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# VALUING WATER IN THE AGRICULTURAL ENVIRONMENT OF EGYPT: SOME ESTIMATION AND POLICY CONSIDERATIONS \*

by Dale Whittington\*\* and Kingsley E. Haynes\*\*\*

## Introduction

The vast majority of Egypt's annual water supply is used for irrigation. Approximately fifty billion cubic meters per year are currently used to irrigate about 6 million feddans (1 feddan = 1.04 acres). Approximately two billion cubic meters are used for industrial and municipal purposes, the majority of which will have a much higher value per unit than water used in agriculture. To a certain extent, there is a trade-off between water for hydro-power generation and agriculture, but given the *existing* water supply and demand conditions, agriculture is currently the marginal water user in Egypt during years with normal discharges from Lake Nasser (U.S. Department of Agriculture, 1976; Guariso, Haynes, Whittington, and Younis, 1979b). This means that the value of a unit of water used in agriculture is lower than in other uses. An understanding of the marginal benefits of water use in agriculture is thus a critical component in decisions regarding the management of the water supply system, the Aswan High Dam, water resources development efforts, and any major water-using project.

The purpose of this paper is to offer some preliminary estimates of the marginal value of water in Egyptian agriculture — or its shadow price. The shadow price of a commodity or factor of production is simply its social value, or alternatively, the social opportunity cost of doing without it. There are essentially two approaches to the empirical estimation of shadow prices. The first method begins with the market price, and the analyst attempts to adjust this market price to take account of externalities in consumption and production, the effects of income distribution on the price structure, and consumers' surpluses (Marglin, [17]). The second entails solving the dual of a programming problem in which at least in theory, the maximand is some social welfare function, (Maass, [16]). In practice, the objective function for this problem of deriving the shadow price of water in Egyptian agriculture would be to maximize total benefits at either the national, regional, or farm level.

Since there are no market prices for water nor any administrative charges with any social welfare significance, and since mathematical programming models of agricultural operations have been well developed elsewhere (e.g., Beneke and Winterboar, [2] and Kelso, *et. al.*, [11]), the second method of

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estimating the shadow price of water has seemed the natural choice to most analysts concerned with this problem. The programming approach requires, however, a detailed understanding of the agricultural production functions, the social value of agricultural production, water use practices, and other aspects of farm-level microeconomics (Bain, *et. al.*, [1]). The estimation of a shadow price of water in Egyptian agriculture has been delayed until this data is readily available and organized (Fitch, *et. al.*, [5]). In this paper, we present a crude, but simple method of estimating the shadow price of water with the data presently available, which we show represents an upper bound on the shadow price of water given certain assumptions.

### Water Use In Egyptian Agriculture: Theoretical Considerations And Some Comparative Statics

A typical crop yield-water relationship results in a benefit function for water use per unit of agricultural area in crop  $i$  such as presented in Figure 1A. The physical yield per feddan in crop  $i$  increases as the quantity of water available increases, but gradually the rate of increase in production declines. After  $Q^*$  more water for the given area is actually detrimental, leading to waterlogging, disease, increased salinity and reduced crop yield. When total benefits are simply defined as the physical output times constant product price (in competitive market conditions), the derivative of this total benefit function for water use is the economist's standard demand curve (Qayum, [19]; Layard and Walters, [15]). This curve relates the marginal benefits of using water to the quantity of water used (Figure 1B). Integrating from 0 to  $Q^*$  in Figure 1B yields  $X^*$  in Figure 1A.

Different crops have different crop yield — water relationships (i.e. different production functions with respect to water) and different product prices, and thus different demand curves for water. Consider the demand curves for three crops and assume for simplicity, that there are three separate farming operations each growing a different crop on a fixed acreage. The aggregate demand curve for water for the three farming operations is presented in Figure 2D, and is obtained by adding the quantities of water demanded by each farming operation at a given price of water (or its marginal benefit). For example, at  $P_1$ , the

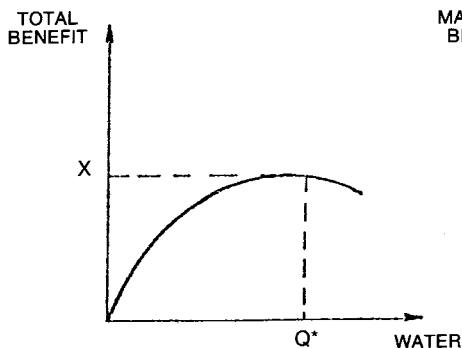


FIGURE 1A

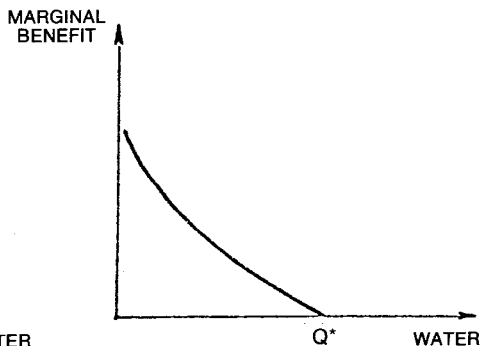
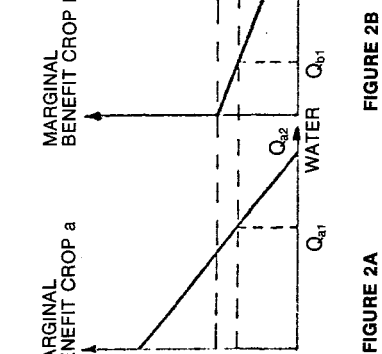
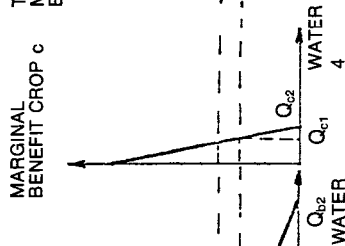
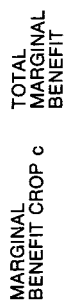
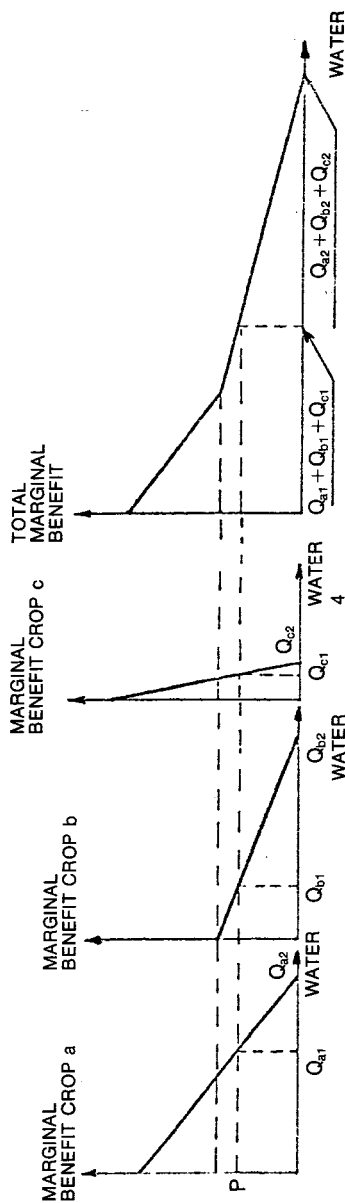


FIGURE 1B



farmer growing crop A demands  $Q_{ai}$ , the farmer growing crop B demands  $Q_{bi}$ , and the farmer growing crop C demands  $Q_{ci}$ . The aggregate demand at  $P_i$  is thus  $Q_{ai} + Q_{bi} + Q_{ci}$ .

This approach is generalizable to a demand function for water for Egyptian agriculture. Assuming a fixed crop mix and fixed factor proportions in the production of each crop, an aggregate demand curve for water in Egyptian agriculture can be estimated by multiplying the number of feddans in crop  $i$  by the "optimal" water required per feddan in crop  $i$  ( $Q^*$  in Figure 1A), and then summing over all crops to obtain a step demand function as illustrated in Figure 3A. The assumption of fixed factor proportions implies a water to output relationship as illustrated in 3B. Note that at  $Q^*$  in Figure 3A, the marginal benefit of additional water to agriculture is zero, and that this is the optimal quantity of water only if water is a free resource.

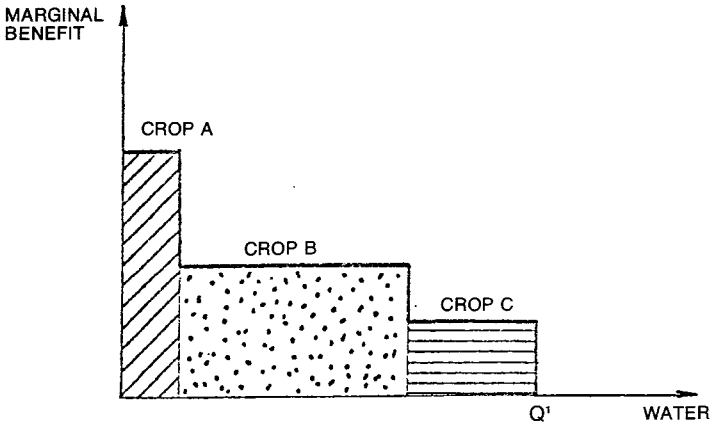


FIGURE 3A

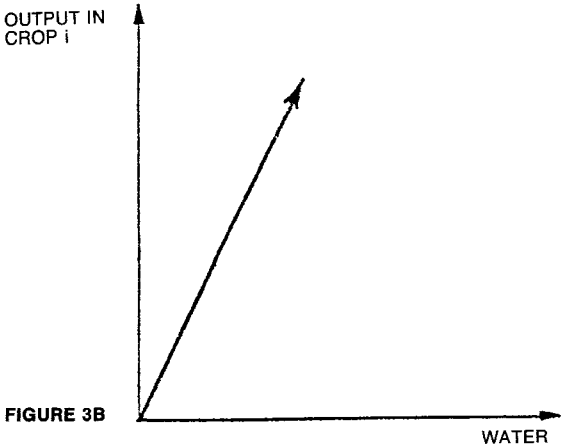


FIGURE 3B

The conventional wisdom is that the Egyptian farmer overwaters his crops, and thus water use per feddan is thought to be in excess of  $Q^*$ . Several explanations of this overwatering have been offered. The first is that the farmer has few incentives to conserve water because he is not charged for it.<sup>1</sup> This would explain why the marginal value of water to the farmer might be low, but not why it is negative. In fact, the real cost to the farmer of using water is significant because it must be laboriously lifted to the fields. He would thus have a strong incentive not to overwater even in the absence of charges. Indeed, this was one of the primary reasons for the design of the existing irrigation supply system.

A secondary explanation places the blame on the ignorance of the fellaheen — that they do not know the optimal amount of water required by their crops. Historically, summer water has always been in short supply, and thus the prevalent belief was that the more the better. The solution to the problem from this point of view, is one of educating the farmer to change traditional, but outdated, practices. A corollary associated with this position is that the peasant has been slow to correct this error because of the classic "problem of the commons" — that the social costs of overwatering in terms of waterlogging and increased salinity are externalities which are not only borne by the individuals responsible, but by all those on the surrounding groundwater table.

A third explanation is that the distribution system for irrigation water is not managed to respond to the farmer's demands for water at the field level, thus placing part of the responsibility on the Ministry of Irrigation. Since water is not delivered precisely when the crops need it, the argument is that the farmer takes more than he needs when he can get it, either because he is not certain when he will get it again, or because he will not get it again until after his crops have sustained some damage. Too much water is thus felt to be better than the right amount of water available at the wrong time.

This conventional wisdom regarding overwatering has not yet been confirmed due to lack of data on agricultural water use at the field level. Estimates of crop water requirements in the literature differ widely — both for specific crops and in total (Kinawy, [13]). One of the most recent estimates of optimal water use for different crops in various agricultural regions of Egypt have, in fact, indicated that not enough water is currently being used (Kramer, [14]). These estimates were made on the basis of equations relating rates of evapotranspiration, the length of the growing season, and the type of crop (Doorenbos and Pruitt, [3]), as well as estimates of the number of feddans in each region planted with different crops. These calculations of crop water requirements for Egypt are puzzling. One possible explanation is that the estimated crop water requirements are for well-drained soils. Since much of the agricultural lands are subject to high water tables, a portion of the crop water requirements may be satisfied from groundwater. If this is the case, both views may, in a sense, be correct. *Given* the poor drainage conditions, overwatering may be occurring but *if* soils were well-drained, more water might need to be applied.

This matter will probably remain unresolved until additional studies are completed, but several conclusions seem justified. If the Egyptian farmer is "overwatering" (Water use  $< Q^*$  in Figure 1A) all crops and the crop mix is

<sup>1</sup>With the exception of water for sugar cane irrigation in Upper Egypt where charges are based on the cost of lifting water.

fixed, the shadow price of water in agriculture is negative. Considering some recent results of multi-objective programming and simulation models, it would appear that sound management of the High Dam should yield ample water to meet the existing level of agricultural water use in all but a very small number of years (Guariso, *et. al.*, [8]). If too much water is currently being used in agriculture, the water requirements for the old lands can almost always be met. Even if industrial and municipal water demands triple, acreage could still be maintained by a shift in the crop mix to less water-intensive crops — although the optimal strategy from strict economic efficiency criteria might include some reduction in water supplies to the existing crop mix or some reduction in areas cultivated.

The benefits of supplying these agricultural water requirements in the old lands of the Nile Valley will be significant. The old lands are among the richest, best endowed agricultural lands in the world,<sup>2</sup> and Egypt depends upon this agricultural production for food supplies, export earnings, and employment for a large portion of its population. Thus, for the existing crop mix, the shadow price of water in agriculture should be positive when the quantity supplied is below approximately 50 billion cubic meters per year. If additional benefits from water in agriculture are possible from supplies greater than approximately 50 billion cubic meters per year. If additional benefits from water in agriculture are possible from supplies greater than approximately 50 billion cubic meters per year, they must be achieved in lands to be reclaimed in the future or from a shift toward more water-intensive crops.

### **Lar.3 Reclamation: Water Use Implications**

The history of Egypt's land reclamation efforts is difficult to unravel from the publicly available statistics, but the gist of the story is that desert reclamation has proved a very expensive and largely unrewarding enterprise (El-Tobgy, [4] and Waterbury, [21]). One of the primary benefits of the Aswan High Dam was supposedly to provide the additional water necessary for the reclamation of 1.3 million feddans (El-Tobgy, [4]). This goal is not close to being achieved despite rather massive investments. Waterbury [21] reports that in 1972, only 518,000 feddans were being cultivated in the reclaimed lands, but that only 345,000 feddans had reached even marginal levels of productivity. In 1972, expanded reclamation efforts were stopped and from 1972 to 1978, the emphasis of investment policy was shifted to the vertical expansion of agricultural production in the old lands of the Nile Valley, specifically the installation of Nile Drainage Systems (Khedr, [12]) and the Soil Improvement and Conservation Project.

Although admittedly difficult to unravel from a social point of view, the rates of return from desert reclamation projects appear very low. Soil properties are very poor, and land preparation has taken much longer and has been more expensive than anticipated. The establishment of community infrastructures has been particularly difficult. If the social benefits from desert reclamation projects are very low, then the marginal social benefit of supplying water to reclaimed areas is also very low.

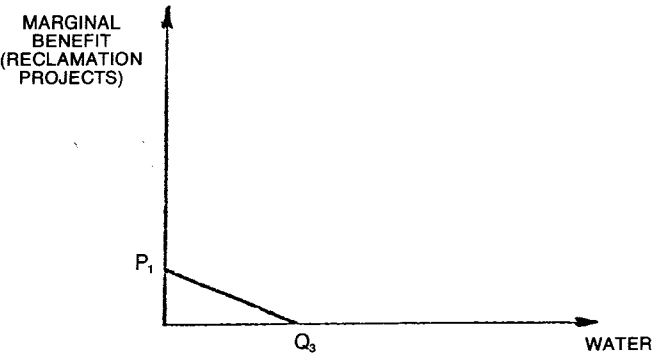
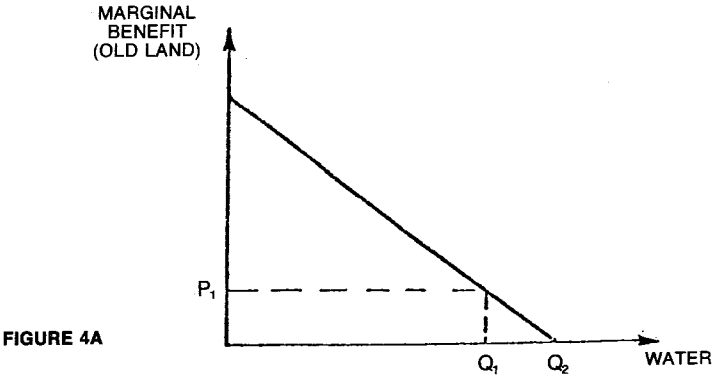
Land reclamation projects have again been undertaken as a matter of national policy — whether or not they are poorly conceived from an economic ef-

<sup>2</sup>Since approximately 1970, however, yields in many areas of Egypt have declined due in part to salinity and waterlogging.

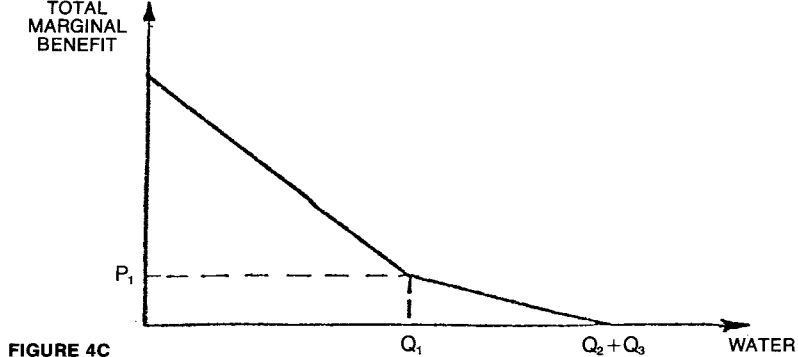
iciency point of view. If the government continues to be willing to sink whatever resources are necessary into a reclamation project in order to make it viable, then reducing the water available to such a project may seriously disrupt the efforts in land and crop preparation. For example, if water deliveries were reduced below a certain level in a reclaimed area in which orchards were being established, the result of the water shortage might be worse than if the shortage had occurred in the old lands.

The shadow price of water in Egyptian agriculture will thus depend in part upon the government policy toward horizontal expansion of agricultural acreage. This policy now sets the reclamation at 3.2 million feddans as its goal by the mid-1990's (Waterbury, [22]). If reclamation projects must be justified upon their economic rates of return, the aggregate demand function for water in agriculture will result from the addition of Figures 4A and 4B.

Thus, any quantity of water up to  $Q_1$  will be best used in the existing agricultural lands. Additional water up to  $Q_2 + Q_3$  can be beneficially used in the existing lands and in some reclaimed areas. Quantities of water in addition to  $(Q_2 + Q_3)$  have a negative value in agriculture in Egypt. Egypt could have more

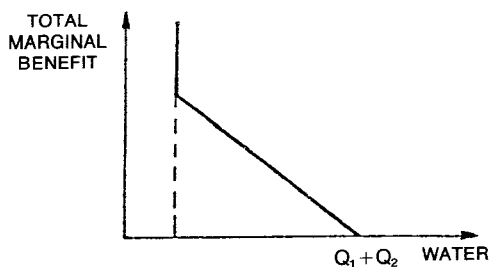
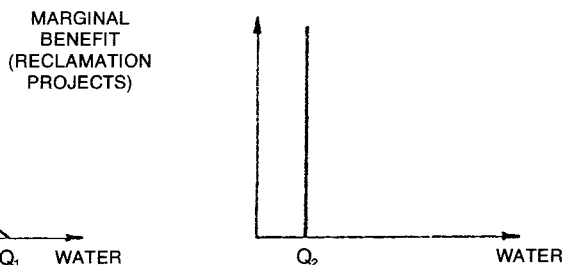
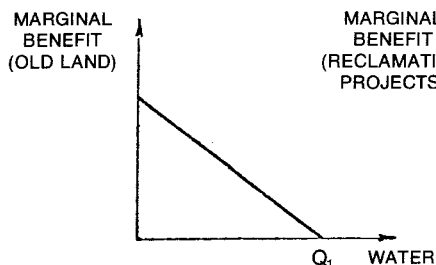






water than good land to put it on, i.e. additional water for agriculture may have no value because land reclamation efforts may not be socially beneficial even with free water.

Since the Egyptian government has committed itself to another major try at reclamation, we assume that this water will have priority. The aggregate demand function for water in agriculture in this instance will result from the addition of Figures 5A and 5B. In this case, any reduction in water available to agriculture must come from the old lands, and the shadow price of water in agriculture will be determined by the marginal benefits of water in existing agriculture areas. Our estimates of the shadow price of water in agriculture will thus focus on the value of water in the existing lands.



## The Method Of Estimating The Shadow Price Of Water And Its Implications

Data has been obtained from the Egyptian Ministry of Agriculture on the profitability and area under cultivation for the major crops in Upper, Middle, and Lower Egypt. The net revenue data for the years 1975, 1976 and 1977 were originally expressed in domestic prices. To obtain these estimates at world prices, we have simply used the world prices at Alexandria and the farmgate costs multiplied by a crop specific markup factor to reflect the value of imported inputs. No adjustments have been made to account for transportation of the product to Alexandria or any processing required in order to prepare the product for export. Neither have any adjustments been made to account for shadow prices of foreign exchange or labor. These adjustments to world prices should also be made for non-traded commodities in order for the estimates to be comparable (Hansen and Nashibi, [9]) (Table 1).

TABLE 1 — CULTIVATED AREA AND CROP PROFITABILITY DATA: WORLD PRICES (L.E.)

Crop	Total Cultivated Area*				World Price		Gross Revenue		Cost	Net Revenue	
	75	76	77	75	76	75	76	75	76	75	76
Upper Egypt											
Cotton	173	161	182	54.3	46.85	312.17	301.25	143.77	161.15	168.40	140.10
Rice											
Wheat		344	324	79.5	65.1	112.1	86.6	72.6	76.9	39.5	9.7
Middle Egypt											
Cotton	283	257	288	54.3	46.9	250.8	229.6	130.4	163.7	120.4	65.9
Rice		17	16	150.0	77.7	279.2	144.7	80.7	99.1	198.5	45.6
Wheat	240	197		79.5	65.1	119.2	93.8	68.3	73.3	50.9	20.5
Lower Egypt											
Cotton	881	829	962	54.3	46.9	268.2	259.1	128.6	158.1	139.7	101.0
Rice		1056	1021	1150.0	.7	347.4	166.5	80.7	99.1	266.8	67.4
Wheat		812	686	79.5	65.1	116.8	93.2	66.2	74.7	50.6	18.45
National Level											
Cotton	1423	1248	1346	54.3	46.9	270.4	258.6	131.0	159.6	139.4	99.0
Rice		1056	1035	150.0	77.7	346.4	167.9	80.7	99.1	265.7	98.8
Wheat		1396	1207	79.4	65.1	116.0	91.9	68.2	75.0	47.8	16.8

Source: Ministry of Agriculture: \* — feddans

If resource  $m$  is water, the shadow price of water is  $\partial \Pi / \partial Z_m$  i.e. the change in total profits caused by a change in one unit of water, holding the levels of the other resources constant (Gouevsky and Maidment, [6]).

Consider a simple example in which there are two factor inputs to the production process — water and land — and both are binding constraints on agricultural production. This problem can be expressed in terms of the following three linear equalities:

$$(5) \text{ Total Profits} = \Pi_1 x_1 + \Pi_2 x_2$$

$$(6) \quad a_{11} x_1 + a_{12} x_2 = Z_1$$

$$(7) \quad a_{21} x_1 + a_{22} x_2 = Z_2$$

where  $x_1$  and  $x_2$  are the quantities of crop type 1 and 2 respectively.  $\Pi_1$  and  $\Pi_2$  are profit per unit of output for crop 1 and 2.

$a_{11}$  = water per unit of output of crop 1  
 $a_{12}$  = water per unit of output of crop 2  
 $a_{21}$  = land per unit of output of crop 1  
 $a_{22}$  = land per unit of output of crop 2  
 and where  $Z_1$  = the amount of water available  
 $Z_2$  = the amount of land available

We assume there are solution values.

This system of equations can be solved to yield the following shadow price of water in agriculture (appendix):

$$(8) \quad \partial \Pi / \partial Z_1 = \frac{\Pi_1 a_{22} - \Pi_2 a_{21}}{a_{11} a_{22} - a_{12} a_{21}}$$

If we assume that crop 1 is the marginal crop in terms of profits per cubic meter

TABLE 2 — CROP WATER REQUIREMENTS (M<sup>3</sup> per feddan)

CROP	LUXOR		BENI SWEF		TANTA	
	CWR <sup>(1)</sup>	CWR+EL <sup>(2)</sup>	CWR	CWR+EL	CWR	CWR+EL
Clover F <sup>3</sup>	2878	4660	2259	3591	1961	3080
Clover C <sup>4</sup>	1685	2501	1377	1989	1230	1747
Onions S <sup>5</sup>	3078	4734	2499	3814	2344	3500
Onions W <sup>6</sup>	2231	3228	1809	2555	1607	2234
Onions N <sup>7</sup>	4235	6547	3549	5426	3107	4708
Wheat	3262	5101	2593	3986	2309	3453
Vegetables S	3394	5006	2913	4256	2564	3707
Vegetables W	2520	3611	2028	2848	2211	1522
Vegetables N	2041	2791	1698	2257	1983	1502
Sorghum S	3940	6036	3366	5106	2948	4430
Sorghum N	3385	5144	2860	4294	2515	3737
Misc. S	4161	6294	3543	5308	3099	4604
Misc. W	2510	3803	2011	2979	1775	2590
Misc. N	3517	5264	2952	4367	2594	3800
Maize S	4484	6690	3822	5665	3337	4909
Maize N	4156	6498	3484	5381	3044	4656
Orchard	6110	9399	4890	7522	4168	6386
Cotton	6448	9750	5472	8077	4650	6954
Sugar Cane	8316	9750	6284	11879	5673	10099
Rice	10422	12166	9162	10579	8337	9342

(1) Crop water requirements at the field level (CWR)

(2) CWR plus conveyance and efficiency losses (EL)

(3) full

(4) catch (short growing period)

(5) summer

(6) winter

(7) nili

**SOURCE:** Basic data for the calculations from Kramer, C. "Agricultural Demand and Distribution Models — Users' Manual," UNDP/UNDT — Project of Assistance to the Hydraulic Research Institute;

of water, then the estimate of the shadow price of water which we have suggested, in Egyptian Pounds (L.E.), is:

$$(9) \frac{\Pi_1 a_{22}}{a_{11} a_{22}} = \frac{\text{L.E.}/(\text{Feddan in Crop 1})}{(\text{M}^3 \text{ of Water})/(\text{Feddan in Crop 1})}$$

This estimate sets an upper bound on the shadow price of water in agriculture, given the assumptions we have made. This can be shown as follows:

$$\begin{array}{ll} \text{Let } a = \Pi_1 a_{22} & \text{and } x = \Pi_2 a_{21} \\ b = a_{11} a_{22} & y = a_{12} a_{21} \end{array}$$

The correct estimate of the shadow price of water in agriculture is  $(a-x)/(b-y)$  illustrated in equation (8). Our estimate of the shadow price of water is  $(a/b)$ . If  $(x/y) > (a/b)$ , then  $(a/b) > (a-x)/(b-y)$ . But  $(x/y) > (a/b)$  by definition, because we have assumed that crop 1 is the marginal crop, in terms of profits per cubic meter of water. Therefore, our estimate is greater than the correct shadow price of water. This result makes sense because our estimate implicitly assumes that a reduction in the quantity of water available reduces the total area irrigated. Our estimate is correct only if land is not a binding constraint on agricultural production at the *new, lower quantity of water supplied*. If this is *not* true, it means that the loss in profits must be less than would have been incurred by a reduction in total area cultivated. Otherwise, the optimal strategy would have included some reduction in the irrigated area. Our estimate effectively attributes all of the economic surplus from production to water. To the extent that this is not true, our estimate of the shadow price of water will be too high.

The fact that the estimate represents an upper bound on the marginal value of water — given the stated assumptions and limitations of the data — is a very useful result. An upper bound on the shadow price of water can be utilized to reject water resource projects which are designed to increase water supplies. If such a project cannot be justified on the basis of the estimated shadow price, it certainly cannot be justified if water is worth less.

This estimate must be interpreted carefully. Egyptian agriculture operates under a complex 2 to 3 crop rotation system. The major winter field crops are clover and wheat; the major summer crops are cotton, maize, and rice. A typical rotation would start with a short crop such as clover, during the winter, followed by a cotton crop which would be harvested in October. The next year winter wheat would be planted, followed by a summer crop of rice, maize, or sorghum. Wheat and maize may be grown in the third year before turning to the cultivation of cotton. Fruits and sugarcane are grown on about 10 percent of the cultivated area, and occupy the land throughout several years. Three crops of vegetables can be grown in one year. Only about 5 percent of the cultivated area is required, however, to meet domestic consumption needs for vegetables.

The fact that water is more valuable in one crop than in another does not necessarily mean that acreage should be shifted from the crop with the low marginal product of water to the one with the high marginal product. This depends upon the stability of the values of the various crops as the crop mix changes, and upon the substitution possibilities in the crop rotation schedules. Even in the absence of existing government regulations, the degree of flexibility available to the farmer in terms of the selection of field crop

rotations is somewhat uncertain. The winter clover crop was traditionally grown every two or three years for its soil-restoring properties, in addition to its value as forage. With proper soil-water management practices and adequate fertilizer inputs, this would appear to be unnecessary in most areas. In this case, there would be substitution possibilities between both summer and winter crops. The winter wheat crop would effectively compete with cotton for land, but not directly for water.

## Results

The estimates of the shadow price of water for selected crops are presented in Tables 3-6. Although these preliminary estimates should be interpreted with caution, there are several interesting results. The high domestic prices and relatively low water requirements for vegetables clearly indicate that water for these crops has a high marginal value. Adjustment of the domestic prices to world prices will only strengthen this conclusion. Water for orchards also has a high value because of high capital investment in the trees.

The theoretically optimal crop water requirements for Upper, Middle, and Lower Egypt have been calculated based upon data from a recent study for the Hydraulic Research Institute (Kramer [14]). A portion of the irrigation water

**TABLE 3 — Preliminary Estimates of the Shadow Price of Water in Egyptian Agriculture: Domestic Prices; (L.E./1000 m<sup>3</sup>) Calculated with Field Water Requirements**

CROP	UPPER EGYPT			MIDDLE EGYPT			LOWER EGYPT		
	75	76	77	75	76	77	75	76	77
Cotton	1.91	8.70	1.30	2.67	3.36	8.17	6.37	14.09	8.54
Maize — N	5.86	5.83	15.75	6.34	5.22	14.20	7.23	4.27	12.19
Rice				.48	.81	1.56	1.51	2.00	3.44
Wheat	5.55	.55	3.68	5.90	.42	.89	6.28	.01	2.10
Sorghum	6.12	3.55	10.61	7.96	3.48	11.26			
Onions W.	58.58	54.73	37.65	24.32	13.16	9.40			
Calculated with national average profitability data:									
Sugar Cane	17.53	15.22							

**TABLE 4 — Preliminary Estimates of the Shadow Price of Water in Egyptian Agriculture: World Prices Calculated with Field Water Requirements (L.E./1000 m<sup>3</sup>)**

CROP	UPPER EGYPT		MIDDLE EGYPT		LOWER EGYPT	
	75	76	75	76	75	76
Cotton	26.12	21.73	22.00	12.04	30.04	21.72
Rice			21.67	4.97	32.00	8.08
Wheat	12.11	2.97	19.63	7.91	21.91	7.99

Source: Lake Nasser-River Nile Project; Egyptian Academy of Scientific Research and Technology

**TABLE 5 — Preliminary Estimates of the Shadow Price of Water in Egyptian Agriculture: Domestic Prices; Calculated with Field Water Requirements + Efficiency Losses (L.E./1000 m<sup>3</sup>)**

CROP	UPPER EGYPT			MIDDLE EGYPT			LOWER EGYPT		
	75	76	77	75	76	77	75	76	77
Cotton	1.26	5.75	.86	1.81	2.28	5.53	4.30	9.42	5.71
Maize	3.60	3.74	10.10	4.11	3.38	9.20	4.73	2.79	7.97
Rice				.42	.70	1.35	1.35	1.79	3.07
Wheat	3.55	.35	2.35	3.84	.28	.58	4.20	.01	1.40
Sorghum	4.00	2.32	6.93	5.25	2.29	7.42			
Onions	40.49	37.83	26.02	17.22	9.32	6.65			
Winter									
Calculated with national ave. profitability data:									
Sugar Cane	9.80	8.51							

**TABLE 6 — Preliminary Estimates of the Shadow Price of Water in Egyptian Agriculture — World Prices Calculated with Field Water Requirements + Efficiency Losses (L.E./1000 m<sup>3</sup>)**

CROP	UPPER EGYPT		MIDDLE EGYPT		LOWER EGYPT	
	75	76	75	76	75	76
Cotton	17.27	14.37	14.91	8.16	20.09	14.52
Rice			18.76	4.31	28.56	7.21
Wheat	7.74	1.90	12.77	5.14	14.65	5.34

Source: Lake Nasser-River Nile Research Project; Egyptian Academy of Scientific Research and Technology

returns to the distribution system as drainage water and is utilized again for irrigation purposes. The estimates of the shadow price of water are thus not for consumptive water use. Two sets of estimates of crop water requirements were presented in Table 2. The first is for application at the field level (CWR). The second includes the losses in the distribution system which must be incurred in order to deliver the first estimate of water requirements to the field (CRW & EL).

The method suggested here for estimating the shadow price of water in agriculture is to divide the profits per feddan in crop *i* in region *j* by the quantity of water required by crop *i* in region *j*. The division yields profits per cubic meter of water in crop *i* in region *j*. To obtain our estimate of the shadow price of water in region *j*, we select the minimum "profits per cubic meter of water" for the crops in this region.

To better understand the meaning of this figure for profits per cubic meter of water and the assumptions implicit in its derivation, consider the following linear programming problem:

$$(1) \text{ Maximize } \Pi + \Pi_1x_1 + \Pi_2x_2 + \dots + \Pi_nx_n$$

subject to

$$(2) \quad a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n \leq Z_1$$

$$(3) \quad a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n < Z_m$$

$$(4) \quad x_i \geq 0$$

Where

$\Pi$  = total profits

$\Pi_n$  = the profits per unit of output in crop n

$x_1 \dots x_n$  are the outputs of the n crops

$z_1 \dots z_m$  are the levels of the m resources available

$a_{mn}$  = the amount of resource m per unit of output used in the production of crop n.

Perhaps more surprising are the results for cotton, wheat, and rice expressed in world prices. When cotton is valued at world prices, water used in its cultivation is significantly more valuable than water used in the cultivation of wheat. This suggests that cotton will maintain its historic comparative advantage in Egypt as water becomes more scarce in the future (Haynes [10] and Waterbury, [22]). In an era of water shortage, economic efficiency would require Egypt to shift acreage from wheat rotations to cotton rotations, thus increasing its dependence upon foreign food supplies.

Before the construction of the High Dam, the area of rice cultivated in Egypt was limited by the availability of summer water. In years of low floods, maize was substituted for rice. It is not clear from these initial estimates, however, that rice is, in fact, a marginal water user. Despite the high water requirements for rice, the value of water used in rice cultivation is still very high. The value of water in the cultivation of sugar cane is also surprisingly high relative to less water intensive crops. Moreover, the profitability data for sugar cane is only expressed in domestic prices, and should be significantly higher when adjusted to reflect world prices. These results suggest that more careful analysis is required before assuming that the appropriate policy during periods of water shortage is to shift the acreage out of heavy water using crops such as rice and sugar cane.

The results also show that the value of water in different crops varies significantly from region to region and from year to year. Water in Lower Egypt is consistently more valuable than water used in Upper Egypt. The year to year variations are primarily due to fluctuation in world prices. This suggests that any policy for handling an emerging water shortage must include a careful assessment of world conditions for several major agricultural products.

The shadow price of water is defined as the decrease in total profits (social benefits) resulting from a decrease in total water available holding the other constraints constant. We thus solve for  $\partial \Pi / \partial Z_1$  in the following set of equations:

$$\begin{aligned} \Pi - \Pi_1 x_1 - \Pi_2 x_2 &= 0 \\ a_{11} x_1 + a_{12} x_2 &= Z_1 \\ a_{12} x_1 + a_{21} x_2 &= Z_2 \end{aligned}$$

where  $\Pi$  = total profits

In matrix notation we have ...

$$\begin{bmatrix} 1 & -\Pi_1 & -\Pi_2 \\ 0 & a_{11} & a_{12} \\ 0 & a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \Pi \\ x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ Z_1 \\ Z_2 \end{bmatrix}$$

Differentiating with respect to  $\Pi$ ,  $x_1$ ,  $x_2$ ,  $Z_1$ , and  $Z_2$  in order to obtain the marginal conditions yields ...

$$\begin{bmatrix} 1 & -\Pi_1 & -\Pi_2 \\ 0 & a_{11} & a_{12} \\ 0 & a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} d\Pi \\ dx_1 \\ dx_2 \end{bmatrix} = \begin{bmatrix} 0 \\ dZ_1 \\ dZ_2 \end{bmatrix}$$

$$\begin{bmatrix} d\Pi \\ dx_1 \\ dx_2 \end{bmatrix} \begin{bmatrix} 1 & -\Pi_1 & -\Pi_2 \\ 0 & a_{11} & a_{12} \\ 0 & a_{21} & a_{22} \end{bmatrix}^{-1} = \begin{bmatrix} 0 \\ dZ_1 \\ dZ_2 \end{bmatrix}$$



Since the quantity of land is held constant,  $dz_2 = 0 \dots$

$$\begin{bmatrix} d\Pi \\ dx_1 \\ dx_2 \end{bmatrix} = \begin{bmatrix} 1 & \frac{\Pi_1 a_{22} - \Pi_2 a_{21}}{a_{11} a_{22} - a_{12} a_{21}} & \frac{\Pi_2 a_{11} - \Pi_1 a_{21}}{a_{11} a_{22} - a_{12} a_{21}} \\ 0 & \frac{a_{22}}{a_{11} a_{22} - a_{12} a_{21}} & \frac{-a_{12}}{a_{11} a_{22} - a_{12} a_{21}} \\ 0 & \frac{a_{21}}{a_{11} a_{22} - a_{12} a_{21}} & \frac{a_{11}}{a_{11} a_{22} - a_{12} a_{21}} \end{bmatrix} \begin{bmatrix} 0 \\ dz_1 \\ 0 \end{bmatrix}$$

$$d\Pi = \left[ \frac{\Pi_1 a_{22} - \Pi_2 a_{21}}{a_{11} a_{22} - a_{12} a_{21}} \right] dz_1$$

$$\frac{\partial \Pi}{\partial z_1} = \frac{\Pi_1 a_{22} - \Pi_2 a_{21}}{a_{11} a_{22} - a_{12} a_{21}}$$

The units cancel out as required to yield L.E. per cubic meters of water in crop 1 ...

$$\begin{aligned} \frac{\partial \Pi}{\partial z_1} &= \frac{(\text{L.E.}/x_1) (\text{Feddan}/x_2) - (\text{L.E.}) (\text{Feddan}/x_1)}{(M^3/x_1) (\text{Feddan}/x_2) - (M^3/x_2) (\text{Feddan}/x_1)} \\ &= \frac{(\text{L.E.}) (\text{Feddan in Crop 1}) - (\text{L.E.}) (\text{Feddan in Crop 2})}{x_1 x_2} \\ &\text{times} \frac{x_1 x_2}{(M^3) (\text{Feddan in Crop 1}) - (M^3) (\text{Feddan in Crop 2})} \\ &= \text{L.E.}/M^3 \text{ in Crop 1} \end{aligned}$$

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A substantial body of theoretical and empirical work pertaining to the models, methods and problems of optimally locating central facilities has been produced in the past decade; with the appearance of this book a gap in the pedagogy of this approach has been filled. In the preface, Rushton explicitly states that this text has been written for undergraduate students and the format of the book is well suited for this purpose.

The reader is initially guided through an introduction to the rationale behind the use of spatial optimizing methods. This section includes a number of examples of applications of these techniques taken from both the public and private sectors. Rushton also presents a parsimonious classification of location problems, and brief descriptions of methods for solving them.

The remaining chapters of the book are the most valuable. Many of the basic types of location problems are included here: single facility location in continuous space and on a network, multiple facility location in continuous space and on a network and finally, shortest paths through a network. Each problem is briefly discussed and the relative merits of different algorithms that may be used to compute solutions to the problems are presented. Next, simple hand calculated problems are offered before advancing to computer generated solutions for these same problems and problems using larger data sets. This approach is laudable because it allows for a better understanding of the algorithms used to derive the computer solutions and minimizes the "black box" anxiety that can afflict novice computer users. Additionally, detailed instructions are included for the preparation of control cards and data sets used by each program.

A few problems do exist with this work. The most nagging problem is the omission of many of the references cited in the body of the text. Since the book has been written for an undergraduate audience, this is especially disquieting. Also because of its nature, the book is not a self-contained unit. Before it can be effectively used in the classroom, the FORTRAN source for the computer programs should be obtained. Fortunately, this is easily accomplished because the code is available on magnetic tape from both the publisher and the Geography Program Exchange; the program listings have also been published in a monograph (1).

In summary, Rushton did not intend this book to be a comprehensive introduction to the facility location literature. Rather, it fulfills its promise as a computer oriented guide to the selection and utilization of appropriate methods to solve location problems. Used in conjunction with the appropriate computer programs, Rushton's book is a worthwhile contribution to the effective teaching of computer aided facility location.

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The authors of this book have attempted to provide a textbook, seemingly addressed to senior undergraduate and graduate students, on probabilistic spatial process models not widely dealt with in other textbooks. Thus, they selected the analysis of point distributions, and of the properties of lines and areas that might be generated from such patterns.

The book opens with a typology of such processes, followed by two chapters on point processes. Much of this material is standard, and clearly dealt with. Throughout, there is an emphasis on quadrat analysis rather than nearest neighbor methods, although the latter are also discussed. Chapter four attempts to introduce some alternative approaches, but is rather confusing. Markov chain, simulation and urn models are suggested for the analysis of contagious patterns, but there is little to show that they are more useful for these than any other processes. Information theory is also introduced very briefly. Indeed, this entire chapter suffers from brevity; the various topics are introduced in a way that tantalizes the reader without giving enough information to evaluate the methods. Information theory in particular is often confusing, and a much more elaborate discussion seems necessary.

Chapter five introduces line patterns by classifying the various ways in which links might be generated from point patterns; as paths, trees, networks and cells. This is an interesting approach, but breaks down a bit in execution. The examples of path patterns and cell generating processes lead to identical forms. Line patterns have been much less researched than point patterns, and as a result the examples the authors have to choose from, where probabilistic theories have been developed, do not necessarily illustrate the concepts well. Some more *ad hoc* examples to show the different types of processes would have aided clarity, even in the absence of neat statistical results in such cases. The sections on networks could also have benefited from being more explicitly related to descriptive and probabilistic graph theory. It should be noted that the shortest tree joining a set of points is a Steiner tree, not the minimal spanning tree suggested on page 99.

The final three chapters introduce area patterns generated from points, with discussion of sequentially generated patterns and growth of cells. Both overlapping and non-overlapping areas are considered. In general this is the most interesting part of the book and is clearly written, with the exception of a return to information theory at the end of Chapter six. This tends to add to any confusion from its earlier use, since conclusions are reached that are opposite to those shown before. This is very unfortunate as the authors do not attempt to clear up a contradiction that also exists in the literature. Oddly there is no conclusion to summarize the book's achievements, although a clear introduction to probability theory is appended.

The authors are in a somewhat difficult situation since there is relatively little theory for many of the topics they have included. Nevertheless, it seems to me that some greater unity could have been achieved. One possibility would have been to consistently compare the theory on Poisson based patterns to other standard distributions for the different classes of point, line and area patterns. In addition to the common comparison with uniform and clustered patterns, simulations of the types of patterns expected from compound and mixed

Poisson processes would have been interesting; giving insight even in the absence of precise statistical theory. Such comparisons running throughout the book would have provided threads to draw the parts together and provide a stronger theme.

Many of the examples used are artificial, very much in the tradition of purist spatial analysis. In particular, they frequently involve generating results of a Poisson process, and then showing that this is statistically consistent with the Poisson (the null hypothesis). This hardly generates the excitement that a reader would gain from seeing how processes generated by other assumptions are found to be statistically significant, and in addition no idea of the power of the tests can be gained. More attempts to show the potential applicability of line and area models to actual phenomena would have been nice to see, making the mathematics less dry.

Two issues frequently recurred to this reviewer while reading the book. The first concerns spatial autocorrelation. It is true that the authors chose to exclude this, which is in itself a pity because it would seem to fall within their terms of reference. However one issue still arises; the possible autocorrelation observable in quadrat size, line length, or area characteristics which cannot be revealed by simply counting such characteristics. Although this difficulty could perhaps be avoided by only analyzing homogeneous Poisson processes, in practice it is very hard to guarantee this. Thus, an extensive discussion of this problem and of ways to deal with it seems a major omission.

The second issue is the persistent problem of overidentification in static analysis of dynamic processes; that there may be many processes consistent with one pattern. This is discussed with respect to point processes, but no reason is provided to show that these problems will not be just as endemic to line and area processes. This raises philosophical and methodological questions that seemingly deserve the full attention of a textbook on the topic. By not fully facing up to issues like these, the authors run the risk of allowing readers to involuntarily repeat past mistakes in using these methods.

Overall the book is clearly written, although there were a few ambiguities; the suggestion that close high order neighbors implies clustering when this may also occur for uniform distributions (p. 31), and a reference to table 2.6 (p. 60) that does not make sense. Certainly the relevant material is covered, and readers should be grateful for a bibliography that brings together research from many disciplines. However, for a book covering many esoteric topics it is rather dry, and may not generate the excitement and desire to pursue this research further that the authors hope for.

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TOMMY CARSTEIN, DON PARKES and NIGEL THRIFT (eds.): *Timing Space and Spacing Time*. Vol. 1: *Making Sense of Time*. Vol. 2: *Human Activity and Time Geography*. Vol. 3: *Time and Regional Dynamics*. New York: Halsted Press, a division of John Wiley & Sons, Inc., 1979 (Originally published by London: Edward Arnold, 1978). Vol 1: ix, 150 pp. Vol. 2: ix, 286 pp. Vol 3: viii, 120 pp.

The purpose of this collection of essays is to point to the role of both time and space in the structuring of society and the environment. Volume 1, *Making Sense of Time*, focuses on the awareness of time and on its role in societies.

Tuan's essay on "Space, Time, Place: A Humanistic Frame," pictures place as pause in movement, while movement takes time and occurs in space. The thoughts are expressed imaginatively, but disjointly, leap-frogging from Pueblo Indians' mythic space, to Chinese religious architecture, to the Hebrew God of History. Everything is supposed to fall into place somehow. The Parkes and Thrift essay, "Putting Time in its Place," follows the experiential themes in Tuan's essay, and discusses how the notion of a "place" is realized through the interaction of locational and experiential elements and constraints.

Another essay, "Time: Cultural and Social Anthropological Aspects," by Doob, discusses how various time-related ideas vary among different societies . . . In what activities do temporal judgements arise, and how frequently? How is time measured and valued? And is society's orientation towards the past, present or future? "Time and Historical Geography," by Prince, is one of the better essays for its wide-ranging discussions of antiquarianism, the historical development of human landscapes, spatial diffusion theory, and simulation models. A main underlying theme of the essay is that the evolution of human landscapes is the result of infinitesimally-complex human decisions and of never-ending changes; and as a result, is inadequately explained by any analytic model which forces reality into a fixed, unambiguous, and simplified picture. This is also the view shared by Gregory's "Social Change and Spatial Structure." However, with such pronouncements it is surprising that the editors do not attempt to reconcile the disparate views expressed between these essays and those in Volume 3. The latter would likely be favored by Regional Scientists who tend to prefer rigorous scientific explanations of society; and who may view the papers by Tuan, Parkes and Thrift, Doob, Prince, and Gregory as nothing more than pleasant bedtime reading.

The remaining essays in Volume 1 do not relate well with those just discussed, and one is left with a smorgasboard of different views of time. Shackle, in "Time, Choice and Uncertainty," views time as the void, able to be filled only by imagination (he then develops a set of differential equations for interest rates!). Orme, in "Time: Psychological Aspects," stresses that individual behavior is highly influenced by biological rhythms. The studies by Golledge ("Learning about Urban Environments") and Forer ("Time-Space and Area in the City of the Plains") are similar to the extent that both look at time slices — Golledge, to observe the changes in individuals' cognitions of urban structure; Forer, to show that transportation technology has led to a "shrinking" of the urban environment.

Volume 2, *Human Activity and Time Geography*, focuses on the description of individuals' activities in terms of their temporal and spatial patterns. Chapin's "Human Time Allocation in the City" tabulates the number of hours spent in different activities (work, eating, shopping, . . .). Cullen's "The Treatment of

Time in the Explanation of Spatial Behavior" uses harmonic regression analysis (curve fitting using a series of sine waves) to describe the relative number of individuals engaged in a particular activity at different hours of the day. Shapcott and Steadman, in "Rhythms of Urban Activity," make no attempt to describe statistically such distributions; but graphically portray the changes in such distributions between 1961 and 1973, thus summarizing transformations in society lifestyles in terms of the timing and time spent on different activities.

Parkes and Wallis, in "Graph Theory and the Study of Activity Structure," represent the sequence of daily activities in terms of a graph (not that with vertical and horizontal axes). For a given individual, the nodes of the graph represent types of activities, and are ordered from subsistence (eating and sleeping) to highly discretionary (leisure and voluntary participation) activities. The edges of the graph represent transitions from one activity to another. Various measures of the structure of the graphs can be used as bases for description and comparison, though such approaches have been used long before to describe the structure of transportation networks and of stream patterns, and have met with limited success.

The second section of Volume 2 consists of papers by Hagerstrand and his associates at the University of Lund, who have popularized the notion of time-budget research. Hagerstrand ("Survival and Arena" and "A Note of the Quality of Life-times") describes the life-history of groups of individuals—how many people moved into a farmstead and subsequently moved out, how many stayed, how many births, and how many deaths. Carlstein ("Innovation, Time Allocation and Time-Space Packing") notes how innovations can alter the typical scheduling and spatial pattern of activities such as land cultivation. Lenntorp ("A Time-Geographic Simulation Model of Individual Activity Programmes") uses a simulation model to evaluate the effects of transportation investment and urban structure on the flexibility that different residents will have in their set of choices for a given activity pattern (such as going to a day-care center, to a work place, to a post office, and then back home, all within a prescribed time limit). Martensson ("Time Allocation and Daily Living Conditions: Comparing Regions") presents a graphic illustration of the timing and of the amount of time spent by individuals in different daily activities; and comparisons are made among towns of different sizes in two different regions. Olander and Carstein ("The Study of Activities in the Quarternary Sector") note that tracing activities with regard to their temporal and locational characteristics may be particularly illuminating when done for individuals in the planning, management, and administrative sectors of our economy.

The overview chapter by two of the editors, Carlstein and Thrift ("Afterword: Towards a Time-Space Structured Approach to Society and Environment"), is a welcomed addition (even if the footnotes were missing). Similar chapters should have been included for Volumes 1 and 3. It is one thing to bind a bunch of papers together; it is another to note their similarities and their differences, and to integrate more fully their essential contributions.

The strategy of these time-budget studies is to model the activities of individuals in terms of their temporal and spatial dimensions. The idea is to put individual behavior within explicit contexts and constraints; to observe tendencies in daily, as well as in life-time, patterns; and ultimately to describe and to anticipate how changes in environment, technology and culture would affect such lifestyle patterns. Now these are ambitious goals. Unfortunately, I



am skeptical of the extent to which they will be achieved. Thus far, such studies are based on an accounting of individuals' activity diaries (which is fine as far as it goes), simplistic conceptual models (block diagrams), and the use of elaborate figures and graphs to describe the individuals' time-paths. Pictures are nice, and no doubt worth a thousand words. But neither pictures nor words in themselves will lead to significant gains in science. What are needed are models of the choice processes, and alternative descriptions of the time-paths from which logical deductions can be made.

Volume 2 has two other papers. Flowerdew ("The Role of Time in Residential Choice Models") lists various ways in which time enters into residential decisions. Melbin ("The Colonization of Time") notes that human activity is spreading over more hours of the day.

The third and last volume, *Time and Regional Dynamics*, considers time in a very narrow sense — as a physical unit of measurement. The papers present mathematical models in which the interaction among certain regional attributes are represented by sets of differential or difference equations. This is a rather insipid view of time, though what it lacks in breadth and richness it compensates for in rigor.

The first paper is that by Holly, "The Problems of Scale in Time-Space Research." It is inappropriate for this volume, and is a recapitulation of the scale problem in the temporal and spatial domain. "Regional and Local Components in Elementary Space-Time Models," by Haggett, presents a straightforward disease diffusion model for the number of susceptible people, the number infected and the number recovered as functions of time. Typographical errors are more irritating in equations than in prose, and it is unfortunate that equations (1), (9), and (10) all contain errors. Also, it seems worthwhile to estimate the parameters statistically and to compare these with Haggett's estimates.

"Position, Flow and Person in Theoretical Economic Geography" is a typical Curry paper — full of ideas, but very difficult to follow. It is a wide-ranging essay that advances the LaPlace equation as a description of employment opportunities, and the heat conduction equation for the diffusion of population. Convolution operators are used to represent spatial correlation, with cultural, environmental and technological constraints all complicating the stochastic nature of individual behavior.

"Mathematical Programming Models and the Introduction of Time into Spatial Economic Theory," Macmillan's contribution, criticizes traditional spatial economic modeling in terms of their convexity assumptions, static equilibrium solutions, lack of adaptive behavior, aspatial nature, and fixed equilibrium prices. Macmillan does not have all the answers, but suggests that fuzzy sets and control theory offer some of them.

"The Econometric Specification and Estimation of Spatio-Temporal Models," by Hepple, discusses various representations of the stochastic structure of the disturbance terms when the variables in a regression model are functions of both space and time. Williams and Wilson, in "Dynamic Models for Urban and Regional Analysis," summarize alternative frameworks for dynamic modeling. They present outlines of demographic accounting models, time series analysis, econometric models with lagged terms (which Hepple focuses on), simulation, and control theory.

Grubbström's "Tensor Formulation of Economic Motion" uses tensor calculus (a tensor is a vector, defined as a function of another vector, which satisfies a certain well-defined transformation) to describe transformations in n-dimensional space. Each dimension represents either an economic or decision variable, and the transformations would then describe changes in the economy. This, like many of the other papers in the volume, gives one a taste of a particular modeling approach. But in no way could one learn how to model using that approach simply from reading the paper. Also, with the limited editorial commentary, most of the papers in the volume would be understandable only to the more mathematically inclined Regional Scientist.

My overall impression of the three volumes is that they will likely make a significant contribution to the Regional Science and Geography literatures. This is primarily because of the rather distinct theme of the collection of readings, one which is both intriguing and important; and because of the authors, most of whom are rather prominent in their fields. Yet, this positive reaction is offset by the fact that, in each volume, some of the papers do not relate to most of the others; that the editors do not adequately compare the various papers within a volume, let alone integrate the three major themes of the collection; and that, frankly, the quality of the papers is highly variable.

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DAVID P. VARADY, *Ethnic Minorities in Urban Areas: A Case Study of Racially Changing Communities* Boston/The Hague/London: Martinus Nijhoff Publishing, 1979, xv, 187 pp.

Central to an understanding of the social geography of American cities is knowledge of the process of neighborhood change, which has usually meant the succession of whites by blacks but is increasingly innercity residents replaced by wealthy immigrants in gentrified neighborhoods. Since the Chicago School of Sociology exposition of the concepts of community and invasion-success, efforts to verify these propositions at a miccrolevel have been few. Varady's study of a West Philadelphia neighborhood is clearly an attempt to examine the process of neighborhood change through the reasons responsible for white outmigration. Little consideration is given to black in-migrants nor to the overall neighborhood context in which the changeover took place.

Varady placed four issues at the center of his study. He examined the characteristics of the racial transition process, whether white households accelerated their moving plans in response to black immigration, what factors affected white moving plans and what factors affected white attitudes toward racial integration. The book is a modified dissertation arising out of the request by a Conservative Jewish congregation in Wynnefield for a study of neighborhood change and its effects on the congregation. Three of the eight chapters (the core of the analysis) have been previously published in professional journals.

Varady examined the data from three surveys. A random sample of neighborhood residents (both Jewish and non-Jewish) was interviewed by

telephone in Spring 1969 for religious, demographic and mobility data. In Summer 1969, the previously-identified Jewish families completed mailed questionnaires covering Jewish cultural and religious characteristics. These Jewish families were resurveyed in 1974 to determine their migration behavior, racial attitudes and support for integration efforts. The samples are biased toward middle-income groups and the author confined himself to an explanatory account of his sample's behavior and does not generalize to the neighborhood population. Here a contradiction is present. At the beginning of the monograph, the author devotes a lot of attention to the question of neighborhood change and attempts to show how Wynnefield is typical of white middle-class areas adjoining expanding black ghettos. Yet because of biases in his sample, Varady cannot generalize his results to other, similar communities. Nonetheless, this account contains useful information on one aspect of neighborhood change, the white population that perceives itself under pressure from an expanding black community.

In many cities Jewish neighborhoods have exhibited more rapid rates of outmigration as blacks begin to enter formerly all-white areas. Varady attempted to explain this phenomenon using such variables as religious identification, racial attitudes, length in the neighborhood, age, education, and home ownership. Racial prejudice was not an important predictor of out-movement but, significantly, owners were more likely to remain than renters. Varady suggests that a key factor holding whites in the area was their wish to maximize the quality of housing within limited financial means. Since comparable housing in suburban areas would cost considerably more, many households remained despite their perceived fear of neighborhood deterioration. A strong geographical component is present with households closest to existing black-dominated blocks most likely to move. Varady couches his discussion in terms of invasion-succession and discusses the deleterious consequences of this process for white middle-class neighborhoods. He mentions growing crime rates, deteriorating school performance, and increased blight but does not document his statements to show how these supposed changes correlated with neighborhood change. Data on crime and standardized school tests are for the years after the area changed populations. In addition, the benefits of housing filtering to blacks are ignored. Although many of his respondents were concerned about street crime (90 percent in Wynnefield), the percentages in Lower Merion, an adjacent middle-class suburb, were almost as high (81 percent) although the actual crime rate was significantly lower. Are we to infer that Lower Merion is a prime candidate for population change, despite its reputation as an attractive suburb? Tiny sample sizes prevented Varady from answering mobility hypotheses about Lower Merion residents. Replication of his study in this suburb after a decade might prove enlightening in this regard.

Varady suggests other major conclusions emerging from his study. Whites living close to expanding black communities do not want to be part of a neighborhood numerically dominated by blacks. For his study area, residents' attitudes on Jewish-Gentile relations determined time and location of movement since conservative Jews, with strong links with coreligionists in the area, were most likely to remain. From Varady's study and others for similar neighborhoods, we have a good picture of the process of change from the point of view of the indigenous populations. We know little about the black immigrants or the other actors on this complicated stage (the real estate agents, financial institutions or governmental officials). We gain little of a "sense of place" from Varady's work. While he met his research objectives

(examining the migration motives and racial attitudes of the white population), such division of a complicated picture into segments is debatable. More than passing reference to the other aspects of neighborhood change are needed for a complete study.

Integrated neighborhoods are characterized by temporary existence in American cities. If integration is to become a realistic possibility, white fears of neighborhood deterioration as well as white prejudice have to be overcome. Varady uses the failed attempts of religious and community groups in Wynnefield as lessons for other neighborhoods facing racial change and who wish to persuade whites to remain. He suggests that localistic stabilization strategies are unlikely to succeed because residents' associations are inherently unable to influence those processes that focus black housing demand on the changing neighborhood. Consequently, metropolitan-wide housing policies whose aim is the dispersal of low and moderate income black families are needed to relieve the pressure on white neighborhoods adjoining black ghettos. Neighborhood organizations should devote their energy toward this "dispersal strategy" but Varady overlooks the potential for a split in the white suburban and white central-city alliance resulting from such a push. A trend toward increasing black concentration in some formerly white areas has been arrested by the immigration of young, middle-class whites who are rehabilitating older homes. What distinguishes these areas from other neighborhoods that become completely black is the "place utility" attached to them by the wealthier immigrants. If other transitional areas could provide such attractions, stable, integrated neighborhoods become a distinct possibility. Not many areas possess the combination of circumstances that encourage white immigration to transitional neighborhoods. If residential integration is a worthwhile national goal (and many have argued that it is illusory and only serves to detract from the main issues of housing and job quality and the public service provision), programs of national scope must be designed and implemented at the metropolitan scale. Opposition from suburban dwellers, often former residents of transitional neighborhoods, make such programs almost certain to fail and the weak recommendations offered by Varady are not much of a help in crucial policy questions.

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