THE POSSIBLE EFFECT OF INCREASED IRRIGATION WATER ON CROP DISTRIBUTION IN TWO DISTRICTS OF ISFAHAN TOWNSHIP, IRAN

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THE POSSIBLE EFFECT OF INCREASED IRRIGATION WATER ON CROP DISTRIBUTION IN TWO DISTRICTS OF ISFAHAN TOWNSHIP, IRAN

By

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Any errors remaining in this study are the sole responsibility of the author.

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CHAPTER I

INTRODUCTION

In Iran irrigation is a necessity for a majority of its agriculture. Only in the northern part which is close to the Caspian Sea is rainfall sufficient to meet the needs of agriculture. Therefore water resource allocation is of fundamental importance.

Isfahan Township is located in the center of Isfahan Province. It consists of ten districts from which two districts, Kararaj and Baraan, were chosen for analysis. These two districts depend entirely upon irrigation water. Under the current distribution system Kararaj has water from the river only three days in the fall and Baraan for only four days (Table 1).

Shah Abbas the Great Dam is being built on the Zayandeh-Rood River. The extra water provided by the project will irrigate Isfahan Township including the two districts under analysis.

The objective of this study was to analyze the shift between summer crops and the decrease in the percentage of fallow as a result of the availability of more water. Summer crops in Isfahan Township include sugar beets, melons, cucumbers, onions, potatoes, millet,

Table 1. Method of distribution and rotation of the Zayandeh-Rood River waters among villages having water rights. a/

	Spring	Summer (June 22nd - Sept. 22nd)			Fall		
Village	Khordab b/	Tir	Mordad	Shahrivar	Mehr	Aban	Total Days
			(Days of the Month)				
Lenjan & Alenjan	_____	1-18	1-9 & 16-24	1-9 & 16-24	1-11 & 19-28	_____	75
Marbin & Jay	_____	19-39	10-15 & 25-30	10-15 & 25-30	12-18 & 29-30	1-8	53
Kararaj	_____	____	_____	_____	_____	9-11	3
Baraan	_____	____	_____	_____	_____	12-15	4
Rood Shatein	16-30	____	_____	_____	_____	16-30	30
TOTAL	15 Days	30 Days	30 Days	30 Days	30 Days	30 Days	165 Days

a/ Atai, M., "Economic Report on Agriculture In The Isfahan and Yazd Areas," Tahgigat é egtesadi, The quarterly Journal of the Institute for Economic Research, University of Tehran, Iran, August, 1965. Volume III Nos. 9 and 10, Table 13.

b/ Iranian months in the year 1965, Iranian months were as follows:

Khordad	-- May 22nd - June 21st	Shahrivar	-- Aug. 23rd - Sept. 22nd
Tir	-- June 22nd - July 22nd	Mehr	-- Sept. 23rd - Oct. 22nd
Mordad	-- July 23rd - Aug. 22nd	Aban	-- Oct. 23rd - Nov. 21st

cotton, tobacco, fodder, and some other summer crops. Because of the shortage of data, the analysis was restricted to the first five of the mentioned crops. These five crops, however, represent a high proportion of summer crop hectarage in Kararaj and Baraan (Table 2).

Analysis was carried out under eleven water allocation patterns and price assumptions utilizing Linear programming techniques. The programming was used to determine the optimum crop combinations which would maximize profit, given the current and assumed water constraints and crop prices.

Table 2. Crop distribution and land use in Kararaj and Baraan Districts, Isfahan Township, Isfahan Province, Iran (1964) [a]

	Kararaj District		Baraan District	
	Area	Land in Crops	Area	Land in Crops
	Hectare	Percent	Hectare	Percent
Total Land Area	3,622.5	473.1	15,659.0	729.7
Winter Crops [b]	765.7	100.0	2,146.0	100.00
Summer Crops [c]				
Sugar Beets	147.8	19.3	572.8	26.7
Melons	32.7	4.3	254.1	11.8
Cucumbers	52.9	6.9	28.1	1.3
Onions	68.2	8.9	64.2	3.0
Potatoes	---	---	---	---
Millet	---	---	---	---
Cotton	15.0	2.0	241.2	11.2
Tobacco	---	---	---	---
Other	24.9	3.2	9.6	0.4
Total of Summer Crop Area [c]	341.5	44.6	1,183.2	54.5
Summer Fallow [d]	424.2	55.4	962.8	44.9
Total Summer Irrigable Area [e]	765.7	100.0	2,146.0	100.0
Cover Crop [f]	29.3	3.8	101.0	4.7
Orchard [f]	258.5	33.8	153.2	7.1
Total Cropped Area	1,053.5	137.6	2,400.2	111.8

a/ Data on winter crop area and summer crop area were provided through a personal communication with Engineer H. Basirii. (Appendix A)
b/ Based on judgment estimates
c/ Excluding cover crops and orchards
d/ Winter crop minus summer crop
e/ Total summer irrigable area is assumed to be the same as winter irrigated land.
f/ Assumed not to be available for allocation to summer crops.

CHAPTER II

IRRIGATION AGRICULTURE IN ISFAHAN TOWNSHIP

Iran contains 1,645,000 square kilometers (628,000 square miles) with a population of 25 million. Seventy-five percent of the population is in farming areas. Only 10 percent of the land is cultivated; 40 percent is used for grazing; 15 percent is forested; and 35 percent is desert and waste.

Isfahan Township is located in the center of Isfahan Province (Figure 1 and 2). It has an area of 21,182 square kilometers (2,118,200 hectares) with a population of 296,369.[1] Ninety percent of the farmers in Isfahan Township use traditional methods.

The average farm size for one farmer using hand tools (bilkar) in Isfahan Township in 1963 was estimated to be 0.9477 hectare.[2] This figure does not include fallow. Isfahan has a warm sub-tropical steppe climate with low rainfall.

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1 Atai, M. "Economic Report on Agriculture, In the Isfahan and Yazd Areas, "Tahigat é egtesadi, the quarterly Journal of the Institute for Economic Research. University of Tehran, Iran, August, 1965. Volume III, Nos 9 and 10. Page 74 and table 1a.

2 Ibid. Table 23 and page 144. Data based on the survey carried out by the Cereal Economics Crop and the questionnaires of the Department of Agricultural Economics of Isfahan Province.

Figure 1. Political Map of Isfahan Province

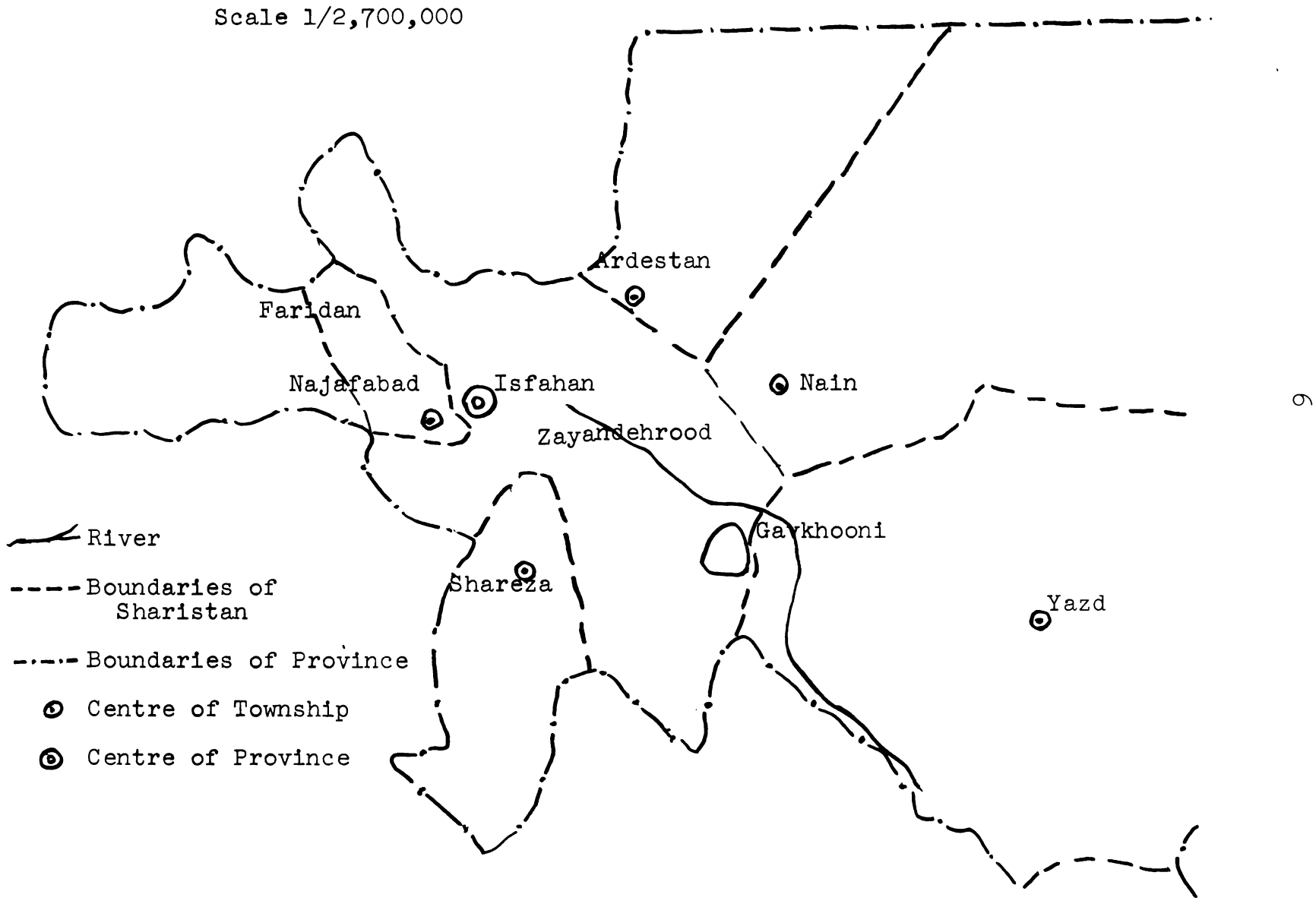
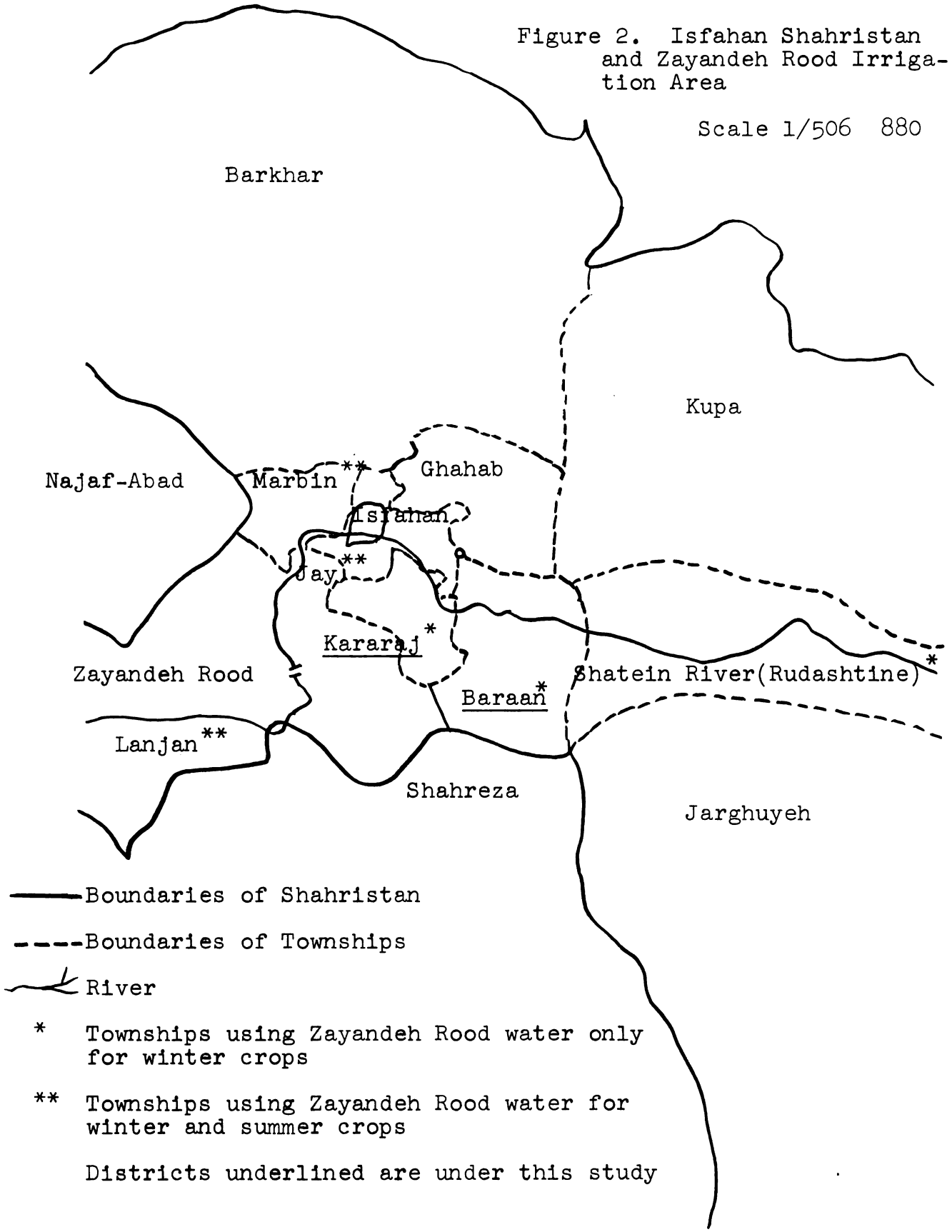


Figure 2. Isfahan Shahristan and Zayandeh Rood Irrigation Area

Scale 1/506 880



Distribution of rainfall in Isfahan Township is as follows.[1]

(inches)

January:	0.6	May:	0.2	September:	0.0
February:	0.4	June:	0.6	October:	0.1
March:	0.1	July:	0.0	November:	0.6
April:	0.6	August:	0.0	December:	0.8

Monthly Average Temperature (F^{o})[2] - Annual Average 60 F^{o}.

January:	36	May:	69	September:	73
February:	40	June:	79	October:	62
March:	49	July:	83	November:	50
April:	59	August:	80	December:	41

This township consists of ten districts. Six districts are irrigated by the water of the Zayandehrud-Rood River. The four remaining districts have the potential of being irrigated by the river. Of the six districts which are irrigated by the river, three of them, Lenjan, Jay and Marbin are heavily irrigated and Kararaj, Baraan, and Rudashtine are lightly irrigated.

Shortage of water has been one of the major limitations of production in these lightly irrigated districts

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1 The Agriculture of West Asia, U.S. Department of Agriculture/Economic Research Service/ERS Foreign-143 page 44.

2 Ibid. Page 42.

as it is for the majority of Iran's agricultural industry. Shah Abbas the Great Dam Project will increase the supply of the water in the summer for Isfahan Township and especially for the lightly irrigated districts of Kararaj and Baraan which have been chosen for study. Rudashtine district was excluded because of the lack of data.

The data used in this study were obtained from a survey of input-output and waterneed data for the districts.[1] The crop rotation in Kararaj is wheat - summer crop - wheat; or sugar beet - wheat - sugar beet. In Baraan the rotation is wheat - one to three years fallow - wheat; or wheat - one to three years fallow - summer crop - wheat. Thus there are two crop seasons each year, winter and summer, which do not compete for water.

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[1] Engineer H. Basirii, the head of this survey, provided most of the data which are in unpublished form. A personal visit by the author in the summer of 1967 determined that there were no other data available.

CHAPTER III

ALTERNATIVE WATER USE PATTERNS, LINEAR PROGRAMS, AND TECHNICAL DATA

In this chapter we consider first alternative use patterns of additional water and then turn to linear programs and technical data used.

A. Alternative Use Patterns of Additional Water

Increased irrigation water is likely to shift the proportions of summer crops. What crops will increase and decrease as more water become available? In addition the two districts to be studied, Kararaj and Baraan, have a considerable percentage of land under fallow, partly because of the existence of salt in the top soil and partly because of the shortage of water. The objective was to specify the shift between summer crops and the decrease in the percentage of the fallow as a result of the availability of more water. The unit of analysis was chosen to be a farm, one hectare in size, under the management of one farmer. It was also assumed that the land would be cultivated by family labor only.

"The main crop in the districts of Kararaj, Baraan and Rudashtine is wheat ... Small amount of summer crop is irrigated by the Cham-abeh (extra water) of the river

or from other sources such as ganat, keis (an open ganat which takes the drainage water of an up-stream village and irrigates another village down stream), oxen wells and nowadays widespread use of engines for pumping water from the wells, as in other districts (another source of water is Zayandeh-Rood River). The main summer crop used to be cotton and some watermelons. Now sugar beets are taking over.

After the addition of Kuhrang water to the Zayandehrud River there were three years of good rainfall and ample water. But in the last two drought years, water did not reach Baraan for the irrigation of their summer crop."[1]

Basirii said the increased water supplied by the project will be distributed to the districts under a new system and new canals will be made for this purpose.

The summer crops under study compete in water usage during the five months: Ordibehest, Khordad, Tir, Mordad, and Shahrivar. That is, two months in spring and three months in summer. We assumed that the water resource requirements for production of all of the crops at all level of production were constant, i.e., we assumed constant returns to scale for the water resource.

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[1] Engineer H. Basirii, "An Agricultural Socio-Economy Study of Zayandehrud River," Isfahan, Iran, page 15. (unpublished)

In this study the optimum use of alternative patterns of increased irrigation water was explored through the use of linear programming.

B. Linear Programs

There are a number of different techniques which might be used in making this analysis, including farm budgeting. Linear programming was chosen for the following reasons: It was an efficient optimizing technique, and"it provided a means of retaining the advantages of budgeting without really sacrificing the economic framework underlying functional analysis."[1]

In these programs we assumed constant returns to scale and constant crop prices. Constant returns to scale refers to constant resource requirements per hectare and constant yields for each additional hectare of land, unit of water, or any other unit of a production factor.

In linear programming, the optimum plan for a given situation depends on (1) the input-output coefficients, (2) the prices employed in the programming, and (3) the resources available. A change in any of these three components will change the optimum plan.

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[1] Warren H. Vincent and Larry J. Connor, An Orientation For Future Farm Planning And Information System, Department of Agricultural Economics, Michigan State University, Ag. Econ. Misc. 1968-5. Page 5.

C. Technical data

Water use, input-output data and prices were obtained for only five of the summer crops; sugar beets, melons, cucumbers, onions and potatoes from a survey.[1] These five, however, represent a high proportion of the summer crop hectarage in Kararaj and Baraan as was shown in Table 2. The analysis is limited to these five crops. The input-output data for the five crops were however compared with other references.[2] The data for cucumber and onions were adjusted according to the references and personal judgment.

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[1] The input-output data are based on data gathered in the locations indicated in Appendix B.

[2] Adams, R. L., Farm Management Crop Manual, University of California Press, Berkley, Los Angeles, 1953.

Atai, M., "Economic Report on Agriculture In The Isfahan and Yazd Areas," Tahgigat e egtesadi, The Quarterly Journal of the Institute for Economic Research. University of Tehran, Iran, August, 1965. Volume III, Nos. 9 and 10.

Eres, Arjeh, "Farm Management Studies, Varamin-Garmsar Project," Tehran, April 1967, Part III, page 5. (Mimeo)

"Wholesale prices agriculture and livestock products (F.A.G.) week ending." Department of Agricultural Economics, Ministry of Agriculture, Tehran, Iran, May 25, June 8 and 15, 1967. (Unpublished)

1. Input-output coefficients. They can be defined as the quantity of resources required to produce one unit of specified crop or to cultivate one hectare of land. In our analysis only water requirements for five months are considered (Table 3). Because of the lack of data and since labor is largely supplied by the family, labor was not included in our analysis. Input-output coefficients for water were the same for all of the problems.

2. Price, yield and net income. Net income was calculated as gross revenue minus total variable cost (Tables 4 and 5). Total variable cost was defined as the sum of cash costs which the farmer had to pay: seed, fertilizer (organic and artificial), herbicide, and hauling. Total variable cost and net income per hectare for five crops with current crop proportions in Kararaj and Baraan are shown in Table 6.

3. Resources available (constraints). Water resources available for five months were calculated from the current usage of water for one hectare under current crop distribution (Table 7). These constraints vary for the two districts. Land resources available were assumed to be one hectare for each farmer. In the problems which were included in our analysis the land limitation for each crop was set at a specified percentage of one hectare

Table 3. Crop water requirements by months[a/]
-Cubic meters per hectare

Months [b/]	Sugar beets	Melons	Cucumbers	Onions	Potatoes
Ordibehesht	2,014	1,718	-----	1,344	2,039
Khordad	2,597	1,702	-----	2,396	6,396
Tir	2,323	2,523	-----	3,576	4,063
Mordad	4,388	1,685	4,641	2,590	1,309
Shahrivar	2,030	235	2,109	759	818
Total (five months)	13,352	7,863	6,750	10,665	14,625
Total for the whole cultivation period	13,532	7,864	7,460	13,111	16,332

Water requirement was measured by the means of partial flume method.

a/ Engineer H. Basirii, personal communication (Appendix B).
b/ Iranian Months (see Table 1).

Table 4. Gross Revenue, Total Variable cost, and net income per hectare. a,j/

	Sugar Beets			Melons (Observation No.1)			Melons (Observation No.2)		
~~Variable~~ cost:	Amount Kilo	Price Rials	Total Rials	Amount Kilo	Price Rials	Total Rials	Amount Kilo	Price Rials	Total Rials
Fertilizer									
Organic				1,000b	6	6,000	1,020	6	6,120
Artificial	200c	13	2,600	170c	12.5	2,125	400	11	4,400
	200e	10	2,000						
Seed			Free	10	120	1,200	16	80	1,280
Herbicide			Free			500g	10h	40	400
Hauling	35,000		8,050						
Total Variable Cost			12,650			9,825			12,200
~~Gross Revenue~~	35,000	1.25	43,400	24,000	2.17	52,000	27,692	2.17	60,000
Net Income i			30,750			42,175			47,800

Table 4. (Con't.)

	Cucumbers			Onions			Potatoes		
Variable cost:	Amount Kilo	Price Rials	Total Rials	Amount Kilo	Price Rials	Total Rials	Amount Kilo	Price Rials	Total Rials
Fertilizer									
Organic	1,000[b]	10	10,000	1,000[b]	10	10,000	600[b]	7.5	4,500
Artificial	250[d]	19.1	4,775				120[c]		2,760
	250[f]	3	7,500				120[e]		
Seed	15	500	7,500	25	120	3,000	1,200	8.33	10,000
Herbicide			1,000						
Hauling									
Total Variable Cost			23,275			13,000			17,260
Gross Revenue	15,000	3	45,000	30,000	2	60,000	12,960	4.43	57,500
Net Income[i]			21,725			47,000			40,240

[a] Engineer H. Basirii, personal communication, (Appendix B)
[b] Galeh - 120 Kilograms
[c] Amunium Phosphate
[d] 20 - 20
[e] Urea
[f] Urea and Nitrate
[g] D.D.T.
[h] Sulfur
[i] Gross Revenue minus total variable cost
[j] Ten jeribs was assumed to be one hectare. One jerib may be slightly more than 1,000 square meters due to local measures.

Table 5. Calculation of Net Income per hectare with different price assumptions [a]

A. Current Prices

Crops	Yield	Price	Gross Revenue	Total Variable Cost	Net Income
	kilo/ha.	Rials	Rials	Rials	Rials
Sugar Beets	35,000	1.24	43,400	12,650	30,750
Melons	25,846	2.17	56,000	11,012	44,988 [b]
Cucumbers	15,000	3	45,000	23,275	21,725
Onions	3,000	2	60,000	13,000	47,000
Potatoes	12,960	4.44	57,500	17,260	40,240

B. All Crop Prices Doubled

Sugar Beets	35,000	2.48	86,800	12,650	74,150
Melons	25,846	4.34	120,000	11,012	100,987
Cucumbers	15,000	6	90,000	23,275	66,725
Onions	30,000	4	120,000	13,000	107,000
Potatoes	12,960	8.87	115,000	17,260	97,740

C. Sugar Beet Price Doubled and a 50 percent Increase in other Crops

Sugar Beets	35,000	2.48	86,800	12,650	74,150
Melons	25,846	3.25	83,999	11,012	72,987
Cucumbers	15,000	4.5	67,500	23,275	44,225
Onions	30,000	3	90,000	13,000	77,000
Potatoes	12,960	6.65	86,250	17,260	68,990

a/ Derived from Table 4.
b/ This figure is the average of melons net income of two observations (Table 4).

Table 6. Crop Land Used, Gross Revenue, Total Variable Costs and Net Income per Hectare for five Summer Crops based on current Crop Distribution, Kararaj and Baraan Districts. [a]

A. Kararaj

Crops	Land in Summer Irrigated Crops	Gross Revenue	Total Variable Cost	Net Income[b]
	Percent	Rials	Rials	Rials
Sugar Beets	19.30	8,376	2,441	5,935
Melons	4.27	2,391	470	1,921
Cucumbers	6.90	3,105	1,606	1,499
Onions	8.90	5,340	1,157	4,183
Potatoes	0	0	0	0
TOTAL CROPS[c]	39.37	19,212	5,674	13,538

B. Baraan

Sugar Beets	26.69	11,583	3,376	8,207
Melons	11.84	6,630	1,304	5,326
Cucumbers	1.30	585	302	282
Onions	2.99	1,794	389	1,405
Potatoes	0	0	0	0
TOTAL CROPS [c]	42.82	20,592	5,371	15,220

[a] Derived from Tables 2 and 5
[b] Gross revenue minus total variable cost
[c] The remaining crop land is fallow

Table 7. Estimated average water used per hectare by the current combination of five crops - cubic meters [a]

A. Kararaj

Crop	Crop Percentages	Ordibehesht	Khordad	Tir	Mordad	Shahrivar	Total of Five Months
Sugar Beets	19.3	389	501	488	847	392	2,577
Melons	4.3	73	73	108	72	10.0	336
Cucumbers	6.9	0	0	0	320	146	466
Onions	8.9	120	213	318	230	68	949
Potatoes	0	0	0	0	0	0	0
TOTAL CROPS [b]	39.4	582	787	874	1,469	616	4,328

B. Baraan

Sugar Beets	26.7	538	693	620	1,171	542	3,564
Melons	11.8	201	201	299	200	28	931
Cucumbers	1.3	0	0	0	60	27	88
Onions	3	40	72	107	77	23	319
Potatoes	0	0	0	0	0	0	0
TOTAL CROPS [b]	42.8	779	966	1,026	1,508	610	4,902

a/ Derived from Tables 2 and 3.
b/ The rest of the land is mostly fallow due to lack of water, see Table 2.

(Table 8). The constraints were established on the basis of some maximum increase from the current percentage of the crop. These constraints vary for the two districts.

D. Summary of Programs used.

Specifically, eleven problems were prepared, the first five problems were for Kararaj and the last six were for Baraan. The model set up for problem 1 included current crop prices and specified waterneeds (Table 9). A similar model was used for all of the other problems with changing constraints and prices.

The model uses two constraints. The land constraints were set on the basis of the current crop distribution of each district (Table 2) by roughly doubling the area percentages. The reason for limiting the area of each crop was because not all of the factors could be included in the model. If this was not done the results would probably have suggested growing only one or two of the most profitable crops, an unrealistic result. Water constraints were varied based upon the analysis summarized in table 7.

Net income under specified price was maximized for solution of the program (Table 5 and 10).

Table 8. Water and Land Constraints.

	Kararaj					Baraan					
Problem ~~Number~~	1	2	3	4	5	6	7	8	9	10	10A
Water	Cubic Meters					Cubic Meters					
~~Orbidehesht~~	582	1731	1447	582	1731	779	1960	1759	779	1960	1960
Khordad	787	1731	1652	787	1731	966	1960	1946	966	1960	1960
Tir	874	1731	1307	1307	1731	1026	1960	1516	1516	1960	1960
Mordad	1469	1731	1469	2335	1731	1508	1960	1508	2488	1960	1960
Shahrivar	615	1731	615	1480	1731	620	1960	622	1600	1960	1960
Land	Percent of Summer Crop Land					Percent of Summer Crop Land					
Sugar beet	50	50	50	50	50	60	60	60	60	60	60
Melons	15	15	15	15	15	30	30	30	30	30	30
Cucumbers	15	15	15	15	15	10	10	10	10	10	10
Onions	20	20	20	20	20	10	10	10	10	10	10
Potatoes	30	30	30	30	30	30	30	30	30	30	30

Table 9. Linear Program for Problem 1.
Kararaj, Current Crop Prices and Specified Water Needs

	Sugar Beets	Melons	Cucumbers	Onions	Potatoes	Fallow		(Constraints)
Net Income	-30,750	-44,987	-21,725	-47,000	-40,240	0		
Water Requirements[a]								
Orbidehesht	2,014	1,718	0	1,344	2,039	0	≤	582
Khordad	2,597	1,702	0	2,396	6,396	0	≤	787
Tir	2,323	2,523	0	3,576	4,063	0	≤	874
Mordad	4,388	1,685	4,641	2,590	1,309	0	≤	1,469
Shahrivar	2,030	235	2,109	759	818	0	≤	616
Land	1	1	1	1	1	1	=	1 Hectare
Sugar Beet	1	0	0	0	0	0	≤	.50
Melons	0	1	0	0	0	0	≤	.15
Cucumbers	0	0	1	0	0	0	≤	.15
Onions	0	0	0	1	0	0	≤	.20
Potatoes	0	0	0	0	1	0	≤	.30

[a] Cubic meters

Table 10. Net Income from crops used in the different problems - Rials Per Hectare [a]

	Sugarbeets	Melons	Cucumbers	Onions	Potatoes	Fallow
Problems 1, 2, 3, 4, 6, 7, 8, and 9	30,750	44,988	21,725	47,000	40,240	0
Problems 5 and 10	74,150	100,987	66,725	104,000	97,740	0
Problem 10A	74,150	72,987	44,225	77,000	68,990	0

Kararaj problems. The first problem was the control problem. Therefore the survey water available and prices were used. The purpose was to observe how different the program results were from the empirical crop distribution. The second problem specified a 100 percent increase in total water limitations. In the third problem water constraints were increased by 50 percent of the total water available for five months. The extra water was proportioned among the first three months as follows: 2/5 for each of the first and second months and 1/5 for the third month.

[a] Derived from Tables 5A, 5B, and 5C

Problem four was the same as problem three except the extra water was proportioned among the last three months as follows: 1/5 for the third month, and 2/5 for each of the fourth and fifth months. Problems three and four were set up assuming that because of some socio-economical reasons the district could receive water at the beginning or at the end of their season only. In problem five both water constraints and crop prices were doubled. Land limitations were held the same in all of the five problems (Table 8).

Baraan Problems. Problems 6 - 10 were similar to problems 1 - 5, except water use for Baraan was used. Problem 10A was the same as problem 10 except that only sugar beet price was doubled, while prices for the other crops were increased by 50 percent. Problem 10A was set up because the market for all of the crops except sugar beets is in Isfahan city, a considerable distance away. The market for sugar beets is the sugar processing plant. Land limitations were held the same in all of the Baraan problems (Table 8).

CHAPTER IV

SHIFTS IN CROP PATTERNS SUGGESTED BY PROGRAMMING - DISCUSSION AND CONCLUSIONS

A. Summary of Results

The objective was to explore the shifts between summer crops and the decrease in the percentage of the fallow resulting from the availability of more water.

Five problems were set up for Kararaj and 6 problems for Baraan. The variables were water constraints and crop prices. The results indicated that in all of the cases except problem 9, extra water remains available in the first and last months.

In the discussion of the results we will compare the results of each problem with the current crop combination for each district. This will indicate the suggested changes to the crop distribution under different assumed conditions.

1. Kararaj results

The survey showed a current crop combination of 19.3 percent of land for sugar beets, 4.3 percent melons, 6.9 percent cucumbers, 8.9 percent onions, 0 percent potatoes and 60.6 percent fallow. This provided 13,538

rials profit per hectare (Table 11). Problem 1 was the control problem. The programming results indicated that under the specified existing conditions put in the program, maximizing net income would call for 5.9 percent sugar beets, 15.0 percent melons, 15.0 percent cucumbers, 9.9 percent onions, 0 percent potatoes and 54.0 percent fallow. This combination would increase net income to 16,533 rials per hectare. The comparison of the crop combination suggested for the control problem (Problem 1) and the survey crop combination showed that sugar beets should be reduced. The factors which appear to have influenced the farmers to grow more low return sugar beets included the provision of the seed, herbicide, fertilizer, transportation facilities as well as the certainty of income for farmers from the sugar processing plant. Melons and cucumbers both increased to 15.0 percent of their constraints. The reasons that farmers currently grow only 4.3 percent melons and 6.9 percent cucumbers could be market capacity and uncertainty of prices. Intensive labor requirements for these two products could be another reason. Fallow was reduced only a few percentage points to 54.0 percent. In terms of net income current practices provided lower income than the control problem. The main reason is due to the high percentage of sugar beets grown in current practices which reduce net income.

Table 11. Problem Results

A. Kararaj

	Current Crop Combination	Control Proj Current Water Avail. & Prices	100% Inc. In Water Constraints	50% Inc. In Water Const. 2/5 for ea. 1st and 2nd mo.; 1/5 for third	50% Inc. In Water Const. 1/5 for 3rd mo. & 2/5 for each fourth & 5th	100% Inc. In Water & 100% Inc. in Prices	100% Inc. In Water & Sugar Beet Price 50% Inc. In Other Crop Prices
~~Problem~~		1	2	3	4	5	
Crops	Crop Percentages Per Hectare						
Sugar Beets	19.3	5.9	1.6	0	2.0	1.6	
Melons	4.3	15.0	15.0	15.0	15.0	15.0	
Cucumbers	6.9	15.0	15.0	13.5	15.0	15.0	
Onions	8.9	9.9	20.0	20.0	20.0	20.0	
Potatoes	0	0	14.7	5.2	0	14.7	
Fallow	60.6	54.0	33.6	46.1	47.1	33.6	
Profit/Ha. Rials	13,538	16,533	25,845	21,209	20,028	62,184	

B. Baraan

~~Problem~~	6	7	8	9	10	10A
Crops	Crop Percentages Per Hectare					
Sugar Beets	26.7	11.5	12.6	4.1	5.0	12.6	25.3
Melons	11.8	30.0	30.0	30.0	30.0	30.0	30.0
Cucumbers	1.3	10.0	10.0	10.0	10.0	10.0	0
Onions	3.0	0	10.0	10.0	10.0	10.0	10.0
Potatoes	0	0	13.5	7.5	1.3	13.5	6.3
Fallow	57.1	48.4	23.7	38.3	43.6	23.7	28.3
Profit/Ha. Rials	15,220	19,230	29,719	24,664	22,460	70,312	52,755

The results of problem 2, 100 percent increase in water, indicated that melons, cucumbers, and onions would increase to their limitations, i.e., 15.0, 15.0 and 20.0 percent, respectively. It was interesting that potatoes came in to the solution and the results indicated 14.7 percent of the land be placed in potatoes. This happened because potatoes required the largest amount of water in the second and third months when all of the crops compete for water (Table 3). Under the conditions of problem 2 the fallow dropped to 33.6 percent in comparison with survey figure of 60.6 percent. This showed that with a 100 percent increase in water, the fallow decreased almost 50 percent.

Results of problem 3, more water the first three months, indicated that sugar beet hectarage would drop to 0 percent. This was because sugar beets require large amounts of water at the end of the season. Potatoes came into the solution somewhat 5.2 percent. Fallow dropped to 46.1 percent.

The results of problem 4, more water for the last three months, showed melons, cucumbers, and onions at their acre limits and no potatoes. Note that when more water was available at the end of the season, potato hectarage dropped to zero. This was due to the fact that

sugar beets required more water at the end of the season while potatoes required it at the beginning.

The crop combination suggested for problem 5 (100 percent increase in water and crop prices) was the same as problem 2. This was because the rank of the net income was not changed from problem 2.

2. Baraan Results

The survey crop combination was 26.7 percent of land for sugar beets, 11.8 percent melons, 1.3 percent cucumbers, 3.0 percent onions, 0 percent potatoes, and 57.1 percent fallow.

Problem 6 was the control problem for Baraan. The suggested results indicated 11.5 percent sugar beets, 30.0 percent melons, and 10.0 percent cucumbers should be grown. Neither onions nor potatoes came into the results. Fallow was suggested to be 48.4 percent. The net income provided by this suggested crop combination was 19,230 rials in comparison with 15,220 rials which was earned under the survey crop combination. The comparison of the suggested crop under current conditions and survey crop combination showed that sugar beets would drop to 11.5 percent from 26.7 percent. The factors which caused the farmers to grow more sugar beets, as it was mentioned in the Kararaj results, were the provision of some agricultural factors and the certainty of income from the sugar

processing plant. Less melons and 1.3 percent cucumbers were grown than indicated by this problem suggested. The reason for these differences could be the market capacity and uncertainty of prices. Intensive labor requirements for these two crops could be another reason. Onions did not come into the solution because of high water requirements. No potatoes were included in the program results because of the large amounts of water required for this crop in the critical months of Khordad and Tir.

The results of problem 7, 100 percent increase in water constraints, indicated that onions and potatoes come into the solution also. Onions were recommended to be grown on 10.0 percent of the land at the program limit and potatoes at the level of 13.5 percent. Fallow decreased by more than 50 percent to 23.7 percent.

In Problem 8, more water for the first three months, sugar beet hectarage decreased further to 4.1 percent. Onions again met their land limitation and potatoes were included at the level of 7.5 percent.

In problem 9, more water in the last three months, potatoes declined to 1.3 percent. This was because potatoes required a large amount of water at the beginning of the season.

The results of Problem 10, 100 percent increase in water and crop prices, were the same as those of Problem 7.

In Problem 10A cucumbers dropped out. This problem had a 100 percent increase in water and in the price of sugar beets with a 50 percent increase in prices of other crops. Melons and onions again increased to their land limitations. Potatoes were in the solution but only at a 6.3 percent level.

3. General results

With all of the assumed conditions the problems showed sugar beets at a level of production less than the current level. The factors which caused the farmers to grow more sugar beets probably included the facilities provided by the plant mentioned earlier and the certainty of income provided by sugar processing plants.

In all of the assumed cases melons increased to the land limitations. Currently melons and cucumbers were grown in both districts at a lower level than that which was suggested by programming. The reasons could include market capacity, price uncertainty and intensive labor requirements for these two crops. Cucumbers had the lowest profit per hectare but because they did not compete for water usage in critical months, they were included up to their land limitations except in Problem 3

and 10A. In problem 10A net income per hectare for cucumbers was too low to bring them into the solution.

Onions had the highest profit per hectare and the programming indicated that onions be grown up to the land limitations except in the two control problems (Problem 1 and Problem 6). This was due to the fact that onions require a large amount of water.

Potatoes were included whenever more water was available, at the beginning of the season.

The results indicated that in all of the cases, except Problem 9, water in the first and the last months was in excess. Therefore, only in three months, i.e., in the last month of spring and in the first two months of summer, was there high competition for water use among the crops.

B. Conclusions about the use of programming

Linear programming technique is an efficient method for analyzing optimum crop combinations. However it has some shortcomings including linearity and homogenity of resources. By linearity we mean that input factors combine in fixed proportions at all levels of output. Also, output will vary in fixed proportions with any given input, and thus, neither economies nor diseconomies of scale exist. In the "real world" this is not always the

case, because of the existence of the increasing or decreasing return to scale.

Homogenity of resources is another assumption. This means that each category of resource is homogenous in the linear programming approach. Under an actual farm situation, resources such as land may not be homogenous, neither among farms nor within farms.[1]

In the model which was used in our study risk and uncertainty were not included. As we observed in the survey proportion of the crops sugar beets were grown at the levels greater than the result of programming indicated. It appears this was because of the certainty of income and facilities provided by the sugar processing plant. The certainty of sugar beet income could be taken into account by increasing its net income by a reasonable percentage. On the other hand the uncertainty of income from melons and cucumbers could be offset by discounting net income from these crops. The amount of increase or decrease in net incomes should be decided on the basis of past experience with such variables as: price fluctuation, input availability, marketing facilities, physical conditions and other related factors.

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[1] Ching-yuan Chao, Optimum Resource Allocation Single Crop Paddy Farms in Southern Taiwan, National Taiwan University, August, 1964. Bulletin No. 1 Page 29.

Data shortcomings.

In our analysis the water use and input-output data were available for only five crops. Although these five crops represented a high proportion of the summer crop hectarage in Kararaj and Baraan, still a considerable percentage of land was under vegetable cultivation.

Only the data for onions were from a village in Kararaj district. The data for other crops were from other districts in Isfahan Township (Appendix B). Only one observation for each of the crops was available, except for melons, which had two observations. This input-output information shortage highlights the critical need for much higher quality data for decision making in agriculture in this area.

The water constraints in the problems were set by personal judgment since the dam has not been built and therefore the amount of water that is going to be given to these districts is not clear.

The data for labor, capital, acquisition and salvage prices for resources were not available.

Because only a few requirements and limitations were introduced into the model, it was possible that the results would suggest growing only one or two of the most profitable crops. To prevent this, land limitations for

crops were established on personal judgment based on acreages currently grown (Table 2).

Further development of this model could include a market demand curve. In this case quadratic programming would be used. If market data for several years were available price could be treated as a function of the prices of previous years. Under this circumstance some form of dynamic programming such as recursive programming might be used.

Finally it should be remembered that the results of the study depend upon the limitations imposed by the assumptions made in the study.

BIBLIOGRAPHY

Adams, R. L. Farm Management Crop Manual, University of California press, Berkley, Los Angeles, 1953.

Atai, M. "Economic Report On Agriculture In the Isfahan and Yazd Areas," Tahgigate egtesadi, The quarterly Journal of the institute for Economic Research. University of Tehran, Iran, Volume III, Nos. 9 and 10, August,1965.

Basirii, H. (Engineer) "An Agricultural Socio-Economy Study of Zayandehrud River," Isfahan, Iran, (unpublished).

Chig-Yuan, Chao, Optimum Resource Allocation Single crop paddy Farms in Southern Taiwan, National Taiwan University, Bulletin No. 1, August, 1964.

Department of Agricultural Economics, Ministry of Agriculture, "Wholesale prices Agriculture and livestock products (F.A.G.) Tehran, Iran, week ending May 25, June 8, and 15, 1967.

Eres, Arjeh, "Farm Management Studies, Varamin-Garmsar Project," Tehran, Iran, Part II, April, 1967.

U.S. Department of Agriculture/Economics Research Service/ERS Foreign-143, The Agriculture of West Asia.

Vincent, Waren H., Conner, Larry J., An Orientation for Future Farm Planning and Information System, Department of Agricultural Economics, Michigan State University, Ag. Econ. Misc. 1968-5.

APPENDIX

APPENDIX A

Villages from which current crop distribution data was obtained

Kararaj. It contains 30 villages. Crop distribution data only for the following 22 villages were available:[1]

1. Kocharane
2. Teheriane
3. Djodarmane
4. Ghalah Mardane
5. Ozvar
6. Rochnane
7. Echkovand
8. Tehoum
9. Raddane
10. Kouziane
11. Foundane (Didoun)
12. Fizadane
13. Diadane
14. Denart
15. Yousof Abad
16. Kazemabad
17. Sadeghabad
18. Kohdjoune
19. Heidarabad
20. Esfahanak
21. Molana Soufi
22. Salimi

Baraan. It contains 60 villages. Crop distribution data only for the following 46 villages are available:

1. Kaboutar abad
2. Zeyor
3. Itehi
4. Esfina
5. Fesaran
6. Rouhon
7. Rourane
8. Zaghmar

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[1] Engineer H. Basirii, personal communication. The data were gathered during 1966 and 1967.

APPENDIX A (Con't.)

9. Yafrane
10. Golastane
11. Kodj
12. Chahverdeze
13. Timirax
14. Monchiane
15. Doulab
16. Kondjavane
17. Echkechane & Harrim-Abad
18. Vadjareh
19. Poudr Batcheh
20. Nazade
21. Hormadane
22. Essfahrantehe
23. Karchegane
24. Ghazaldonk
25. Pilehvarane
26. Ezirane
27. Karveh
28. Layane
29. Koloudane
30. Endelane
31. Kelartoan
32. Ozvartcheh
33. Didehzane
34. Hadjiabad
35. Yahya abad
36. Eram Pocht
37. Abad
38. Abad Soleymane
39. Kondelane
40. Dastadja
41. Katchloulch
42. Ghalah zamini
43. Teham
44. Galah Boghal
45. Djouzdane (A)
46. Djouzdane (B)

APPENDIX B

Villages from which Input-output and water use data was obtained[1]

Crops	Village	District
Sugar beets	Ghahdariyan	Lenjan
Melons observation 1	Khatoonabad	Borkhar
Melons observation 2	Ghalahshah	Marbin
Cucumbers	Dorcheh	Marbin
Oniona	Heiderabad	Kararaj
Potatoes	Eshahran	Lenjan

[1] Engineer H. Basirii, personal communication
The data were gathered during 1966 and 1967.