1-1-1982

Irrigation Development: It's Potential Impact on South Dakota's Economy

Richard Shane
South Dakota State University

Ralph J. Brown
University of South Dakota

IRRIGATION DEVELOPMENT
IT'S POTENTIAL IMPACT ON SOUTH DAKOTA'S ECONOMY

by

Richard C. Shane and Ralph J. Brown*
Supported by the South Dakota
Department of Water and Natural Resources
Pierre, South Dakota

Economic's Research Report No. 82-1

*Richard C, Shane is an Assistant Professor of Economics at South Dakota State University, Brookings, South Dakota and Ralph J. Brown is a Professor of Economics at the School of Business, University of South Dakota, Vermillion.

IRRIGATION DEVELOPMENT:
ITS POTENTIAL IMPACT ON SOUTH DAKOTA'S ECONOMY

by

Richard C. Shane and Ralph J. Brown

Irrigation development has been and will continue to be a key issue facing the people of the state of South Dakota. As irrigated acreage increases, benefits accrue throughout the State. The irrigator's income earning potential is expanded and income variability is reduced as drought impacts on yields are ameliorated. In addition, a more stable, larger quantity of feed can be produced for livestock production. This may allow for expansion in the livestock industry or less importation of feedstuffs into an area.

The nonfarm economy may also benefit from irrigation development. Since irrigation requires the purchase of more inputs such as seed and fertilizer, allows for the feeding of more livestock and enhances consumption of nondurable and durable goods, what is the impact of develment on the State's economy? It has been hypothesized and generally accepted that as irrigators increase purchases and sales, turnover or multiplier effects on the State's economy are positive. The magnitude of these turnover effects on South Dakota's economy, however, is not agreed upon.

Objectives

The general objective of this study was to estimate the magnitude of potential economic impacts of irrigation development in South Dakota. The purpose was to quantify the impacts when irrigation development took place within four distinct regions of the State non-simultaneously.

The specific objectives or steps taken to accomplish the overall purpose of this project were as follows:

1. An econometric model of the economy of South Dakota was derived.

2. Dryland and irrigated crop rotations and cost of production enterprise budgets for each area in the study were synthesized with current trends in costs and secondly with a doubling of energy costs.

3. The impact of irrigation development on livestock enterprises was estimated.

4. The impact of drought on area crop and livestock production was hypothesized and estimated.

5. Estimates of the potential impacts of irrigation development on South Dakota's economy under varying conditions of irrigated acreage, livestock change, energy price rises and drought were made.

Methodology

The basic metholodology used in this study was an econometric modeling technique. An econometric model capturing the main features and interactions of South Dakota's economy was used to simulate the direct (to the irrigator) and indirect (to the State economy) impacts of irrigation development in four areas of the State. The model used was the South Dakota Labor Market Model (SDLM). The model was used to derive details on output by industry, employment, personal income and its components, farm income and expenses, and State tax collections using alternative assumptions about irrigation development. A diagram depicting the direct impacts of development is shown in Figure 1.

Simulations run with the model provided "with" and "without" irrigation development scenarios. The "without" irrigation scenario provided a control solution with which to compare "with" irrigation scenarios.

Results can then be presented as differences from the control solution when compared with solutions containing varying irrigation development assumptions. Simulations were performed for each study area for the years 1980 through 1990. Only statewide impacts of a fully constructed irrigation project were estimated and no temporary impacts of the construction phase were included. The assumption made was that water would be available at the irrigator's field. A more complete explanation of the model is contained in the study report, "Simulating the Statewide Impact of Irrigation Development in South Dakota," submitted to the South Dakota Department of Water and Natural Resources. The same is true for other subjects addressed in this abbreviated report.

CHARACTERISTICS OF THE FOUR STUDY AREAS AND CROP COSTS

The four study areas included much of central/east central South Dakota, or a 29 county area. The counties included in the four study areas are presented in Figure 2. The areas vary markedly in soil types, irrigability, rainfall, and growing days. The four study areas were chosen taking these factors into account.

The four study areas each contain over two million cropland acres (see Table 1). However, after removing pastured land from total cropland, Study Area 4 has only 1.6 million acres cropped and Study Area 2 has the largest acreage cropped with 2.6 million acres. Study Area 3 has the most pastured acreage. The amount of land irrigated in the four study areas as of the 1978 Agricultural Census is presented in Table 2. Study Area 2 has the most farmers irrigating and irrigated land at 188 and 40,603 acres, respectively.

The crop rotations by percentage of cropland devoted to each crop are presented in Table 3. The predominant dryland crop is wheat in

Figure 1. Direct Impact of Irrigation Development on State Economy

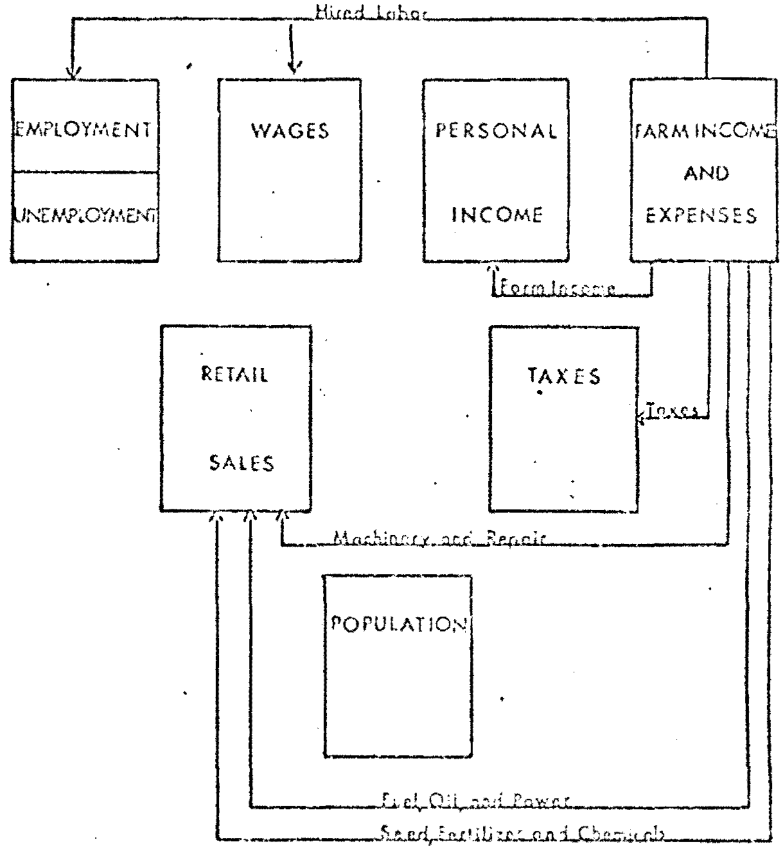
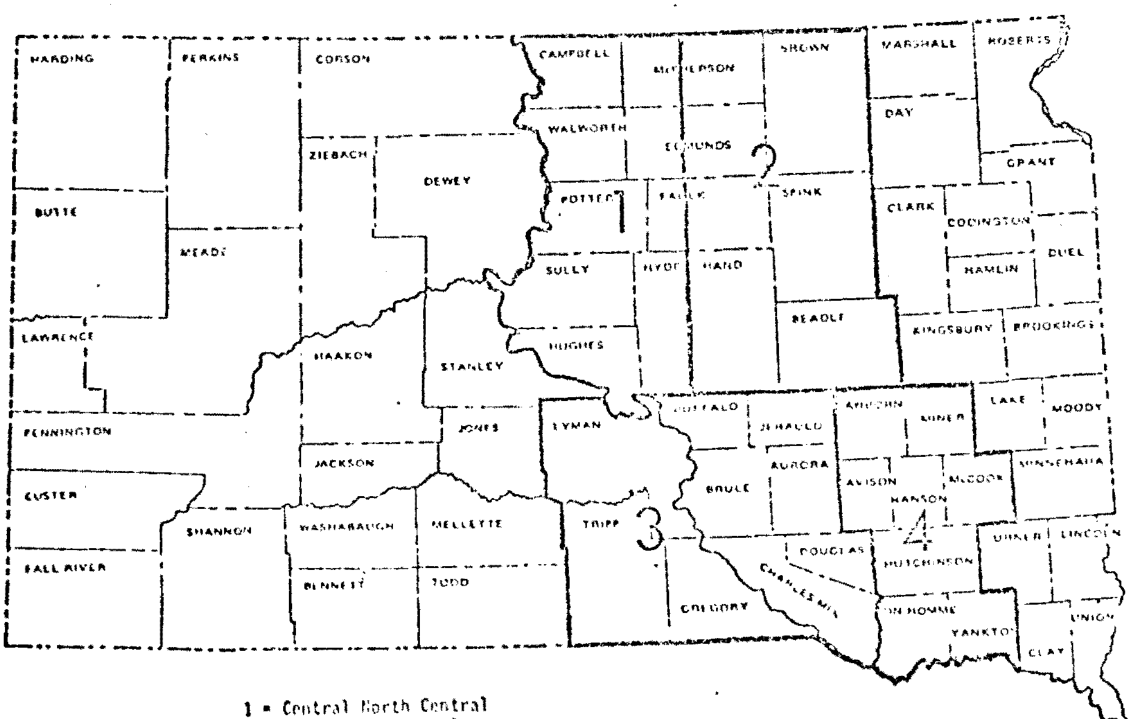


Figure 2. District Breakdown of Study Area



1 = Central North Central
2 = East North Central
3 = South Central
4 = West Southeastern

Table 1. Crop Pasture Land by Region

	Study Area			
	Central North Central	East North Central	South Central	West South Eastern
	(1,000 acres)			
Cropland	2,128	2,963	2,502	2,005
Cropland Pastured	194	372	402	349
Land in Crops	1,934	2,591	2,100	1,656
Pasture	1,639	1,460	2,394	471
Woodland Pastured	1	6	10	5
Land in Pasture	1,834	1,838	2,806	825

Source: U.S. Department of Commerce, Bureau of the Census, "1978 Census of Agriculture". Volume 1 - State and County Data, Part 41 - South Dakota, 1981.

Table 2. Irrigated Cropland by Study Area, 1978[1/]

	Farms Irrigating	Irrigated[2/] Land (Acres)	Percent of Total Cropland Irrigated
Study Area 1[3/]	137	35,607	1.7
Study Area 2	188	40,603	1.4
Study Area 3	161	36,630	1.5
Study Area 4	82	9,292	0.5

Source: U.S. Department of Commerce, Bureau of the Census, "1978 Census of Agriculture". Volume 1 - State and County Data, Part 41 - South Dakota, 1981.

1/Approximately 450,000 acres are currently irrigated in South Dakota.

2/Understates actual Irrigated acreage because county data was not given when individual irrigators operations would have been divulged.

3/Includes all the farms and irrigated land in Edmunds, Faulk, and McPherson Counties. Region 2 includes no irrigation data from these three counties.

Study Areas 1 and 2 and corn in Study Areas 3 and 4. Corn is the predominant irrigated crop in all study areas.

After crop rotation estimates were developed, irrigated and dryland crop production budgets were obtained for each crop in the model. Baseline irrigated crop budgets were obtained from the Economic Research Services in Lincoln, Nebraska. These budgets were derived using the system commonly known as the Oklahoma Budget Generator System or Feds Budgets. The budgets thus obtained were adjusted for regional variations in yield and accompanying harvest and marketing costs. Then the adjusted budgets were taken directly to groups of irrigators from each study region. Each individual cost item and yields were discussed by the groups and adjustments were made where necessary to reflect more accurately the actual average conditions in each region.

The total costs of production for each dryland and irrigated crop are presented in Tables 4 & 5. The total costs of production are nearly equal for individual crops across the four study areas. The major differences in costs arose because of the use of increased amounts of inputs in areas where more rainfall was expected. For example, in Study Area 4, higher seeding and fertilization levels led to higher costs. Since more rainfall was expected in the southern regions, and producers planted and fertilized to attain higher yields, accompanying harvest and handling costs were also higher than in lower rainfall areas.

Table 3. Dryland and Irrigated Crop Rotations by Study Area

Crop	Study Area 1	2	3	4
Dryland		(Percent)		
Corn	14.6	19.6	23.1	44.0
Oats	12.8	10.9	15.5	25.1
Barley	5.8	6.7	3.8	*
Wheat	39.4	33.9	13.5	*
Alfalfa	15.2	16.3	19.9	13.3
Sorghum	*	*	12.0	*
Soybeans	*	*	*	4.2
Other	12.2	12.6	12.2	13.4
Irrigated				
Corn	68.7	70.0	85.4	83.1
Alfalfa	17.8	17.6	11.6	13.8
Wheat	7.5	11.0	--	--
Soybeans	6.0	D	*	3.1
Other	--	1.4	3.0	--

Source: U.S. Department of Commerce, Bureau of the Census, "1978 Census of Agriculture". Volume 1 - State and County Data, Part 41 - South Dakota, 1981.

*Included in other.

D - Withheld to avoid disclosure.

Table 4. Irrigated Crop Budgets, 1980

	Study Areas 1 & 2		Study Area 3		Study Area 4		All Areas
	Corn	Alfalfa	Corn	Alfalfa	Corn	Alfalfa	Soybeans
Yield	130 bu	5 T	130 bu	5.5 T	140 bu	5.5T	35-40[1/]
			($ per acre)				
Variable Costs	$169.00	$ 81.10	$169.55	$ 83.75	$179.65	$ 95.35	$111.50
Ownership Costs	$108.25	$ 80.10	$ 98.90	$ 89.80	$103.00	$ 89.80	$ 95.50
Subtotal Costs	$277.25	$161.20	$268.45	$173.55	$282.65	$185.15	$207.00
Land Charge	$ 36.00	$ 36.00	$ 36.00	$ 36.00	$ 36.00	$ 36.00	$ 36.00
Management Charge	$ 25.00	$ 17.50	$ 26.50	$ 19.25	$ 24.50	$ 19.25	$ 20.00
TOTAL COSTS	$338.25	$214.70	$330.95	$228.80	$343.15	$240.40	$263.00

[1/] Yields varied from 35 to 40 bushels depending on the study area.

Table 5. Dryland Crop Costs, 1980

Crop	Corn	Oats	Barley	Wheat	Alfalfa	Flax	Rye	Sorghum	Soybeans
					($/acre)				
Area 1	107	96	97	98	63	91	91	---	---
Area 2	126	99	103	101	76	97	96	---	---
Area 3	108	92	89	93	63	---	---	98	97
Area 4	144	112	109	109	103	109	---	120	112

Source: Allen and Aanderud, 1980.

IMPACT OF IRRIGATION DEVELOPMENT ON LIVESTOCK ENTERPRISES

A major limiting factor for livestock expansion is a stable supply of feed. It is generally agreed that irrigation development can lead to larger, more stable feed supplies within a region. With a larger quantity of feed available, the question arises, will more livestock be produced as irrigation develops? Also, will such expansion be by individual farmers or by large independent (custom) feedlots or farrow-to-finish hog units?

A 1978 sample survey of irrigators from Turner County indicated that irrigation caused them to make changes in their livestock enterprises. Around 45 percent indicated an expansion in livestock numbers, 45 percent no change, and 10 percent a reduction in their livestock enterprises. Of those reporting no change in numbers, 35 percent reported that they no longer had to buy corn to complete their rations.

A second survey was done in 1978 to ask county agents in South Dakota's Third Planning District if irrigation had caused an expansion of livestock enterprises in their areas. Forty percent indicated that there had been no change and 60 percent only minor changes in total numbers. They also indicated that no independents or custom operations had started business as a result of irrigation development.

Based on these survey results and historical data, it is conceivable that in the short run livestock enterprises will not expand. However, if increased feed production were used in the same proportion as it currently is, livestock enterprises could use up to 60 or 70 percent of increased production in Study Areas 1, 3, and 4 and as high as 100 percent in Study Area 2 where relatively less corn is produced. In the time frame of this study, the use of 25 percent of the expanded crop production for livestock is feasible. A long run upper bound of 60 percent is also highly possible. In this study livestock simulations were run assuming that 25 percent of increased production would be fed to livestock.

In order to make livestock expansion operational within the model, factors were determined which indicate how many livestock could be fed from each acre of irrigated land assuming that all the crop was used for livestock feed.

Several steps were taken to do this. First, livestock enterprises that were limited by the supply of the principle irrigated crops were identified. They are hogs, dairy, and cattle feeding. Sheep composed an insignificant portion of the total and were not included and cow-calf enterprises were limited by pasture. Second, the proportion of feed fed to each enterprise currently was estimated by taking the number of each type of livestock on hand in each region from the 1978 Census of Agriculture and multiplying times feed requirements per head. These feed requirements were summed and proportions per enterprise were calculated. The proportions were then used to allocate feed grain production increases to livestock enterprises. The factors presented in Table 6 represent the amount that livestock enterprises can be expanded per acre of irrigation development. For example, for each irrigated acre in Study Area 1, .69 feeder calf, .05 dairy cow, and .14 sow (plus 16 pigs) can be added to existing enterprises. Finally, these factors are reduced according to the total amount of increased production being fed to livestock. For example, if 25 percent of increased production is fed to livestock, .035 or (.25 x .14) sows per irrigated acre can be added to existing enterprises in Study Area 1. Again, this represents additional livestock due to the larger feed production from irrigation development.

Table 6. Distribution of Additional Feed Produced from Irrigation Among Livestock Enterprises[1/]

Study Area	Pork[2/]	Beef[2/]	Dairy[2/]
1	.14	.69	.05
2	.15	.59	.05
3	.20	.60	.04
4	.23	.36	.06

[1/]Assumes expansion in all enterprises so that the proportion of feed used in each enterprise is equal before and after the expansion.

[2/]Pork included one sow and 16 pigs, beef includes one feeder steer, and dairy includes one cow with 12,500 pounds of annual milk production.

Impact of Drought on Dryland Crop Production

The lack of adequate growing season rainfall for crop development is not uncommon in South Dakota. The impact of drought can be devastating on local or even a state economy like South Dakota's which is agriculturally based. Not only are farmers and ranchers hurt by drought when crops and pastures fail, but so are the local farm suppliers of goods and services.

The degree of drought varies in different parts of South Dakota and within the four study areas. Therefore, drought severity was estimated separately for each area. The method used weighted drought severity by county within each study area.

The drought impact on crop production stemmed from three sources. First, acres harvested were less with drought than without drought. Second, yield per harvested acre declined during drought periods. Finally, costs of production were decreased due to less harvesting and marketing activity.

In order to estimate the impact of drought or farmers' crop production and revenues, a factor was derived which accounted for harvested acre and yield reductions. USDA, South Dakota Crop and Livestock Reporting Service data was used for this process. Yield reductions were estimated by summing production over all the counties per study area and dividing by harvested acres per study area for the best eight production years of the decade from 1971-1980 to obtain "normal" yields. An average yield per acre per region was also calculated for the worst and second worst crop years of the decade. These averages were assumed to be yields for years of severe and moderate drought within the regions. Normal yields were then divided into drought yields to obtain the drought yield factor. For example, during the eight best years in Study Area 1, 15,604,000 bushels of barley were produced from 557,050 harvested acres. By dividing, a weighted average (normal) yield of 31.6 bushels per acre was derived. Similarly, the worst year average was 10.4 bushels per acre and the second worst year was 16.5 bushels per acre. Next, the production factor based on yield reduction for the severe drought was estimated as .3291 by dividing 31.6 (normal yield) into 10.4 (drought yield). The moderate drought yield factor was .5222 or (16.5/31.6).

The impact of a decline in harvested acres on crop production associated with drought was calculated using the best eight year data to estimate normal harvested acres and the worst two years to estimate severe and moderate drought. Normal harvested acres were estimated by dividing total acres planted for the eight best years into total acres harvested for the same years. Drought harvest factors were then derived by dividing normal harvested acres into severe and moderate drought year harvested acres. Again, using barley in Study Area 1 as an example, planted acres for eight years were 609,250 and harvested acres were 557,050, so normally 91.4 percent of planted acres were harvested. The percent of acres planted that were harvested in the worst two years were 29.4 and 45.1, respectively. The factors then were .3217 or (29.4/91.4) and .4934 or (45.1/91.4).

Since both factors are multiplied times normal production a single multiplicative factor can be derived. With barley and severe drought in Study Area 1 this factor becomes .106 or (.3217 x .3291). This factor multiplied times normal production yields drought adjusted production per study area. Drought factors for all crops in each study area are presented in Table 7. Note that the factors for alfalfa are the same for all areas. Area factors could not be derived because only statewide data were available. The South Dakota Crop and Livestock Reporting Service quit publishing county and district alfalfa data in 1975 due to funding cut-backs.

These factors show that generally the severity of drought is greatest in Study Area 1, followed by that in Study Area 2. Study Area 4 incurs the least drought damage of the four study areas. Correspondingly, whichever Study Area has the most severe drought also has the largest cost reductions due to less harvesting activity.

Impact of Drought on Livestock Enterprises

The impact of drought on a dryland farming region is to reduce the feed supply for livestock enterprises. As a result, livestock numbers must be reduced or feed must be transported into the drought-stricken region. Data available suggest that both results occurred in the study areas during periods of drought. Unfortunately, detailed livestock data by county are not available for South Dakota since 1975, making it difficult to obtain estimates of drought impacts on livestock that were as good as those that were obtained for crop enterprises. Since data are not available on livestock numbers by region by year, state data were combined with crop drought factors to estimate drought impacts on livestock. The drought factors were applied to determine crop or feed grain losses and then the feed losses were translated into livestock losses based on how many livestock would have to be sold when the feed supply decreased.

Statewide data reported by the Crop and Livestock Reporting Service indicated that sheep and cow numbers, and correspondingly lambs

Table 7. Factors for Severe and Moderate Drought in Central South Dakota

Crop	Study Area 1	Study Area 2	Study Area 3	Study Area 4
		Severe		
Barley	.106	.128	.247	---
Corn	.035	.035	.165	.448
Oats	.096	.075	.232	.555
Wheat	.344	.243	.481	---
Alfalfa 1/	.438	.438	.438	.438
Sorghum	---	---	.282	---
Soybeans	---	---	---	.710
		Moderate		
Barley	.258	.494	.429	---
Corn	.319	.364	.593	.512
Oats	.136	.518	.419	.810
Wheat	.526	.672	.796	---
Alfalfa 1/	.796	.796	.796	.796
Sorghum	---	---	.561	---
Soybeans	---	---	---	.735

1/ State of South Dakota, no regional data available.

and feeder calves, declined as a result of drought. However, cattle on feed did not show a decline with the calf crop as inflows of cattle from other states for feeding increased to offset the smaller South Dakota calf crop. Also, hog and dairy numbers did not show a drought impact leading to herd liquidation. Indications are that corn and hay were transported to the drought regions to sustain these enterprises. These statewide indicators for livestock losses due to drought were assumed to hold true for each of the four study areas.

In order to estimate drought impacts a base number of livestock per enterpise was required. It was assumed that the livestock populations by county reported in the 1978 Census of Agriculture approximated predrought conditions.

State data indicate that there was a 24 percent larger than expected culling of beef cows in 1976, the worst drought year in the past decade. Normal cyclic herd liquidation accounted for eight percent of this culling and drought the remaining 16 percent. Applying this drought culling to the base beef cow numbers led to a larger than normal selling of cows ranging from 13,019 head in Study Area 4 to 37,935 head in Study Area 3. Because of the sell-down forced by drought and poor pasture conditions, calf sales and cull cow sales were assumed to decrease for four years after the drought. It took four years after the drought to replace all the cows sold assuming one-third were replaced each year after the drought.

Sheep reductions were handled the same way as beef cows. As pasture conditions diminished more ewes were sold. According to State data, ewe sales were eight percent larger than normal during the 1976 drought. Consequently fewer lambs and cull ewes were sold in the years following the drought. Ewes were replaced to pre-drought levels over a three year period.

Decreases in hogs, feeder cattle, and dairy enterprises could not be directly attributed to the drought. Rather, increased costs or lower profits were incurred through the importing of feed and feeder livestock. All three enterprises incurred increased feed prices the year of the drought. These increases were estimated by calculating feed grain decreases due to drought and then assuming replacement of feed through imports. Feed grain cost increases were due to transport and handling costs.

Finally, feeder cattle costs increased in the two years after the drought because of larger than normal imports of feeder calves. Importation led to increased transportation costs. Other possible negative effects of longer than normal transport were not included.

ANALYSIS SIMULATIONS

In this section, policy simulations of the impact of irrigation development in the four study areas are presented. Five policy simulations were performed for each study area. A policy simulation involves a control solution for the 1980-1990 period assuming no additional irrigation development. Then a second simulation is performed assuming irrigation development. The calculated difference between the two simulations represents the impact of irrigation development.

The five policy analysis simulations performed for each study are as follows:

1. simulation of the impact of additional crop production under average conditions,

2. simulation of the impact of additional crop and livestock production under average conditions,

3. simulation of the impact of additional crop production assuming rapidly rising energy prices,

4. simulation of the impact of additional crop production assuming 1970 decade-type droughts, and

5. simulation of the impact using the "best guess" combination of the above simulations.

These five simulations were performed assuming 75,000, 125,000, 75,000, and 50,000 irrigated acres for each of the respective study areas.

The following is a brief description of each simulation.

Simulation 1: This simulation measures the statewide impact of additional crop production due to irrigation in each of the four study areas under average conditions. The impacts of irrigation were measured in terms of additional crop production, additional expenses, additional net farm income, additional retail sales, additional labor, and additional taxes.

Simulation 2: In this simulation it was assumed that some of the additional feed produced under irrigated agriculture would lead to increased livestock production. The additional livestock production would take the form of increased numbers of cattle, hogs, and dairy. The particular composition of this production would vary between study areas. It was assumed that only 25 percent of the additional feed produced under irrigated conditions would be used in additional livestock production.

Simulation 3: The rapidly rising energy price simulation assumes that energy prices will rise twice as rapidly as those incorporated in the other simulations. The energy price forecasts were obtained from Chase Econometric Associates. Added livestock production was not included in this simulation.

Simulation 4: All the previous simulations based the dryland crop yields on normal weather conditions. This policy simulation modifies this assumption by assuming a moderate drought in 1984 and a serious drought in 1986. Droughts of this type will substantially reduce dryland yields and acres harvested which will reduce cash receipts and net farm incomes. In addition, reduced yields and acres harvested will also slightly reduce dryland expense because of lowering costs. No livestock impact was captured in this simulation.

Simulation 5: This simulation represents that combination of the previous simulations that in our opinion has the most likely chance of occurrence. It represents a combination of the first (additional crop production), second (additional livestock production), and a variation of the fourth (drought) simulation. In this simulation, a serious drought is assumed in 1984 followed by a moderate drought in 1985. This approach was taken so as to capture the effect of a reduction in livestock numbers such as that which occurred following the drought of 1976.

The impact of these two droughts would be to reduce farm income in the year of the drought due to less income from crop production and higher expenses for feed shipped in. The second year would force herd liquidation with prolonged impacts of subsequent herd rebuilding.

Cumulative Impacts of Irrigation Development

The cumulative impacts of irrigation refer to the changes in economic conditions over the period 1980-1990 induced by development. In each of the tables of cumulative impacts (Tables 8-11), the numbers presented refer to the difference in the South Dakota economy when comparing the control or "without" irrigation simulation to the "with" irrigation simulation for a study area. Also, the cumulative impacts are presented for each of the five policy alternatives.

The first part of each table deals with employment and the agricultural labor force and gives the average change per year over the eleven year simulation. The personal income and retail sales and tax remittance sections show the summation of changes over the eleven year period.

Study Area 1

The cumulative impact of irrigation development of 75,000 acres in Area 1 on the South Dakota economy is presented in Table 8 for each policy analysis simulation. Examples of the data results are as follows. Over the period 1980-1990 in Study Area 1, the additional crop production enabled by irrigation results in (1) an increase in total non-ag employment of an average of 90 people per year; (2) a negative impact on population of two persons per year; (3) an increase in personal income over 11 years of $128 million, in current dollars, or $11.6 million per year; and (4) an increase in retail sales tax remittances of $7 million.

All of the simulations indicate positive impacts on income variables, retail sales and sales tax remittances, and the labor force; but

Table 8. Cumulative Impact of Alternative Simulations, Study Area 1, 75,000 Acres

	Simulation Alternatives[1/]				
	Additional Crop Production	Additional Crop & Livestock Production	Additional Crop Production With High Energy Prices	Additional Crop Production With Drought	Additional Production With "Best Guess" Circumstances
Annual Change in Employment					
Total Non-Ag Employment*	90	109	103	90	143
Labor Force*	44	52	51	44	68
Population*	-2	-3	-1	-2	-12
Unemployment Rate (%)*	-.01	-.01	-.01	-.01	-.01
Eleven-Year Change in Personal Income			-Millions of Current Dollars-		
Personal Income	128	162	94	134	201
Personal Income[2/]	45	56	34	47	71
Non-Farm Personal Income	26	32	30	25	40
Farm Personal Income	102	130	65	110	161
Total Wages & Salaries	23	40	27	23	48
Proprietor's Income-Nonfarm	3	4	2	3	5
Proprietor's Income-Farm	101	118	64	107	148
Eleven-Year Change in Retail Sales and Tax			-Millions of Current Dollars-		
Retail Sales Gross & Use	667	813	799	765	1056
Retail Sales Tax Remittances	7	7	7	6	9

[1/] Under average conditions. All numbers are differences between simulating the economy from 1980-1990 "with" and "without" irrigation development.

[2/] Millions of 1972 dollars.

*Annual Average

they also have a slight negative impact on population and show a slight decrease in the umemployment rate. The very slight reduction in the unemployment rate and modest increase in labor force could infer that the current labor force can facilitate much of the increased economic activity from irrigation development. For example, the existing banks can handle more financing and seed salesmen can handle larger quantities of seed sales.

The changes in farm personal income are consistently greater than the increases in nonfarm personal income. This result is consistant with a finding in a similar study done by the authors' of this report for South Dakota's Third Planning District.[1/] This 1981 study incorporated technological advance in the form of yield increases into all of the simulations. In the previous study where technological advance was not assumed the nonfarm income increases exceeded farm income increases with some simulations.[2/]

It is apparent from the table that the "best guess" simulation leads to the greatest impacts on the South Dakota economy. This is as expected since this simulation included two successive years of drought. The other simulations either had no drought or drought in non-successive years.

Study Area 2

The simulations used with Study Area 2 indicate much larger impacts on the state's economy than for Study Area 1 (Table 9). This is true

---

[1/] Brown, Ralph J. and Richard C. Shane, Simulating the Impact of Irrigation Development in the Third Planning District, Bulletin No. 127 Business Research Bureau, School of Business, University of South Dakota, Vermillion, South Dakota, March 1979.

[2/] See the appendix for technological advance assumptions for this report.

Table 9. Cumulative Impact of Alternative Simulations, Study Area 2, 125,000 Acres

	Simulation Alternatives[1]				
	Additional Crop Production	Additional Crop & Livestock Production	Additional Crop Production With High Energy Prices	Additional Crop Production With Drought	Additional Production With "Best Guess" Circumstances
Annual Change in Employment					
Total Non-Ag Employment*	140	165	155	142	215
Labor Force*	67	79	74	68	101
Population*	-2	-2	-1	-4	-2
Unemployment Rate (%)*	-.01	-.01	-.01	-.01	-.02
Eleven-Year Change in Personal Income			-Millions of Current Dollars-		
Personal Income	206	270	152	231	323
Personal Income[2]	72	94	55	68	111
Non-Farm Personal Income	40	49	43	40	61
Farm Personal Income	166	221	109	191	262
Total Wages & Salaries	35	61	40	35	69
Proprietor's Income-Nonfarm	4	6	3	5	7
Proprietor's Income-Farm	165	201	108	190	241
Eleven-Year Change in Retail Sales and Tax			-Millions of Current Dollars-		
Retail Sales Gross & Use	1070	1279	1241	1076	1674
Retail Sales Tax Remittances	9	12	10	9	14

[1] Under average conditions. All numbers are differences between simulating the economy from 1980-1990 "with" and "without" irrigation development.

[2] Millions of 1972 dollars.

*Annual Average

partially because the irrigation development assumed was 125,000 acres compared to the 75,000 acres in Area 1. The direction of results was the same for the two areas--only the magnitudes have changed with increased irrigated acreage.

The labor force grew modestly in this area under all simulations but the average population decrease was not as large as with the smaller acreage development of Area 1. The population increased in the early years of development and decreased in the later years of the study time period. The modest labor force change suggested the current existence of unused capacity in the state economy.

Cumulative impacts of farm personal income were smallest in the simulation with high energy prices. However, the nonfarm economy experienced the smallest gains in personal income with the drought simulation and the crop production increase simulation. In these two simulations, farm input expenditures and net farm income are smallest, consequently, the turnover impacts are smallest also.

In these scenerios, retail sales tax remittances grew steadily over time except with the best guess simulation where remittances fell with consecutive drought years. Nevertheless, the best guess simulation had the largest cumulative remittance at $14 million and the largest annual average remittance of $1.3 million. The smallest remittances resulted from the simulations with crop production alone and crop production with drought.

Study Area 3

The simulations for Study Area 3 were completed under the assumption that 75,000 acres would be developed (the same as Area 1). Therefore, one might expect the impacts of irrigation development on South

Dakota's economy to be similar for these two study areas. Table 10 contains cumulative results for Area 3. For most of the simulations, our expectations hold. Personal income differences between "with" and "without" irrigation scenarios were very close but neither area was consistently higher than the other. Area 3 had a $5 million advantage with the best guess scenario. Labor force and population average annual changes were nearly identical except that with the best guess simulation Area 3 had a 10% lower annual average decline in population than Area 1.

Cumulative sales tax remittances were also similar between Area 1 and Area 3. Area 3 sales tax remittances averaged $.91 million per year for the best guess simulation. However, the magnitude of increases in sales tax remittances did not continually grow as with other simulations but had a drop after two consecutive years of drought and then regained pre-drought levels.

Study Area 4

Table 11 contains the results of the simulations for Study Area 4. The cumulative economic impacts in this study area resulted from the assumed irrigation development of 50,000 acres. This area has higher annual rainfall than the other areas and, therefore, the "with" and "without" irrigation simulations have smaller differences than for the other three regions. This is also true for all of the measures of economic impacts.

Labor force increases are modest as are population decreases for each simulation. Unemployment differences were slight with reductions for all five simulations.

Personal income changes stemmed mostly from increases in farm proprietors income with slight changes in nonfarm proprietor's income.

Table 10. Cumulative Impact of Alternative Simulations, Study Area 3, 75,000 Acres

	Simulation Alternatives[1]				
	Additional Crop Production	Additional Crop & Livestock Production	Additional Crop Production With High Energy Prices	Additional Crop Production With Drought	Additional Production With "Best Guess" Circumstances
Annual Change in Employment					
Total Non-Ag Employment*	94	112	106	86	171
Labor Force*	44	53	51	45	78
Population*	-3	-3	-1	-2	-2
Unemployment Rate (%)*	-.01	-.01	-.01	-.01	-.01
Eleven-Year Change in Personal Income		-Millions of Current Dollars-			
Personal Income	122	169	90	134	206
Personal Income[2]	43	58	33	46	75
Non-Farm Personal Income	25	32	28	29	45
Farm Personal Income	97	137	62	105	161
Total Wages & Salaries	24	41	27	24	53
Proprietor's Income-Nonfarm	3	4	2	3	4
Proprietor's Income-Farm	94	123	54	95	147
Eleven-Year Change in Retail Sales and Tax		-Millions of Current Dollars-			
Retail Sales Gross & Use	500	858	825	703	1262
Retail Sales Tax Remittances	6	7	7	6	10

1/ Under average conditions. All numbers are differences between simulating the economy from 1980-1990 "with" and "without" irrigation development.

2/ Millions of 1972 dollars.

*Annual Average

Table 11. Cumulative Impact of Alternative Simulations, Study Area 4, 50,000 Acres

	Simulation Alternatives[1]				
	Additional Crop Production	Additional Crop & Livestock Production	Additional Crop Production With High Energy Prices	Additional Crop Production With Drought	Additional Production With "Best Guess" Circumstances
Annual Change in Employment					
Total Non-Ag Employment*	62	75	68	63	95
Labor Force*	30	36	36	31	44
Population*	-3	-3	-1	-2	-4
Unemployment Rate (%)*	-.01	-.01	-.01	-.01	-.01
Eleven-Year Change in Personal Income		-Millions of Current Dollars-			
Personal Income	93	138	78	108	166
Personal Income[2]	33	47	28	38	58
Non-Farm Personal Income	17	22	19	18	28
Farm Personal Income	76	116	58	90	138
Total Wages & Salaries	14	26	21	17	32
Proprietor's Income-Nonfarm	2	3	2	2	4
Proprietor's Income-Farm	76	108	58	89	130
Eleven-Year Change in Retail Sales and Tax		-Millions of Current Dollars-			
Retail Sales Gross & Use	431	543	491	441	714
Retail Sales Tax Remittances	4	5	4	4	6

1/ Under average conditions. All numbers are differences between simulating the economy from 1980-1990 "with" and "without" irrigation development.

2/ Millions of 1972 dollars.

*Annual Average

These changes were less fluctuating amongst simulations than for other regions probably as a result of less drought impacts in a higher rainfall area.

Retail sales tax remittances were lowest in this area for all simulations when compared to the other three areas with a range of four to six million dollars over the eleven year study period. Average annual tax remittances were highest at $.54 million with the best guess simulation.

IMPACT OF IRRIGATION DEVELOPMENT ON PERSONAL INCOME

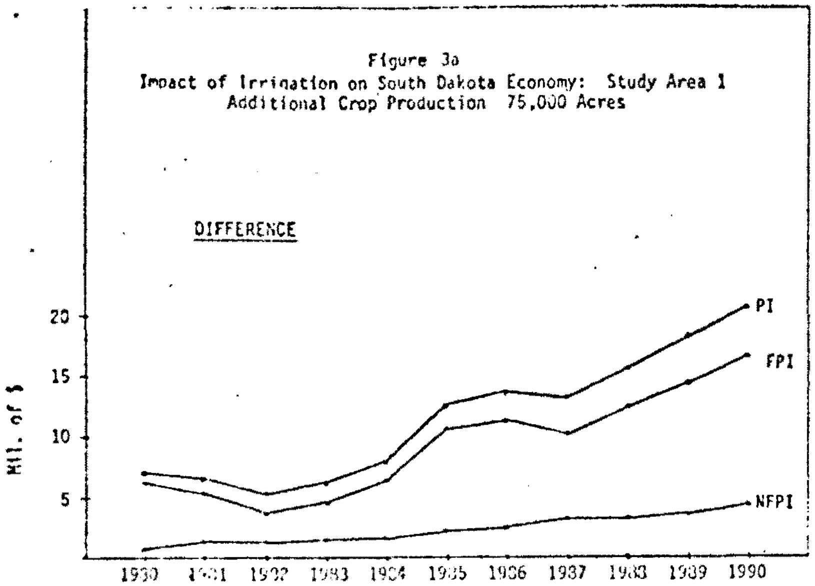
In the previous section the impact of irrigation development on South Dakota's economy was discussed by comparing simulations across a given study area. The following discussion is directed at comparing study areas given a simulation. The emphasis here is on personal income impacts. Employment and labor force impacts were modest for all simulations for all areas. Also, retail sales tax remittances were very consistent by area when the size of development was considered.

Each simulation result is a comparison of "with" and "without" irrigation development. In other words, the reported personal incomes represent the difference between South Dakota's personal income with irrigation water applied and without any water applied to acreages in the four study areas.

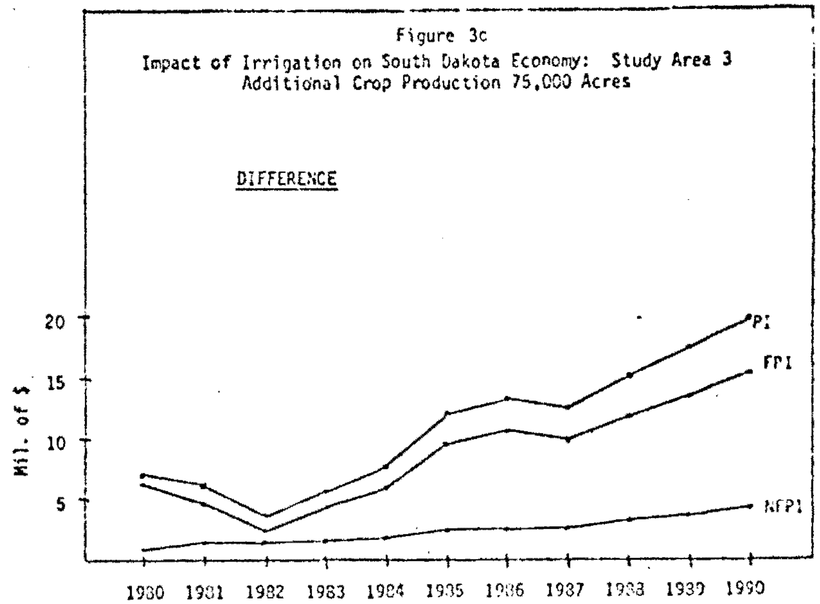
Simulation 1

The impact on personal income in each area with the irrigation of additional acres is presented in Figure 3. The impact was positive on personal income in all four study ares. The magnitude of impact varied

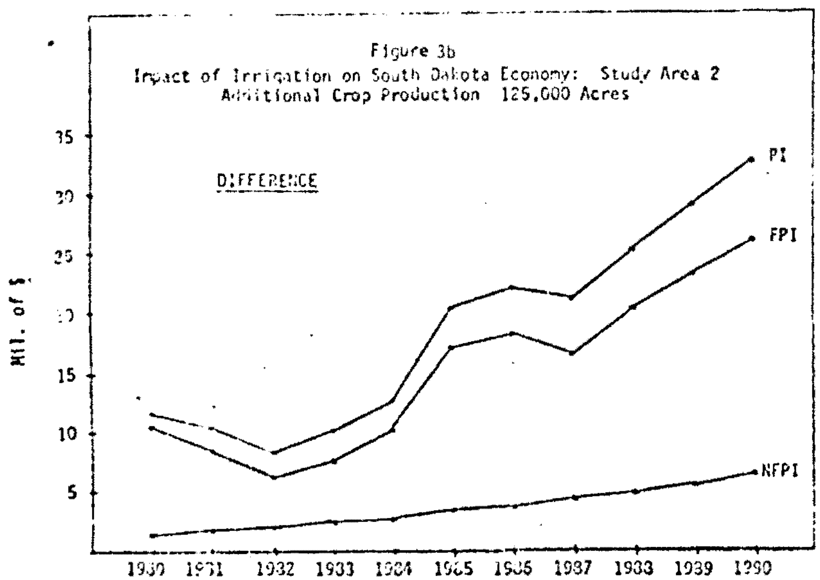
Figure 3. Impact of Irrigation Development on Personal Income within the South Dakota Economy-Simulation 1: Additional Crop Production

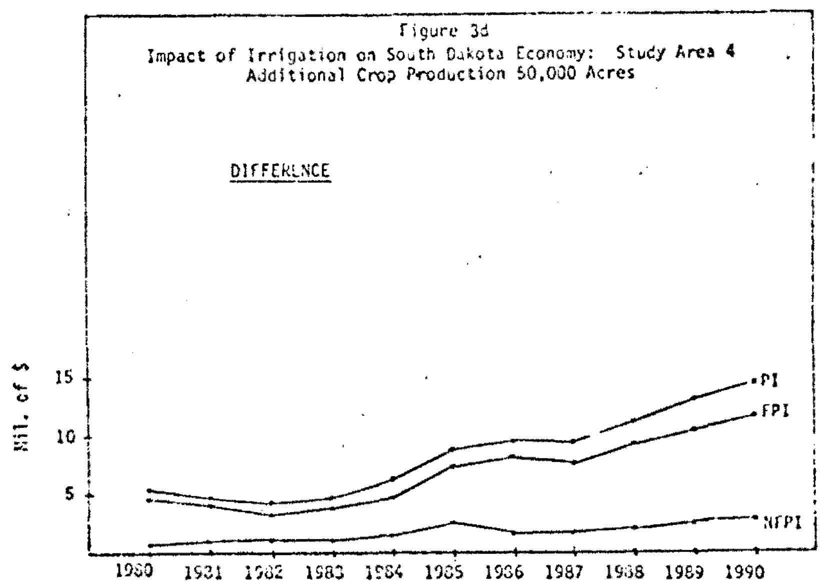


*PI=Personal Income FPI=Farm Proprietors' Income NFPI=Nonfarm Pers. Income



*PI=Personal Income FPI=Farm Proprietors' Income NFPI=Nonfarm Personal Income





principally with size of irrigation development, for example, note Figure 3b with 125,000 acres compared to Figure 3d with 50,000 acres of development.

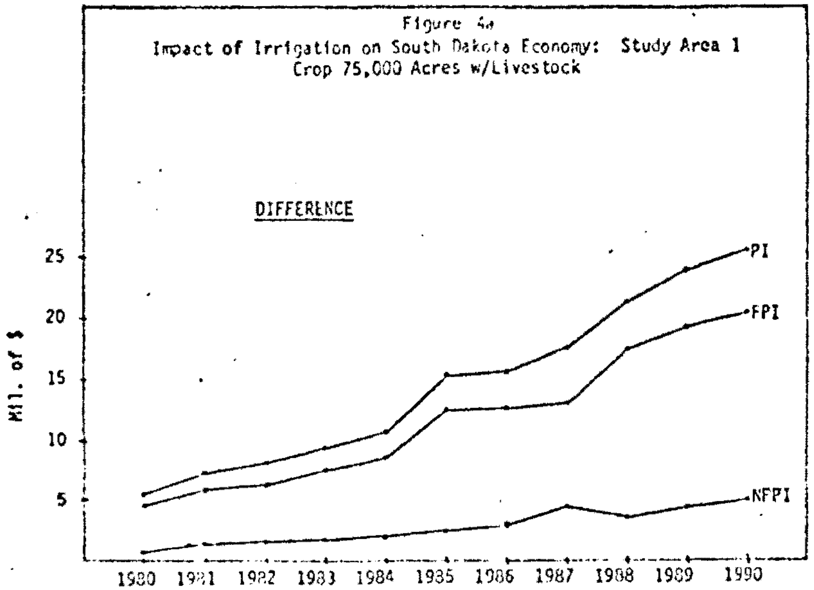
The components of personal income are nonfarm personal income and farm proprietor's income. In all areas, the farm proprietor's income (net income = total sales total costs) impacts were larger than the nonfarm personal income impacts. Farm personal income grew consistently over time as did nonfarm personal income. However, the nonfarm income growth exhibited more stability or a constant upward growth whereas farm income had its ups and downs around its upward trend. This was due to the sporadic nature of farm production and prices and the fact that the sale of inputs to farmers do not vary according to farm prices. These projections indicate hard times for farm income early in the 1980's followed by potentially better times until 1986 and then another surge in personal income in the late 1980's, given the assumed rates of inflation.

Simulation 2

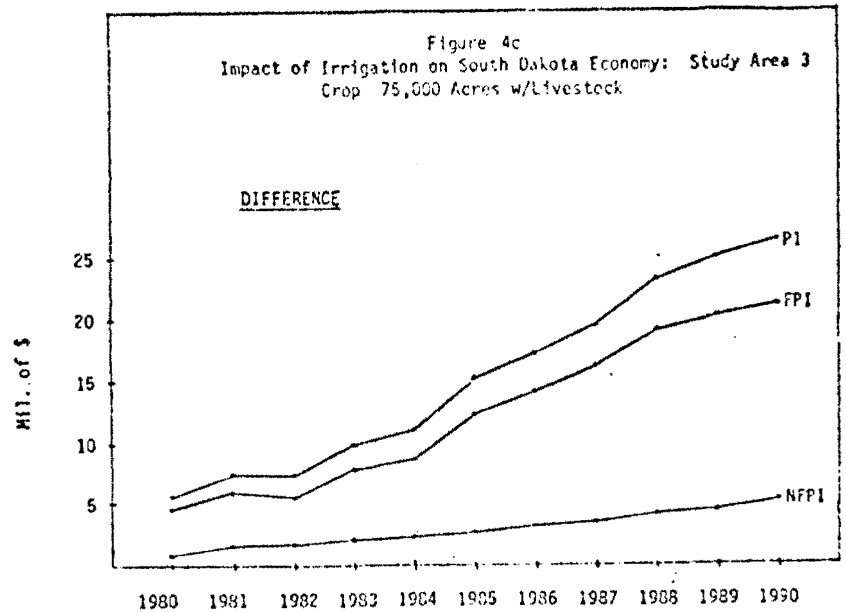
This simulation incorporated livestock expansion into the irrigation development by assuming 25% of added crop production would be marketed through livestock. The results of this assumption as it impacted statewide personal income, is presented in Figure 4.

With the additional livestock production, personal income increased by larger magnitudes when compared to simulation 1 for all four study areas. The largest per acre impacts were generated by Area 2 which developed 125,000 acres. One of the reasons for this is the fact that Area 2 is currently importing more feed than other areas and much of

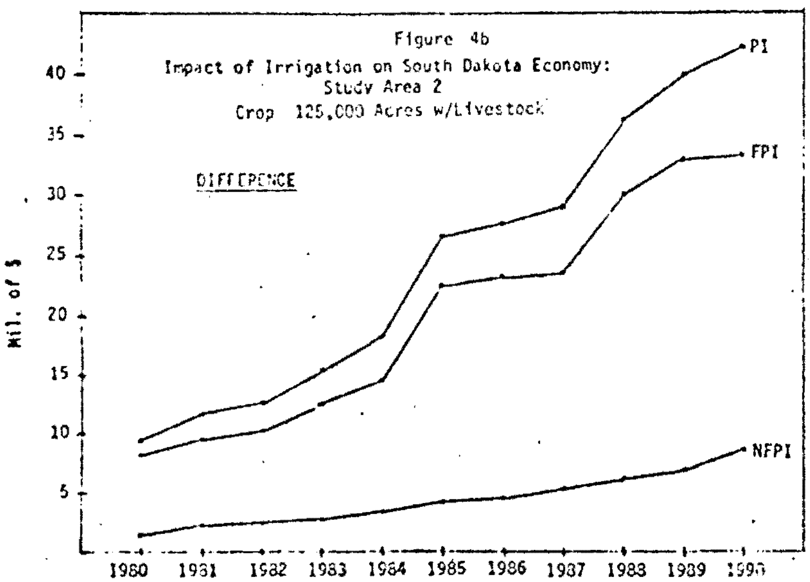
Figure 4. Impact of Irrigation Development on Personal Income within the South Dakota Economy-Simulation 2; Additional Crop and Livestock Production

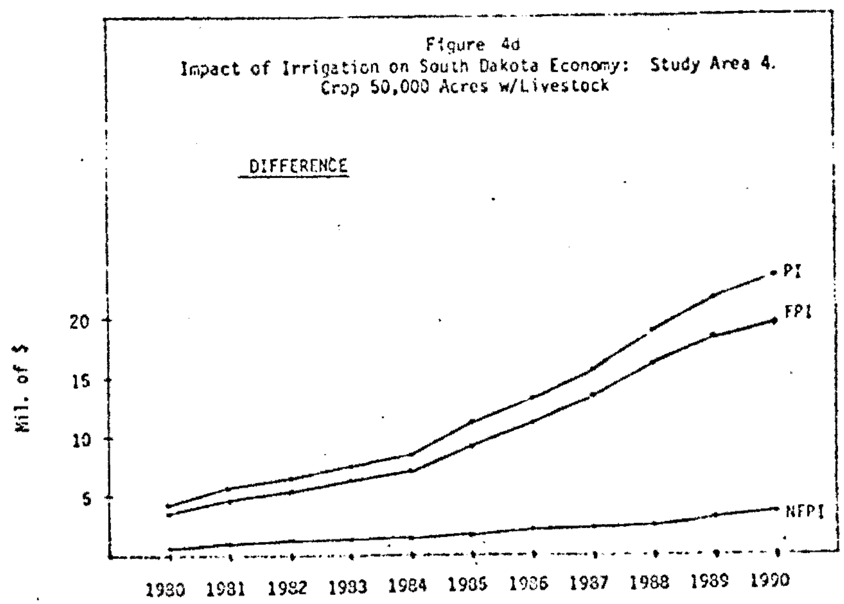


*PI=Personal Income FPI=Farm Proprietors' Income NFPI=Nonfarm Pers. Income



*PI=Personal Income FPI=Farm Proprietors' Income NFPI=Nonfarm Pers. Income





this could be eliminated as more feed becomes available. Also, more livestock could be finished which means greater per unit value when sold.

As before, farm personal income impacts always exceeded nonfarm personal income impacts. The nonfarm personal income growth over time was consistently upward esentially without interruption. The increase in farm personal income was also continuously upward but with several plateaus. The diversification into more livestock did not reduce sporadic impacts in either crop or livestock income but the two tended to occur at different times so that income never decreased over time but did exhibit times of very slow growth.

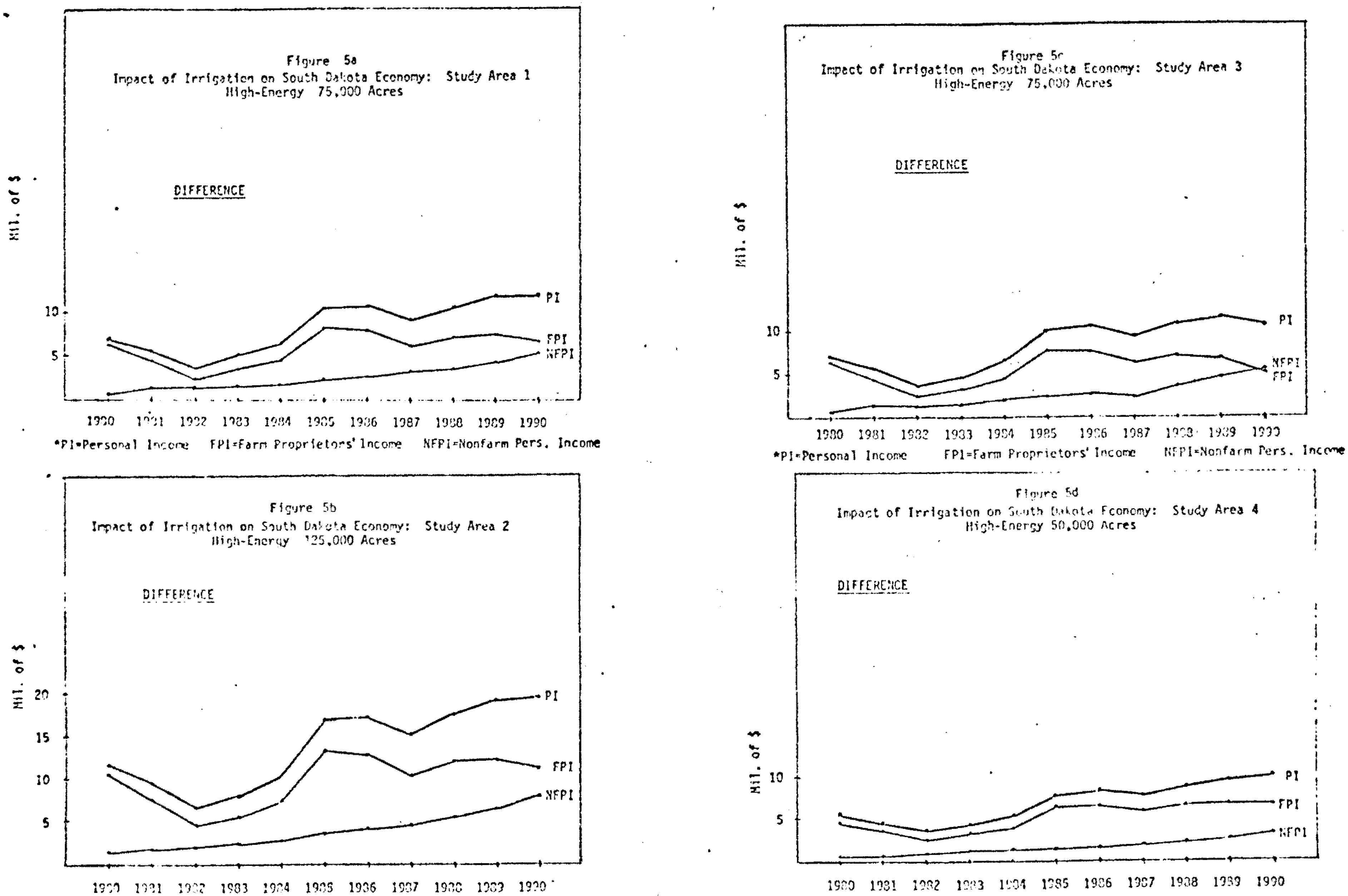
Simulation 3

This simulation allowed for the doubling of the rate of increase in disembodied energy[1/] energy inputs into the crop production enterprises of each area. The personal income impacts were again positive for all four areas. However, the upward trend was not as evident as with other simulations. The average personal income impacts were not much greater over time than the first year's impact.

Farm personal income impacts were greater then nonfarm personal income impacts but were also much more variable. Nonfarm income continually increased over time as did sales volume because of increased energy costs to farmers. Farm income exhibited the cyclic nature of crop income and at the end of the study period was converging toward the same level as nonfarm income increases. In Area 3, the nonfarm income impacts exceed farm income impacts in 1990.

[1/] Disembodied energy refers to direct use of energy as in fuel, lube and irrigation power costs. It does not include energy used in the manufacture of inputs such as fertilizer, chemicals and machinery.

Figure 5. Impact of Irrigation Development on Personal Income within the South Dakota Economy-Simulation 3: Additional Crop Production Assuming Rapidly Rising Energy Prices



The early 1980's would be hard times for the farmers with better times in the mid 1980's. The mid to late 1980's demonstrate harder times prevailing again.

Simulation 4

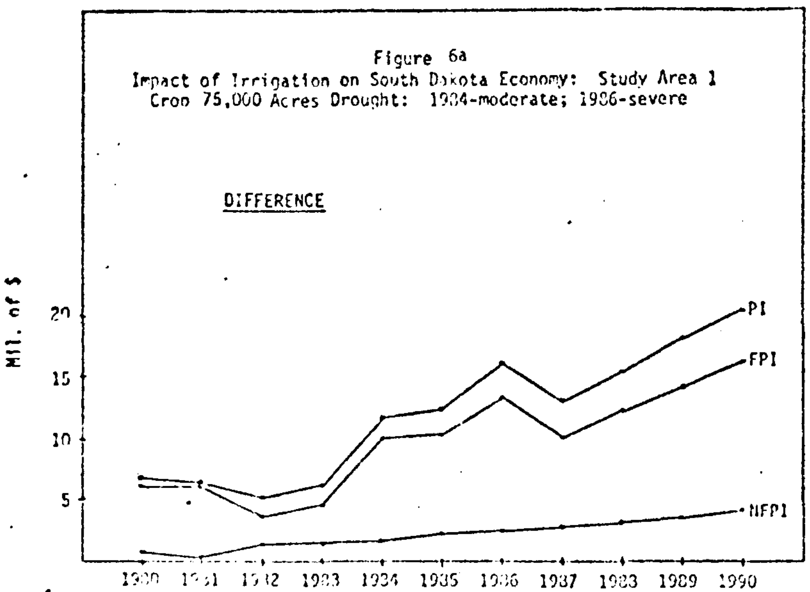
Simulation 4 personal income results are presented in Figure 6. These personal income impacts were simulated by allowing a moderate drought in 1984 and a severe drought in 1986.

With the application of water during drought years, the impact on South Dakota's personal income is very significant. Figure 6b which presents the impact of irrigation development and drought with a large acreage clearly shows the potential benefits of having enough water to produce a crop. In the severe drought of 1986 farm personal income is over $35 million greater with irrigation than without irrigation. The other study areas with smaller simulated developments experienced similar impacts but of lesser magnitude.

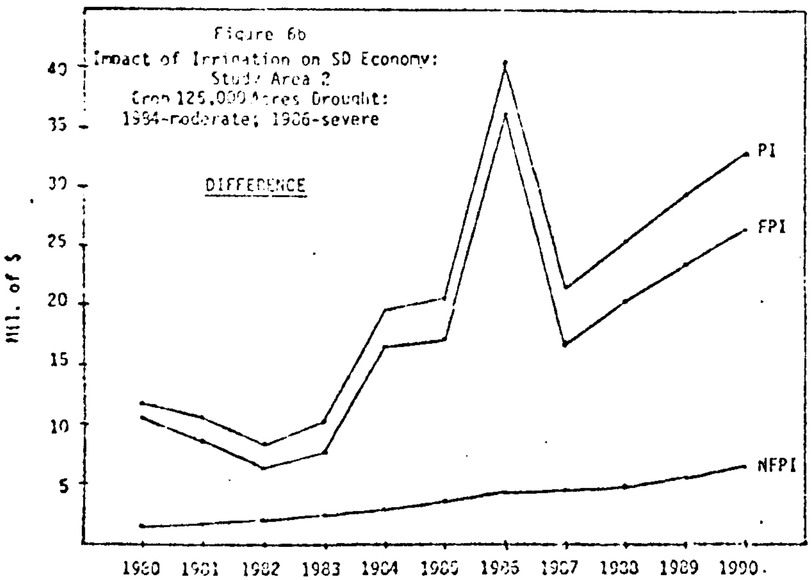
Note again, that the nonfarm economy is more isolated from the drought than the farm economy. Nonfarm personal income continued to climb regardless of the amount of rainfall because farmers had to purchase inputs whether a harvest was forthcoming or not. This simulation clearly demonstrates the potential benefits of irrigation development in a droughty area. The more land that is irrigable in a drought area, the larger the impact of irrigation when rainfall is inadequate.

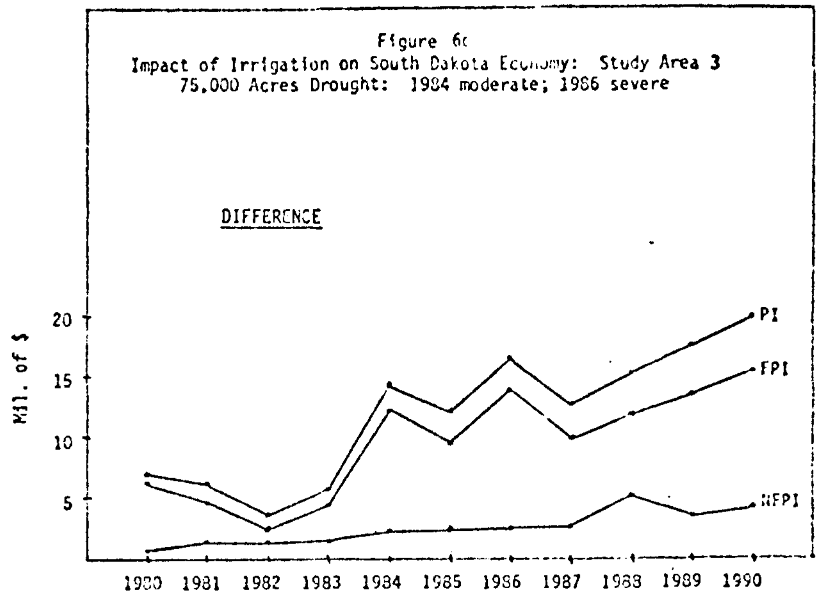
It must be pointed out here that these income figures do not indicate the profitabilty of farmers during the drought or any other years of the simulation. The income figures are differences in income for the state when water is or is not applied through irrigation. Inital crop budgets indicate that on the average a profit can be ob-

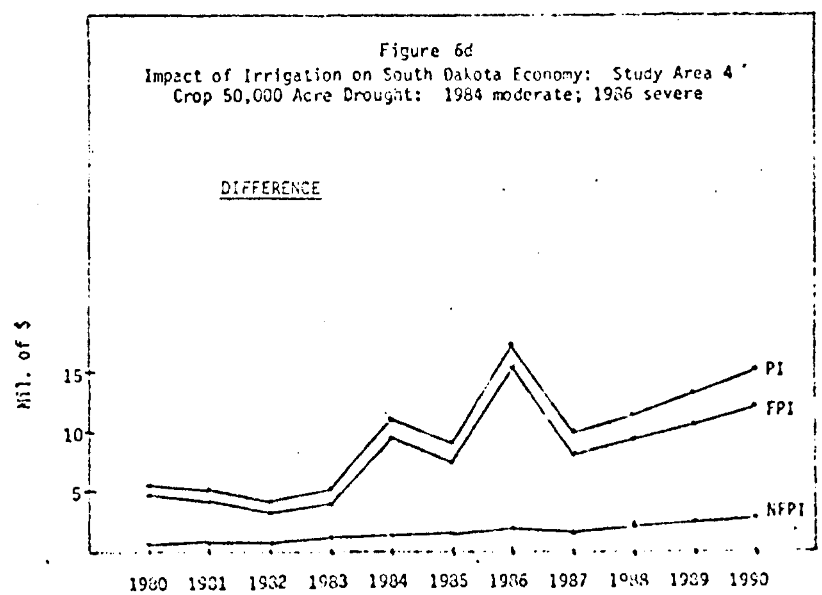
Figure 6. Impact of Irrigation Development on Personal Income within the South Dakota Economy-Simulation 4 Additional Crop Production Assuming 1970 Decade-Type Drought



*PI=Personal Income FPI-Farm Proprietors' Income NFPI=Nonfarm Pers. Income







tained by either dryland or irrigated crop production so the differences normally mean differences in farm profit. This is not necessarily true in a drought year. The dryland farmer is probably operating at a loss and therefore, the difference when compared to the irrigator is great. The irrigator's profit may be lower also in a droughty year if water application isn't timely.

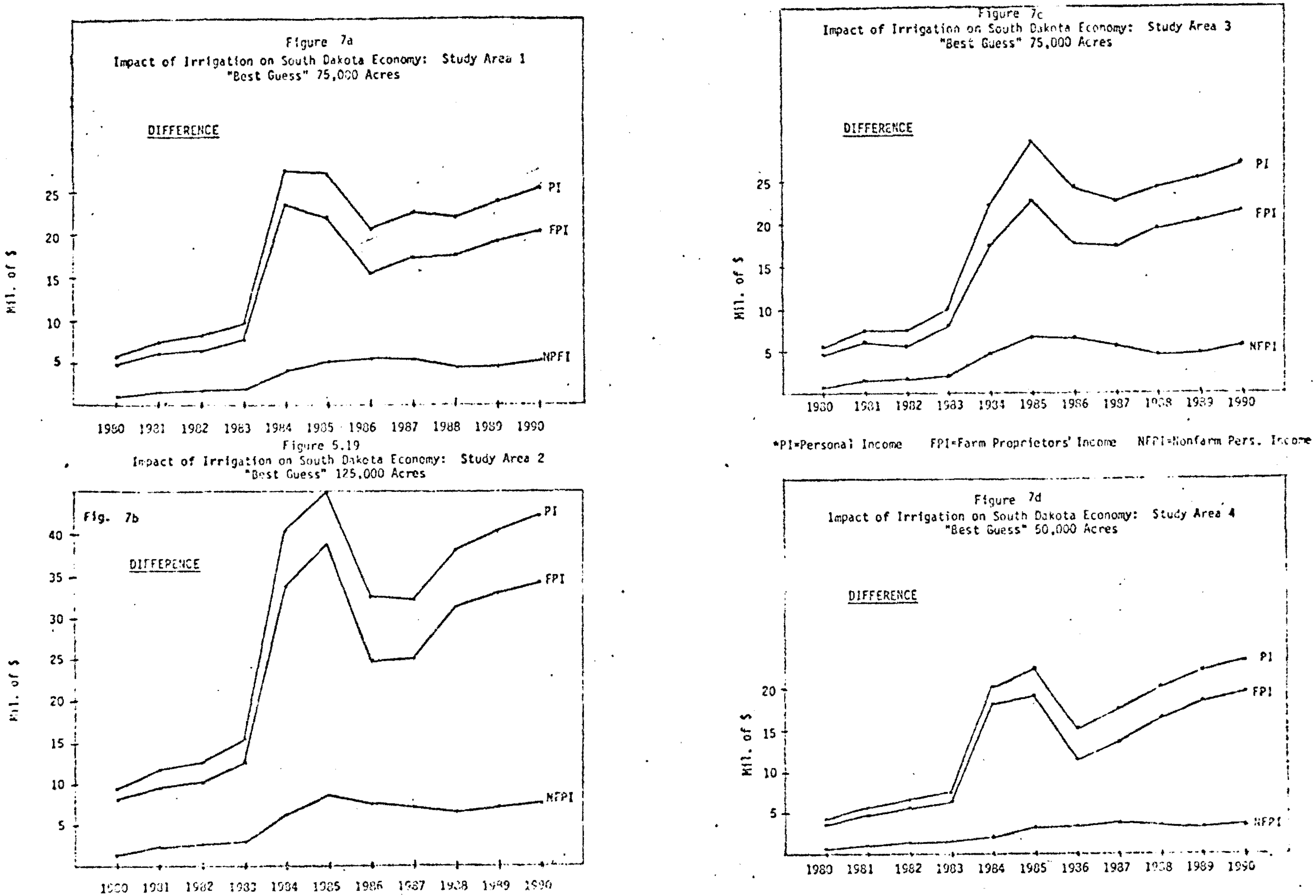
Simulation 5

This simulation is labeled the "best guess" simulation and represents the conditions that the authors feel have the best chance of occuring in a decade of South Dakota agriculture. It is a combination of the previous simulations.

Personal income impacts are positive in all regions with the results from this simulation showing that continued drought has an impact on the nonfarm economy as well as the farm economy of the state. Nonfarm personal income grows during the drought as farmers sell off livestock and require more services and purchase more inputs. After the drought, the nonfarm personal income gain from irrigation drops off again but not so low as to interrupt its upward trend.

Farm personal income is impacted considerably by the two consecutive drought years. The difference in farm income with irrigation over not irrigating varies from $20 to $50 million by area depending on how much land is developed. The first year the impact is large but it is even larger in the second year with an extended drought and depletion of subsoil moisture reserves. Following the drought years, farm income differences with irrigation drop again as expected but not as low as in other simulations. This demonstrates the prolonged impact of severe drought on dryland farmers and the entire state. The reason that the impact was prolonged is because it takes several years to rebuild one's enterprises to pre-drought levels.

Figure 7. Impact of Irrigation Development on Personal Income within the South Dakota Economy-Simulation 5 "Best Guess" Combination



SUMMARY

This report contains the results of econometric model-based simulations of the economic impact of irrigation development in four areas in South Dakota. The four study areas included a 29 county area in central/east-central South Dakota. The study emphasis was on the determination of the statewide impact of irrigation development within given areas of the State. The statewide econometric model used was the South Dakota Labor Market Model which provides details in terms of employment, income, and retail sales.

The simulations were performed with and without irrigation for the years 1980 through 1990. Five alternative simulations for each project study area were performed to allow comparisons of how different assumptions would affect the results. The alternative simulations were as follows:

1. simulation of impact of additional crop production,
2. simulation of impact of additional crop and livestock production,
3. simulation of impact of additional crop production assuming rapidly rising energy price,
4. simulation of impact of additional crop production assuming 1970 decade-type droughts,
5. simulation of impact using "best guess" combination of above simulations.

Each of these simulations showed higher farm and nonfarm incomes and minimal impacts on employment and population as a reult of irrigation develoment.

Of the five simulations the most favorable in terms of farm income is the "best guess" simulation, while the least favorable was the rapidly rising energy price simulation. In terms of the nonfarm income impacts the most favorable and unfavorable simulations were the same as

for the farm sector. In the "best guess" simulation the much higher expenditures under irrigation compared to dryland farming had considerable impacts on the nonfarm sector. The rapidly rising energy price simulation gives rise to additional spending for energy inputs, but any favorable nonfarm impacts were more than offset by the negative farm income effects of increased energy costs. In terms of positive employment or population impacts the overall effects would have to be considered slight. Retail sales tax remittances were generally increased one-half to one million dollars per year.

Some readers of our previous study[1/] which indicated that the effects of irrigation development were often greater for the nonfarm than the farm sector may wonder why these results were not generally reported in this study. We think this can be explained in the following way. In the previous study only one simulation alternative incorporated an increase in yields over time due to increases in productivity. It was this one simulation that yielded nonfarm and farm impacts of similar size. In this study all of the simulations incorporated increased yields due to increases in productivity.

CONCLUSIONS

The results of the econometric modeling of the economy of the state of South Dakota with various irrigation development scenarios led to several conclusions.

1. Irrigation development will have positive short and long-term impacts on both the farm and nonfarm sectors of the economy. With most scenarios, the farm income benefits exceed nonfarm income benefits. Technological innovation is necessary, however, in order for this conclusion to be achieved.

[1/] Ralph J. Brown and Richard C. Shane, Simulating the Impact of Irrigation Development in the Third Planning District. Bulletin No. 127, Business Research Bureau, School of Business, University of South Dakota, Vermillion, South Dakota, March, 1979.

2. Farm sector income impacts will be more variable than nonfarm sector impacts due to the cyclic nature of farm prices and drought.

3. State sales tax revenues will increase under any type of irrigation development in the State. The magnitude of collections varies directly with the size of development.

4. Some unused capacity currently exists in the State's economy. Irrigation development will lead to more complete utilization of existing resources. This is particularly true in the nonfarm sector.

5. Rapidly rising energy prices in the farm sector may offset positive income impacts in the nonfarm sector unless technological innovations occur which increase crop yields or lower production costs on a per unit basis.

LIMITATIONS OF THE STUDY

The analysis presented herein has important limitations of which readers and policy-makers should be aware. Some of the limitations follow:

1. Construction phase not considered - the analysis assumes that for simulation purposes the irrigation projects were fully operational beginning in 1980. No consideration was given to the temporary impacts during the construction phase of the projects.

2. No cost-benefit analysis - the analysis presented herein should not be construed as a cost-benefit analysis of the proposed irrigation projects. While the information contained in this study would be useful in a cost-benefit analysis, this study does not constitute a cost-benefit analysis.

3. Statistical approach - the data on dryland and irrigated farm budgets are based on surveys, studies, and consultation with the farmers, which present average relationships at the time of the study. Potential irrigators may experience costs and returns different from the average experience presented in this study.

4. Econometric modeling - the econometric modeling approach depends on historical relationships between variables and the introduction of large-scale irrigation projects might alter the state's economy so as to significantly change these structural relationships implied by the model.

5. Exogenous variable forecasts - since the model simulations are for the period from 1980 through 1990, exogenous variables had to be forecasted. The major forecast used in this model relied on the econometric model forecasts provided by Chase Econometrics. Simulation error may be introduced into the analysis due to forecasting error in the exogenous variables.

6. Aggregation problems - because of the nature of the data available, the sector breakdowns in the model are quite aggregated. Consequently, changes in some categories of these aggregate sectors may be different than the changes for the whole sector.

7. Average yield - most of the calculations are based on the average yield for irrigated crops versus the average or normal weather yield of dryland crops.

BIBLIOGRAPHY

Aanderud, W. G. and H. R. Allen, "Expected Production Costs for Major Crops for Six Production Areas in South Dakota - 1980," Cooperative Extension Service, U.S. Department of Agriculture, South Dakota State University, Brookings, South Dakota, 1980.

Allen, H. R. and W. G. Aanderud, "Budgets for Major Livestock Enterprises in South Dakota," C234, Cooperative Extension Service, U.S Department of Agriculture, South Dakota State University, Brookings, South Dakota, 1980.

Brown, Ralph J. and Richard C. Shane, Simulating the Impact of Irrigation Development in the Third Planning District, Bulletin No. 127, Business Research Bureau, School of Business, University of South Dakota, Vermillion, South Dakota, March 1979.

Brown, Ralph J. and Richard C. Shane, Simulating the Statewide Impact of Irrigation Development in South Dakota, Bulletin No. 129, Business Research Bureau, School of Business, University of South Dakota, Vermillion, South Dakota, December 1981.

Chase Econometrics, U.S. Food and Agriculture Long-Term Forecast Report, Chase Econometrics Associates, Inc., 150 Monument Road, Bala Cynwyd, PA, 19004, July 1981.

Chicago and Northwestern Transportation Company, Supp. 21, Freight Tariff (NW402). Grain, Grain Products and Seeds. October 15, 1979 (Eff. November 25, 1979). Issued by C. D. Pamlet, Tariff Publication, 400 West Madison St., Chicago, IL, 60606.

Shane, Richard C. and Ralph J. Brown, An Analysis of the Impact of Irrigation Development on the Economy of South Central South Dakota. Water Resources Intsitute, South Dakota State University, Brookings, South Dakota, October 1980.

U. S. Department of Agriculture, South Dakota Crop and Livestock Reporting Service. Historic Crop and Livestock Estimates, 1970 - 1975 and 1976 - 1980. Published September 1978 and July 1981.

Van Duyne, Carl, Modsim: A Computer Program For Simulating Macroeconometric Models, Published by Conduit, P.O. Box 388, Iowa City, Iowa, 52244, 1980.

Appendix Table 1
Summary of Chase Econometrics
Long-Term Forecasts for Key
Macroeconomic and Agricultural Variables

Item	Average Annual 1971-1980	Percent Increase 1982-1990
Macroeconomic Variables		
Gross National Product (1972 $)	3.13%	3.18%
Implicit Deflator GNP	7.06%	6.31%
Unemployment Rate (Average %)	7.12%	5.33%
Consumer Price Index	7.86%	6.82%
U.S. Disposable Income (1972 $)	3.10%	3.03%
Agricultural Variables		
Prices Recvd. Livestock	8.04%	8.12%
Prices Recvd. Crop	10.37%	7.43%
Prices Paid, Prodn. Items	9.97%	7.76%
Prices Paid, Fuel & Energy	14.61%	9.78%
Net Farm Income (1967 $)	1.01%	2.05%
Net Farm Income (Curr. $)	8.87%	8.87%
Corn Prices, Farm	10.52%	6.96%
Soybean Prices, Farm	13.04%	6.28%
Cattle Prices, Farm	10.24%	7.58%
Hog Prices, Farm	8.70%	8.72%
Hay Prices, Farm	10.72%	5.28%
Corn Yield (Bu./Acre)	2.78%	2.05%
Alfalfa Yield (Bu./Acre)	1.61%	1.05%
Barley Yield (Bu./Acre)	1.34%	0.73%
Oats Yield (Bu./Acre)	-0.37%	1.63%
Wheat Yield (Bu./Acre)	0.08%	1.53%
Soybeans Yield (Bu./Acre)	1.95%	1.66%
Sorghum Yield (Bu./Acre)	1.94%	0.82%

Source: Chase Econometrics, U.S. Food and Agriculture Long-Term Forecast Report, July 1981, Chase Econometric Associates, Inc., 150 Monument Road, Bala Cynwyd, PA 19004.