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THE EFFECT OF INCREASED WATER SALINITY ON MOSHAVIM IN THE SOUTH AND NEGEV REGIONS OF ISRAEL

by

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D. Yaron and A. Ratner

Supplement to

Economic Evaluation of the Rate of Substitution between Quantity and Quality (Salinity) of Water in Irrigation.

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THE EFFECT OF INCREASED WATER SALINITY ON MOSHAVIM IN THE SOUTH AND NEGEV REGIONS OF ISRAEL

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A sample of ten moshav villages provided the empirical background for the study. Similar to the kibbutz sample, the geographical area extended from the Lackish region in the North to the Bessor region in the South, with a variety of soil types and rainfall ranging from 200 to 500 mm The number of families per moshav ranged from 50 to 106 . Each family farm owns and operates between 3 to 4.5 hectares of land divided into 2 - 3 plots. Generally one plot, called "Plot A" is adjacent to the homestead. Over and above the family owned and operated land, the village cooperative has at its disposal jointly operated fruit groves and sometimes field crops.

The family farms grow fruit crops, vegetables and flowers and raise cattle, poultry and other livestock. Due to the fragmented field plots the family farms refrain from growing cotton, which, on the kibbutzim is generally the recipient of the marginal water quantities and determines the MVP of water.

At present, the sample moshavim receive their water supply from the national water carrier at a uniform salinity level ranging from 220 ppm/Cl to 250 ppm/Cl, depending on the year, season and other factors. In view of the projected deterioration of the water quality to be supplied to the South and the Negev, one of the alternatives for water supply to the moshavim in the region is a dual supply system to the villages, with high quality being supplied to the homestead and the adjacent Plot A and the other plots receiving water of lower quality (higher salinity). While the dual water supply originates primarily in sanitary considerations there is a high correlation between sanitary quality and the salinity content.[1] The other alternative for water supply to the moshavim in the region is unified water quality to all plots of the farm.

The unique features of the moshavim distinguishing them from the kibbutzim are the following:

A. A large number of decision making units (family farms within each village);

B. Water supply is not a clear cut limiting factor of production; on some villages and farms it is, on others it is not. This is due to the fact that moshavim do not grow cotton and similar crops which fulfill the duty of "the recipient of the marginal water". Whether this fact is the result of objective circumstances or of subjective factors originating in the type of organization of the moshav cooperatives - this issue remains unsolved within the context of this study.

C. The relative weight of the profit maximizing approach is less emphasized in the decision making of family farm operations than on the kibbutzim.

In view of the above, an analytical optimization approach to the evaluation of the effect of increased water salinity on the income and the crop composition of the moshavim was considered inadequate. The only way to apply an analytical approach implied sampling of family farm units within the villages and studying the salinity effects at the family farm

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[1] The motivation is to keep water originating in reclaimed sewage away from homesteads and the adjacent Plots A. While this water is scheduled to meet <u>all the sanitary criteria</u> of water quality presently known, keeping this water away is a means of precaution over and above the criteria currently practiced with respect to other sources of water.

level as well as the interactions between the family farms and the village cooperative. Such an endeavour fell beyond the scope of this study. Instead a simulation model was applied to moshav villages at an aggregate level.

In an earlier study (Yaron et al 1979, in Hebrew, p. 21), the yield losses accrued to major salinity-sensitive vegetable crops, under conditions of sprinkler irrigation and a variety of agroclimatic situations, were estimated to be up to 4% of the potential "standard" yield at water salinity of 200 ppm Cl, 7-9% at 300 ppm Cl and up to 12-13% at 400 ppm Cl. The incremental losses due to increase in salinity from 200 to 300 ppm Cl were, accordingly, 3-5%, and due to an increase in salinity from 200 to 400 ppm Cl - 8-9%. The corresponding losses in income are percentagewise, about double that of the physical losses to yield.

It was decided not to include the losses accrued to vegetable crops in the analysis. This was due to:

(i) The fact that the estimated losses are not large;

(ii) The losses were estimated with reference to sprinkler irrigation (for which base data is available) while the losses can be reduced and in reality are reduced by drip irrigation.[1]

It is not claimed that the potential losses to vegetables are completely negligible; in the range of the relevant salinities they are small and our ability to estimate them is lacking.

As the result of the above, the simulations leading to the estimates of salinity damages to the sample moshavim were restricted to fruit groves. Sprinkler irrigation was referred to in the simulations, as the predominating technology used in the irrigation of the major fruit crops - citrus and avocado.

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[1] The extent of this reduction is not presently known.

The computer program designed for the study, written in FORTRAN, is documented, including detailed explanations and comments, as a Library Program SALIN at the Computer Center of the Hebrew University of Jerusalem, and is available for common use. The flowchart of the essentials of the program is presented in the Appendix to this supplement.

With respect to each moshav and its agroclimatic conditions (soil type and rainfall distribution) the following elements were simulated:

1) The process of salt accumulation and leaching in the soil over a series of years, till a steady state in terms of soil salinity is achieved. This process was simulated for all fruit crops with reference to sprinkler irrigation. The major functional relationships and parameters are described in Appendix A. For more details the reader is referred to Yaron et al (1979, in Hebrew).

2) For each fruit crop the process was replicated with reference to 5 different rainfall series, randomly selected from historical records. These five series were used repeatedly for all simulations performed with respect to the same village.

3) The yields and the incomes of the various crops per land unit area were computed with reference to the steady state soil salinity. Again the major functional relationships and parameters are described in Appendix A and more details can be found in Yaron et al. (1979, in Hebrew).

4) The income derived from the total acreage of the various crops were computed and summarized.

The above simulation process was applied to each moshav, assuming the following situations:

a) Three levels of water salinity, namely 220, 300 and 400 ppm Cl.

b) Two alternatives with respect to water supply to the moshav villages:

(i) Alternative I : Unified water quality supplied to all plots of the family farms and those operated by the cooperative.

(ii) Alternative II: Dual water supply to the family farms with "Plots A" (adjacent to homesteads) being supplied with "good" quality water (220 ppm Cl), and the other (families' and common) plots being subject to varying levels of water salinity within the range of 220-400 ppm Cl.

c) Two policy scenarios with respect to fruit groves:

(i) "Scenario 1": The acreage of the fruit groves being fixed.

(ii) "Scenario 3": The less profitable fruit groves being substituted by profitable and salinity sensitive ones. The rationale for "Scenario 3" was discussed in reference to the kibbutzim.

Table 1 presents the estimated losses accrued to fruit groves on Plot A and Plot B and others[1] under conditions of fixed acreage of fruit crops, uniform quality of water supply to all plots, with salinity levels of 220, 300 and 400 ppm Cl, respectively. The table points to three noteworthy phenomena:

(a) Income loss of 11-26% is observed already at the 220 ppm Cl base salinity level.

(b) The major share of the losses originate in Plots B and others. (See Table 2).

(c) No pattern discriminating between the losses in the three subregions South, North and South Negev is evident.

Of special importance to policy decisions is the relatively small share of losses on Plots A. It suggests that the policy option aimed at

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[1] With Plot B and others including the commonly operated groves.

Table 1 Estimated Income Derived from Fruit Crops and Losses Accrued due to Increased Water Salinity under Conditions of Fixed Acreage of Fruit Crops and Uniform Quality of Water Supply, in Moshavim in the South and the Negev.

Moshav No. and Region [1]	Standard Income 000 I.L.			Salinity of Low Quality Water ppm Cl	Loss 000 I.L. [1]			Loss, %		
	Plot A	Plot B & others	Total		Plot A	Plot B & others	Total	Plot A	Plot B & others	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) South	0	8,627	8,627	220	0	927	927	0	11	11
				300	0	1,824	1,824	0	21	21
				400	0	2,884	2,884	0	33	33
(2) South	0	1,998	1,998	220	0	288	288	0	14	14
				300	0	611	611	0	31	31
				400	0	991	991	0	50	50
(3) South	1,379	4,033	5,412	220	214	805	1,019	16	20	19
				300	459	1,638	2,097	33	41	39
				400	746	2,616	3,367	54	65	67
(4) N. Negev	1,305	4,107	5,412	220	243	771	1,014	19	19	19
				300	481	1,506	1,987	37	37	37
				400	776	2,550	3,326	59	62	61
(5) N. Negev	3,142	6,540	9,682	220	403	880	1,283	13	13	13
				300	492	1,881	2,373	16	29	29
				400	808	3,102	3,910	26	47	47
(6) N. Negev	0	6,525	6,525	220	0	1,228	1,728	0	26	26
				300	0	2,241	2,241	0	34	34
				400	0	4,810	4,810	0	24	24
(7) N. Negev	1,141	2,326	3,467	220	255	440	695	22	19	20
				300	532	908	1,440	47	39	42
				400	853	1,435	2,288	75	62	66
(8) S. Negev	2,383	3,684	6,067	220	605	646	1,251	25	18	21
				300	786	924	1,710	33	25	28
				400	1,264	1,484	2,748	53	40	45
(9) S. Negev	0	5,723	5,723	220	0	1,071	1,071		19	19
				300	0	2,175	2,175		38	38
				400	0	3,479	3,479		61	61
(10)	0	5,900	5,900	220	0	1,070	1,070		18	18
				300	0	2,181	2,181		37	37
				400	0	3,472	3,472		59	59

[1] At Spring 1978 price level; one I.L.(Israel pound) = 6 US cents approximately.

Table 2 Share of Losses of Plots A and B and others under Conditions of Uniform Quality of Water Supply in Moshavim in the South and the Negev

Moshav No. and Region	Salinity of poor quality water ppm Cl	Plot A	Plot B & others
(1)	(2)	(3)	(4)
(1)	220	0	100
South	300	0	100
	400	0	100
(2)	220	0	100
South	300	0	100
	400	0	100
(3)	220	21	79
South	300	22	78
	400	22	78
(4)	220	24	76
N. Negev	300	24	26
	400	23	77
(5)	220	31	69
N. Negev	300	21	79
	400	21	29
(6)	220	0	100
N. Negev	300	0	100
	400	0	100
(7)	220	37	63
N. Negev	300	37	63
	400	37	63
(8)	220	48	52
S. Negev	300	46	54
	400	46	54
(9)	220	0	100
S. Negev	300	0	100
	400	0	100
(10)	220	0	100
S. Negev	300	0	100
	400	0	100

Source: Based on Table 1

Of special importance to policy decisions is the relatively samll share of losses on Plots A. It suggests that the policy option aimed at water supply of high quality to Plots A only is questionable. The issue is further illuminated by Tables 3 and 4. Table 3 presents the estimated incremental losses accrued to fruit crops due to salinity, with 220 ppm Cl referred to as the basis for the comparisons (status quo, approximately). Table 4, (which is based on Table 3) presents the estimated benefits (equivalent to reduced losses) in fruit crops production due to dual water quality supply, with Plots A only receiving good quality water. Table 4 shows that on five moshavim the benefits are zero while the average benefit per moshav (including the above five) is estimated at 52, 103 and 273 thousands I.L.[1] for salinity levels of 260, 300 and 400 respectively.

If we take 300 ppm Cl as a benchmark for policy decisions, the amount of 103,000 IL (at 1978 Spring price level) should be compared with the investment cost involved in a dual water supply. Preliminary estimates of these costs, now available, suggest that they are considerably higher than the above amount; inclusion of income losses in vegetable crops (not included in the 103,000 I.L. estimate) most likely will not change this conclusion.

To summarize, considering fixed acreage policy with respect to fruit crops, the salinity issue does not justify the supply of high quality water to Plots A only. The reason for this is the prevailing distribution of fruit groves between Plots A and others with only a small share being grown on Plots A (Table 5). If the justification for supplying high quality water to Plots A and the homestead is based on sanitary considerations, the question arises as to why the quantity to be supplied is

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[1] At Spring 1978 price level; one I.L. (Israel pound) = 6 US cents.

not just the quantity needed for home consumption? On the whole the issue of dual supply implies more elaboration. Especially, elaboration is needed with respect to the spatial allocation of good quality and low quality water in each particular moshav, in reference to its spatial distribution of plots, soil types and fruit groves.

How would the conditions of "Scenario 3" affect the above conclusions? As shown below the conclusions remain unchanged and valid.

Table 6 presents a comparison of losses due to increased water salinity under conditions of Scenarios 1 and 3, and Table 7 (derived from Table 6) shows the estimated benefits due to dual quality supply, with Plots A only receiving "good" quality water.

It is interesting to discover that while the losses due to salinity under "Scenario 3" are considerably higher than those under "Scenario 1" (Table 6), the benefits attributable to the separation of water supply to Plots A under Scenario 3, are very close to those under Scenario 1. This is due to the fact that under Scenario 3 the whole schedule of losses is shifted up, while the incremental losses between the various salinity levels remain nearly unchanged.

Summary

This supplement presents estimates of income losses to a sample of 10 moshav villages in the South and the Negev regions, due to a potential rise in the salinity of the irrigation water. The estimates refer to the losses accrued to fruit crops only, which constitute the major part of the potential losses.

The estimates address two alternatives of water supply to the villages: (i) a unified water quality supplied to all land plots of the family farms and those operated by the cooperative, and (ii) a dual water supply to the family farms with Plots A (adjacent to homesteads) only being supplied with good quality water, and the other plots being subject to differing levels of water salinity.

The estimates derived in this study provide information needed for policy decisions regarding the salinity aspect of water supply to the region. The following findings should be especially emphasized:

(1) The share of the potential losses on Plots A is, on the average, about 16% only of the total potential losses (Table 2).

(2) The benefits attributable to low salinity, due to the alternative of a dual quality supply are small relative to the cost. The salinity factor by itself does not justify the dual supply according to the terms previously specified.

(3) The issue of dual supply implies more elaboration, with respect to the <u>spatial allocation</u> of good quality and low quality water in each moshav in reference to its spatial distribution of crops and plots.

Table 3 Estimated Incremental Losses Accrued to Fruit Crops Due to Increased Water Salinity under Conditions of Uniform Water Supply, in Moshavim in the South and the Negev

Moshav No. and Region	Base Income at 220 ppm Cl 000 I.L. (1			Change in Water Salinity ppm Cl	Incremental Loss 000 I.L. (1			Incremental Loss %		
	Plot A	Plot B & others	Total		Plot A	Plot B	Total	Plot A	Plot B	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	0	7,700	7,700	220-300	0	897	897		12	12
				300-400	0	1,060	1,060		14	14
South				220-400	0	1,957	1.957		26	26
(2)	0	1,770	1,770	220-300	0	383	383		22	22
				300-400	0	380	380		21	21
South				220-400	0	763	763		43	43
(3)	1,165	3,228	4,393	220-300	245	833	1,078	21	26	25
				300-400	287	478	1,265	25	30	29
South				220-400	532	1,811	2,343	46	56	53
(4)	1,062	3,336	4,398	220-300	238	735	973	22	22	22
				300-400	295	1,044	1,339	28	31	30
N. Negev				220-400	533	1,779	2,312	50	53	52
(5)	2,739	5,660	8,399	270-300	89	1,001	1,090	3	18	13
				300-400	316	1,221	1,537	12	22	18
N. Negev				220-400	405	2,222	2,627	15	40	31
(6)	0	4,797	4,797	220-300	0	513	513		11	11
				300-400	0	2,569	2,569		54	54
N. Negev				220-400	0	3,082	3,082		65	65
(7)	886	1,886	2,772	220-300	277	468	745	31	25	27
				300-400	321	527	848	36	28	30
N. Negev				220-400	598	995	1,593	67	53	57
(8)	1,778	3,038	4,816	220-300	181	278	459	10	9	10
				300-400	478	560	1,038	27	18	22
S. Negev				220-400	659	838	1,497	37	27	32
(9)	0	4,652	4,652	220-300	0	1,104	1,104		24	24
				300-400	0	1,304	1,304		28	28
S. Negev				220-400	0	2,408	2,408		52	52
(10)	0	4,830	4,830	270-300	0	1,111	1,111		23	23
				300-400	0	1,291	1,291		27	37
S. Negev				220-400	0	2,402	2,402		50	50

(1 At Spring 1978 price level; one I.L. (Israel pound) = 6 US cents.

Table 4 Estimated Benefits (=Reduced Losses) in Fruit Crops Production due to Dual Quality Supply with Plots A Receiving "Good Quality" Water (220 ppm Cl) under Fixed Acreage Policy

000 I.L.

Water Salinity ppm Cl / Moshav No. and Region	(1) South	(2) South	(3) South	(4) N.Negev	(5) N.Negev	(6) N.Negev	(7) N.Negev	(8) S.Negev	(9) S.Negev	(10) S.Negev	Average per Moshav
220	0	0	0	0	0	0	0	0	0	0	0
260	0	0	123	119	45	0	139	91	0	0	52
300	0	0	245	238	89	0	277	181	0	0	103
400	0	0	532	533	405	0	598	659	0	0	273

Source: Based on Table 3.

Table 5 Acreage of Fruit Groves on Plots A, Plots B and Others in the Sample Moshavim

Moshav No. & region	Plots A Acres	Plots B & others Acres	Total Acres	Plots A in total %
(1) South	0	116.0	116.0	0
(2) South	0	58.2	58.2	0
(3) South	16.7	74.9	91.6	18
(4) N.Negev	17.7	61.8	79.5	22
(5) N.Negev	36.3	114.8	151.1	24
(6) N.Negev	0	115.0	115.0	0
(7) N.Negev	20.1	51.5	71.6	28
(8) S.Negev	37.3	65.4	102.7	36
(9) S.Negev	0	94.3	94.3	0
(10) S.Negev	0	79.8	79.8	0
Average	12.8	83.2	96.0	12.8

Source: Department of Settlement, The Negev Region.

Table 6 Estimated Losses Accrued to Fruit Crops Due to Increased Water Salinity under Conditions of Uniform Water Supply, Scenarios 1 and 3

Moshav No. and Region	Water Salinity ppm Cl	Losses Scenario 1 000 I.L.[1]		Losses Scenario 3 000 I.L.[1]		Increase in Losses under Scenario B %	
		Plot B & others	Total[2]	Plot B & others	Total[2]	Plot B & others	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) South	220	927	927	1,319	1,319	42	42
	300	1,824	1,824	3,882	2,882	58	58
	400	2,884	2,884	4,307	4,307	49	49
(2) South	220	288	288	463	463	51	51
	300	611	611	1,033	1,033	69	69
	400	991	991	1,702	1,702	72	72
(3) South	220	805	1,019	1,032	1,229	28	21
	300	1,638	2,097	2,123	2,558	30	22
	400	2,616	3,362	3,430	4,139	31	23
(4) N.Negev	220	771	1,014	858	1,111	11	95
	300	1,506	1,987	1,727	2,235	15	12
	400	2,550	3,326	2,828	3,636	11	9
(5) N.Negev	220	880	1,283	1,165	1,586	32	24
	300	1,881	2,373	2,524	3,063	34	29
	400	3,102	3,910	4,194	5,082	35	30
(6) N.Negev	220	1,728	1,728	2,299	2,299	33	33
	300	2,241	2,241	2,891	2,891	29	29
	400	4,810	4,810	6,459	6,459	34	34
(7) N.Negev	220	440	695	684	952	55	37
	300	908	1,440	1,471	2,030	62	41
	400	1,435	2,288	2,321	3,219	62	41
(8) S.Negev	220	646	1,251	927	1,634	43	31
	300	924	1,710	1,233	2,134	33	25
	400	1,484	2,748	2,008	3,477	35	27
(9) S.Negev	220	1,071	1,071	1,326	1,326	24	24
	300	2,175	2,175	2,538	2,538	17	17
	400	3,479	3,479	4,368	4,368	26	26
(10) S.Negev	220	1,070	1,070	1,191	1,191	11	11
	300	2,181	2,181	2,444	2,444	12	12
	400	3,472	3,472	3,888	3,888	12	12

Footnotes: (1 Spring 1978 price level; one I.L. (Israel pound) = 6 US cents.
(2 Total Losses = Losses Plots A + Losses Plots B & others.

Table 7 Estimated Benefits (=Reduced Losses) in Fruit Crops Production due to Dual Quality Supply with Plots A Receiving "Good"Quality Water (220 ppm CL) under Conditions of "Scenario 3"

000 I.L.[1)]

Water Salinity ppm Cl / Moshav No. and Region	(1) South	(2) South	(3) South	(4) N.Negev	(5) N.Negev	(6) N.Negev	(7) N.Negev	(8) S.Negev	(9) S.Negev	(10) S.Negev	Average per Moshav
220	0	0	0	0	0	0	0	0	0	0	0
260	0	0	119	128	59	0	131	97	0	0	53
300	0	0	238	255	118	0	291	194	0	0	110
400	0	0	512	555	467	0	630	762	0	0	293

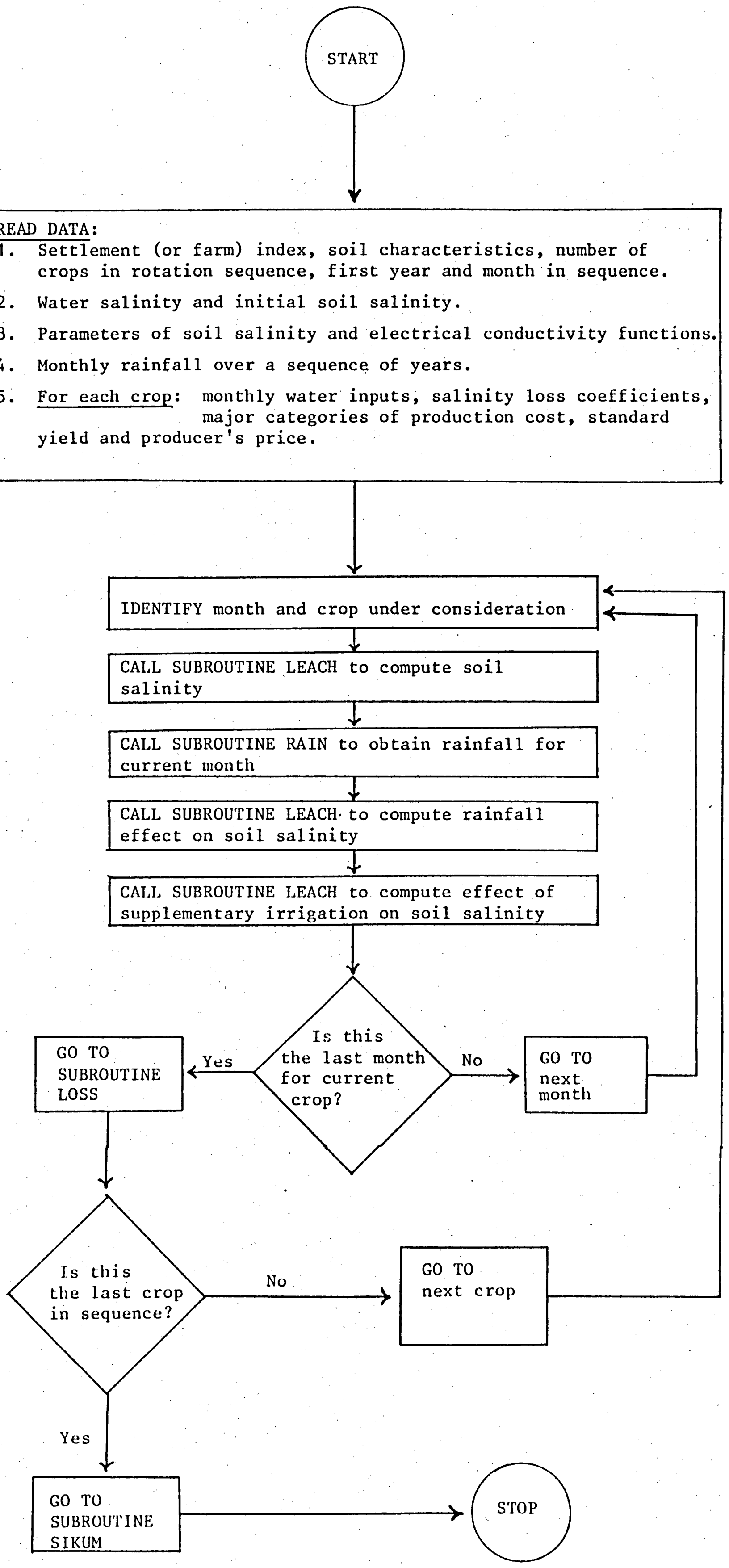
Footnote: 1) Spring 1978 price level; one I.L. (Israel pound) = 6 US cents.

APPENDIX TO SUPPLEMENT

FLOWCHART OF PROGRAM SALIN B

MAIN PROGRAM

(Essentials only)



SUBROUTINE LEACH

OBTAIN:
Current month, soil salinity before water application (or rain), soil characteristics, quantity and salinity of water applied, parameters of soil salinity and electrical conductivity functions

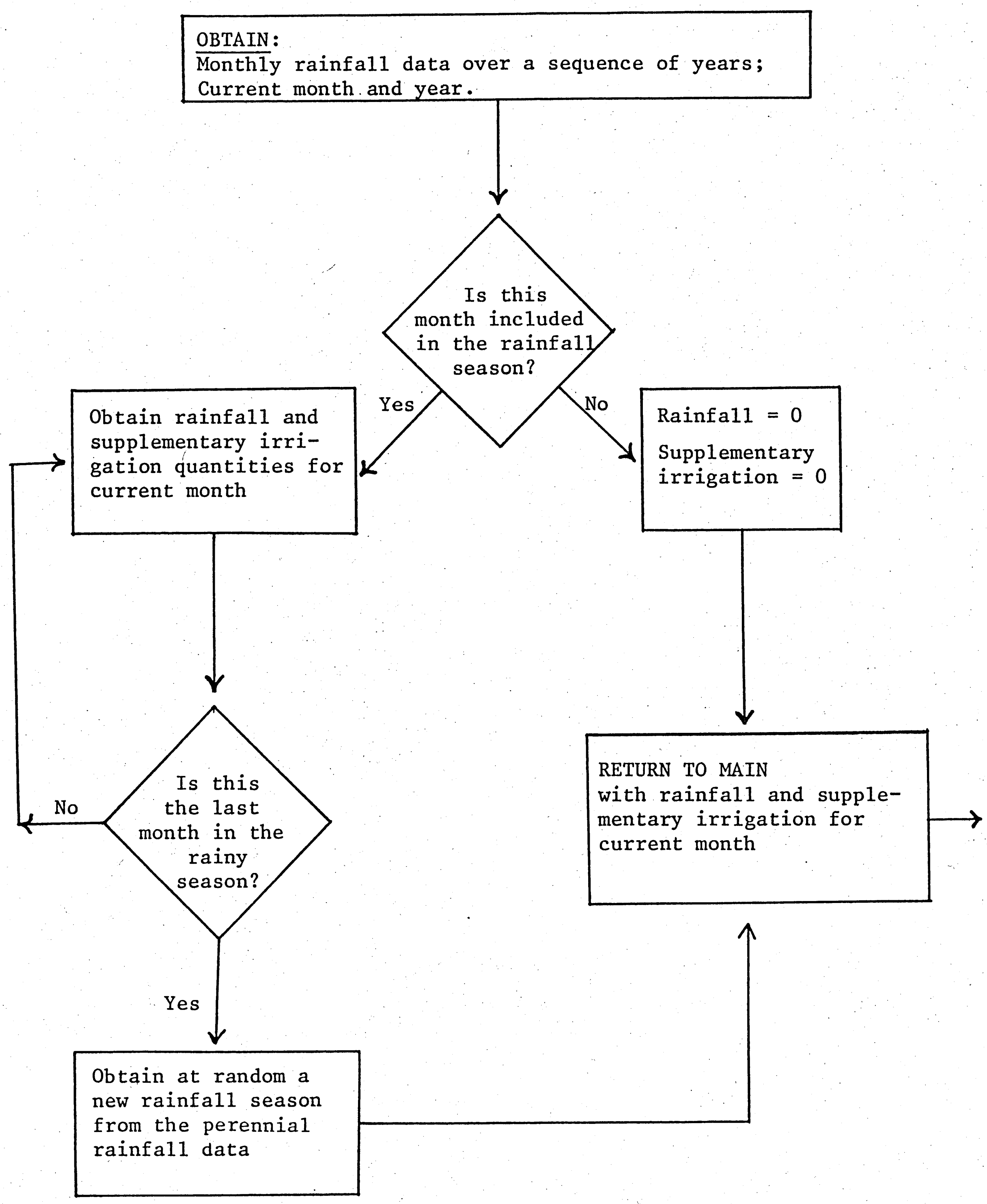
↓

COMPUTE:
Soil salinity after water application (or rain)

↓

RETURN TO MAIN:
With computed soil salinity as initial conditions for the following period.

SUBROUTINE RAIN



SUBROUTINE LOSS

OBTAIN:
Soil parameters, the current crop, crop yield and standard income data, crop loss function parameters, soil initial and terminal salinity levels according to crop growth season

↓

COMPUTE:
Yield loss (%) accrued to current crop

↓

COMPUTE:
Monetary loss, as percent of standard income accrued to current crop

↓

RETURN TO MAIN:
With computed losses as inputs for continuation

SUBROUTINE SIKUM

OBTAIN RELEVANT INPUTS AND PRINT:

1) Table 1.

   Soil salinity at the end of each month, total rainfall and supplementary winter irrigation in each year.

2) Table 2.

   For each crop in the sequence:

   Soil salinity, initial and terminal data, salinity loss function parameters, standard yield, standard income, physical loss accrued, income loss, relative income loss (% of standard) quantity and salinity of water used.

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6901 Yoav Kislev and Hanna Lifson - An Economic Analysis of Drainage Projects.

6902 Yair Mundlak and Ran Mosenson - Two-Sector Model with Generalized Demand.

6903 Yoav Kislev - The Economics of the Agricultural Extension Service. (Also in Hebrew).

7001 Dan Yaron and Gideon Fishelson - A Survey of Water Mobility on Moshav Villages. (Hebrew).

7002 Yakir Plessner - Computing Equilibrium Solutions for Various Market Structures.

7003 Yoav Kislev and Yeshayahu Nun - Economic Analysis of Flood Control Projects in the Hula Valley, Stage One - Final Report. (Hebrew).

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