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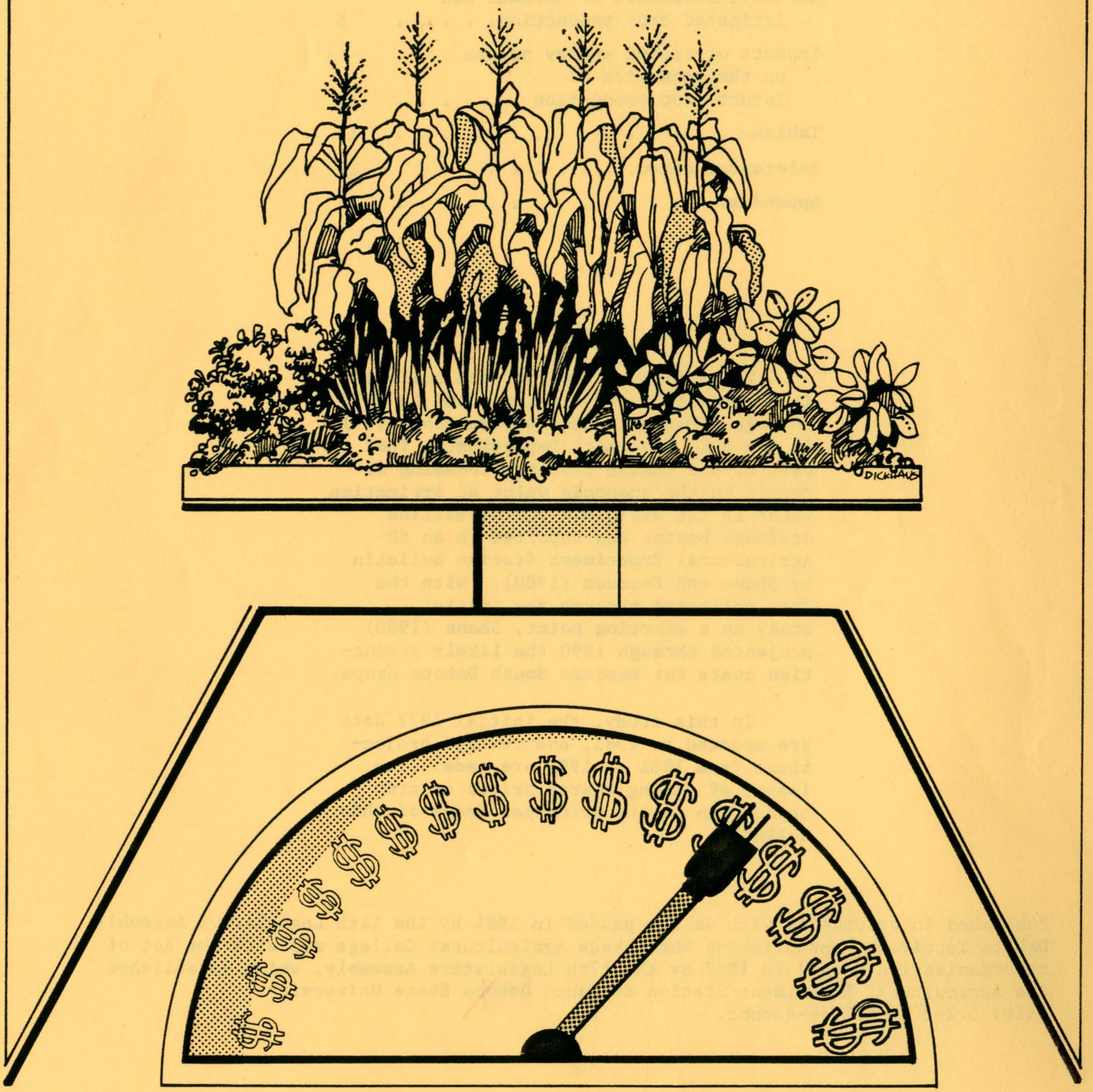

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PREFACE

The study reported in this bulletin is an extension of work initiated in 1977 through a Master's thesis (Everson, 1979) in the SDSU Economics Department. That part of the thesis research focusing directly on the economic value of irrigation water in the Big Sioux and Vermillion drainage basins was reported in an SD Agricultural Experiment Station bulletin by Shane and Everson (1980). With the data collected through the initial study as a starting point, Shane (1980) projected through 1990 the likely production costs for eastern South Dakota crops.

In this study, the initial 1977 data are updated to 1981, and revised projections from 1981 to 1990 are made. The impact of rising energy prices on crop production is the principal focus of this bulletin.

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Brookings and Turner counties:

The impact of rising energy prices on crop production

Donald C. Taylor and Richard C. Shane*

SUMMARY

The economics of dryland versus irrigated crop production in two of South Dakota's fast irrigation-growth counties -- Brookings and Turner -- are examined in this bulletin. Special attention is given to the economic impacts of rising energy prices through 1990.

The main findings from the study are as follows.

1. The yields of corn, alfalfa, and soybeans grown by farmers under irrigation are 1.7 to 2.3 times more than when the crops are grown under dryland conditions.

2. The total costs for producing most dryland crops in 1981 in Brookings County were commonly $140 to $150/A, but they ranged from $119/A for alfalfa to $192/A for corn. The total costs of producing most dryland crops in Turner County were about 15% higher than those in Brookings County. The per-acre costs of irrigated crops in both counties were about twice those for the respective dryland crops.

3. The single largest cost item in all the crop budgets is the charge for land, which most commonly accounts for 35 to 40% of the total costs of dryland and 25 to 35% of the total costs of irrigated production.

4. The "direct" energy embodied in the fuel and lubrication for crop production and grain drying, plus the "indirect" energy embodied in fertilizer and plant production chemicals, comprise about two fifths of the variable costs for dryland production and about one half for irrigated production. The energy expenditure per acre for corn, soybeans, and alfalfa is from 2.0 to 2.8 times higher for irrigated than dryland production. The total energy bill (direct and indirect) for a quarter section of corn raised in 1981 under irrigation was about $7,500 greater than if the corn were raised under dryland conditions.

5. Of the eight crops studied, corn is most energy-intensive and alfalfa and soybeans are least energy-intensive. The energy bill for a 350 A dryland farm under corn production in 1981, for example, was over $10,000 more than the energy bill for that same farm with alfalfa and soybeans.

6. With the prices prevailing in 1981, alfalfa was clearly the most profitable crop in both Brookings and Turner counties. If the price of alfalfa were to return to its average for 1977 to 1979 and the price of corn were to return to its 1980 level, corn would be more than twice as profitable as alfalfa.

7. The short-run break-even price -- defined as the variable production cost per unit of output produced -- was about 15% less for corn raised under irrigation than under dryland conditions in 1981 in Brookings County. For the other crop situations studied, however, the break-even price for irrigated production is roughly the same as or more than that for dryland production. Thus, the use of irrigation does not necessarily lead to the production of lower-cost farm commodities.

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8. The short-term profitability of irrigated production is clearly superior to that of dryland production.

9. The longer term profitability of agricultural production may be questionable, however. For all crops except alfalfa, under both dryland and irrigated conditions, the net returns over total production costs in 1981 were negative. Net returns over the total production costs in 1981 were lower with than without irrigation.

10. Assuming current trends in input prices, the net returns over variable costs projected to 1990 are considerably more for corn and soybeans (from 15 to 80%) than for alfalfa.

11. With a rapidly rising energy price alternative (doubling of 1981 prices by 1986), the projected net returns from dryland crop production in 1990 are most commonly \$35 to \$45/A less than the projected net returns if input prices were to rise according to current trends. The reduction in net returns for corn, however, exceeds \$80/A. For a 350 A dryland farm planted to most crops, the projected net returns are \$12,000 to \$16,000 per year less with the rapidly rising energy price alternative. If the farm were under corn production, however, the reduction in net returns with high energy prices would be roughly \$30,000 per year.

12. With the rapidly rising energy price alternative, the projected net returns from irrigated corn production in 1990 are roughly \$190/A less than with the current trend input price assumption. The corresponding reductions in net returns for irrigated soybeans and alfalfa are less than one half those for corn.

The projected net return for an irrigated quarter section under corn production is about \$25,000 per year less under the rapidly rising energy price assumption. If the quarter section were in alfalfa, the reduction in net returns with higher energy prices would be about \$10,000 per year. Nevertheless, under the higher energy price, irrigated corn is still considerably more profitable than irrigated alfalfa.

13. With rapidly rising energy prices and dryland conditions, corn -- the most energy-intensive crop -- loses considerably in its comparative advantage relative to alfalfa and soybeans which are the least energy-intensive crops. With rapidly rising energy prices and irrigated conditions, corn's comparative advantage relative to alfalfa is reduced, but not to the point where it ceases to maintain a considerable profit margin over alfalfa. With rapidly rising energy prices and under both dryland and irrigated conditions, the 1990 projections show soybeans to be clearly the most profitable of the various crops considered.

14. With rapidly rising energy prices, the projected net returns per acre to farmers from producing the various crops in 1990 would be about 15 to 40% less than with the current trends in input prices. Nevertheless, the returns from production exceed the variable production costs for all the crop-energy price situations considered. Further, the amounts of net returns from crops raised under irrigation are larger than those from the crops raised under dryland conditions. Thus, even if energy prices were to escalate rapidly during the 1980's, farmers already having irrigation facilities would appear to be well advised to continue to use them.

Each of these findings is influenced by the assumptions which underlie the analysis in the study. These assumptions -- outlined in the main body of the report -- should be carefully considered in interpreting the study's results.

Introduction

The 10 Great Plains states account for half of the U.S. irrigated cropland. South Dakota has less than 1% of that acreage (USDA, 1980, 420-421).

Nevertheless, expansion in South Dakota irrigation during the past decade has been considerable. The S.D. Department of Water and Natural Resources reports an over fourfold increase, from 77,197 acres in 1969 to 316,043 acres in 1977. Informed opinion indicates as many as 450,000 acres under irrigation in 1981.

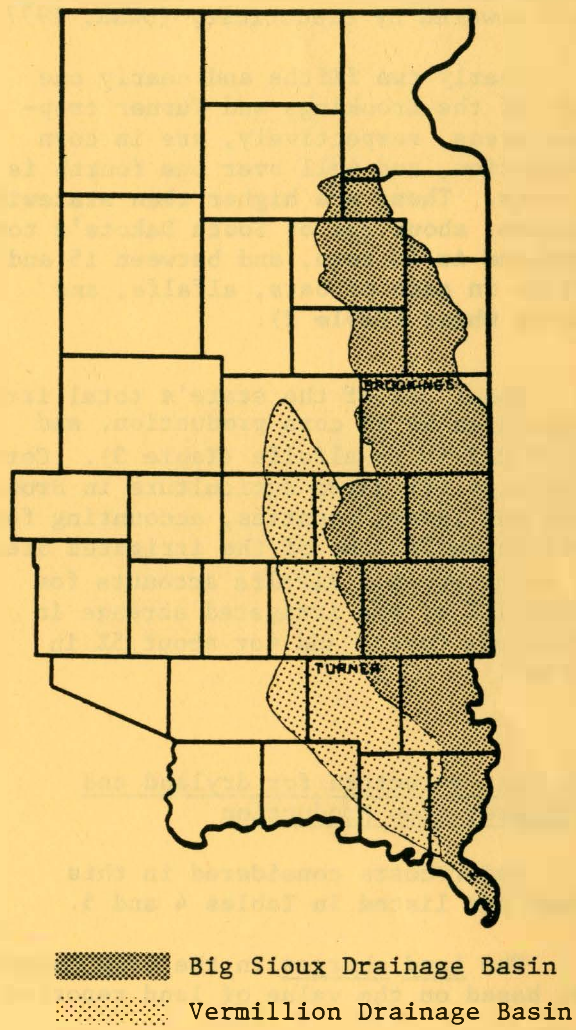
Over 10,000 acres were irrigated in each of four South Dakota counties west of the Missouri River and seven counties east of the Missouri in 1978 (Table 1). From 1969 to 1978, irrigated area increased in these major West River counties by 1.1 times and in the major East River counties by as much as 4.3 times.

Two East River counties -- Turner and Brookings -- rank fourth and fifth in the state in irrigation expansion into new land during the past decade. In terms of relative increase, Brookings and Turner rank second and fourth among major irrigated counties. Thus, both have relatively large and rapidly increasing irrigated areas.

From an economic standpoint, will (or should) this rapid development continue during the 1980's? Of particular concern is the cost of energy. The overall objective of this report is to examine the impacts of high (and rising) energy prices on the current and prospective economics of dryland versus irrigated crop production in Brookings and Turner counties.

Brookings and Turner counties are in the Big Sioux and Vermillion drainage basins that rest adjacent to one another in the far eastern part of South Dakota (Fig 1). The annual precipitation in the Big Sioux and Vermillion basins ranges from an average of 20 inches in the north to 24 inches in the south. Irrigators usually add 10 to 15 inches a year. The number of frost-free days ranges from 130 in the north to 150 in the south. The soils in the two counties are mainly loamy and silty, although alluvial and clayey-loam soils are also found in low lying areas in the south.

Fig 1. The Big Sioux and Vermillion drainage basins in eastern South Dakota.



Ground water from wells is the primary source of irrigation water in the study area[1] and is distributed

1. The average well depths of the farmers surveyed by Everson (1979) in Brookings and Turner Counties are 45 and 85 feet, respectively.

mainly through center pivot machines (about $44,000 for a typical new pivot in 1982[2]). The growth of center pivot irrigation reflects both the movement of irrigation into hillier areas less well suited for other types of irrigation and the lesser labor requirement of pivot systems.

The main energy source for irrigation in both basins in the late 1970's was electricity. In 1977 in the Big Sioux and Vermillion basins, 70 and 87% of the irrigation systems, respectively, were powered by electricity (DWNR, 1977).

Nearly two fifths and nearly one half of the Brookings and Turner cropland areas, respectively, are in corn production, and well over one fourth is in oats. These are higher than statewide figures; about 25% of South Dakota's total cropland is in corn, and between 15 and 20% is in each of oats, alfalfa, and spring wheat (Table 2).

About 55% of the state's total irrigated area is in corn production, and about 25% is in alfalfa (Table 3). Corn dominates irrigated agriculture in Brookings and Turner counties, accounting for over three fourths of the irrigated area in each county. Alfalfa accounts for about 10% of the irrigated acreage in Brookings County and for about 5% in Turner.

The cost structure for dryland and irrigated crop production

Major costs considered in this study are listed in Tables 4 and 5.

The land charges in the crop budgets are based on the value of land reported in 1977. The mean values in Brookings and Turner counties for irrigable dryland were $600 and $750/A, respectively. Corresponding values for irrigated land were $1,000 and $1,200. The assumed annual rate of appreciation in land values is 12%. The annual charges for land -- including real estate taxes -- in the crop budgets are 6% of current land values.

Depreciation on farm machinery, irrigation systems, and storage facilities was computed using the actual investment figures provided by farmers. Insurance and repair data were obtained directly from farmers, as was the information on the amount of electrical power to pump irrigation water.

The interest rate used in the cost computations is 18%, the rate commonly experienced by farmers who borrowed investment and operating capital in 1981. The average loan period for operating capital was assumed to be 6 months. The interest on investment capital was calculated on the average value over the lifetime of assets.

For dryland crops in Brookings County, nitrogen fertilizer application levels vary from zero for alfalfa and 6 lb/A for soybeans to 60 lb/A for corn. Phosphorus application levels vary from 10 lb P_2O_5/A for flax to 45 lb P_2O_5/A for alfalfa. The levels of dryland crop fertilization in Turner County are either the same as, or slightly more than, those in Brookings County.

Nitrogen applications for irrigated corn are 2.5 times as much as those for dryland corn. Phosphorus applications for irrigated crops are also considerably higher than those for dryland crops.[3] Potassium applications ranging from 13 lb

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2. The cost of a "typical" new center pivot system for a quarter-section in 1981 in the study areas is roughly as follows: center pivot machine - $30,000, pump panel and meter - $8,000, 40-ft well - $4,000, and electrical connections - $2,000, for a total of $44,000.

3. The reported nitrogen and phosphorus levels on irrigated crops in Turner County are higher than those recommended as "maintenance" levels (i.e., following the initial 3 to 4 years of crops being raised with irrigation) by the Cooperative Extension Service.

K_2O/A for soybeans to 60 lb/A for corn in Turner County were reported by farmers with irrigation (Table 6).

Fuel costs per acre were determined through a four-step process. The first step involved listing the field operations performed on each crop, and for each operation the width of the implement used and the speed traveled. The acres per hour for each field operation, calculated from this information, were divided by a 0.75 field efficiency factor. The second step involved using hourly fuel consumption data (UN, 1977) in conjunction with the hours required per acre, to compute the fuel consumption per acre. Third, the after-tax fuel price (Table 7) was multiplied by the gallons consumed per acre to obtain the diesel fuel cost per acre. Finally, 5% of the fuel cost was added to reflect engine oil and other lubrication costs.

Not covered in this study are expenditures on hired labor and charges for crop and irrigation management.

The total variable costs of dryland production per acre in 1981 in Brookings County range from $41 for alfalfa to $97 for corn (Table 4). They are about $50/A for oats, barley, and flax, and about $60/A for soybeans, spring wheat, and sunflowers. The total variable production costs per acre of dryland crops are about the same in Turner County as in Brookings for barley and soybeans, but 10 to 15% higher for corn, flax, and oats, and about 45% higher for alfalfa (Tables 4 and 5). The total per-acre costs of producing various dryland crops in Brookings County range from $119 for alfalfa to $192 for corn. They are commonly 12 to 17% less than those for corresponding crops in Turner County. For alfalfa, however, the Brookings County costs are 47% less. The costs of producing irrigated crops in both counties are about twice those for the respective dryland crops.

The fixed costs, as a group, constitute between 50 and 70% of the total costs of producing the various crops. The proportions of fixed costs for most crops are slightly higher in Turner than in Brookings County.

The single largest cost item in all the crop budgets is the charge for land, which most commonly accounts for 35 to 40% of the total costs of dryland production and 25 to 35% of the total costs of irrigated production. The next four line items -- (1) depreciation and insurance, (2) interest on investment, (3) fertilizer, and (4) machinery fuel and lubrication -- each account for roughly 8 to 15% of total production costs for the various crops. For irrigated production, however, the interest on investment accounts for more than 15%, and fuel and lubrication for less than 8% of total production costs.

The final aspect of cost structure examined is the expenditure on irrigation system power and repair as a percentage of the total variable production costs. In Brookings and Turner counties, the percentages are as follows: corn, 15 and 16%; soybeans, 25%; and alfalfa, 30 and 32%.

Energy costs in dryland and irrigated crop production

Farm production accounts for less than 3% of total U.S. energy consumption. Efforts by farmers to conserve energy, therefore, cannot be expected to have much influence on the national energy picture. Nevertheless, rising energy prices provide economic incentives to individual farmers to conserve energy.

The total energy required in agricultural production consists of "direct" and "indirect" components. "Direct" energy is embodied in the fuel and lubrication for farm machinery and irrigation systems, and the power for grain drying. "Indirect" energy is that energy required to produce and deliver the inputs -- materials and human services -- used in agricultural production.

In examining the indirect energy content of specific South Dakota crops in this study, attention is given to the energy embodied in fertilizer and plant protection chemicals, but not to the generally smaller amounts in seeds, machinery, transportation, and human labor. See the

Appendix for the procedures used in determining the energy content in fertilizer and plant protection chemicals.

The per-acre energy bill in 1981 for most dryland crops in Brookings and Turner counties ranged from $22 to $26 (Tables 8 and 9). The $13 to $19/A energy bills for alfalfa and soybeans, and the $35 for sorghum and $57 and $54 for corn, however, are outside this range. In relative terms, energy accounts for about one third to one half of the total variable costs of dryland production, with the ratios lowest for alfalfa and soybeans and highest for barley and corn. Thus, of the dryland crops, corn is considerably the most energy-intensive and alfalfa and soybeans are least energy-intensive.

Farm application: The energy bill for a 350 A dryland farm[4] under corn production in 1981 is over $10,000 per year more than the energy bill for that same farm with alfalfa and soybeans.

Of the various energy components in dryland production, the machinery fuel and lubrication category is definitely the largest. The expenditures on this component, which range most commonly from $15 to $18/A, account for over one half of the energy bill for all crops except corn (which also involves grain drying) and sorghum. For soybeans and alfalfa -- for which fertilizer levels are low and no grain drying is required -- machinery fuel and lubrication account for well over three fourths of the total energy costs. For all dryland crops except alfalfa and soybeans, fertilizer is the second most important energy cost component, and the energy in plant protection chemicals is only a small fraction (one third or less)[5] of that in fertilizer.

The energy bill for corn and soybeans raised under irrigation is 2.0 to 2.2 times as much as that for the crops grown under dryland conditions. For alfalfa, the irrigation-dryland differential is 2.7 to 2.8 times. Energy accounts for slightly over one half of the total variable cost for irrigated corn, 40 to 46% for irrigated alfalfa, and 35% for irrigated soybeans. These data, of course, reflect the much greater energy-intensity of irrigated than dryland agriculture.

Farm application: The energy bill for a quarter section of irrigated corn (130 A under a center pivot) in 1981 is about $7,500 greater than if the corn were raised under dryland conditions.

Fertilizer, the largest energy cost component in irrigated corn production, accounts for 34 and 47% of total energy costs in Brookings and Turner counties, respectively. The fuel to power irrigation pumps accounts for 28% of the total crop production energy costs. Machinery fuel and lubrication and grain drying are next in importance, with the energy embodied in plant protection chemicals of least importance. For alfalfa and soybeans, on the other hand, well over 60% of the total energy expenditure is on the fuel to power irrigation pumps. From one quarter to one third of the energy is for machinery fuel and lubrication. Fertilizer and plant protection chemicals account for only 10% of the total soybean energy cost and from 3 to 4% of the total alfalfa energy cost.

Relative economics of dryland and irrigated crop production

Dryland and irrigated yields are shown in Table 10. The assumed crop prices for 1981 are shown in Table 11. The yields under irrigation are generally 1.7 to 1.9 times as much as under dryland conditions. For corn in Brookings County,

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4. The USDC (1980) shows average per-farm cropland acreages in 1978 in Brookings and Turner counties of 370 and 300 acres, respectively. The 350 acres in the "farm application" illustrations is used to typify these farms.

5. For sunflowers, however, the energy embodied in plant protection chemicals is almost one half that in fertilizer.

however, the irrigation-dryland yield differential is 2.3 times.

"Break-even" prices are used in the analysis. A "break-even" price is defined as the cost per unit of output produced. Unless otherwise noted, break-even prices in this bulletin are computed with respect to the total variable costs of production. In the short run, as long as the actual market price for a commodity exceeds its break-even price, production can profitably be continued. In the longer run, when the possible disposition of a farm's fixed assets (land, irrigation equipment, farm machinery, and storage facilities) is considered, a break-even price should be defined with respect to total rather than variable production costs.

The most popular crop in Brookings and Turner counties, corn, is also the most energy-intensive crop produced in these counties (Tables 12 and 13). Except for irrigated corn whose energy bill is 2.1 to 2.2 times that for dryland corn, the $47 and $54/A energy bills for dryland corn are greater than those for any other crop -- dryland or irrigated -- in either county. The energy expenditure for most of the dryland crops is roughly one half that for dryland corn, but the proportions are somewhat higher for sorghum (65%) and somewhat lower for soybeans and alfalfa (29 to 39%). The energy bills for irrigated alfalfa in Brookings County and irrigated soybeans in Turner County are only three fourths as much as those for dryland corn. The amount of energy used for irrigated alfalfa in Turner County is about the same as that used for dryland corn production in the same county.

The total variable dryland production costs are most commonly $50 to $65/A. They range, however, from $41/A for alfalfa in Brookings County to $109/A for corn in Turner County.

<u>Farm application</u>: The total variable costs for a 350 A dryland farm under corn production in 1981 are $18,000 per year greater than if the farm were in alfalfa production.

Total dryland production costs are most commonly $150 to $175/A, with the range from $119 for alfalfa in Brookings County to $217 for corn in Turner County. The relative intensity with which capital is used in producing the various dryland crops is the same as that for energy, except for soybeans which ranks third or fourth in capital intensity and only seventh or eighth in energy intensity. The relatively greater capital intensity of soybean production is explained largely by the generally greater expenditures on seeds and plant protection chemicals.

The total variable production costs for irrigated alfalfa and soybeans are roughly the same as those for dryland corn. The total production costs for irrigated alfalfa and soybeans, however, are from 39 to 84% higher than those for dryland corn. This differential arises because of the annual costs associated with the substantial investment in irrigation facilities and the higher land price for irrigated than for dryland production. The total variable production costs and the total production costs for irrigated corn are both roughly double what they are for dryland corn.

Under the prices assumed for 1981, alfalfa is by far the most profitable crop in both counties.[6] The net returns over total variable costs for dryland alfalfa are $120 and $168/A in Brookings and Turner counties, respectively, with the corresponding figures for irrigated alfalfa being $206 and $275. Furthermore, alfalfa is the only crop whose gross returns exceed the total costs of production (irrigated alfalfa in Turner County is a minor exception).

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6. A presupposition of the analysis underlying this and other statements concerning inter-crop profitability is that technical conditions would not preclude the satisfactory production of different crops on the same piece of land. In particular situations, this presupposition of course is not completely valid.

If the price of alfalfa were $33.50/T (as it averaged in South Dakota in 1977-79) rather than $65/T as assumed for 1981, however, alfalfa would lose its profit superiority. Under irrigation, for example, its net return over total variable costs would be 95% less than that for corn in Brookings County, and from 65 to 75% less than that for corn and soybeans in Turner County. Under dryland production, alfalfa would occupy an intermediate profit position among the other dryland crops.

Among the dryland crops other than alfalfa, the differences in net returns are rather limited. In Brookings County, the net returns from the most profitable crop — soybeans — are only about $25/A more than those for the least profitable crops (flax and sunflowers). In Turner County, the profit differential between the most profitable crop (soybeans) and the least profitable crops (spring wheat and barley) is somewhat greater, about $40/A.

If the price of corn were $3.00/bu. (as it was in 1980) rather than $2.40 as assumed for 1981, corn would have a rather clear profit advantage relative to all dryland crops except alfalfa in both counties. At this higher price for corn and under irrigation, corn would enjoy a definite economic advantage over alfalfa priced at $33.50/T in both counties and over soybeans priced at $5.75/bu in Turner County.

One of the most significant findings emerging from this analysis is that, under the prices prevailing in 1981, the gross returns from producing the various crops exceed the total variable production costs but are less than the total production costs (alfalfa is an exception to the latter). This outcome suggests that farmers in 1981 had positive short-run economic incentives to farm. The economic incentives for farmers to remain in farming over the longer run, however, were not altogether positive. We must remember, however, the motivation of farmers to own land is not limited to just the short-run profits earned.

A second finding is that, under 1981 prices, alfalfa was clearly the most profitable crop under both dryland and irrigated conditions. If the price of alfalfa were to return to its average for 1977 to 1979 and the price of corn were to return to its 1980 level, then corn would be the most profitable.[7] That corn production is highly energy and capital intensive tends to limit its economic attractiveness. On the other hand, corn has at least three advantages over alfalfa: it permits year-to-year flexibility in cropping plans, it is less bulky to transport, and it has a firmly established market.

The economics of raising alfalfa, corn, and soybeans under dryland versus irrigated conditions are detailed in Tables 14 and 15. The per-acre capital intensity -- for both total variable production costs and total production costs -- is about twice as much under irrigation as under dryland conditions. The irrigation-dryland capital intensity differential is slightly greater for alfalfa than for corn or soybeans.

The energy cost per unit of land is 2.0 to 2.2 times as much under irrigation as under dryland conditions for corn and soybeans, and 2.7 to 2.8 as much for alfalfa. The energy cost per unit of output produced is also greater under irrigation (except for corn in Brookings County).

The break-even price for corn raised under irrigation in Brookings County is 16% less than that for corn raised under dryland conditions. For the other crop situations studied, however, the break-even price for irrigated production is roughly the same as (corn and soybeans in Turner County) or is more than (alfalfa in both counties) that for dryland production. These findings show that the use of irrigation does not necessarily lead to the production of lower cost farm commodities.

The relative profitability of irrigated versus dryland production differs depending on whether the point of reference in the profit calculations is total vari-

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7. Hewlett and Bateman (1979) also show the profitability of corn versus alfalfa in Butte County to depend on the relative market prices assumed for the two crops.

able costs or total costs. To illustrate, the net returns over variable costs are 1.6 to 3.4 times higher under irrigation than under dryland conditions. Thus, farmers with cropland already under irrigation in 1981 appear to have earned considerably greater returns per acre to their fixed assets (or above their variable costs) than farmers raising crops without irrigation.

In the cases studied, however, the net returns over total production costs are without exception lower with than without irrigation. The net returns with irrigation versus without irrigation range from $11/A less for corn in Brookings County to $62/A less for alfalfa in Turner County. If these findings for 1981 were interpreted to portray the longer term economic potential for agricultural production in the two counties studied, the future prospects particularly under irrigation would have to be viewed as somewhat dismal.

At least four factors temper such a conclusion, however. The input-product price relationships for 1981 (except for alfalfa) are generally acknowledged to have been unusually unfavorable for farmers. Second, a major benefit from irrigation arises in drought years, an aspect not taken into account in this study. Third, the level of management plays a key role in determining the profitability of farming. The future economic prospects of agriculture for above-average managers are, of course, brighter than those for below-average managers. And fourth, the incentives that farmers have to own land differ. Some, for example, might be willing to own land more for the prospect of future possible appreciation in the value of the land than for the current return.[8]

The analysis in Table 16 shows data on existing market prices and 1981 break-even prices computed with respect to variable production costs, total production costs minus land charges, and total production costs. The 1981 market prices are higher than the break-even prices which take into account only variable production costs for each crop -- whether irrigated or dryland -- in both counties. This finding, of course, affirms the economic value of farmers continuing in the short run to operate their farms.

However, in each case except for alfalfa, the 1981 market prices are less than the break-even prices which take into account the total costs of production. These findings are consistent with the earlier ones based on the net returns to the total assets in farming.

If the 1981 market prices are compared with the 1981 break-even prices for all production costs except for the land charge, conclusions are not as clear-cut. In a majority of instances, market prices exceed the break-even prices. In three instances, however, they do not (corn, flax, and sunflowers in Brookings County); in two instances the market and break-even prices are essentially the same (barley and spring wheat in Turner County). Thus, farmers who believe that the product-input price relationships of 1981 were unusually unfavorable and are willing to continue farming, even if the return on land is not necessarily what they could earn from other uses of their funds, will likely continue over the long run in farming. Those who are less optimistic about the prospect of more favorable farm product-input price relationships, do not place a special value on land ownership, and are qualified for non-farming occupations may prefer to leave farming.

<u>Impacts of rising energy prices on the economics of future crop production</u>

At the national level, the prices farmers paid for all production inputs, services, interest, taxes, and wages more than doubled between 1965 and 1977. In the four years from 1977 to 1981, these prices increased an additional 50%.

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8. Farmers whose land is heavily mortgaged, of course, have no choice. Their current returns from farming must be adequate to meet their debt obligations on the land, or they will be forced out of the farming business.

Since 1977, the prices of fuels and energy have more than doubled, whereas the prices of other farm inputs have increased by no more than about 50%. Even the farm real estate market has not experienced such a rise.

In this study, the impacts of rising energy prices on the economics of crop production are projected to 1990. The yields and input-levels reported in 1977 are assumed to not change. While this may be rather conservative,[9] most crops showed either modestly increasing or unchanging yields from 1965 to 1980 in the two counties (CLRS, 1971, 1976, 1981). Except for borrowed funds (the interest rate was assumed to remain constant throughout the study period)[10] and energy, the prices of farm inputs were assumed to increase between 1977 and 1980 at the rates projected by Shane (1980).

Two alternative levels of price increase are assumed for energy. An intermediate rate of increase involves an assumed doubling of the 1981 energy price by 1990. The high rate reflects an assumed doubling of the 1981 energy price by 1986. In contrast with the 1981 to 1990 annual rates of increase in diesel fuel and electricity prices of 2.7 to 2.8%, the intermediate and high rates of price increase involve annual growth rates of 8.0 and 14.9%, respectively.[11]

The projected growth rates in product prices are based on forecasts provided by Chase Econometrics (1981) and our knowledge of commodity interrelationships. The annual growth rates in product prices projected in this study for 1977 to 1990 are most commonly 6.4 to 6.6% (Table 17). They do range, however, from 5.8% for alfalfa to 7.7% for corn and sorghum. These projected growth rates for product prices -- roughly comparable with those for the variable production costs under the intermediate energy price increase assumption -- were applied against the mean prices for the various crops during 1978 to 1980 to obtain the projected prices in 1990 shown in Table 11.

The impacts of rising energy prices on the economics of future crop production are evaluated in terms of the absolute and relative expenditures on energy, net returns over variable production costs, net returns over total production costs, and break-even prices (relative to variable production costs).

Assuming current trends in input prices, the net returns over variable costs projected to 1990 are considerably more (ranging from about 15 to 80%) for

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9. The yield assumption is probably more conservative for crops raised with than without irrigation. The improved moisture environment for crops provided through irrigation alleviates a common critical constraint to the achievement of higher yields. Since achieving possibly higher yields would require the use of additional inputs, however, providing in the analysis for increased yields over time would have required providing also for the payment for additional inputs over time.

10. The authors do not believe that interest rates will remain constant over the decade of the 1980's. Forecasting with any precision how the interest rate will change from year to year is infeasible. The authors therefore used the simplifying assumption of unchanging interest rates over the study period. The impact on crop profitability of interest rates higher and lower than the assumed 18% is reported by Shane (1982).

11. Here and elsewhere in the bulletin, the rates of price increase are in "nominal" not "real " terms.

The U.S. Department of Energy (USDE, 1981, 40) projects oil prices to increase between 1980 and 1990 at "low", "medium", and "high" rates of 6.8, 9.2, and 11.0% per year.

corn and soybeans than for alfalfa (Table 18).[12] In Turner County, under both irrigated and dryland conditions, corn is more profitable than soybeans. In Brookings County, dryland soybeans has a slight edge over dryland corn. Alfalfa's profit superiority in 1981 appears to have reflected its unusually high price in that (and the preceding) year.

Assuming that the 1981 energy price doubles by 1986, the projected net returns from dryland crop production in 1990 are most commonly $35 to $45/A less than the projected net returns with the current trends in input prices. The reduction in net returns for corn, however, exceeds $80/A.

Farm application: The projected net return in 1990 for a 350 A dryland farm under the "high energy price increase" assumption for crops other than corn is $12,000 to $16,000 per year less than under the "current trends in input prices" assumption. If the farm were under corn production, however, the difference in net returns because of high energy prices would be roughly $30,000 per year.

In relative terms, the projected net returns in 1990 under dryland conditions are most commonly from 35 to 50% less with rapidly increasing energy prices, although the reduction in net returns is as low as 14 to 19% for alfalfa and soybeans.

Under irrigation and with rapidly increasing energy prices, the projected net returns from corn production in 1990 are roughly $190/A less than with the current trends in input prices assumed. The corresponding reductions in net returns for irrigated soybeans and alfalfa are less than one half as much as those for corn.

Farm application: The projected net return in 1990 for an irrigated quarter section of corn under the "high energy price increase assumption" is about $25,000 per year less than under the "current trends in input prices" assumption. If the quarter section were in alfalfa, the reduction in net returns because of higher energy prices would be about $10,000 per year. Nevertheless, under higher energy prices, irrigated corn is still considerably more profitable than irrigated alfalfa.

The relative reduction in net returns from rapidly rising energy prices ranges from 16% for irrigated soybeans to about 40% for irrigated corn.

The ranking in the projected relative profitability among crops in 1990 is rather different under the high energy price assumption from that under the current trends in input prices assumption. The most striking difference is the emergence of soybeans as the most profitable crop under both dryland and irrigated conditions. Its net return per acre ranges from 13 to 25% more than that from its nearest competitor. Under dryland conditions in Brookings County, alfalfa has a marked profit advantage over corn (46%). In Turner County, alfalfa and corn are about equal in their profitability. Under irrigation, however, corn continues to enjoy a considerable economic advantage over alfalfa (32 to 41% higher net returns), even under rapidly rising energy prices.

Differences in the relative ranking of crops under different rates of escalation in energy prices, of course, reflect differences in the amounts of energy required to produce the different crops. Thus, in summary, under rapidly rising energy prices and dryland conditions, corn which is the most energy-intensive crop loses considerably in its comparative

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12. The net returns per acre from crop production projected to 1990 are much higher than the net returns in 1981 (except for alfalfa). This outcome arises because (1) the base point for most calculations underlying the 1990 projections is 1977 and (2) input prices -- especially for energy and borrowed funds -- rose much more rapidly than output prices between 1977 and 1981.

advantage relative to alfalfa and soybeans which are the least energy-intensive. Under rapidly rising energy prices and irrigated conditions, corn's comparative advantage relative to alfalfa is reduced, but not, however, to the point where it ceases to maintain a considerable profit margin over alfalfa. Irrigated corn's profit superiority relative to irrigated soybeans in Turner County is eroded away under high energy prices; irrigated soybeans provides a 19% greater net return per acre than does irrigated corn.

The projected cost of energy per acre with high energy prices for the various crops is about 2.4 times as much as with current trends in input prices (Tables 19 and 20). Under high energy prices, the total variable costs per dryland acre are about 45% higher for alfalfa and soybeans and about 70% higher for corn. Under irrigation, the total variable cost increments are about 10 percentage points higher than under dryland conditions.

The energy cost relative to the total variable costs of producing various crops is about 20 percentage points higher under the high energy price increase assumption. The least energy-intensive situations -- dryland alfalfa and soybeans -- involve energy comprising about 34% of the total variable costs under current trends in input prices versus about 54% under high energy price increases. The corresponding percentage comparison for the most energy-intensive crop situation — irrigated corn -- is about 55 versus 75%.

In some situations, the 1990 projected break-even prices are higher for irrigated than dryland crops, and in others they are lower. For example, the break-even prices for alfalfa produced with irrigation are from 15 to 30% higher than those for alfalfa produced without irrigation. For corn in Brookings County, on the other hand, the projected break-even price in 1990 with irrigation is from 12 to 17% less than that without irrigation. For corn and soybeans in Turner County, the break-even prices for dryland and irrigated production are almost the same (they differ by 7% or less).

Under rapidly increasing energy prices, break-even prices are from about 45% higher (for dryland alfalfa) to 75% higher (for irrigated corn) than with the current trends in input prices assumed. These differences in the increase in break-even prices, of course, are directly related to the amounts of energy required to produce the various commodities.

For each crop-energy price situation, the net returns over total variable costs per acre are positive. Further, they are higher with than without irrigation. The irrigated-dryland increment in net returns ranges from 40 to 60% for alfalfa in Turner County to 2.6 to 3.0 times for corn in Brookings County. Thus, even if energy prices were to escalate rapidly during the 1980's, farmers already having irrigation facilities would appear to be[13] well advised to continue irrigating.

Nevertheless, the net returns from production would be adversely affected if energy prices were to rise rapidly. Under the high energy price rise assumption in this study, the net returns per acre range from 14% less (dryland soybeans in Turner County) to over 40% less (corn in Brookings County) than with the current trends in input prices.

The results of this study show the longer term economics of irrigated agriculture — especially if faced with rapidly rising energy prices — to vary considerably by crop. Under each of the three energy price situations considered, for example, the net returns over the total costs of producing alfalfa in both Brookings and Turner counties are negative. For irrigated soybeans in Turner County, on the other hand, the net returns over total costs are positive under all three energy price situations. Irrigated corn in both counties occupies an intermediate position. With current trends in input prices, the projected net returns over total costs in 1990 exceed $160/A. Under the high energy price increase assumption, however, the total costs of producing irrigated corn exceed gross returns by over $20/A.

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13. This statement presupposes that the salvage value of used irrigation equipment is relatively low.

If energy prices were to rise rapidly, farmers having to borrow funds to invest in new irrigation equipment could encounter some trouble in meeting their principal and loan payments from the annual cash flows realized through crop production. Irrigated corn is shown to be especially vulnerable to rapidly rising energy prices.

Table 1. South Dakota counties with 10,000 or more acres under irrigation, 1969 and 1978.

County	Acres under irrigation 1969	1978	Increase from 1969 to 1978 Acres	Ratio
West River				
Meade	6,035	10,001	3,966	1.7
Fall River	12,388	15,764	3,376	1.3
Pennington	9,689	10,752	1,063	1.1
Butte	50,262	50,344	82	1.0
Sub-total	(78,374)	(86,861)	(8,487)	(1.1)
East River				
Union	1,048	19,510	18,462	18.6
Beadle	2,524	14,250	11,726	5.7
Spink	6,602	18,139	11,537	2.8
Turner	3,123	13,139	10,016	4.2
Brookings	984	10,697	9,713	10.9
Charles Mix	4,047	11,877	7,830	2.9
Hughes	4,675	10,853	6,178	2.3
Sub-total	(23,003)	(98,465)	(75,462)	(4.3)

Sources: USDC (1972, 269-270); USDC (1980, 121-122)

Table 2. Planted acres of selected crops, Brookings and Turner counties, average for 1970-1979.

Crop	Brookings County[a] Acres	Percent	Turner County Acres	Percent	South Dakota Acres ('000)	Percent
Corn	115,300	39.0	131,300	49.4	3,466.0	25.6
Oats	83,700	28.3	70,300	26.4	2,551.0	18.9
Alfalfa[b]	39,300	13.3	23,000	8.7	2,487.7	18.4
Spring wheat	13,100	4.4	1,100	0.4	2,053.4	15.2
Winter wheat	2,000	0.7	c	n/a	930.3	6.9
Barley	8,100	2.7	1,600	0.6	568.5	4.2
Sorghum	1,300	0.4	2,900	1.1	439.0	3.3
Flax	20,800	7.0	c	n/a	425.4	3.1
Soybeans	9,400	3.2	35,700	13.4	351.3	2.6
Winter rye	3,000	1.0	c	n/a	247.3	1.8

Sources: CLRS (1980, 1981)

[a] The planted acreages of sunflowers in 1978, 1979, and 1980 in Brookings County were 3,000, 13,400, and 10,500 acres, and in South Dakota they were 165,000, 620,000, and 525,000 acres, respectively.

[b] The harvested, rather than planted, acreage of alfalfa is shown.

[c] Less than 500 acres.

Table 3. Areas under irrigation, selected crops, Brookings and Turner counties, 1978.

	Brookings County		Turner County		South Dakota[a]	
	Acres	Percent	Acres	Percent	Acres	Percent
Corn	8,045	75.2	10,069	76.6	175,323	54.6
Alfalfa	1,012	9.5	636	4.9	79,222	24.6
Soybeans	369	3.4	1,852	14.1	12,596	3.9
Other[b]	1,271	11.9	582	4.4	54,198	16.9
Total	10,697	100.0	13,139	100.0	321,339	100.0

Source: USDC (1980; 18-20, 202, 204, 487, 490)

a The DWNR (1977) reports 62% of the East River irrigated area under corn and only 15% under alfalfa, whereas over 40% of the West River irrigated area is under alfalfa and only 29% is under corn.

b The principal "other" crops in Brookings County are oats (303 acres) and wheat (228 acres), and in South Dakota they are wheat (10,896 acres) and oats (7,166 acres).

Table 4. Cost structure, selected dryland and irrigated crops, Brookings County, 1981.

	Dryland crops								Irrigated Crops	
Cost item	Alfalfa	Barley	Corn	Flax	Oats	Soybeans	Spring wheat	Sunflowers	Alfalfa	Corn
Fixed costs										
Land charge	53.62	53.62	53.62	53.62	53.62	53.62	53.62	53.62	89.35	89.35
Depreciation and insurance	13.36	19.49	23.92	18.70	19.19	19.19	19.49	17.85	40.31	41.06
Interest on investment	10.49	17.92	17.56	19.24	17.72	18.31	17.82	15.74	47.37	61.05
Fixed cost sub-total	77.47	91.03	95.10	91.56	90.53	91.12	90.93	87.21	177.03	191.46
Variable costs										
Fertilizer	10.28	16.57	20.28	11.93	12.93	5.57	16.57	11.93	23.77	55.13
Machinery fuel and lubrication	11.96	14.64	18.14	14.10	14.10	14.78	14.88	13.70	9.24	11.23
Seeds	2.53	4.26	10.69	12.00	6.02	13.32	10.00	4.60	5.20	15.75
Plant protection chemicals	1.73	3.63	15.38	2.12	2.90	7.80	4.46	13.77	0	15.45
Interest on operating capital	3.26	4.12	6.96	3.87	3.82	4.30	4.34	4.88	6.40	13.42
Machinery repair	9.59	3.88	5.25	3.77	3.77	4.23	3.88	3.94	9.46	8.12
Miscellaneous overhead costs	1.80	2.27	4.29	2.33	2.37	2.55	2.66	2.80	2.38	6.69
Crop insurance	0	2.49	3.45	2.38	2.43	2.54	2.54	2.70	0	1.88
Grain storage[a]	0	0	2.36	.30	1.18	2.71	.80	5.30	0	1.53
Grain drying	0	0	10.20	0	0	0	0	0	0	24.74
Custom hiring	0	0	0	0	0	0	0	0	6.55	6.04
Irrigation system repair	0	0	0	0	0	0	0	0	.99	.44
Irrigation system power	0	0	0	0	0	0	0	0	25.92	29.03
Variable cost sub-total	41.15	51.86	96.99	52.80	49.32	57.80	60.13	63.62	89.91	189.45
Total costs	118.62	142.89	192.09	144.36	139.85	148.92	151.06	150.83	266.94	380.91

(dollars per acre)

Table 5. Cost structure, selected dryland and irrigated crops, Turner County, 1981.

	Dryland Crops								Irrigated Crops		
Cost item	Alfalfa	Barley	Corn	Flax	Oats	Sorghum	Soybeans	Spring wheat	Alfalfa	Corn	Soybeans
Fixed costs											
Land charge	67.02	67.02	67.02	67.02	67.02	67.02	67.02	67.02	107.23	107.23	107.23
Depreciation and insurance	25.19	23.56	25.19	23.31	22.58	23.01	22.28	23.56	76.06	49.64	44.13
Interest on investment	23.32	18.39	15.92	13.68	18.08	17.46	18.98	18.36	100.85	81.51	68.25
Fixed cost sub-total	115.53	108.97	108.13	104.01	107.68	107.49	108.28	108.94	284.14	238.38	219.61
Variable costs											
Fertilizer	13.71	16.57	25.71	14.35	16.57	23.85	5.57	16.57	34.27	74.64	16.71
Machinery fuel and lubrication	18.13	14.40	18.40	14.40	14.64	16.40	15.30	14.88	17.20	12.01	10.21
Seeds	4.13	4.26	12.25	18.00	7.20	3.38	13.20	12.00	4.72	19.88	13.92
Plant protection chemicals	1.73	1.84	13.93	.67	2.12	7.75	9.25	2.06	0	13.56	10.03
Interest on operating capital	4.52	4.00	7.76	4.28	4.30	5.82	4.48	4.16	8.00	15.12	8.32
Machinery repair	14.33	4.05	4.91	3.94	4.05	4.29	4.00	4.05	8.50	7.46	7.99
Miscellaneous overhead costs	2.60	2.21	4.80	2.72	2.43	3.29	3.18	2.64	3.23	7.42	3.33
Crop Insurance	0	3.08	3.78	2.70	2.54	2.75	2.54	2.49	0	9.22	6.74
Grain storage[a]	0	0	3.24	.41	1.53	7.36	3.54	.71	0	0	1.06
Grain drying	0	0	13.86	0	0	0	0	0	0	11.60	0
Custom hiring	0	0	0	0	0	0	0	0	2.63	4.23	6.56
Irrigation system repair	0	0	0	0	0	0	0	0	3.11	1.34	2.24
Irrigation system power	0	0	0	0	0	0	0	0	33.81	30.36	25.72
Variable cost sub-total	59.15	50.41	108.64	61.47	55.38	74.89	61.06	59.56	115.47	206.84	112.83
Total costs	174.68	159.38	216.77	165.48	163.06	182.38	169.34	168.50	399.61	445.22	332.44

(dollars per acre)

Table 6. Levels of fertilizer application, selected dryland and irrigated crops, Brookings and Turner counties, 1977.

Crop	Nitrogen(N) Brookings	Nitrogen(N) Turner	Phosphorus (P_2O_5) Brookings	Phosphorus (P_2O_5) Turner	Potassium(K_2O) Brookings	Potassium(K_2O) Turner
	(pounds per acre)					
Dryland crops						
Alfalfa	0	0	45	60	0	0
Barley	40	40	30	30	0	0
Corn	60	75	25	33	0	0
Flax	40	45	10	15	0	0
Oats	30	40	25	30	0	0
Sorghum	n/a	70	n/a	30	n/a	0
Soybeans	6	6	17	17	0	0
Spring wheat	40	40	30	30	0	0
Sunflowers	35	n/a	15	n/a	0	n/a
Irrigated Crops						
Alfalfa	0	0	95	138	15	22
Corn	150	220	70	60	20	60
Soybeans	n/a	0	n/a	66	n/a	13

Sources: The levels of fertilizer application for dryland crops reflect the judgments of selected extension and farm management research personnel at SDSU. Application rates for irrigated crops are those reported by the farmers surveyed in the Everson (1979) study.

Table 7. Prices of inputs for selected crops, Brookings and Turner counties, actual prices in 1977 and 1981 and projected prices in 1986 and 1990[a]

Input	Unit	Prices Actual 1977	Prices Actual 1981	Prices Projected 1986	Prices Projected 1990	Compound annual growth rate(%)[b] 1977-1981	1981-1990	1977-1990
Energy								
Diesel fuel	$/gal.	0.45	1.20	1.42	1.54	27.8	2.8	9.9
Electricity	¢/KWH	2.30	5.10	5.90	6.50	22.0	2.7	8.3
Interest rate								
Operating capital	Percent	9	18	18	18	18.9	0	5.5
Investment capital	Percent	7	18	18	18	26.9	0	7.5
Fertilizer								
Nitrogen (N)	$/lb.	0.17	0.24	0.28	0.30	9.0	2.5	4.5
Phosphorous (P_2O_5)	$/lb.	0.16	0.23	0.27	0.28	9.5	2.2	4.4
Potassium (K_2O)	$/lb.	0.09	0.13	0.15	0.16	9.6	2.3	4.5
Seeds								
Alfalfa	$/lb.	2.05	2.36	2.65	2.81	3.6	2.0	2.5
Barley	$/pk.	0.75	0.85	0.93	0.97	3.2	1.5	2.0
Corn	$/MVK	0.55	0.75	0.83	0.87	8.1	1.7	3.6
Flax	$/pk.	1.85	3.00	3.24	3.41	12.9	1.4	4.8
Oats	$/pk.	0.55	0.60	0.66	0.70	2.2	1.7	1.9
Sorghum	$/lb.	0.40	0.48	0.53	0.56	4.7	1.7	2.6
Soybeans	$/bu.	9.00	12.00	13.44	14.36	7.5	2.0	3.7
Spring Wheat	$/pk.	0.97	2.00	2.19	2.33	19.8	1.7	7.0
Sunflowers	$/lb.	1.50	2.00	2.16	2.29	7.5	1.5	3.3

(continued on next page)

Sources: The actual prices for 1977 are those reported by the farmers surveyed in the Everson (1979) study. The originally projected prices for 1981 were checked against the prices actually charged to farmers in 1981, as reported by selected input suppliers. Where the actual prices differred from those projected, the actual prices were used. The prices projected from 1981 to 1990 reflect the relative rates of projected increase reported by Shane (1980).

[a] Alternative levels to those shown in the table were projected for energy. The alternatives involve an assumed doubling of the 1981 prices for energy -- i.e., for diesel fuel and electricity and the energy embodied in fertilizer and plant protection chemicals -- by 1990, on the one hand, and by 1986, on the other. The assumed doubling of the 1981 energy price by 1990 and by 1986 involve compound annual growth rates from 1981 to 1990 of 8.0 and 14.9%, respectively.

[b] Compound annual growth rates from 1977 to 1990 for cost items not shown in the table are as follows: custom-hire (primarily diesel fuel)-9.9%; irrigation system repair - 8.7%; plant protection chemicals - 3.8%; depreciation, taxes, and farm and equipment insurance - 3.3%; grain storage - 2.9%; machinery repair - 2.1%; and crop insurance - 1.6%.

Table 8. Estimated energy cost components in the production of selected dryland and irrigated crops, Brookings County, 1981.

Crop	Irrigation system power	Machinery fuel and lubrication	Fertilizer manufacture	Grain drying	Plant protection chemicals manufacture	Total[a]
		(dollars per acre)				
Dryland crops						
Corn	0	18.14	14.17	10.20	4.35	46.86 (48.3)
Sunflowers	0	13.70	8.09	0	3.91	25.70 (40.4)
Spring wheat	0	14.88	9.40	0	1.26	25.54 (42.5)
Barley	0	14.64	9.40	0	1.03	25.07 (48.3)
Flax	0	14.10	9.17	0	0.63	23.90 (45.3)
Oats	0	14.10	7.08	0	0.81	21.99 (44.6)
Soybeans	0	14.78	1.53	0	2.19	18.50 (32.0)
Alfalfa	0	11.96	0.51	0	0.49	12.96 (31.5)
Irrigated crops						
Corn	29.03	11.23	35.07	24.74	4.32	104.39 (55.1)
Alfalfa	25.92	9.24	1.28	0	0	36.44 (40.5)

[a] The total energy costs as percentages of the total variable costs of production are shown in brackets.

Table 9. Estimated energy cost components in the production of selected dryland and irrigated crops, Turner County, 1981.

Crop	Irrigation system power	Machinery fuel and lubrication	Fertilizer manufacture	Grain drying	Plant protection chemicals manufacture	Total[a]
			(dollars per acre)			
Dryland crops						
Corn	0	18.40	17.39	13.86	3.95	53.60 (49.3)
Sorghum	0	16.40	16.19	0	2.20	34.79 (46.5)
Flax	0	14.40	10.34	0	0.19	24.93 (40.6)
Spring wheat	0	14.88	9.40	0	0.59	24.87 (41.8)
Oats	0	14.64	9.40	0	0.60	24.64 (44.5)
Barley	0	14.40	9.40	0	0.52	24.32 (48.2)
Soybeans	0	15.30	1.53	0	2.53	19.36 (31.7)
Alfalfa	0	18.13	0.67	0	0.49	19.29 (32.6)
Irrigated crops						
Corn	30.36	12.01	51.39	11.60	4.34	109.70 (53.0)
Alfalfa	33.81	17.20	1.61	0	0	52.62 (45.6)
Soybeans	25.72	10.21	0.80	0	3.01	39.74 (35.2)

a
The total energy costs as percentages of the total variable costs of production are shown in brackets.

Table 10. Per-acre yields of selected dryland and irrigated crops, Brookings and Turner counties, 1977.

Crop	Unit	Brookings	Turner
Dryland crops			
Alfalfa	Ton	2.5	3.5
Barley	Bushel	41	41
Corn	Bushel	55	75
Flax	Bushel	12	17
Oats	Bushel	50	65
Sorghum	Cwt	n/a	29
Soybeans	Bushel	19	25[a]
Spring wheat	Bushel	28	27
Sunflowers	Cwt	9	n/a
Irrigated Crops			
Alfalfa	Ton	4.55	6.0
Corn	Bushel	129	145
Soybeans	Bushel	n/a	45[a]

Sources: The yields for dryland crops are those reported by Allen et al. (1979). Yields for irrigated crops are those reported by the farmers surveyed by Everson (1979).

a
The Cooperative Extension Service reports that soybeans yields on farmer fields in Turner County in 1981 were commonly 30 to 35 bu/A under dryland conditions and 55 to 60 bu/A with irrigation.

Table 11. Farm prices for selected crops; Brookings and Turner counties; 3-year mean, 1978-80; assumed for 1981; and projected for 1990.

Crop	Unit	3-year mean 1978-80[a]	Assumed for 1981[b]	Projected for 1990[c]
		(dollars per unit)		
Alfalfa	Ton	42.50	65.00	79.02
Barley	Bushel	2.23	2.25	4.50
Corn	Bushel	2.34	2.40	5.29
Flax	Bushel	6.42	6.75	12.83
Oats	Bushel	1.36	1.80	2.75
Sorghum	Cwt	3.67	4.20	8.30
Soybeans	Bushel	6.53	5.75	12.92
Spring wheat	Bushel	3.59	3.75	7.25
Sunflowers	Cwt	9.82	10.00	19.43

a The data used in the calculation of the three-year means are "seasonal average prices" published by CLRS (1981).

b Since only part of the 1981 crop was sold by October 1981 when these calculations were performed, attention in estimating 1981 prices was given not only to the prices during any peak marketing months already experienced in 1981, but also futures prices (minus appropriate "bases") for subsequent peak marketing months in which the 1981 crop is likely to be sold, seasonal average prices from recent years, 1981 government loan rates (where applicable), and the judgment of grain marketing specialists.

Postscript: The seasonally adjusted "1981" prices for the various crops, as first reported on February 1, 1982 by the South Dakota Statistical Reporting Service (SRS, 1982), are all within 10 percent of the "assumed for 1981" prices indicated below, except sorghum whose actual price was reported to be $3.45 per cwt.

c The projected compound annual growth rates for product prices for 1977 through 1990 reported in Table 20 were applied against the three-year means for 1978-80 to obtain the projected prices for 1990.

Table 12. Energy and overall production costs, net returns, selected dryland and irrigated crops, Brookings County, 1981.

Crop	Energy cost	Overall production costs: Variable	Overall production costs: Total	Net returns over: Variable costs	Net returns over: Total costs
		(dollars per acre)			
Dryland crops					
Corn[a]	46.86	96.99	192.09	35.01	-60.09
Sunflowers	25.70	63.62	150.83	26.38	-60.83
Spring wheat	25.54	60.13	151.06	44.87	-46.06
Barley	25.07	51.86	142.89	40.39	-50.64
Flax	23.90	52.80	144.36	28.20	-63.36
Oats	21.99	49.32	139.85	40.68	-49.85
Soybeans	18.50	57.80	148.92	51.45	-39.67
Alfalfa[b]	12.96	41.15	118.62	121.35	+43.88
Irrigated crops					
Corn[a]	104.39	189.45	380.91	120.15	-71.31
Alfalfa[b]	36.44	89.91	266.94	205.84	+28.81

a If the price of corn were $3.00/bu (as it was in 1980), rather than the $2.40/bu which is assumed in the table, the net returns over variable and total costs from dryland corn production would be $68.01 and -$27.09/A, respectively, and from irrigated corn production $197.55 and $6.09/A, respectively.

b The prices of alfalfa in 1980 and 1981 were unusually high. If the price of alfalfa were $33.50/T (as it averaged in 1977-1979), rather than the $65/T which is assumed in the table, the net returns over variable and total costs from dryland alfalfa production would be $42.60 and -$34.87/A, respectively, and from irrigated alfalfa production $62.52 and -$114.52/A, respectively.

Table 13. Energy and overall production costs, net returns, selected dryland and irrigated crops, Turner County, 1981.

Crop	Energy cost	Overall production costs: Variable	Overall production costs: Total	Net returns over: Variable costs	Net returns over: Total costs
Dollars per acre					
Dryland crops					
Corn[a]	53.60	108.64	216.77	71.36	-36.77
Sorghum	34.79	74.89	182.38	46.91	-60.58
Flax	24.93	61.47	165.48	53.28	-50.73
Spring wheat	24.87	59.56	168.50	41.69	-67.25
Oats	24.64	55.38	163.06	61.62	-46.06
Barley	24.32	50.41	159.38	41.84	-67.13
Soybeans	19.36	61.06	169.34	82.69	-25.59
Alfalfa[b]	19.29	59.15	174.68	168.35	+52.82
Irrigated crops					
Corn[a]	109.70	206.84	445.22	141.16	-97.22
Alfalfa[b]	52.62	115.47	399.61	274.53	- 9.61
Soybeans	39.74	112.83	332.44	145.92	-73.69

[a] If the price of corn were $3.00/bu (as it was in 1980), rather than $2.40/bu which is assumed in the table, the net returns over variable and total costs from dryland corn production would be $116.36 and -$8.23/A, respectively, and from irrigated production $228.17 and -$10.21/A, respectively.

[b] The prices of alfalfa in 1980 and 1981 were unusually high. If the price of alfalfa were $33.50/T (as it averaged in 1977-1979), rather than the $65/T which is assumed in the table, the net returns over variable and total costs from dryland alfalfa production would be $58.10 and -$57.43/A, respectively, and from irrigated alfalfa production $85.53 and -$198.61/A, respectively.

Table 14. Economics of dryland versus irrigated production, alfalfa and corn, Brookings County, 1981.

Economic criterion	Unit	Alfalfa: Dryland	Alfalfa: Irrigated	Corn: Dryland	Corn: Irrigated
Variable costs	$ per acre	41.15	89.91	96.99	189.45
Total cost	$ per acre	118.62	266.94	192.09	380.91
Energy cost					
Per unit of land	$ per acre	12.96	36.44	46.86	104.39
Per unit of output[a]	$ per ton/bushel	5.18	8.01	0.85	0.81
Energy cost relative to variable costs	Percent	31.5	40.5	48.3	55.1
Break-even price[a]	$ per ton/bushel	16.46	19.76	1.76	1.47
Net returns over:					
Variable costs	$ per acre	121.35	205.84	35.01	120.15
Total cost	$ per acre	43.88	28.81	-60.09	-71.31

[a] The dryland and irrigated yields used in these calculations for alfalfa are 2.5 and 4.55 T/A, respectively, and for corn they are 55 and 129 bu/A, respectively. The variable costs of production are used in the break-even price calculations.

Table 15. Economics of dryland versus irrigated production; alfalfa, corn, and soybeans; Turner County; 1981.

Economic criterion	Unit	Alfalfa Dry-land	Alfalfa Irri-gated	Corn Dry-land	Corn Irri-gated	Soybeans Dry-land	Soybeans Irri-gated
Variable costs	$ per acre	59.15	115.47	108.64	206.84	61.06	112.83
Total cost	$ per acre	174.68	399.61	216.77	445.22	169.34	332.44
Energy cost							
Per unit of land	$ per acre	19.29	52.62	53.60	109.70	19.36	39.74
Per unit of output[a]	$ per ton/bushel	5.51	8.77	0.71	0.76	0.77	0.88
Energy cost relative to variable costs	Percent	32.6	45.6	49.3	53.0	31.7	35.2
Break-even price[a]	$ per ton/bushel	16.90	19.25	1.45	1.43	2.44	2.51
Net returns over:							
Variable costs	$ per acre	168.35	274.53	71.36	141.16	47.41	145.92
Total cost	$ per acre	52.82	-9.61	-36.77	-97.22	-60.08	-73.69

a
The dryland and irrigated yields used in these calculations for alfalfa are 3.5 and 6.0 T/A, respectively; for corn they are 75 and 145 bu/A, respectively; and for soybeans they are 25 and 45 bu/A, respectively. The variable costs of production are used in the break-even price calculations.

Table 16. Market prices versus break-even prices, selected dryland and irrigated crops, Brookings and Turner counties, 1981.

Crop	Unit	Market prices: Average price received 1978-80[a]	Market prices: Assumed 1981 price	1981 break-even prices, taking into account: Variable production costs, Brkgs. County	Variable production costs, Turner County	Total production costs except the charge for land, Brkgs. County	Total production costs except the charge for land, Turner County	Total production costs, Brkgs. County	Total production costs, Turner County
Dryland									
Alfalfa	Ton	42.50	65.00	16.46	16.90	26.00	30.76	47.45	49.91
Barley	Bu	2.23	2.25	1.26	1.23	2.18	2.25	3.49	3.89
Corn	Bu	2.34	2.40	1.76	1.45	2.52	2.00	3.49	2.89
Flax	Bu	6.42	6.75	4.40	3.62	7.56	5.79	12.03	9.73
Oats	Bu	1.36	1.80	0.99	0.85	1.72	1.48	2.80	2.51
Sorghum	Cwt	3.67	4.20	n/a	2.58	n/a	3.98	n/a	6.27
Soybeans	Bu	6.53	5.75	3.04	2.44	5.02	4.09	7.84	6.77
Spring wheat	Bu	3.59	3.75	2.15	2.21	3.48	3.76	5.40	6.24
Sunflowers	Cwt	9.82	10.00	7.07	n/a	10.80	n/a	16.76	n/a
Irrigated									
Alfalfa	Ton	42.50	65.00	19.76	19.25	39.03	48.73	58.67	66.60
Corn	Bu	2.34	2.40	1.47	1.43	2.26	2.33	2.95	3.07
Soybeans	Bu	6.53	5.75	n/a	2.51	n/a	5.00	n/a	7.39

a
These are averages of the "seasonal average price" for each of the 3 years as reported in CLRS (1981,3). The average price shown for alfalfa in the table is for the CLRS's "all hay" category, and the average price for spring wheat is for the CLRS's "all wheat" category.

Table 17. Projected compound annual growth rates, product prices and variable production costs, selected crops, Brookings and Turner counties, 1977 through 1990.

Crop	Product prices[a]	Variable production costs[b]: Current trends in input prices assumed	Variable production costs[b]: An assumed doubling in the 1981 energy price by 1990	Variable production costs[b]: An assumed doubling in the 1981 energy price by 1986
	(percentage growth rate)			
Alfalfa	5.8	4.9-5.8	6.3-7.9	7.6-9.6
Barley	6.6	4.9	6.8	8.4
Corn	7.7	4.9-5.2	6.9-7.4	8.5-9.2
Flax	6.5	5.2-5.3	6.9-7.1	8.3-8.6
Oats	6.6	4.8	6.5-6.6	8.0-8.1
Sorghum	7.7	4.7	6.5	8.0-
Soybeans	6.4	4.7-4.9	6.1-6.6	7.4-8.0
Spring wheat	6.6	5.5-5.6	7.2-7.3	8.6-8.7
Sunflowers	6.4	4.6	6.1	7.6

[a] The projected growth rates for alfalfa, corn, soybeans, and wheat are the growth rates forecast by Chase Econometrics (1981) for 1978 through 1990 (except for 1981 through 1990 for alfalfa). Based on these forecasts and commodity interrelationships, the authors projected the indicated growth rates for the other commodities.

[b] The ranges in growth rates reflect a usually somewhat higher growth in variable production costs for irrigated crops than for dryland crops, and differences in the growth rates for particular crops in Brookings versus in Turner County.

Table 18. Impacts of rising energy prices on the net returns over total variable production costs, selected dryland and irrigated crops, Brookings and Turner counties, 1981 and projected to 1990.

Crop	Net returns in 1981	Net returns projected to 1990: Current trends in input prices assumed	Assumed doubling in the 1981 energy price by 1990	Assumed doubling in the 1981 energy price by 1986	Reduction in net returns because of a doubling in the 1981 energy price by 1986[a]
Brookings County			(dollars per acre)		
Dryland crops					
Alfalfa	121	147	136	124	23 (15.6)
Soybeans	51	173	157	140	33 (19.1)
Spring wheat	45	128	106	83	45 (35.2)
Oats	41	76	57	38	38 (50.0)
Barley	40	118	96	73	45 (38.1)
Corn	35	168	128	85	83 (49.4)
Flax	28	89	68	46	43 (48.3)
Sunflowers	26	93	71	48	45 (48.4)
Irrigated crops					
Alfalfa	206	247	216	182	65 (26.3)
Corn	120	443	353	257	186 (42.0)
Turner County					
Dryland crops					
Alfalfa	168	204	187	169	35 (17.2)
Soybeans	83	245	229	211	34 (13.9)
Corn	71	259	213	164	95 (36.7)
Oats	62	110	89	66	44 (40.0)
Flax	53	144	122	99	45 (31.3)
Sorghum	47	146	116	84	62 (42.5)
Barley	42	121	100	78	43 (35.5)
Spring wheat	42	122	100	78	44 (36.1)
Irrigated crops					
Alfalfa	275	330	284	236	94 (28.5)
Soybeans	146	440	406	370	70 (15.9)
Corn	141	508	413	312	196 (38.6)

[a] The reductions are with respect to the net returns under the current trends in input prices assumption. The reductions, in percentage terms, are shown in brackets.

Table 19. Economic impacts of rising energy prices, projected to 1990, dryland versus irrigated production, alfalfa and corn, Brookings County.

Crop and economic criterion	Unit	Dryland production: Current trends in input prices assumed	Dryland production: An assumed doubling in the 1981 energy price by 1990	Dryland production: An assumed doubling in the 1981 energy price by 1986	Irrigated production: Current trends in input prices assumed	Irrigated production: An assumed doubling in the 1981 energy price by 1990	Irrigated production: An assumed doubling in the 1981 energy price by 1986
Alfalfa							
Energy Cost	$ per acre	16.71	27.79	39.66	46.50	78.14	111.53
Variable costs	$ per acre	50.96	62.04	73.91	112.16	143.80	177.19
Total cost	$ per acre	170.46	181.54	193.41	372.62	404.26	437.65
Energy cost relative to:							
Variable costs	Percent	32.8	44.8	53.7	41.5	54.3	62.9
Total cost	Percent	9.8	15.3	20.5	12.5	19.3	25.5
Break-even price	$ per ton	20.38	24.82	29.56	24.65	31.60	38.94
Net returns over:							
Variable costs	$ per acre	146.59	135.51	123.64	247.38	215.74	182.35
Total cost	$ per acre	27.09	16.01	4.14	-13.08	-44.72	-78.11
Corn							
Energy cost	$ per acre	60.70	100.28	143.39	133.14	223.86	319.43
Variable costs	$ per acre	123.36	162.94	206.05	239.17	329.89	425.46
Total cost	$ per acre	265.29	304.87	347.98	518.22	608.94	704.51
Energy cost relative to:							
Variable costs	Percent	49.2	61.5	69.6	55.7	67.9	75.1
Total cost	Percent	22.9	32.9	41.2	25.7	36.8	45.3
Break-even price	$ per bushel	2.24	2.96	3.75	1.85	2.56	3.30
Net returns over:							
Variable costs	$ per acre	167.59	128.01	84.90	443.24	352.52	256.95
Total cost	$ per acre	25.66	-13.92	-57.03	164.19	73.47	-22.10

Table 20. Economic impacts of rising energy prices projected to 1990, dryland versus irrigated production, alfalfa, corn, and soybeans, Turner County.

Crop and economic criterion	Unit	Dryland production: Current trends in input prices assumed	Dryland production: An assumed doubling in the 1981 energy price by 1990	Dryland production: An assumed doubling in the 1981 energy price by 1986	Irrigated production: Current trends in input prices assumed	Irrigated production: An assumed doubling in the 1981 energy price by 1990	Irrigated production: An assumed doubling in the 1981 energy price by 1986
Alfalfa							
Energy Cost	$ per acre	24.76	41.37	59.04	67.19	112.85	161.04
Variable costs	$ per acre	73.02	89.63	107.30	144.39	190.05	238.34
Total cost	$ per acre	246.27	262.88	280.55	548.61	594.27	642.46
Energy cost relative to:							
Variable costs	Percent	33.9	46.2	55.0	46.5	59.4	67.6
Total cost	Percent	10.1	15.7	21.0	12.3	19.0	25.1
Break-even price	$ per ton	20.86	25.61	30.66	24.00	31.56	39.54
Net returns over:							
Variable costs	$ per acre	203.55	186.94	169.27	329.73	284.07	235.88
Total cost	$ per acre	30.30	13.69	-3.98	-74.49	-118.73	-168.34
Corn							
Energy cost	$ per acre	68.83	114.70	164.02	139.48	234.76	335.68
Variable costs	$ per acre	137.47	183.34	232.66	258.94	354.22	455.14
Total cost	$ per acre	301.18	347.05	396.37	604.92	700.20	801.12
Energy cost relative to:							
Variable costs	Percent	50.1	62.6	70.5	53.9	66.3	73.8
Total cost	Percent	22.9	33.1	41.4	23.1	33.5	41.9
Break-even price	$ per ton	1.83	2.44	3.10	1.79	2.44	3.14
Net returns over:							
Variable costs	$ per acre	259.28	213.41	164.09	508.11	412.83	311.91
Total cost	$ per acre	95.57	49.70	0.38	162.13	66.85	-34.07
Soybeans							
Energy cost	$ per acre	25.09	41.43	59.24	51.22	85.28	121.71
Variable costs	$ per acre	77.52	93.86	111.67	140.91	174.97	211.40
Total cost	$ per acre	241.50	257.84	275.65	462.84	496.90	533.30
Energy cost relative to:							
Variable costs	Percent	32.4	44.1	53.1	36.4	48.7	57.6
Total cost	Percent	10.4	16.1	21.5	11.1	17.2	22.8
Break-even price	$ per bushel	3.10	3.75	4.47	3.17	3.95	4.79
Net returns over:							
Variable costs	$ per acre	245.48	229.14	211.33	440.49	406.43	370.00
Total cost	$ per acre	81.50	65.16	47.35	118.56	84.50	48.07

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APPENDIX
PROCEDURES FOR DETERMINING "INDIRECT" ENERGY

The procedures for determining the energy content in fertilizer and plant protection chemicals are as follows.

Natural gas and electricity are involved in the production of fertilizer. The amounts of natural gas (cu ft) and electricity (kilowatt hour = KWH) required to produce one pound of fertilizer nutrient are as follows (Maryland, n.d., 29):

-Nitrogen (N) = 30.674 and 0.120;
-Phosphorus (P_2O_5) - 1.030 and 0.060; and
-Potassium (K_2O) - 1.275 and 0.088.

In 1977, the price of natural gas was $0.0052/cu ft and the price of electricity was $0.023/KWH. Thus, the energy embodied in one pound of nutrient had values in 1977 as follows: N - $0.1623, P_2O_5 - $0.0067, and K_2O - $0.0087. The prices of these nutrients increased from 1977 to 1981 by 41, 44, and 44 percent, respectively. Therefore, the 1981 values of energy in one pound of each N, P_2O_5, and K_2O were $0.2288, $0.0097, and $0.0125, respectively.

Pimental, et al. (1973, 445) report that about 11,000 kilocalories (KCAL) of energy are embodied in one pound of insecticide or herbicide. One KCAL of energy is equivalent to 0.00116 KWH (Waelti, 1975, 18). The price of one KWH in 1981 was $0.051. Thus, the value of energy embodied in each pound of plant protection chemicals in 1981 was:

11,000 KCAL x 0.00116 KWH/KCAL x $0.051/KWH

or $0.65.