic demand. At time $T + \frac{K_i}{B}$, there is no excess capacity.

The time τ is selected to minimize net present discounted project costs, taking into account import costs, export revenues, and all production costs for project i coming on line with full capacity at time τ. Except for these new net present discounted costs replacing the previous $\{Y_i\}$ in formula (7)

and elsewhere, the analysis based on equation (8) remains the same. The effect of having import or export possibilities is generally to increase the relative desirability of large scale projects.

With a slightly different interpretation, the same analysis covers the case of a piecewise linear benefit function kinked at time t around the target demand level A + Bt. In this interpretation, the import price is the welfare loss of falling short a unit from target and the export price is the welfare gain of delivering an extra unit above target.

Some other generalizations of the model are possible, but it would be tedious to go on listing them.

Footnotes

1. See, for example, Chenery [1959].

2. See Chenery [1952] or Manne [1967].

3. See, for example, Westphal [1971].

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