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Economic Effects of Added Growing Season Rainfall on North Dakota Agriculture

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Acknowledgements

Weather modification continues to be of strong interest to North Dakota farmers and ranchers. This second report presents a current analysis of expected economic effects of added growing season on North Dakota agriculture and the state economy. Hail patterns and economic effects are still being studied.

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Possible negative effects of added growing season rainfall were not analyzed in this study. The previous report (Inter-disciplinary "ARE" Research Team, 1974) reviewed studies to date; few negative effects have been identified or evaluated in detail.

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ECONOMIC EFFECTS OF ADDED GROWING SEASON RAINFALL ON NORTH DAKOTA AGRICULTURE

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Farmers in North Dakota have been interested in weather modification to increase precipitation since the drought of the 1930s and going as far back as the 1800s. Knowledge has been accumulated on the operational procedures for modifying weather but little has been done on results and effects on society. This second economic study used rainfall increase models developed in other studies to analyze the current economic effects on four farming areas and the state as a whole.

The report is divided into three sections. The first reviews the amount of added growing season rainfall that a total well managed cloud seeding program might produce, presents expected changes in crop/forage yields, and summarizes the land resources of each of the four farming areas.

The second section presents the resources and organization of agriculture in each farming area under "normal" and added growing season rainfall and develops an estimate of added direct returns to agriculture with more growing season rainfall.

The final section completes the economic analysis by examining the total impact of the added direct returns to agriculture on the state's economy. Input/output analysis is used to measure the impacts of added direct returns on the various sectors of the economy and the total impacts of added growing season rainfall. The appendix presents an alternative way of studying the economic effects within the four farming areas by creating a representative farm in each area.

The study has five goals:

1. To measure the dollar values of direct benefits to farmers and ranchers of added growing season rainfall;

2. To determine needed enterprise adjustments by farmers and ranchers because of increased rainfall;

3. To measure total added direct benefits to the four farming areas and to the state;

4. To examine enterprise shifts within farming areas due to added growing season rainfall;

5. To measure the total impact of added growing season rainfall on the state economy.

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Section 1. The Setting for the Economic Analysis

The analysis is based on four farming areas as shown in Figure 1. The analysis treats a farming area as one large farm. Data on a typical farm for each farming area are shown in the Appendix.

The rainfall increases were based on the Illinois State Water Survey Rainfall Increase Model B (1947), calculated for a 50-year period for 40 climatic stations in North Dakota for June, July, and August. Several rainfall models were evaluated to simulate the probable change in rainfall amounts and distribution due to cloud seeding. The models take into account that (a) the amount of rainfall increase by cloud seeding depends principally upon the nature and physics of the clouds being seeded, (b) the presence of cloud types in the past may be represented by the recorded 24-hour amounts of rainfall that fell, and (c) proportionately more rain may be produced from seeding smaller cloud systems than from more intensive storms. These hypotheses are based on results of various cloud seeding experiments and originally were suggested by Changnon and Huff of the Illinois State Water Survey (1971).

It was assumed that all storms would be seeded and the results for stations in each farming area were averaged and are given in Figure 1.

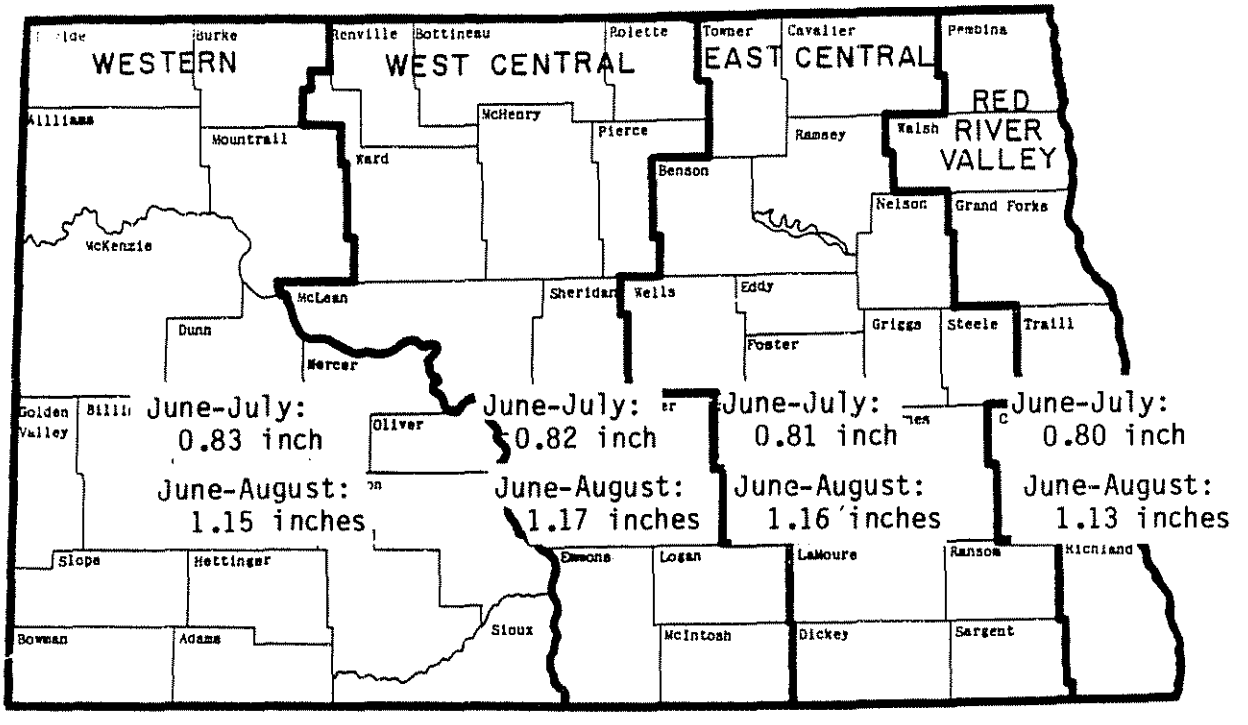

Figure 1. Average Added Growing Season Rainfall in Inches by Farming Areas Using Illinois State Water Survey Rainfall Increase Model B

Increased rainfall for short-term growing crops, such as small grains, would range from 0.83 inch in the Western farming area to 0.80 inch in the Red River Valley farming area. The longer-term increase, June through August, would range from 1.17 inches in the West Central farming area to 1.13 inches in the Red River Valley farming area.

Expected yield increases resulting from the added growing season rainfall are given in Table 1. The yield increases were based on the North Dakota State University Added Rainfall Effects Study (1974). Sunflower yields for Western and West Central farming areas have been added since this cash crop has become important in both areas.

TABLE 1. EXPECTED YIELD INCREASES DUE TO ADDED GROWING SEASON RAINFALL IN FOUR FARMING AREAS IN NORTH DAKOTA, PER HARVESTED ACRE

Crop	Unit	Western	West Central	East Central	Red River Valley
Wheat[a]	bu.	2.25	2.2	1.7	1.4
Barley[a]	bu.	2.08	2.3	2.4	2.0
Oats[a]	bu.	2.91	4.1	3.2	2.4
Flax[a]	bu.	0.50	1.6	1.3	1.0
Corn Grain[b]	bu.	3.17	4.1	3.5	2.8
Corn Silage[b]	ton	0.58	0.8	0.6	0.45
Sunflower[b]	lbs.	156	158	139	136
Alfalfa Hay[b,c]	lbs.	317	350	319	339
Native Hay[b,c]	lbs.	69	82	93	d
Native Pasture[b,c]	lbs.	115	140	151	d
Tame Pasture[b,c]	lbs.	230	233	232	226
Deferred Native Pasture[b,c]	lbs.	115	140	151	d
Soybeans[b]	bu.	d	d	d	1.7
Sugarbeets[b]	ton	d	d	d	1.1
Potatoes[b]	cwt.	d	d	d	15.8

[a]June-July added rainfall was used in calculating yield increase.
[b]June-August added rainfall was used in calculating yield increase.
[c]Dry matter basis.
[d]Not applicable.

Land resources of the four farming areas are presented in Table 2. These data were used to create the land resources for the farm for each of the four farming areas. The maximum number of acres of each crop that could be grown are shown in Table 2. These maximums were derived by using the five-year average (1977-1981) of actual acreages grown. Acreage limitations were put in the models to prevent one crop from being produced to the extent that its production could be large enough to affect the marketing and pricing of that crop.

TABLE 2. AGRICULTURAL LAND RESOURCES BY FOUR FARMING AREAS OF NORTH DAKOTA, 1977-1981

Item	Western	West Central	East Central	Red River Valley	North Dakota
	acres				
Total Land in Farms[a]	15,232,276	10,570,682	11,229,118	4,993,287	42,025,363
Cropland[a]	7,696,456	7,008,568	8,834,205	4,410,032	27,949,261
Native Pasture[a]	6,678,335	2,525,781	1,438,959	249,066	10,892,141
Native Hay[a]	191,795	419,653	216,446	40,246	868,140
Farmstead and Waste[a]	665,690	616,680	739,508	293,943	2,315,821
Number of Farms[a]	11,298	10,889	12,057	6,925	41,169
Average Farm Size[a]	1,348	971	931	721	1,021
Average 1977-81 Acres of:[b]					
Wheat	2,834,000	2,836,380	3,410,960	1,562,400	10,643,740
Barley	168,700	359,100	966,120	704,080	2,198,000
Oats	438,000	447,780	317,540	100,680	1,304,000
Flax	25,080	217,980	175,980	38,960	458,000
Corn	9,300	14,420	127,640	184,000	335,360
Sunflower	136,580	329,380	1,237,540	654,500	2,358,000
Soybeans			15,440	184,380	199,820
Potatoes				119,200	119,200
Sugarbeets				141,120	141,120
Dry Edible Beans			87,880	163,625	222,450
Alfalfa Hay	680,120	522,760	374,640	87,880	1,665,400
Summer Fallow	2,548,200	1,766,800	1,536,000	365,000	6,216,000

[a]United States Department of Commerce, Bureau of the Census, 1978 Census of Agriculture, North Dakota, Vol. 1, Part 34, Washington, D.C., July 1981.
[b]North Dakota Crop and Livestock Statistics, Annual Summaries for 1978 through 1982.

The data for each farming area in Table 2 show two outstanding differences: (1) the proportion of cropland to total farmland and (2) the proportion of cropland in summer fallow. The ratio of cropland to total acreage increases from 50 percent in the Western area to 88 percent in the Red River Valley area. The amount of land in summer fallow decreases from west to east in the state. About 33 percent of the cropland in the Western area was in summer fallow compared to only 8 percent in the Red River Valley area.

Linear programming was the tool used to select the most profitable farm enterprise plan using "normal" rainfall, and then with added growing season rainfall. Linear programming is an empirical tool by which the one optimum farm plan can be selected from among many alternative plans. It is a mathematical procedure which can quickly select the most profitable plan.

Prices used for the crops and livestock products of each farming area were the 1977 to 1981 averages of prices received by farmers (North Dakota Crop and Livestock Statistics, 1978 to 1982) and are listed in Table 3. These prices may be different from the prices prevailing today, but this does not invalidate the results. The relationship of prices to one another and to production costs are more important than a given level. The 1977 to 1981 period also was used for the costs of inputs. The five-year average was long enough to smooth out variations in prices received and paid by farmers.

TABLE 3. PRODUCT PRICES USED IN THE ECONOMIC ANALYSIS OF ADDED GROWING SEASON RAINFALL BY FOUR FARMING AREAS

Product	Unit	Western	West Central	East Central	Red River Valley
Wheat	bu.	3.18	3.23	3.31	3.31
Malting Barley	bu.			2.16	2.18
Feed Barley	bu.	1.89	1.98		
Oats	bu.	1.38	1.31	1.32	1.31
Flax	bu.	5.88	6.03	6.03	6.00
Sunflower	cwt.	10.10	10.35	10.40	10.40
Corn Grain	bu.	2.26	2.24	2.26	2.25
Soybeans	bu.				6.20
Dry Edible Beans	cwt.				19.35
Potatoes	cwt.				4.00
Sugarbeets	ton				28.50
Beef Cow	cwt.	38.00	38.00	38.00	38.00
Calves	cwt.	70.00	70.00	70.00	70.00
600 lb. Yearling	cwt.	63.90	63.90	63.90	63.90
800 lb. Yearling	cwt.	58.60	58.60	58.60	58.60
700 lb. Yearling Off Pasture	cwt.	62.00	62.00	62.00	62.00

The yields used were county averages per planted acre reported by the North Dakota Crop and Livestock Reporting Service. These yields also were averaged for the years 1977 to 1981.

Crop and livestock enterprises most common to each farming area were the alternatives the linear programming model could select from. However, dairy, sheep, hogs, and beef finishing were not included. Sugarbeets, soybeans, potatoes, and dry edible beans were only included in the Red River Valley area. In general there were 17 crop and 31 livestock enterprises included in the linear programming model. There were 11 basic livestock enterprises with several alternative types of rations that could be used. The basic livestock enterprises included beef cows-selling calves, beef cows-backgrounding[1] calves to 600 and 800 pounds, beef cows-selling yearlings off pasture, and buy yearlings in the spring and pasturing over the summer months and selling in the fall.

Labor was restricted primarily to the operators and their families. However, a labor hiring activity was included in which labor could be hired at $3.75 per hour.

The economic analysis assumed no change in cultural practics for crops grown as rainfall was increased. A five-year study reported by Conlon et al. (1974) indicated that no change in tillage on summer fallow was required for the addition of 1 to 2 inches of rainfall over the growing season. Costs of fertilizer and harvesting were adjusted to compensate for increased yields.

Section 2. Added Direct Returns to Agriculture for the Four Farming Areas

This section reports the results of the linear programming models for each farming area. These results present the most profitable combination of resources used in each area as well as the returns over direct costs. The results will be discussed for each farming area.

The initial economic analysis determined the most profitable combination of crops and acreages for each farming area and the level of returns over direct or variable costs under "normal" rainfall. Then the increases in crop and forage yields due to added rainfall were entered into the analysis. The optimal resource combinations and levels of returns were recalculated for the added growing season rainfall situations. The cost of cloud seeding, at $0.10 per acre, was deducted from returns in each case.

Western Farming Area

Under "normal" rainfall the optimum use of the land resources would be wheat after fallow, wheat after crop, flax, sunflower, corn grain, corn silage, and alfalfa hay (Table 4). There were 3,353 hours of labor hired. The livestock enterprises consisted of beef cows-backgrounding calves to 600 pounds and beef cows-backgrounding calves to 800 pounds. Returns over variable costs for the Western area under "normal" rainfall were $270 million or an average of $18.56 per acre.

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[1]Backgrounding is a short-term or "warm-up" feeding period prior to entry into the finishing feedlot. In general, calves fed from weaning, or about 400 pounds, to 550 to 800 pound weights are referred to as backgrounded feeders.

TABLE 4. CROP AND LIVESTOCK ENTERPRISE PLANS FOR THE WESTERN AND WEST CENTRAL FARMING AREAS UNDER "NORMAL" AND ADDED RAINFALL SITUATIONS, NORTH DAKOTA

Item	Unit	Western Area		West Central Area	
		Normal Rainfall	Added Rainfall	Normal Rainfall	Added Rainfall
Wheat After Fallow	acres	2,450,000	2,450,000	1,766,800	1,766,800
Wheat After Crop	acres	181,285	176,123		
Barley After Crop	acres			560,518	547,006
Flax After Crop	acres	384,823	384,823	350,430	350,430
Sunflower After Crop	acres	1,285,308	1,285,308	1,168,095	1,168,095
Corn Grain	acres	59,278	60,400	1,079,440	1,069,923
Corn Silage	acres	341,913	333,847		
Corn Feed Grain	acres	152,954	159,898	88,655	98,172
Alfalfa Hay	acres	390,895	396,057	227,830	241,342
Native Hay	acres	191,795	191,795	245,721	290,916
Native Pasture	acres	6,678,335	6,678,335	2,525,781	2,525,781
Beef Cow-Backgrounding Calf 600#	number	288,129	362,605		
Beef Cow-Backgrounding Calf 800#	number	142,731	142,731	190,481	225,516
Spring Labor Hired	hours	3,353	527,506		
Return Over Variable Cost	dollars	270,350,591	324,759,285	333,808,143	383,120,524
Gain[a]	dollars		52,952,035		48,316,981

[a]Cloud seeding cost of $0.10 per acre was deducted.

The results of linear programming of the farm resources with increased growing season rainfall also are shown in Table 4. The same combination of farm enterprises was selected but some crop acreages changed. Wheat after crop acreage was reduced 5,162 acres, which went to increase the alfalfa hay acreage. Corn silage was reduced 8,066 acres, which shifted to producing more corn grain. The beef cow-backgrounding calves to 600 pounds was increased by 74,476 head. Returns over variable costs averaged $22.19 per acre, which was an increase of $3.63 per acre over "normal" rainfall. Total gain for added rainfall was $53.0 million after allowing for the cost of cloud seeding. Most of the gain in income is due to the increase in crop and forage yields from increased growing season rainfall.

West Central Area

The West Central area under "normal" rainfall would produce wheat after fallow, barley after crop, flax, sunflower, corn grain, and alfalfa hay (Table 4). The major livestock enterprise was beef cows-backgrounding calves to 800 pounds. Returns over variable cost were $334 million or about $33.54 per acre.

The kinds of enterprises selected did not change with added growing season rainfall, only the number of acres devoted to each crop. Barley acreage was reduced 13,512 acres, which shifted to produce more alfalfa hay. Corn grain for sale was reduced 9,517 acres and was used to produce corn grain for feed. Native hay use was increased by 45,195 acres, which was taken from unused native hay acres. The beef cow-backgrounding calves to 800 pounds was increased by 35,035 head. Summer fallow acreage did not change under added growing season rainfall because there was a minimum acreage required and the acreage was never more than the minimum. Returns over variable cost with added rainfall were $382.1 million or about $38.39 per acre. Returns over variable costs went up $48.3 million compared with "normal" rainfall or about $4.85 per acre.

East Central Area

Farm adjustments for the East Central area are given in Table 5. The crop enterprises under "normal" rainfall consisted of wheat grown on summer fallow land, barley after crop, flax, sunflower, corn grain, and alfalfa hay. Soybeans can be grown in the East Central area, with 16,700 acres planted in 1981. Because of the lack of a good yield history on soybeans in the East

TABLE 5. CROP AND LIVESTOCK ENTERPRISE PLANS FOR THE EAST CENTRAL AND RED RIVER VALLEY FARMING AREAS UNDER "NORMAL" AND ADDED RAINFALL SITUATIONS, NORTH DAKOTA

Item	Unit	East Central Area		Red River Valley Area	
		Normal Rainfall	Added Rainfall	Normal Rainfall	Added Rainfall
Wheat After Fallow	acres	1,536,000	1,536,000	365,000	365,000
Wheat After Crop	acres				1,197,400
Barley After Crop	acres	4,103,066	4,091,861	2,231,827	1,019,487
Flax After Crop	acres	175,980	175,980		
Sunflower After Crop	acres	1,237,540	1,237,540	654,500	654,500
Corn Grain	acres	82,265	76,092	184,000	175,881
Corn Feed Grain	acres	45,375	51,548		8,119
Soybeans	acres			183,380	183,380
Potatoes	acres			121,580	121,580
Sugarbeets	acres			141,120	141,120
Dry Edible Beans	acres			163,625	163,625
Alfalfa Hay	acres	117,979	129,184		14,940
Native Hay	acres	123,717	141,656		24,085
Native Pasture	acres	1,438,959	1,438,959		249,066
Beef Cow Selling Calf at 800#	number	116,045	138,361		21,471
Return Over Variable Cost	dollars	444,808,844	492,985,773	373,240,173	402,898,083
Gain[a]	dollars		47,127,968		29,187,976

[a]Cloud seeding cost of $0.10 per acre was deducted.

Central area and the small acreage grown, they were not considered as a crop alternative in this study. The livestock enterprise was beef cows-backgrounding calves to 800 pounds. Return over variable costs for the East Central area was $444.8 million or $42.40 per acre.

Changes in crop acreages with added growing season rainfall included a reduction in barley acreage which shifted to grow more alfalfa hay. Barley was reduced by 11,205 acres. Corn grain for sale was reduced 6,173 acres and was added to the corn feed grain acreage. Native hay was increased 17,939 acres which was taken from the 92,729 total acres which were not fully utilized with either "normal" or added growing season rainfall. The beef cow-backgrounding calves to 800 pounds was increased by 22,316 head.

Returns over variable cost were $491.9 million after deducting costs of cloud seeding. This averages $46.89 per acre. Returns over variable costs to the East Central area increased $47.1 million with added growing season rainfall compared to "normal" rainfall. This increase averages about $4.49 per acre of cropland, native pasture, and native hay.

Red River Valley Area

The Red River Valley grows many specialized crops like potatoes, sugarbeets, soybeans, and dry edible beans. Acreages of these crops were limited in the model to the average number of acres grown in the 1977-1981 period.

The Red River Valley area under "normal" rainfall produces wheat on fallow, barley after crop, sunflower, corn grain, soybeans, potatoes, sugarbeets, and dry edible beans. No livestock was produced in the Red River Valley under "normal" rainfall (Table 5). This combination of resources produced returns over variable costs of $373.2 million or $79.42 per acre. Wheat after fallow was not profitable but farmers in the Red River Valley still had about 8 percent of their cropland in summer fallow during the 1977-1981 period. This amount of summer fallow was forced in the farm plans to make it comparable with how farmers are currently using their land.

Changes in land use with added growing season rainfall included adding wheat after crop of 1,197,400 acres, which were taken from barley. Another 14,940 acres were taken from barley which were used for alfalfa hay. Corn grain for cash acreage was reduced 8,119 acres and used for feed grain for the livestock enterprise. There were 24,085 acres of native hay grown which was taken from the total of 40,246 acres of unused native hay acres. A livestock enterprise of beef cow-backgrounding calves to 800 pounds was added. Total size of the livestock enterprise was 21,471 head.

Returns over variable costs were $402.4 million with added growing season rainfall or $85.63 per acre. Returns over variable costs in the Red River Valley with added growing season rainfall went up $29.2 million compared to "normal" rainfall. This increase averages about $6.21 per acre of cropland, native pasture, and native hay.

Figure 2 summarizes the direct benefits of added growing season rainfall to the agriculture of North Dakota. Total dollars of direct benefits

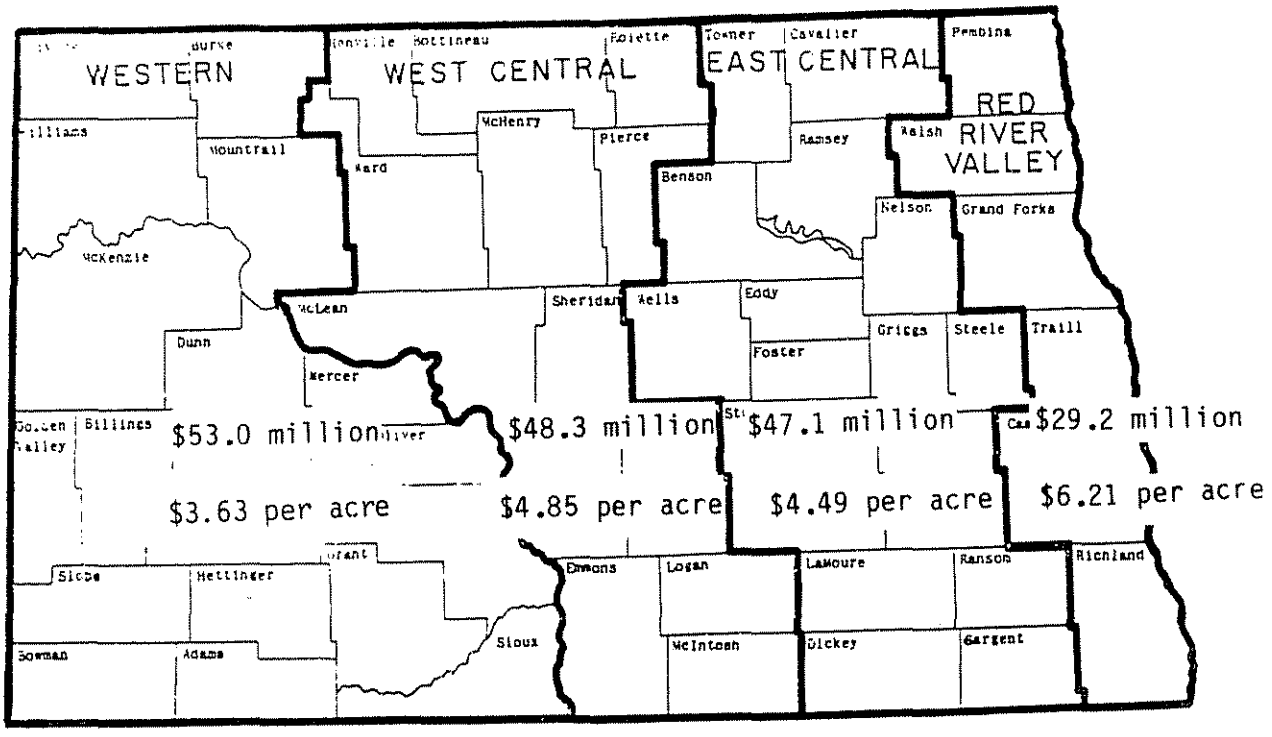

Figure 2. Estimated Direct Benefits of Added Growing Season Rainfall to Farmers, Totals Per Farming Area and Per Acre in Dollars in North Dakota

to agriculture are given for each farming area and per acre of cropland, native pasture, and native hay. The increased returns over variable costs resulted from the increase in yields of crops and forages. Changes in acreage of crops grown was to provide winter feed for the increased number of livestock.

Section 3. Total Impact of Added Growing Season Rainfall on the North Dakota Economy

The analysis of the total economic impacts of increased agricultural production due to added growing season rainfall uses the results of the four farming areas in a Leontief input/output model to estimate the interdependence relationships among the various sectors of businesses in the North Dakota economy. Each sector of an economy is dependent on other sectors for inputs; other sectors also will be affected by changes in agricultural incomes and expenditures. Increases in farm income and expenditures will result in an increase in business volume in the North Dakota economy. The North Dakota input/output model is based on actual expenditure data of North Dakota businesses (Sand, Bartch, Senechal, Hertsgaard).

Input/output analysis is a technique for tabulating and describing the linkages or interdependencies between various industrial or business groups within an economy. Interdependence coefficients, or multipliers, show the number of times a dollar injected into an economy is turned over, or spent and respent.

The increased agricultural incomes and expenditures from added growing season rainfall were distributed among 13 economic sectors. The 13 economic sectors to which increased gross business volume accrued were:

Sector No.	Description
1	Agriculture livestock production
2	Agriculture crop production
3	Sand and gravel (mining)
4	Construction
5	Transportation
6	Communication and utilities
7	Wholesale and agricultural processing
8	Retail
9	Finance, insurance, and real estate
10	Business and personal services
11	Professional and social services
12	Households
13	Government

An economic sector is a group of firms engaged in similar economic activity. Only eight sectors received the initial payments of the increased income and expenditures from added growing season rainfall. These were sectors 1, 5, 7, 8, 9, 10, 11, and 12.

Returns over variable costs described in the four area analyses were allocated to facilitate the input/output analysis (Table 6). Figure 2 showed the direct benefits to farmers while Table 6 presents those direct benefits plus the added spending and respending that occurs within the farming area.

TABLE 6. ALLOCATION OF INCREASED FARM INCOME AND EXPENDITURES BY SECTORS FOR ADDED GROWING SEASON RAINFALL BY FARMING AREAS

Economic Sector Receiving Payment	Increased Farm Income and Expenditure			
	Western	West Central	East Central	Red River Valley
	thousand dollars			
Agricultural Livestock Production	448.6	229.8	146.4	140.8
Construction	168.1	74.6	47.5	45.7
Transportation	391.4	184.6	117.6	113.2
Wholesale and Agricultural Processing	2,120.8	29.4	969.3	186.5
Retail	5,491.2	5,670.0	7,637.5	8,099.4
Finance, Insurance, and Real Estate	1,912.6	1,107.8	882.0	1,056.9
Business and Personal Services	1,477.6	3,652.1	589.6	1,782.9
Professional and Social Services	1,955.7	1,294.2	1,239.3	653.1
Households	53,382.3	47,363.9	46,932.3	28,451.2
Total Added Income and Expenditure	67,348.3	59,606.4	58,561.5	40,529.7

Interest on operating costs and investment and depreciation were deducted from returns over variable costs. An annual depreciation cost was assumed to be used to replace machinery and equipment and spent in the retail sector. Building depreciation was assumed spent in the construction sector. Interest on operating capital and livestock and machinery investment was allocated 32 percent to the finance sector and 68 percent to the household sector. Interest from 10 percent of the real estate investment was allocated to the finance sector and the remainder to the household sector. Estimated real estate taxes were deducted from return over variable costs but were not used in the input/output model since the amount spent on taxes did not change within the models analyzed. Cost of cloud seeding was assumed to be $0.10 per acre and was assigned to the professional and social services sector. All other purchased inputs were assigned to the sector where the payment likely was made.

Total Economic Impact on Western Farming Area

The estimated direct effect of increased growing season rainfall would be to increase farm income, part of which is farm expenditures and part is returns over variable costs, by $67.3 million for the Western farming area (Table 6). Most of the increased farm income consists of earnings of households (the farm operator's returns to the land he owns, capital, labor, and management, as well as payments for hired farm labor). About 19 percent of the increased farm income goes for production costs for items purchased for the retail, construction, and other sectors of the economy.

The multiplier process, measuring the spending and respending of added income, continues until the money leaves the community as payment for products purchased outside the community. By the time the $67.3 million is spent and respent in the community, it is estimated to generate another $139.1 million of business volume for a total of $206.6 million (Table 7). The estimated total income generated through the multiplier process from added growing season rainfall was $206.6 million in the Western farming area.

Total Economic Impact on West Central Farming Area

The estimated total increased farm income and expenditures for added growing season rainfall in the West Central farming area was $59.6 million (Table 6). Spending and respending of these amounts generated an estimated total business volume of $178 million for added growing season rainfall (Table 7). Three sectors which received about 77 percent of the added business volume were the household; retail; and finance, insurance, and real estate sectors.

Total Economic Impact on East Central Farming Area

The estimated increased farm income and expenditures resulting from added growing season rainfall in the East Central farming area was $58.6 million (Table 6). Another $116.3 million was estimated to be generated through the process of spending and respending for an estimated total of $174.9 million (Table 7). The sectors receiving the majority of the business volume

TABLE 7. ESTIMATED INCREASED ADDED BUSINESS VOLUME RESULTING FROM INCREASED FARM INCOME AND EXPENDITURES FROM ADDED GROWING SEASON RAINFALL BY FARMING AREAS

Economic Sector Receiving Added Business	Added Business Volume			
	Western	West Central	East Central	Red River Valley
	----------million dollars----------			
Added Farm Income and Expenditures	67.3	59.6	58.6	40.5
Economic Sector to Which Business Volume Accrued:				
Agricultural Livestock Production	5.3	4.3	4.4	3.0
Agricultural Crop Production	3.3	1.7	2.2	1.3
Sand and Gravel Construction	5.7	5.0	4.8	3.1
Transportation	1.1	0.8	0.7	0.5
Communication and Utilities	6.8	6.0	5.8	3.9
Wholesale and Agricultural Processing	6.7	2.6	4.2	2.1
Retail	51.9	46.1	47.1	33.8
Finance, Insurance, and Real Estate	12.3	10.2	9.7	6.8
Business and Personal Services	5.3	7.0	3.8	3.9
Professional and Social Services	8.0	6.5	6.4	3.9
Households	93.0	81.6	79.8	51.1
Government	6.8	5.9	5.7	3.8
Total Added Business Volume	206.2	178.0	174.9	117.4

were the same for all four farming areas. The major sectors include households; retail; and finance, insurance, and real estate.

Total Economic Impact on Red River Valley Farming Area

The estimated increased farm income and expenditures of added growing season rainfall was $40.5 million in the Red River Valley farming area. This generated another $76.9 million of estimated business activity. Estimated total business volume increased to $117.4 million for added growing season rainfall. The allocations to the various sectors receiving payment and accruing additional business volume are presented in Tables 6 and 7.

Total Impact on State Economy

Direct purchases by farmers from the local economy resulting from increased farm income and expenditures because of added growing season rainfall was estimated to total $226.0 million (Table 6). This total was derived by adding the totals for the four farming area models. The spending and respending of this increased income and expenditures generated another

$450.9 million of estimated gross business volume from added growing season rainfall. The total benefit to the state economy derived from the four farming area models was estimated at $676.9 million. Added rainfall increased gross business volume by about $3.00 for each dollar the farmer received and spent above what he would have under "normal" rainfall conditions.

Added growing season rainfall increased gross business volume by an estimated $10.72 per acre. The Western farming area had an estimated increase in gross business volume for added growing season rainfall of $9.14 per acre, West Central farming area $11.20, East Central farming area $10.36, and the Red River Valley farming area $15.40. Some of the difference in the above figures was due to higher product prices in the east than west because of freight rate differences. The yields under "normal" rainfall also increased from west to east. More types of crops can be grown in the East Central and Red River Valley farming areas, many of which have a higher return per acre than wheat and barley, the principal crops in the two western areas. The Eastern farming area also had a smaller proportion of land in summer fallow and native pasture so a greater proportion of the farmland was devoted to crop production.

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APPENDIX

An Alternative Way to Analyze Added Direct Returns to Agriculture Using a "Typical" Farm in Each Farming Area

The main part of this manuscript treated each of the four farming areas as one farm. This appendix offers an alternative analysis, where a typical farm within each farming area was estimated. This analysis provides similar results to those presented above in Section 2. Appendix Table 1 shows the typical farm size was 1,760 acres in the Western farming area, 1,280 acres in the West Central, 1,120 acres in the East Central, and 920 acres in the Red River Valley.

The acreage restraints for various crops are given in Appendix Table 1. These restraints were used in linear programming to prevent any one crop, which would be the most profitable for the resources available, from taking

APPENDIX TABLE 1. CHARACTERISTICS OF MODEL FARMS BEFORE ADDED RAINFALL ANALYSIS FOR FOUR FARMING AREAS AND RESTRAINTS USED FOR EACH FARM

Item	Western	West Central	East Central	Red River Valley
			acres	
Total Farm Size	1,760	1,280	1,120	920
Cropland	898	845	885	810
Native Pasture	774	307	146	46
Native Hay	18	51	22	9
Waste	10	77	67	55
Other Restraints				
Wheat	330	342	342	287
Flax	45	42	18	7
Sunflower	150	140	124	121
Corn	65	140	30	34
Soybeans	--	--	--	34
Summer Fallow	296	213	154	67
Labor (Hours)				
Spring	780	780	780	780
Summer	780	780	780	780
Fall	910	910	910	910
Winter	1,040	1,040	1,040	1,040

over the total farm acreage. The acreages were based on the average acreages of these crops grown in the 1977-1981 period. Hours of family labor available for farm work also is shown. If the crop or livestock enterprises required more labor it could be hired at $3.75 per hour.

The typical farm for each farming area was linear programmed to select the most profitable farm enterprise plan using "normal" rainfall and with

added rainfall. The linear programming model included the same farm enterprises and same acreage and labor restrictions adjusted to an individual farm basis as for the area farm. The individual farm results for each of the four farming areas will be summarized.

Western Area

Under "normal" rainfall the typical farm enterprise plan for the Western farming area would grow 296 acres of wheat on fallow and 3 acres of wheat, 45 acres of flax, 150 acres of sunflower, and 5 acres of corn grain on land following a crop (Appendix Table 2). A farmer generally will not plant small acreages of crops but would plant that acreage to a crop with a larger acreage. Feed for the livestock operation included 43 acres of alfalfa hay, 18 acres of native hay, 17 acres of corn grain, and 43 acres of corn silage. The livestock enterprise included 50 beef cows-backgrounding calves.

APPENDIX TABLE 2. CHANGES IN RETURNS AND FARM ENTERPRISE PLANS FOR THE "TYPICAL" FARM IN EACH OF THE FOUR FARMING AREAS UNDER "NORMAL" AND ADDED GROWING SEASON RAINFALL

Item	Unit	Western Area		West Central Area	
		Normal Rainfall	Added Rainfall	Normal Rainfall	Added Rainfall
Wheat After Fallow	acres	296	296	213	213
Wheat After Crop	acres	3	2		
Barley After Crop	acres			69	68
Flax After Crop	acres	45	45	42	42
Sunflower After Crop	acres	150	150	140	140
Corn Grain	acres	5	6	129	128
Corn Feed Grain	acres	17	17	11	12
Corn Silage	acres	43	42		
Alfalfa Hay	acres	43	44	28	29
Native Hay	acres	18	18	30	35
Native Pasture	acres	774	774	307	307
Beef Cow-Backgrounding Calf 600#	number	35	45		
Beef Cow-Backgrounding Calf 800#	number	15	14	23	27
Spring Labor Hired	hours		55		
Return Over Variable Costs	dollars	31,150	37,530	40,203	46,142
Gain[a]	dollars		6,211		5,819

[a]Cloud seeding cost of $0.10 per acre was deducted.

Added rainfall did not change the enterprises selected, only the acreages planted of crops and forages. The livestock numbers were increased by nine beef cows. Returns over variable costs increased by $6,211 due to increased yields of crops and forages. Cost of cloud seeding, at $0.10 per acre, was deducted from the returns over variable costs. Increased return over variable cost was $3.68 per acre compared with "normal" rainfall for the typical farm situation.

West Central Area

The typical farm in the West Central farming area under "normal" rainfall conditions would grow 213 acres of wheat on fallow and 69 acres of barley, 42 acres of flax, 140 acres of sunflower, and 129 acres of corn on land that was cropped the previous year (Appendix Table 2). Feed for livestock included 28 acres of alfalfa hay, 30 acres of native hay, 11 acres of corn, and 307 acres of native pasture. Twenty-three head of beef cows-backgrounding calves to 800 pounds made up the livestock enterprise.

Added growing season rainfall did not change the crop enterprise plan. The same acreage supported four additional beef cows. Increased returns over variable costs with added rainfall was $5,819 for the farm or $4.84 per acre.

East Central Area

The typical farm under "normal" rainfall conditions in the East Central farming area would grow 154 acres of wheat on fallow and 393 acres barley, 124 acres sunflower, and 30 acres of corn grain on land following a crop (Appendix Table 3). The livestock enterprise was 12 head of beef cows-backgrounding the calves to 800 pounds. Winter feed was grown on 12 acres of native hay, 12 acres of alfalfa hay, and 5 acres of corn. There was a total of 22 acres of native hay available but only 12 acres were utilized.

There were no changes in the farm enterprise plan with added rainfall. Native pasture yields increased with added rainfall to accommodate two more beef cows. Increase in returns over variable costs was $4,742 or $4.50 per acre compared with "normal" rainfall.

Red River Valley

The typical farm in the Red River Valley with "normal" rainfall grew 67 acres of wheat after fallow and 487 acres of barley, 121 acres of sunflower, 34 acres of corn grain, and 34 acres of soybeans on land that was cropped the previous year (Appendix Table 3). Wheat after fallow was not the most profitable enterprise but farmers in this area had about 8 percent of their cropland in summer fallow during the 1977-1981 period. This amount of summer fallow was forced into the farm plan and wheat was the most profitable way to utilize the fallow ground. The farm plan under "normal" rainfall conditions has no livestock.

The crop enterprise plan with added rainfall was shifted by reducing barley by 223 acres. This acreage was used for 220 acres of wheat after crop and 3 acres of alfalfa hay. The typical farmer would not have livestock even

APPENDIX TABLE 3. CROP AND LIVESTOCK ENTERPRISE PLANS FOR THE TYPICAL FARM UNDER "NORMAL" AND ADDED RAINFALL SITUATIONS IN THE EAST CENTRAL AND RED RIVER VALLEY FARMING AREAS, NORTH DAKOTA

Item	Unit	East Central Area		Red River Valley Area	
		Normal Rainfall	Added Rainfall	Normal Rainfall	Added Rainfall
Wheat After Fallow	acres	154	154	67	67
Wheat After Crop	acres				220
Barley After Crop	acres	393	392	487	264
Flax After Crop	acres	18	18		
Sunflower After Crop	acres	124	124	121	121
Corn Grain	acres	25	25	34	32
Corn Feed Grain	acres	5	5		2
Soybeans	acres			34	34
Alfalfa Hay	acres	12	13		3
Native Hay	acres	12	14		4
Native Pasture	acres	144	144		46
Beef Cow-Backgrounding Calf at 800#	number	12	14		4
Return Over Variable Cost	dollars	45,341	50,188	52,734	57,135
Gain[a]	dollars		4,742		4,315

[a]Cloud seeding cost of $0.10 per acre was deducted.

though the profitable farm plan with added rainfall specified four beef cows-backgrounding calves to 800 pounds. The returns over variable costs were increased $4,315 or $4.99 per acre compared with "normal" rainfall.

The benefits of added growing season rainfall came from increased yields of crops and forages. The increase in yields resulted in increasing the returns over variable costs by an average of $4.38 per acre compared with "normal" rainfall. This varied from $3.68 in the Western area to $4.99 per acre in the Red River Valley.