TEXAS WATER DEVELOPMENT BOARD

REPORT 11

IMPORTANCE OF IRRIGATION WATER TO THE ECONOMY OF THE TEXAS HIGH PLAINS

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FOREWORD

This report was prepared under provisions of the General Research Agreement between Texas Technological College and the Texas Water Development Board. It is one of five reports by various members of the Texas Technological College staff arranged for as a direct contribution to the development of a State Water Plan. The Texas Water Development Board gratefully acknowledges the cooperation extended and the staff time and expense incurred by Texas Technological College in developing this information. The Board also thanks the authors for providing valuable and useful data important to water planning.

Texas Water Development Board

Joe G. Moore, Jr.
Executive Director

PREFACE

This report is written for the purpose of presenting information pertinent to the development of a Texas water plan. The importance of water to the West Texas economy has long been a subject of major interest to West Texas, Texas, and other areas. Interest is intensified by the fact that irrigation water is now obtained from an underlying, exhaustible aquifer. Although a relatively large supply of ground water remains to be used, the water table has been declining at a rate sufficiently rapid to demonstrate imminent economic if not physical exhaustion of present irrigation water supplies.

The West Texas area is predominantly an agricultural area, where at present both dryland and irrigated production are practiced. Dryland agriculture has a history almost as old as white man's settlement in West Texas, and is expected to continue indefinitely, but present water supplies will not support High Plains irrigated agriculture indefinitely. For long-range planning purposes it is necessary to have a clear understanding of the importance of High Plains irrigated agriculture to the local, State, and national economies. Although this study deals primarily with the contribution of irrigation to the local High Plains economy, some non-local irrigation benefit estimates are made.

The present study does not deal with important questions of intersectoral relationships within the High Plains economy, nor does it consider the contribution of High Plains irrigation to capital formation. Data were not available and the time allotted to conduct the study did not permit analyses of these kinds. Further study of these topics is urgently needed, if effective planning with regard to High Plains water problems is to be accomplished.

This study was carried out under a research grant from the Institute of Science and Engineering, Texas Technological College. The author wishes to acknowledge also the assistance of the Agricultural Economics staff of Texas Technological College in the preparation of the report. Dr. Willard F. Williams and Dr. James E. Osborn were especially helpful through their consultations with the author and through their reading and criticizing early drafts of the manuscript. The author, however, assumes full responsibility for the contents of the study.

The author also wishes to thank those members of the staffs of the High Plains Underground Water Conservation District No. 1 and the North Plains Underground Water Conservation District for their assistance in making irrigated acreage projections. Without this assistance the study could not have been completed. Many thanks are also extended to Mr. Paul Gillett and Mr. James Goodwin of the Texas Water Development Board for their help in coordination of this research project with planning efforts of the Texas Water Development Board and for reading and editing the manuscript.

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INTRODUCTION

The Texas High Plains economy is a complex mixture of agricultural and non-agricultural activity. The agricultural sector of this economy employs a combination of irrigated and dryland crop production activities and in addition carries on important livestock enterprises. The non-agricultural sectors are engaged in several areas of activity, which includes marketing agricultural produce, manufacturing, and consumer merchandising.

Irrigation in the High Plains is used to supplement annual precipitation for the production of important agricultural commodities such as cotton, grain sorghum, wheat, sugar beets, and vegetables. Supplemental irrigation in agriculture results directly in a larger total use of agricultural inputs complementary with irrigation such as fertilizer, labor, chemicals for insect and weed control, steel, petroleum products, and agricultural marketing facilities. In addition irrigation reduces risk of year-to-year crop failures. Larger total and individual farm incomes are a direct result of irrigation in the High Plains. High Plains irrigation adds to the bundle of consumable agricultural products in the local, State, and national markets, and in turn provides a demand for goods and services produced by non-agricultural sectors of the local, State, and national economies. The latter effect stems from increased farm incomes, increased employment of resources used to produce agricultural inputs, and increased employment of resources required to market agricultural commodities.

"Dryland" production of cotton, grain sorghums, and wheat is carried on successfully, but per-acre crop yields are lower, and dryland production techniques preclude the use of chemical fertilizers. On a per-acre basis, dryland agriculture uses fewer purchased agricultural inputs and produces a smaller quantity of product than High Plains irrigated agriculture. Both of these circumstances result in lower levels of economic activity for the area than comparable irrigated agriculture produces.

Irrigation in the Texas High Plains has developed on a widespread scale since the late 1940's. Irrigated acreage has increased annually since the early 1950's and has increased from 3.6 to more than 5 million acres between 1959 and 1965. In recent years, as irrigation has expanded to practically all

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parts of the High Plains, the water table has declined at a fairly rapid rate (3 to 4 feet per year). The declining water table of the Ogallala aquifer (major source of irrigation water) clearly indicates that the supply of irrigation water is exhaustible. The Ogallala Formation receives much less annual recharge than is presently being pumped. This phenomenon has prompted local and State agencies who are concerned with water to undertake assessment of the overall importance of High Plains irrigation water to the local, State, and national economies.

PURPOSE AND METHOD

The purpose of this study is to present information pertaining to the contributions of water to the High Plains economy (a 42-county area delineated in Figure 1). The major objective is to analyze the present economic importance of irrigation in the Texas High Plains and, on the basis of present importance, to project irrigation benefits at each 10-year interval for the period 1970-2020. Some attention also is given to possible avenues of adjustments to the declining High Plains water supply.

Irrigation Benefits

The use of irrigation in the High Plains results in a total economic benefit which is composed of three distinct kinds of benefits. The following expression is a statement of these irrigation benefits:

$$Y = PB + SB + ATB + CTB$$

where Y is total High Plains, local area benefits from irrigation, PB is primary benefits to irrigation, SB is secondary benefits to irrigation, ATB is tertiary benefits to agricultural-inputs used by irrigated agriculture, and CTB is tertiary benefits to the consumer goods sectors as a result of irrigation. A brief explanation and clarification of meaning of each of these benefits concepts is presented below. Methods used in calculating the benefits are found in Appendix A.

Primary benefits are defined for use in this study as the additional net farm income derived from irrigation. Primary benefits are net of all costs associated with irrigation except the farm management cost. There is no payment for water. Primary benefits, however, can be considered returns to High Plains irrigation water and farm management used in High Plains irrigation. Primary benefits equal gross revenue from irrigation-output minus cost of producing irrigation-output. The primary benefits estimates of this study plus pumping costs can be viewed as an estimate of the maximum price farmers could pay for an equal amount of water delivered to the present farm well sites. For example, if surface water were used for irrigation instead of ground water, pumping costs could be applied to the purchase price of irrigation water.

Secondary benefits to irrigation in the High Plains are defined as the payment to local resources employed in marketing the agricultural product added by irrigation in the High Plains. In reality, agriculture produces raw materials for the food and fiber industry. The processing, storing, packaging, transportation, and other services performed by the agricultural marketing industries are viewed in this study as value added to the basic farm-produced

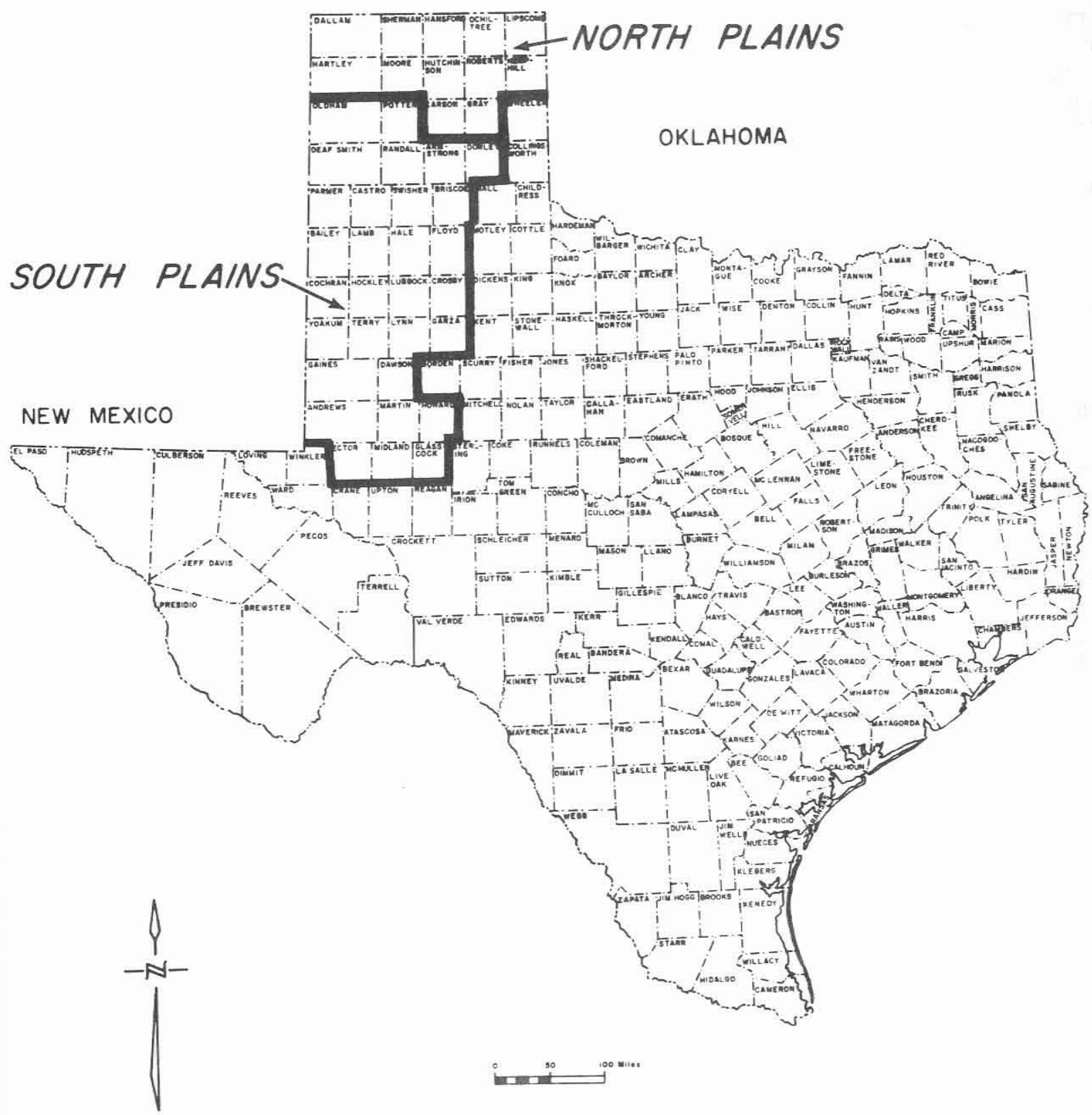

Figure 1

TEXAS HIGH PLAINS 42-COUNTY AREA

raw material. Some of the value added to agricultural production by the High Plains farm product marketing system logically can be attributed to irrigation. This additional value added is associated with the additional volume and value of farm production derived from irrigation. It is measured by calculating the difference between (1) finished product values minus farm product values, or value added, assuming a dryland agricultural economy on the High Plains, and (2) finished product values minus farm product values, or value added, assuming irrigation at specified levels. Even though very little actual processing of agricultural products takes place in the High Plains, marketing the "irrigation-output" provides employment for local High Plains resources, especially in cotton ginning, storage, and transportation. The development of irrigation in the High Plains has attracted some agricultural marketing resources into the area and caused local resources to be allocated to agricultural marketing enterprises. A decline in irrigation-output would result in unemployment of some of these resources.

In this study the term "tertiary benefits" is used to describe those benefits to the non-agricultural sectors which are "induced" by irrigation. In order to obtain a better understanding of these "induced" effects, tertiary benefits are separated into two major parts, (1) tertiary benefits associated with agricultural-inputs and (2) tertiary benefits associated with consumption. The nature of these two kinds of tertiary benefits is similar in that both kinds of activity deal with the sale and movement of goods and services from retail to the consumer. The benefits themselves, however, are distinctly different as the following definitions and explanations will show.

"Agricultural-inputs tertiary benefits" to irrigation are defined as the payment to locally owned resources employed in supplying and servicing those items of agricultural-inputs which must be purchased for use in irrigated agriculture or as a result of irrigation; i.e., the difference in cost of production between irrigated and dryland agriculture is a measure of the gross amount of added input resulting from irrigation. The use of water for irrigation enables the irrigation farmer to use more fertilizer and seed per acre and requires the irrigation farmer to use more fuel, labor, insecticides, herbicides, and farm machinery per acre, than the dryland farmer uses. The additional employment of High Plains resources required to supply and service these additional agricultural-inputs is attributable to irrigation and, as such, their earnings can appropriately be counted as local benefits to irrigation.1/

All three types of benefits, primary, secondary, and tertiary, are related in some manner or other to employment either in irrigated agricultural production, in the marketing of irrigated agricultural-output, or in supplying and servicing inputs used in irrigated agriculture. The additional incomes generated in these irrigation and irrigation-associated activities eventually become

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1/ In this study, national tertiary benefits are not estimated because of the unresolved question of alternative employment of these resources. If the resources would be unemployed in the absence of High Plains irrigation then their total cost to the High Plains farmers is the appropriate estimate of national tertiary benefits to High Plains irrigation. If the resources were to be employed in their next highest paying use, then the above estimate would need to be reduced by the amount of this lower payment in order to obtain an accurate estimate of net national tertiary benefits to irrigation.

transformed into additional consumption within the High Plains area. Employment of High Plains resources in consumer retailing, to supply the additional goods and services demanded as a result of income generated by High Plains irrigation, gives rise to consumer-items tertiary benefits from irrigation. Consumer-items tertiary benefits are defined in this study as the payment or returns to locally owned resources employed in the consumer goods sectors of the High Plains economy to service the additional consumption generated by irrigation income. Local consumer-items tertiary benefits are measured by the difference between cost to retailers and retail value for that quantity of consumption directly supported by primary, secondary, and agricultural-inputs tertiary benefits.[2]

Definition of Terms

It is necessary in a study of this kind to use specialized terminology. The following definitions and illustrations of specialized terms are presented for the reader's information.

A projection point is one of the future decades between 1970 and 2020 for which benefits to irrigation are estimated. Projection points of this study are 1970, 1980, 1990, 2000, 2010, and 2020.

The composite irrigated acre is the representative or average irrigated acre of land in the High Plains in 1959, adjusted to reflect some shift in irrigation to the North Plains. The adjusted composite irrigated acre contains 32 percent cotton, 38 percent grain sorghum, and 21 percent wheat.

Irrigation-output is the yield per composite irrigated acre above that which would be expected on the same acre farmed dryland. Irrigation-output is estimated by adjusting yields on irrigated land for their dryland components.

The expansion coefficient is a number which relates 1 dollar worth of irrigation-output valued at farm price to the final value of High Plains irrigation-output when it is released either to the consumer or to agricultural processors outside the High Plains area. The expansion coefficient minus unity gives an estimate of value added per dollar of irrigation-output and as such is used to estimate secondary benefits per dollar of irrigation-output. Both the local High Plains and the national expansion coefficients for the composite irrigated acre are estimated in this study.

The composite consumer dollar is the representative or average dollar of expenditure in the High Plains area in 1959. In 1959, 18 percent of the High Plains composite consumer dollar was spent for food.

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[2] In this study both the first round and total consumer-items tertiary benefits are estimated. Data needed to estimate irrigation benefits to the wholesale sector are not available. Since wholesaling used only 7.3 percent of labor employed in merchandising and servicing, it is assumed that irrigation benefits in this sector are small in comparison to other irrigation benefits.

Assumptions

Any study which attempts to project future economic benefits encounters difficult data and analytical problems of method and procedure. The analysis and the desired projections required a number of specified and itemized conditions and assumptions. In general, where data were not available or had not been generated, future farm prices and crop yields for example, the most recent reliable data were used. The most recent reliable data pertaining to all segments of the High Plains economy were found in the various 1958, 1959, and 1960 census reports of the U.S. Government, and in publications released early in the 1960's by the Texas Agricultural Experiment Station.

The following specific assumptions were made for use in this study:

1. The composite irrigated acre (defined above) remains constant with time; i.e., as the number of irrigated acres changes, the percentage planted to the various crops now irrigated does not significantly change.

2. Irrigation-output remains constant with time but irrigation water use efficiency increases with time; i.e., irrigation water application per composite irrigated acre declines from 13 acre-inches to 9 acre-inches per year between 1970 and 1990. Crop yields per acre irrigated are assumed to remain constant as irrigation water use efficiency improves.

3. Prices of agricultural products, agricultural-inputs, and consumption items remain constant at the 1959 level.

4. Maximum irrigation development in the High Plains area is achieved by 1980 and, due to declining water, the total number of irrigated acres declines after this date.

5. High Plains irrigated land would be farmed on a dryland basis with no significant change in the kinds of crops produced (this assumption is crucial to estimation of irrigation-output).

6. High Plains farm managers are qualified to carry out irrigated agricultural production.

7. The composite consumer dollar remains constant with time; i.e., as the quantity of consumption changes, the percentages spent on the present array of consumer items does not change significantly with time.

8. Present levels of High Plains livestock feeding will not be affected by declines in irrigated acreage between 1965 and 2020. High Plains cattle feeders use less total feed grains than could be produced on present feed-grain acreage if this acreage were farmed exclusively as dryland.

9. Income generated by irrigation is consumed in the local High Plains area.

10. Locally owned High Plains resources are used to market irrigation-output and to merchandise and otherwise service agricultural-inputs and consumer items used in the High Plains as a result of irrigation.

Data

Practically all the data used in this study are obtained from secondary sources which include the 1959 census of agriculture, the 1958 census of manufacturing, the 1960 census of population, the agricultural statistics 1960, Sales Management Magazine, and various publications of the Texas Agricultural Experiment Station (see Selected References). A limited number of personal interviews with High Plains wholesalers and retailers were conducted to obtain data about wholesale-retail price spreads on the various categories of consumer items and agricultural-inputs handled in High Plains commerce.

Average crop yields were calculated from production reported by the 1959 census of agriculture, both for dryland and irrigated acreage. Dryland average yields were used to separate average yields on irrigated land into dryland-output and irrigation-output.

Irrigated acreage projections were made by a task force of High Plains geologists and hydrologists. The task force based its irrigated acreage projections on the assumption of an annually decreasing rate of water application (increasing technical efficiency in the use of irrigation water); therefore, to maintain consistency, the 1959 crop yield data are held constant when irrigation benefits projections are made. Agricultural production costs used in benefits calculations were obtained from High Plains crop enterprise budgets published by the Texas Agricultural Experiment Station.

High Plains warehousemen, elevator operators, and transportation firms supplied data on storage costs, length of time in storage, and transportation rates. These data are used in calculating secondary benefits to irrigation. Consumer expenditure data reported by Sales Management Magazine in 1960 were used to calculate the composite consumer dollar. These data were supplemented with data, furnished by local High Plains wholesalers and retailers, pertaining to wholesale markups for each of the 11 major classifications of items consumed in the High Plains (Appendix D, Table D2). These data are used in calculating tertiary benefits to irrigation.

PRIMARY BENEFITS ESTIMATION

Primary benefits to High Plains irrigation are obtained directly from irrigation-output of the composite irrigated acre. With 71 percent of the gross value of crop production on the High Plains in 1959 stemming from irrigated cropland, it can be said that the contribution of irrigation water to the gross farm income was 39 percent (Table 1). The major crops from which irrigation-output is obtained are cotton, grain sorghum, and wheat. Other crops such as vegetables, sugar beets, castorbeans, and soybeans also contribute to total High Plains irrigation-output, but these crops accounted for only 3.5 percent of the composite irrigated acre in 1959.

The following brief discussion of each of the major irrigated crops will aid in gaining perspective about High Plains agricultural production and High Plains irrigation-output. The discussion pertains specifically to 1959. Cotton accounted for 25 percent of total cropland use and 32 percent of irrigated cropland use. Dryland cotton produced an average yield of about 1/2 bale per acre, and irrigated cotton produced slightly more than 1 bale per acre. Cotton produced 58 percent of gross farm income from crops and 57 percent of gross farm income from irrigation-output.

Table 1.--Texas High Plains total cropland, irrigated cropland, dry cropland, and value of production from each, 1959

Cropland	Thousands of acres	Gross value of crop production*	Percent of total value
Total cropland	8,355	$482,340	100
Irrigated cropland	3,695	343,976	71
Dry cropland	4,660	138,364	29
Water contribution†	3,695	190,580	39

* See Appendix B.

† Production on irrigated acres less estimated production on same acres farmed without irrigation; product is valued at 1959 Texas average farm prices.

Irrigated grain sorghum yields were about 1.6 tons per acre compared to 0.7 tons per acre without irrigation. Grain sorghum was produced on 44 percent of total cropland used in 1959 and 38 percent of total acres irrigated in 1959. Grain sorghum accounted for 26 percent of total crop income in 1959 and 20 percent of total farm income from irrigation-output in 1959.

Irrigated wheat yielded an average of 28 bushels per acre while dryland wheat yielded an average of 11 bushels per acre. The wheat crop used 24 percent of total cropland and 15 percent of irrigated cropland, from which 11 and 12 percent, respectively, of gross farm income was produced.

Irish potatoes, vegetables, sugar beets, castorbeans, and soybeans depend almost entirely upon irrigation in the High Plains. Since little output of these crops is possible from strictly dryland production, the total amount of production of these crops is considered to be irrigation-output. These crops, however, are relatively unimportant in the total agriculture of the High Plains (3.5 percent of irrigated cropland was planted to Irish potatoes, vegetables, sugar beets, castorbeans, and soybeans combined). These crops produced only about 9.6 percent of gross farm income from irrigation-output in 1959. Cotton, grain sorghum, and wheat produced about 89 percent of 1959 High Plains gross farm income from irrigation-output.

Gross value of irrigation-output from the High Plains composite irrigated acre was $52.55 (Table 2).[3] Cotton, grain sorghum, wheat, and soybeans used 92.9 percent of the composite irrigated acre and accounted for 89.3 percent of gross irrigation-output in 1959. Primary benefits estimates were made on the

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[3] Irrigation-output is calculated using 1959 crop yields and is valued at 1959 prices. The composite irrigated acre is calculated in Appendix B, Table B6.

Table 2.--Gross farm income from irrigation, Texas High Plains, 1959

Crop	Unit	Irrigation-output (per acre)	Price per unit	Revenue from irrigation-output (per acre)	Proportion of composite irrigated acre* (percent)	Gross value of composite irrigated-acre output
Cotton†	bales	0.59	$142.50	$ 84.08	32.504	$27.33
Cottonseed	tons	.23	38.20	8.78		2.85
Grain sorghum†	pounds	1,734.00	.0157	27.22	38.466	10.47
Sorghum silage	tons	NA	NA	NA	1.209	NA
Wheat†	bushels	16.65	1.76	29.30	20.897	6.12
Oats	bushels	9.10	.67	6.10	.122	.01
Barley	bushels	14.80	.80	11.84	1.636	.19
Corn	bushels	26.50	.92	24.38	.346	.08
Corn silage	tons	NA	NA	NA	.312	NA
Irish potatoes	bushels	107.00	1.37	146.59	.276	.40
Soybeans†	bushels	7.40	1.86	13.76	1.077	.15
Vegetables	dollars	1.00	176.46	176.46	.366	.65
Alfalfa hay	tons	2.00	21.50	43.00	.701	.30
Other hay	tons	1.00	21.50	21.50	.148	.03
Sugar beets	tons	24.00	13.50	324.00	.835	2.70
Castorbeans	pounds	2,300.00	.05	115.00	1.105	1.27
				Total......	100.000	$52.55

NA means not applicable because these crops are used exclusively for livestock feed.

* The composite irrigated acre is derived from Appendix B, Table B6.

† These major crops account for 0.92 percent of the composite irrigated acre and are valued at $46.92 using 1959 prices.

basis of these four crops since cost of production data are not available for other crops in the composite irrigated acre.4/

Cost of producing irrigation-output of the composite irrigated acre is calculated at $26.91 (Table 3). Part of these costs (fertilizer, fuel, labor, harvesting, etc.) associated with irrigation are flexible enough to be eliminated rather quickly, say within 1 year, if irrigation were to be discontinued. Once incurred, other costs, such as depreciation on irrigation equipment and farm machinery associated with irrigation, would almost certainly have to be paid, until such equipment on hand is completely depreciated, even though declining water levels were to cause discontinuation of irrigation. Since High Plains irrigation water supplies are declining, the number of irrigated acres is expected to decline. Quite different primary benefits estimates are obtained under conditions of declining irrigation, depending upon whether or not one assumes some cost fixity to irrigation farmers.5/ When the assumption of no cost fixity is used, primary benefits are $20 per composite irrigated acre ($46.92 - $26.91).6/

When one assumes cost fixity on farm machinery and equipment and irrigation equipment, the primary benefits to irrigation are $23.63 per composite irrigated acre ($46.92 - $23.29). When one further assumes that labor is also fixed, as in the case where the farmer and his family supply the total farm labor supply, primary benefits to irrigation are $26.45 per composite irrigated acre.7/ Total High Plains area primary benefits are calculated under the assumption of no cost fixity; i.e., $20 per composite irrigated acre (Table 4) for each projection point of the study. Calculations are not made under assumptions of cost fixity because cost fixity would not apply beyond, say, 10 to 15 years in the case of machinery and equipment. In the case of labor it is almost impossible to determine the time period for which the fixity assumption would apply.8/

Projected primary benefits to High Plains irrigation increase from 1970 to 1980 and decrease after 1980 (Table 4). The peak in these benefits is reached in 1980 when, it appears, maximum High Plains irrigation will have been developed. While most of the increased irrigation development reflected in increased irrigated acres shown in Table 4 is located north of the Canadian River, there also is scattered development of new irrigation throughout the South Plains area. Simultaneously, there is scattered discontinuation of irrigated acreage,

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4/ This method of calculating most likely results in an underestimate of primary benefits on 7.1 percent of the composite irrigated acre. The error, however, is thought to be small, especially when price and yield uncertainty in vegetable crops is considered.

5/ Cost fixity means that resources are owned and cannot be freely disposed of; usually their remaining value cannot be fully recovered either through use or through sale.

6/ The composite irrigated acre used approximately 1.1 acre-feet of water in 1959.

7/ The composite irrigated acre used $2.82 worth of labor in 1959.

8/ The possibility of salvaging machinery and equipment and employing labor elsewhere further complicates calculations of benefits estimates associated with the fixity assumptions. These two possibilities would result in a reduction in irrigation benefits estimates under declining water supply conditions, toward the minimum primary benefits of $20 per composite irrigated acre.

Table 3.--Costs of irrigating major High Plains crops and costs of producing the composite irrigated acre, Texas High Plains, 1959*

Crop	Costs of irrigation-inputs† (per acre)									Composite irrigated acre			
	Fertilizer	Fuel	Labor‡	Harvesting and hauling	Ginning	Poison	Total variable costs§	Irrigation equipment depreciation	Farm equipment depreciation	Proportion of composite acre# (percent)	Variable costs	Irrigation depreciation costs	Farm machinery depreciation costs
Cotton	$3.40	$5.61	$6.00	$9.60	$9.60	$4.35	$38.56	$3.13	$0.89	32.504	$12.53	$0.98	$0.29
Grain sorghum	6.80	5.61	1.50	4.30	0	0	18.21	3.13	.88	38.466	7.00	1.20	.34
Wheat	7.65	5.61	1.83	1.40	0	1.12	17.61	3.13	.58	20.897	3.68	.65	.12
Soybeans	0	5.61	1.20	.44	0	0	7.25	3.13	1.02	1.077	.08	.03	.76
								Total......		92.944	$23.29	$2.86	$0.76

* Costs in this table refer to dollar values of those inputs that are required as a consequence of irrigation. They are costs of additional inputs per acre above inputs used on comparable dryland. The composite irrigated acre costs are calculated so as to put irrigation costs of the various crops on a 1-acre irrigated base; i.e., one representative (composite) irrigated acre requires $23.29 of variable costs.

† Texas Agricultural Experiment Station, "Production requirements, costs and expected returns for crop enterprises," MP-695 and MP-601.

‡ Valued at $1.00 per hour.

§ Sum of fertilizer, fuel, labor, harvesting and hauling, ginning, and poison columns.

See Appendix B, Table B6.

Table 4.--Projected irrigated acres and projected primary benefits to irrigation, Texas High Plains, 1970-2020

Projection points	Projected thousands of irrigated acres*	Projected primary benefits† (millions of dollars)
1959	3,695	74
1970	5,294	106
1980	5,816	116
1990	4,475	90
2000	3,584	72
2010	2,931	59
2020	2,191	44

* Irrigated acre projections were made by a High Plains task force of hydrologists and geologists. Projections are based on present saturated thickness under each 640-acre section of farmland in the study area, and a declining average annual irrigation application rate per acre irrigated. In 1965 the rate of water application used per acre irrigated was 1.1 acre-feet. This rate was reduced uniformly to 9 acre-inches per acre irrigated by 1990, and held at 9 acre-inches per acre irrigated to 2020. For these projectional purposes irrigation of the overlying 640-acre section is assumed to be discontinued in the South Plains when saturation is reduced to 20 feet and discontinued in the North Plains when saturation is reduced to 40 feet. Maximum potential surface-water development has been used in making irrigation projections.

† Calculated at $20 per composite irrigated acre.

due to declining water, throughout the High Plains, but most of the contraction is taking place in the older irrigated areas of the South Plains. Supplies of irrigation water in portions of the South Plains are nearest exhaustion. Heretofore untapped water is being developed for irrigation in the North Plains, and with the expected contraction of irrigated acreage in the South Plains a major shift in location of irrigation from the South to the North Plains will ensue.

A shift in location of irrigation from the South to the North Plains can be expected to influence the composition of the composite irrigated acre somewhat. Based on present information about potential irrigated crops in the North Plains, it appears that new North Plains irrigation will largely be used to produce grain sorghums and wheat. It is expected that contraction of irrigation in the South Plains will take place first on grain sorghums. There will be enough irrigated acreage in the South Plains in 2000 to allow irrigation of a 2-million-acre cotton allotment. It is conceivable, therefore, that the shift in irrigation from the South to the North Plains will result in a change in composition of the composite irrigated acre to include a larger percentage of wheat. The High Plains composite irrigated acre was adjusted to appropriately reflect this shift (Appendix B, Table B6).

The declining water situation will produce a distributional effect on farm income. The estimates presented in Table 4 are aggregates for the entire High Plains area. Some farmers, however, will be experiencing a decline in net farm income due to exhaustion of individual farm water supplies while others will be developing irrigation and thereby increasing their net farm incomes. The expected distributional effects of shifts in High Plains irrigation cannot be evaluated at this time because the necessary data are not available.

SECONDARY BENEFITS ESTIMATION

Secondary benefits to High Plains irrigation are derived from irrigation-output of the composite irrigated area. Since secondary benefits are dollar values added by the marketing sector to irrigation-output, it is useful, for projection purposes, to derive a secondary benefits expansion coefficient which applies to the composite irrigated acre. The expansion coefficient desired is a number which links the dollar value of irrigation-output, from the composite irrigated acre, to the dollar value of irrigation-output after the marketing sector has performed its functions. As it is conceived here, this coefficient contains the value of 1 dollar of irrigation-output plus the value added by the marketing sector; therefore, the expansion coefficient minus unity expresses secondary benefits on a per-dollar of irrigation-output basis.[9] This procedure is used for calculating secondary benefits because the only data available are marketing margins[10] published by the U.S. Department of Agriculture (1964) and local High Plains storage and freight rates for High Plains agricultural products. Since practically all the value added to High Plains agricultural commodities is done outside the High Plains area by other than local High Plains

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[9] This method of calculation is based on the idea that the marketing sector buys irrigation-output, at the farm price, performs the necessary processing, storage, transportation, packaging, and wholesaling, and sells the resulting product at retail for enough income on the average to cover all the costs of handling each batch. Otherwise, the marketing sector would reduce the price it pays to the farmer, the wages it pays to labor, or make other adjustments to insure that the resources employed would receive an acceptable money return for having been used.

[10] The marketing margins are adjusted to show the percent of 1 dollar of consumer expenditure, at retail, received by the farmer for each major U.S. agricultural commodity. If, for example, the farmer receives 12 percent of the consumers expenditure on bread, then 1 dollar worth of wheat results in 8.33 dollars worth of bread and a value added by the marketing sector of 7.33 dollars.

resources, both national and local expansion coefficients are derived (Appendix C).11/ High Plains resources do little more than store and transport agricultural products, with the exceptions of cottonseed crushing, some livestock slaughtering, and sugar refining. For example, High Plains cotton is shipped outside the area for spinning, weaving, and finishing into textile products.

Table 5 shows how each individual commodity of the composite irrigated acre is weighted to give a single expansion coefficient which applies to the irrigation-output of the composite irrigated acre. For example, the local composite irrigated acre expansion coefficient is 1.35, which means that for each dollar of agricultural-output from the composite irrigated acre there is an average of 35 cents of value added by locally owned marketing resources. By applying this average expansion coefficient to the gross value of High Plains irrigation-output one obtains an estimate of local secondary benefits to High Plains irrigation. The national composite acre expansion coefficient is 5.53 which means that 1 dollar of agricultural-output from the High Plains composite irrigated acre results in an average of $4.53 of value added by the marketing sector. In an analogous way $4.53 is an estimate of average national secondary benefits per dollar of irrigation-output from the High Plains composite irrigated acre.12/ The difference (4.18) between the national and local High Plains expansion coefficients gives an indication of average secondary benefits to High Plains irrigation per dollar of irrigation-output from the composite irrigated acre, which are realized outside the High Plains area.

The gross value of irrigation-output from the High Plains composite irrgated acre was $52.55 in 1959 (Table 2). There are, according to estimates of this study, local secondary benefits of $0.35 per dollar of irrigation-output. On the composite irrigated acre basis, local secondary benefits to irrigation are $18.39, i.e., ($52.55 x 0.35). National secondary benefits per composite irrigated acre are $238.05, i.e., ($52. x 4.53). Local and national secondary benefits projections are presented in Table 6.

Local secondary benefits in 1970 are projected at $97 million. If High Plains irrigation were zero in 1970, local resources employed in marketing agricultural products would experience an estimated reduction in income of $97 million. After 1980, local secondary benefits are estimated to decline due to declining irrigation-output resulting from declining irrigation water. Although secondary benefits projections are positive to the year 2020, there is a projected average annual decline of $1.6 million between 1980 and 2020 if present High Plains marketing functions are continued. Local secondary benefits could be maintained at the expense of secondary benefits realized elsewhere if the

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11/ Value added at the local area level is obtained by adding cost of functions performed by the local marketing sector per unit of agricultural product. This procedure allows an estimate of total High Plains value (farm value + value added by local marketing sector) to be calculated, from which percentage returning to the farmer can be calculated; a local measure analogous to U.S. Department of Agriculture marketing margins discussed in footnote 10.

12/ This is an underestimate because feed grains, which are not included in the national coefficient, contribute to national secondary benefits indirectly through livestock. Data are not available with which to make quantitative estimates of the livestock component of national secondary benefits derived from feed grains produced in the High Plains.

Table 5.--Composite irrigated acre expansion coefficients per dollar of farm sales, Texas High Plains, 1962*

Crop	Proportionate value of irrigation-output† (percent)	Individual item coefficient		Composite acre coefficient	
		National	Local	National	Local
Cotton	52.007	6.666	1.123	3.986	0.584
Cottonseed	5.423	3.846	1.961	.208	.106
Grain sorghum	19.924	NA	1.266	NA	.252
Wheat	11.646	8.333	1.234	.970	.144
Oats	.019	NA	1.149	NA	.001
Barley	.361	NA	1.149	NA	.004
Corn	.152	NA	1.123	NA	.002
Irish potatoes	.761	3.704	1.612	.028	.012
Soybeans	.285	3.846	1.176	.010	.003
Vegetables	1.236	2.941	1.886	.036	.023
Alfalfa hay	.576	(a)	(a)	0	0
Other hay	.057	(a)	(a)	0	0
Sugar beets	5.137	2.941	2.941	.151	.151
Castorbeans	2.416	5.882	2.941	.142	.071
Total	100.000	--	--	5.531	1.353

* See Appendix C for derivation of individual item coefficients. The individual item coefficients are weighted by the respective composite acre fractions to obtain a composite irrigated acre benefits coefficient. The composite irrigated acre benefits coefficient minus unity yields the composite irrigated acre secondary benefits coefficient per dollar of irrigation-output from the composite irrigated acre.

† Proportion of the value of irrigation-output contributed by each crop in the composite irrigated acre.

a Not available.

High Plains agricultural marketing sector were to expand its activities to include more of the marketing functions such as processing. This may or may not be desirable, from an overall economic standpoint, depending upon technical efficiency of potential High Plains processing plants, opportunity to employ High Plains marketing resources in other kinds of activities, and whether or not High Plains processing were to displace processing elsewhere. Thorough study of the matter of processing High Plains agricultural products in the local area is required before deciding whether or not this marketing function should be adopted as a means of maintaining the level of local secondary benefits to irrigation as irrigation declines.

Table 6.--Projections of secondary benefits to irrigation, Texas High Plains, 1970-2020

Years	Thousands of acres irrigated	Farm value of irrigation-output* (millions of dollars)	Secondary benefits† (millions of dollars)	
			Local	National
1959	3,695	194	68	879
1970	5,294	278	97	1,259
1980	5,816	306	107	1,386
1990	4,475	235	82	1,064
2000	3,584	188	66	852
2010	2,931	154	54	698
2020	2,191	115	40	521

* Increased crop yields resulting from irrigation times price per unit of yield. Gross farm income added by irrigation was $52.55 in 1959.

† The local expansion coefficient is 0.35 and the national expansion coefficient is 4.53 per dollar of irrigation-output of the composite irrigated acre.

Secondary benefits cannot be construed as a basis for purchasing irrigation water for High Plains agriculture. Secondary benefits are legitimate incomes to resources employed by the marketing sector, and even though they may be significant in terms of dollar values (Table 6), they are not returns to water.[13/]

13/ Secondary beneficiaries are extremely interested in a continuous flow of irrigation-output. This interest can be reflected in the prices paid for irrigation-output, i.e., by increasing price offered to farmers; farmers could use higher priced (cost) water, if the need arose, in order to continue irrigation. In the case of the High Plains, however, this measure would only temporarily maintain output unless higher priced irrigation-output justified the development of water importation projects. Secondary benefits could be drawn upon through broad-based business or income tax programs, to aid in paying for water development projects that might be undertaken by governmental agencies for the explicit purpose of providing irrigation water needed to maintain High Plains irrigation.

TERTIARY BENEFITS ESTIMATION

Benefits that accrue to agricultural-input suppliers and to consumer items retailers, due to High Plains irrigation, have been broadly classified as tertiary benefits in order to distinguish these from other benefits. These benefits are derived indirectly from irrigation-output of the composite irrigated acre and are estimated in two parts in the following discussion.

Agricultural-Inputs Tertiary Benefits

Costs of inputs required to produce irrigation-output on the High Plains composite irrigated acre were $26.88 in 1959.[14] Of this total cost, $23.29 was spent for variable inputs such as seed, fertilizer, irrigation labor, fuel, harvesting, and ginning; $2.86 was allotted to amortized irrigation equipment; and $0.76 was allotted to amortized farm equipment (Table 3). Labor, harvesting, hauling, ginning, and about 80 percent of the irrigation equipment and supplies are produced or obtained directly from the High Plains area (Moore and others, 1962, 1964). The total farm cost of the irrigation-inputs (well drilling and pumps), therefore, represents payments to High Plains resources and qualifies in full as agricultural-inputs tertiary benefits. Other production items such as farm machinery and equipment, some irrigation equipment, irrigation pipe, and chemicals are manufactured elsewhere and brought into the High Plains for sale. Part of the farm expenditure for these items is sent outside the area to pay for the individual items while the remainder (markup) is left to pay locally owned resources employed in the business of marketing the inputs to farmers. Payments to local resources per dollar spent to produce irrigation-output on the composite irrigated acre were $0.63 in 1965 (Appendix D, Table D1). the remaining $0.37 per dollar of expenditure for irrigation-inputs used on the composite irrigated acre is used to pay for irrigation-inputs produced outside the High Plains area. Based on these estimates, local High Plains resources employed in supplying agricultural-inputs to irrigated agriculture receive a total payment of $16.93, i.e., ($26.88 x $0.63) per composite irrigated acre. The above estimate is used for making projections of agricultural-inputs tertiary benefits.[15] Tertiary benefits projections presented in Table 7 need no further explanation. These benefits are in fact incomes to a major sector of the High Plains economy, and as such, form the basis for additional consumption within the High Plains area.

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[14] This cost figure applies to 92.9 percent of the composite irrigated acre planted to cotton, grain sorghum, wheat, and soybeans. Cost data are not available for crops planted on the other 7.1 percent of the composite irrigated acre.

[15] The $16.93 estimate of agricultural-inputs tertiary benefits is based on crops produced on 92.9 percent of the composite irrigated acre. As such it is likely to be an underestimate of agricultural-inputs tertiary benefits on 7.1 percent of the composite irrigated acre planted to vegetables, castorbeans, sugar beets, and Irish potatoes, all of which use more labor and other purchased inputs than the crops from which this estimate is made. In the aggregate, however, the error in tertiary benefits estimation is small.

Table 7.--Projected agricultural-inputs tertiary benefits from irrigation of the composite irrigated acre, Texas High Plains, 1970-2020

Item	1959	1970	1980	1990	2000	2010	2020
Irrigated acres (thousands)	3,695	5,294	5,816	4,475	3,584	2,931	2,191
Tertiary benefits (million dollars)*	63	89	98	76	60	49	37

* Calculated at $16.93 per acre irrigated.

Consumer-Items Tertiary Benefits

The consumption of primary, secondary, and agricultural-inputs tertiary benefits from High Plains irrigation results in increased employment of resources in the retail goods and services sector of the High Plains economy, to merchandise the added goods and services. Since the High Plains economy imports practically all the goods it consumes from outside the area, a large portion of the consumer dollar is sent outside the local economy to pay the cost of obtaining consumer goods for retail trade. Services utilized within the High Plains economy are supplied largely by locally owned resources. Income to the retail goods and services sectors, therefore, is obtained primarily through the merchandising services provided by High Plains retailers, and amounts to what is commonly referred to as "markup" or the amount added to the wholesale price of an item to cover the cost of performing the merchandising function. This value added, on that amount of consumption directly attributable to income generated by High Plains irrigation, is a measure of consumer-items tertiary benefits defined earlier.[16]

The 1959 composite consumer dollar is used as the basis for calculating estimates of consumer-items tertiary benefits. Estimates made of both the local High Plains first round and total consumer-items tertiary benefits are based on the following information.[17] The wholesale cost of that portion of the composite consumer dollar (90 percent) spent for goods was $0.68 in 1959 (Appendix D, Table D2). The remaining 10 percent of the 1959 composite

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16/ Some of the additional income would perhaps be used for investment purposes, but since there are no data about investment of earnings by irrigation beneficiaries it has been assumed that the added income is consumed. This assumption could lead to an erroneous estimate of overall irrigation benefits since it is not clear whether High Plains investment generates more income than new High Plains consumption generates.

17/ The consumption of first round consumer-items tertiary benefits results actually in subsequent rounds of benefits of the same kind; i.e., receipients, of the first round of consumer-items tertiary benefits, themselves, live within the High Plains area and are similar to other consumers. Increased income in this group provides still further demands upon the retail economy and thereby stimulates more employment and subsequently higher income of the consumer-items tertiary benefits type. (See Appendix A for derivation of the local multiplier.)

consumer dollar was spent for services produced within the High Plains area. The combined returns to retailers and other service suppliers amounted to an estimated 38 cents per composite consumer dollar.[18] The first round change in consumer-item tertiary benefits is $0.38 per dollar of change in consumer spending. The total local High Plains consumer-items tertiary benefits per dollar of change in consumer spending is $0.61 (see Appendix A for derivation). These coefficients or multipliers are used to project consumer-items tertiary benefits to irrigation in the Texas High Plains (Table 8).

Table 8.--Projected consumer-items tertiary benefits from irrigation, Texas High Plains, 1970-2020 (million of dollars)

Projection points	Irrigation income available for consumption spending*	High Plains consumer-items tertiary benefits	
		First round†	Total‡
1959	205	78	125
1970	292	111	178
1980	321	122	196
1990	248	94	151
2000	198	75	121
2010	162	61	99
2020	121	46	74

* The sum of primary, secondary, and agricultural-inputs tertiary benefits from Tables 4, 6, and 7.

† Calculated at the rate of $0.38 per dollar of irrigation income available for consumption.

‡ Calculated at the rate of $0.61 per dollar of irrigation income available for consumption.

Tertiary benefits to irrigation are analogous to secondary benefits to irrigation in that tertiary benefits cannot be drawn upon directly to pay for water used in irrigation. Tertiary benefits, as they are defined and calculated in this study, are incomes to resources (primarily labor, capital, and management) employed by the retail sales and services sector of the economy. The tertiary income from irrigation does, however, increase taxable income in the same way that secondary benefits increase taxable income and could perhaps be drawn upon through broad-based tax programs to aid in financing irrigation water projects to maintain High Plains irrigation. Otherwise, tertiary benefits would not be available to support the continuation of High Plains irrigation even though these benefits are large in relation to other irrigation benefits estimated in this study.

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[18] This coefficient is derived from data supplied through personal interviews of selected High Plains wholesalers and retailers. The 1959 composite consumer dollar was used to weigh the individual item coefficients to obtain the composite consumer dollar coefficient. The proportion of the composite consumer. dollar retained as returns to High Plains resources is $0.38; [(0.32 x 0.9) + 0.10] = 0.38.

SUMMARY AND INTERPRETATIONS

The purpose of this study was to relate the use of irrigation water in the Texas High Plains to the High Plains economy and to make projections of irrigated acreages and net benefits to the High Plains economy at each decade from 1970 to 2020. Irrigated agricultural production, resource use, and consumption data in 1959 were combined with irrigated acreage projections to 2020 for the purpose of estimating and projecting economic benefits to High Plains irrigation.

Three kinds of benefits to High Plains irrigation are estimated: (1) primary benefits, (2) secondary benefits, and (3) tertiary benefits.[19] Primary benefits accrue to High Plains irrigation farmers in the form of increased net farm income, secondary benefits represent incomes to High Plains resources employed by the agricultural business sector in marketing farm products produced by irrigation, and tertiary benefits represent incomes to agricultural-input suppliers and retailers of consumer goods and services who are employed in selling goods and services purchased with other income added by irrigation.

The findings of the study can be summarized most effectively in tabular form (Table 9). Irrigation development has not reached its peak in terms of the number of acres which can be brought under irrigation. The present annual rate of irrigation development, and informed opinion (the basis for an important assumption that maximum development will have been achieved by 1980), indicate that the Ogallala Formation will support a maximum of 5.8 million acres of irrigation, and that this maximum will be reached by about 1980. This is an overall conclusion about the High Plains which obscures some internal contractions in irrigated acreage. Although isolated cases of discontinuation with respect to irrigation will occur throughout the High Plains, beginning within a few years, the earliest and most widespread discontinuation is expected to appear in the older irrigated areas of the Southern High Plains where initial saturation of the aquifer was thinnest. Until 1980, an anticipated expansion in North Plains irrigated acreage is expected to offset anticipated reductions for the South Plains. After 1980, an anticipated net decline in acreage irrigated from the Ogallala Formation was indicated.

Benefits from High Plains irrigation were estimated for the 1959 composite irrigated acre which is modified to reflect anticipated shifts in irrigation to the North Plains. The aggregate High Plains benefits estimates were made from projected irrigated acreages and, therefore, these estimates reflect the pattern of rise and decline projected for irrigated acreage. If, in fact, this pattern of irrigation development and decline does occur, the overall economic effect would be a significant growth of economic activity in the North Plains and some contraction of economic activity in the South Plains, unless offsetting employment in the non-agricultural sectors takes place.

The magnitude of each kind of benefit considered in this study is presented in Table 9. Primary benefits were estimated at $20 per composite irrigated acre in 1959. The gross value of irrigation-output from the composite irrigated acre in 1959 was estimated at $52.55, from which estimated local secondary benefits of $18.39 were obtained. Agricultural-inputs tertiary benefits were estimated at $16.93 per composite irrigated acre in 1959. Local High

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[19] For complete definitions of these terms refer to the preceding text.

Table 9.--Projected total benefits to irrigation, in millions of dollars, Texas High Plains, 1970-2020*

Projection points	Projected thousands of irrigated acres	Primary benefits	Secondary benefits	Agricultural-inputs tertiary benefits	Consumer-items tertiary benefits	Total benefits†
1959	3,695	74	68	63	125	330
1970	5,294	106	97	89	178	470
1980	5,816	116	107	98	196	517
1990	4,475	90	82	76	151	399
2000	3,584	72	66	60	121	319
2010	2,931	59	54	49	99	261
2020	2,191	44	40	37	74	195

* Summary of Tables 4, 6, 7, and 8.

† Total benefits estimates are obtained by summing horizontally all benefits of this table.

Plains consumer-items tertiary benefits in 1959 were calculated at $33.74 per composite irrigated acre. Estimated High Plains total benefits to irrigation--the sum of primary, secondary, and tertiary benefits--in 1959 was $89.06 per composite irrigated acre.

The total benefits estimate is used in projecting benefits for each decade to 2020. It should be remembered that the projections reflect crop yields, agricultural prices, agricultural costs, and consumer prices in 1959. Practically all of these variables can be expected to change in absolute magnitude and in relation to each other in the future. Long-range projections based on such data, therefore, are subject to a high degree of error. Benefits estimates for 1959 of $330 million indicate, however, that irrigation is highly important to the High Plains economy. In 1960, total High Plains income was reported by the U.S. census of population at $1.6 billion. Irrigation benefits estimates for 1959 indicate that irrigation was responsible for approximately 21 percent of total High Plains income from all sources, non-agricultural as well as agricultural, at that time. With anticipated increases in technical efficiency of water use in the future, High Plains irrigation benefits can be expected to increase.

The irrigation benefits estimates of this study provide indications regarding the value of replacement water to the High Plains area. Primary benefits plus pumping costs, $28.74 or ($20 + $8.74) per composite irrigated acre, can be viewed as the maximum price per composite irrigated acre farmers could pay for water and continue irrigated production in the manner in which High Plains irrigation was carried out in the early 1960's. The High Plains composite irrigated acre uses approximately 1 acre-foot of water. At a price of $28.74 per acre-foot, farmers would be receiving no direct return to the water resource and management. However, they would be able to employ more labor and capital and thereby increase net farm income. As primary benefits have been estimated in this study, all of the irrigation-output has been attributed to water. This most likely represents an overestimate of returns to water, especially if water makes other production factors such as land, labor, and capital (fertilizer, insecticides, and machinery) more productive. Therefore, the $20 primary benefits estimate may be higher than water actually is worth to the farmer. However, since water is the limiting factor, irrigation-output would be zero in its absence and the employment of complementary inputs would be zero. Because water is the limiting resource, the primary benefits estimates of this study are reasonable approximations of the average value of water, while primary benefits plus pumping costs indicate the appropriate maximum price farmers could pay for replacement water.

The estimates of this study show that even though positive and significant, the primary benefits are relatively small--22 percent of total benefits per composite irrigated acre--in comparison to other benefits. The implication of this finding is that irrigation is more important to the High Plains economy through its induced effects than in direct benefits to irrigators. This is to say that community, State, and national economic interests of large magnitude, dependent on High Plains irrigation, are at stake. Therefore, considerable support, both in interest and in community-wide or even broader-base funding, may be anticipated as necessary to augment and protect these large, existent interests in provision of needed irrigation or water-supply development. A change in irrigation-output can be expected to have a significant effect upon High Plains aggregate income. Irrigated acreage is expected to increase until about 1980, and with the increase in irrigation, the High Plains economy can be expected to grow.

The anticipated decline in irrigation after 1980 has serious implications for the planning of economic expansion within the High Plains. Among the questions which must be considered are (1) alternative supplies of irrigation water, (2) expansion of employment in industries which do not consume large volumes of water, and (3) the possibility of significant economic contraction within the High Plains.

A continuous research program is needed in the areas of improving technical water-use efficiency, proper allocation of water among competing uses, and in analyzing the ultimate long-range effects of alternative programs and policies pertaining to water use. The key to maintaining an active, high level of economic activity in the Texas High Plains is to begin early with plans to augment present water supplies, and to continue to improve both technical and economic efficiency in water use.

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APPENDIX A

IRRIGATION BENEFITS
ESTIMATION PROCEDURES

APPENDIX A

Irrigation Benefits Estimation Techniques

The purpose of this appendix is to present the general equations used to calculate: (1) primary, (2) secondary, and (3) tertiary benefits to irrigation in the Texas High Plains. These benefits concepts can be outlined, in general, as follows:

$$PB = NR_2 - NR_1$$

where PB are primary benefits, NR_2 are net farm incomes with irrigation, and NR_2 are net farm incomes from dryland.

$$NR_1 = TR_1 - TC_1$$

$$NR_2 = TR_2 - TC_2$$

where TR_1 is total income from dryland, TR_2 is total income from irrigated land, TC_1 is total cost of production with dryland, and TC_2 is total cost of production on irrigated land.

Secondary benefits are derived from the production added by irrigation:

$$SB = K\ (TR_2 - TR_1)$$

where SB are secondary benefits, and K is a constant which expresses the value added per dollar of gross revenue from irrigation.

There are two kinds of tertiary benefits, (1) agricultural-inputs and (2) consumer-items. Agricultural-inputs tertiary benefits are derived from the added use of purchased agricultural production inputs.

$$ATB = h\ (TC_2 - TC_1)$$

where ATB are agricultural-inputs tertiary benefits, and h is a constant which expresses income in the agricultural supply sector per dollar of irrigation inputs sold to the irrigation farmers.

$$CTB = k\ (PB + SB + ATB)$$

where CTB are consumer-items tertiary benefits, and k is a constant which expresses income in the retail goods and services sectors per dollar of additional consumption expenditure of other irrigation income. The specific calculating equations of each of the benefits concepts outlined above are presented below.

The following equation is used to calculate total primary benefits to irrigation in the High Plains:

$$(1) \qquad PB = \sum_{i=1}^{n} a_i\ (R_i - C_i)\ D; \qquad \sum_{i=1}^{n} a_i = 1$$

where PB is annual High Plains primary benefits from irrigation, a_i is the proportion of the representative or composite irrigated acre planted to crop i, R_i is gross farm income added by irrigation of crop i (increased yield per acre of crop i, due to irrigation, times per-unit price of crop i), C_i is added per-acre farm costs associated with irrigation of crop i (additional fertilizer, labor, harvesting, and irrigation costs per acre of crop i due to irrigation), and D is the total number of acres irrigated in a given year. Primary benefits are the increases in net farm income brought about by irrigation, and as stated in equation (1) are the sum of the individual crop contributions. The composite acre is used to calculate annual primary benefits for the total High Plains area because data pertaining to crop yields, farm prices, and acres irrigated are only available in highly aggregate form. For example, the 1959 census of agriculture reported crop acres, irrigated acres, and yields for each crop produced in each county. The county data were aggregated to obtain total High Plains data for calculations. Relevant Texas average farm prices, as reported in the 1960 "Agricultural Statistics," are applied to the production data in order to obtain dollar estimates of the irrigation contributions to net farm income of the High Plains.

Secondary benefits to High Plains irrigation are estimated by equation (2):

$$(2) \qquad SB = \sum_{i=1}^{n} (K_i - 1)\, G_i; \qquad K_i = 1 \div P_i$$

where SB are secondary benefits, G_i is gross farm value of irrigation-output of crop i (additional yield per acre on irrigated acres, times acres irrigated, times farm price of crop i), and K_i is the fraction $1 \div P_i$ where P_i is the percent of the consumer's dollar spent for item i, at retail, which is paid to the farmer for the raw material included in item i at retail. For example, if the farmer receives 86 percent of the consumer's expenditure on beef then there is a value added by the marketing sector of $0.14 per dollar of beef sold at retail. In order to express the dollar value of raw farm product in terms of total value at retail, from which value added by the market sector can be determined, the following question can be asked about the above example: given 1 dollar's worth of beef at farm value, how much value is added by the market sector if the farmer receives 86 percent of the consumer's expenditure on beef? In simple algebra, $0.86x = 1.0$, where x is the unknown retail value of which the farmer receives 86 percent. The farmer has 1 dollar of raw product; therefore, per dollar of raw product (beef) there will be $1.16 worth of finished product (beef). In answer to the above question, the market sector adds a value of $0.16 per dollar of raw product (beef). In the above example K = $1.16 and (K - 1) = $0.16. The value added by the marketing sector per dollar of raw product is (K - 1) or $0.16.

Data pertaining to value added by the agricultural marketing sector are published by the U.S. Department of Agriculture (1964) in the form of percents of consumer's dollars received by farmers for major agricultural commodities. These percentages are used to obtain total or national value-added coefficients.

Since the High Plains agricultural marketing sector does not perform the entire marketing function; i.e., very little processing is done in the local area, value added by High Plains resources is less per dollar of raw product than national value added per dollar of raw product. In order to estimate value added by High Plains agricultural marketing resources per dollar of irrigation-output it was necessary to add the cost of services performed by local agricultural marketing concerns to the farm value of irrigation-output, from which percent returning to the farmer could be obtained. This percent is analogous to national percentages reported by the U.S. Department of Agriculture (see Appendix B).

The above value-added coefficients are derived for each commodity in the composite irrigated acre. Irrigation-output of the composite irrigated acre is valued at farm price. The percent of gross value of irrigation-output contributed by each commodity is used to weight respective commodity value-added coefficients for the purpose of obtaining a single value-added coefficient which applies to gross value of irrigation-output, G_i, of equation (2). Thus, secondary benefits to irrigation are calculated on a composite irrigated acre basis, and projections of secondary benefits can be made simply by multiplying by the projected number of irrigated acres.

Agricultural-inputs tertiary benefits are calculated as follows:

$$(3) \qquad ATB = \sum_{j=1}^{z} h_j X_j D$$

where ATB are agricultural-inputs tertiary benefits, h_j is the payment to locally owned resources employed in supplying irrigation-inputs, per dollar of input j used on the composite irrigated acre to produce irrigation-output, X_j is the number of dollars of input j used on the composite irrigated acre to produce irrigation-output, and D is the number of composite irrigated acres. The composite irrigated acre, h_j, is \$0.63, and X_j for the composite irrigated acre is \$26.88 (see Appendix D, Table D1).

Consumer-items tertiary benefits to irrigation arise from the consumption of all other incomes generated by irrigation, and by successive rounds of consumption of consumer-items tertiary benefits; i.e., an additional consumption expenditure results in a payment to locally owned retail merchandising resources which in turn consume the added income and thus generate additional income on each ensuing round of consumption expenditure. Consumer-items tertiary benefits are estimated as follows:

$$(4) \qquad CTB = (k - 1) M$$

where CTB are consumer-items tertiary benefits to irrigation, k is the multiplier resulting from additional consumption expenditures, and M is the dollar amount of additional consumer expenditures. (M = PB + SB + ATB.) The value (k - 1) is used to adjust for the cost of consumer items outside the High Plains area. The multiplier, k, is obtained in the following manner:

$$(4a) \qquad k = 1 \ (k_1 + k_1^2 + k_1^3 \ . \ . \ . \ . + k_1^s)$$

where k_1 is the percent of the composite consumer dollar which is paid as income to locally owned resources, per dollar of consumer expenditure (retail-wholesale cost). Since k_1 is less than unity, the series expressed in equation (4a) converges to $[1 \div (1 - k_1)]$.[2]

[2] See any standard calculus textbook.

The following equation is used to calculate k_1:

$$(4b) \qquad k_1 = \sum_{q=0}^{P} b_q w_q; \qquad \sum_{q=0}^{P} w_q = 1$$

where b_q is the percent of an additional dollar of consumer income spent on good q, which is retained as income by local High Plains resources employed in consumer merchandising (b_q less than 1), and w_q is the percent of the composite consumer dollar spent for good q (see Appendix D, Table D2).

APPENDIX B

AGRICULTURAL PRODUCTION AND
VALUE OF AGRICULTURAL PRODUCTION
TEXAS HIGH PLAINS, 1959

Table B1.--Production by irrigation and dryland in 42 counties of the Texas High Plains, 1959

Crops	Units of yield	Acres total	Total production	Irrigated			Dryland			Production contribution from use of water
				Acres	Production	Average yield	Acres	Production	Average yield	
Cotton	bales	2,097,215	1,788,860	1,323,753	1,419,536	1.07	773,462	369,324	0.477	784,985
Grain sorghum	tons	3,684,790	4,600,501a/	1,566,559	2,507,084	1.60	2,118,231	1,153,417	.733	1,358,207
Sorghum silage	tons	49,258	410,096	49,258	410,096	8.3	0	0	0	410,096
Sorghum dry forage	tons	167,590	199,878	c/	c/	c/	c/	c/	c/	c/
Wheat	bu.	2,014,436	32,070,973	552,963	15,485,037	28.00	1,461,473	16,585,936	11.35	9,206,834
Oats	bu.	16,461	405,502	4,969	153,950	30.90	11,492	251,552	21.8	45,218
Barley	bu.	151,416	3,370,545	66,639	2,032,564	30.5	84,777	1,337,981	15.7	986,257
Rye	bu.	12,568	157,751	0	0	0	12,568	157,751	12.5	0
Corn	bu.	17,638	946,413	14,091	831,186	58.98	3,547	115,227	32.48	421,321
Corn silage	tons	12,654	153,502	12,654	153,502	12.13	0	0	0	153,502
Irish potatoes	bu.	11,977	3,181,107	11,260	3,062,459	272.0	717	118,648	165.0	1,204,820
Soybeans	bu.	49,157	1,157,797	43,867	1,067,991	24.3	5,290	89,806	16.9	324,616
Vegetables	$	17,543	3,095,708	14,918b/	3,095,708	c/	2,625	0	0	0
Alfalfa	tons	32,325	104,737	28,557	99,335	3.47	3,768	5,402	1.43	58,256
Other hay	tons	20,914	21,840	6,025	10,742	1.78	14,889	11,098	.74	6,266
Total	--	8,355,942	--	3,695,513	--	--	4,492,839	--	--	--

a/ 145,017,913 bushels.
b/ This figure is acres on farms for which the entire vegetable crop was irrigated. There are more acres irrigated but the 1959 census did not report such; neither did it report yield by irrigated class.
c/ Not available.

Table B2.--Value of total crop production, Texas High Plains, 1959[a]

Crop	Units	Quantity	Price	Total value
Cotton	bales	1,788,860	$142.50	$254,912,550
Cottonseed[b]	tons	706,063	38.20	26,971,606
Grain sorghum	pounds	8,121,003,134	.0157	127,499,749
Sorghum silage	tons	410,096	c/	c/
Sorghum dry forage	tons	199,878	c/	c/
Wheat	bushels	32,070,973	1.76	56,444,912
Oats	bushels	405,502	.67	271,686
Barley	bushels	3,370,545	.80	2,696,436
Rye	bushels	157,751	.92	145,131
Corn	bushels	946,413	1.13	1,069,447
Corn silage	tons	153,502	c/	c/
Irish potatoes	bushels	3,181,107	1.37	4,358,116
Soybeans	bushels	1,157,797	1.86	2,153,502
Vegetables	dollars	c/	c/	3,095,708
Alfalfa	tons	104,737	21.50	2,251,845
Other hay	tons	21,840	21.50	469,560
			Total......	$482,340,248

a/ Texas average prices, 1959.
b/ Converted at 0.3947 tons seed per bale of lint.
c/ Not available.

Table B3.--Value of irrigated crop production, Texas High Plains, 1959[a]

Crop	Units	Quantity	Price	Total value
Cotton	bales	1,419,536	$142.50	$202,283,880
Cottonseed[b]	tons	560,291	38.20	21,403,116
Grain sorghum	pounds	5,014,168,433	.0157	78,722,444
Wheat	bushels	15,485,037	1.76	27,253,665
Oats	bushels	153,950	.67	103,147
Barley	bushels	2,032,564	.80	1,626,051
Rye	bushels	0	c/	0
Corn	bushels	831,186	1.13	939,240
Corn silage	tons	153,502	c/	c/
Irish potatoes	bushels	3,062,459	1.37	4,195,569
Soybeans	bushels	1,067,991	1.86	1,986,463
Vegetables	dollars	c/	c/	3,095,708
Alfalfa	tons	99,335	21.50	2,135,702
Other hay	tons	10,742	21.50	230,953
			Total......	$343,975,938

a/ Texas average prices.
b/ Converted at 0.3947 tons seed per bale of lint.
c/ Not available.

Table B4.--Value of dryland crop production, Texas High Plains, 1959[a]

Crop	Units	Quantity	Price	Total value
Cotton	bales	369,324	$142.50	$ 52,628,670
Cottonseed[b]	tons	145,772	38.20	5,568,490
Grain sorghum	pounds	3,106,834,701	.0157	48,777,304
Wheat	bushels	16,585,936	1.76	29,191,247
Oats	bushels	251,552	.67	168,540
Barley	bushels	1,337,981	.80	1,070,385
Rye	bushels	157,751	.92	145,131
Corn	bushels	115,227	1.13	130,206
Irish potatoes	bushels	118,648	1.37	162,548
Soybeans	bushels	89,806	1.86	167,039
Alfalfa	tons	5,402	21.50	116,143
Other hay	tons	11,098	21.50	238,607
			Total......	$138,364,310

a/ Texas average prices (none other available).
b/ Converted at 0.3947 tons seed per bale of lint.

Table B5.--Value of production contributed from use of water, Texas High Plains, 1959[a]

Crop	Units	Quantity	Price	Total value
Cotton	bales	784,985	$142.50	$111,860,362
Cottonseed[b]	tons	309,833	38.20	11,835,621
Grain sorghum	pounds	2,716,413,306	.0157	42,647,689
Wheat	bushels	9,206,834	1.76	16,204,028
Oats	bushels	45,218	.67	30,296
Barley	bushels	986,257	.80	789,006
Rye	bushels	0	0	0
Corn	bushels	421,321	1.13	476,093
Irish potatoes	bushels	1,204,820	1.37	1,650,603
Soybeans	bushels	324,616	1.86	603,786
Vegetables	dollars	c/	c/	3,095,708
Alfalfa	tons	58,256	21.50	1,252,504
Other hay	tons	6,266	21.50	134,719
			Total......	$190,580,416

a/ Calculated by subtracting irrigation contribution from total acres and production.
b/ 0.3947 tons seed per bale of lint.
c/ Not available.

Table B6.--Projected irrigated crop acreage, Texas High Plains, 1970-2020[a]

Crop	Thousands of acres irrigated, 1959[b]	Composite irrigated acre[c] (percent)	Projected thousands of irrigated acres					
			1970	1980	1990	2000	2010	2020
Cotton	1,324	0.32504	1,721	1,890	1,455	1,165	954	712
Grain sorghum	1,566	.38466	2,036	2,238	1,722	1,379	1,127	843
Sorghum silage	49	.01209	64	70	54	43	35	26
Wheat	851[e]	.20897	1,106	1,215	936	749	612	458
Oats	5	.00122	6	7	6	4	4	3
Barley	67	.01636	87	95	73	59	48	36
Corn	14	.00346	18	20	15	12	10	8
Corn silage	12	.00312	17	18	14	11	9	7
Irish potatoes	11	.00276	15	16	12	10	8	6
Soybeans	44	.01077	57	63	48	39	32	24
Vegetables	15	.00366	19	21	16	13	11	8
Alfalfa hay	28	.00701	37	41	31	25	21	15
Other hay	6	.00148	8	9	7	5	4	3
Sugar beets[d]	34[e]	.00835	44	49	37	30	24	18
Castorbeans	45[e]	.01105	59	64	49	40	32	24
Total	4,072	1.00000	5,294	5,816	4,475	3,584	2,931	2,191

a/ Based on irrigated land use in 1959.
b/ Irrigated acres reported by the 1959 census of agriculture (rounded to nearest 1,000).
c/ Calculated from acres irrigated in 1959.
d/ Subject to acreage allotments.
e/ Expected long-term acreages based on recent acreage allotments or trends in growth of High Plains production.

Table B7.--Estimated disposition of farm produce, Texas High Plains, 1959

Item	Total value	Value local use	Value exported
Cotton lint	$254,912,550	$ 0	$254,912,550
Cottonseed	26,971,606	26,971,606	0
Soybeans	2,153,502	2,153,502	0
Feed grains	131,798,459	30,121,226	101,677,233
Wheat	56,444,912	0	56,444,912
Hay	3,721,404	3,721,404	0
Irish potatoes	4,358,116	435,811	3,922,305
Vegetables	3,095,708	619,140	2,476,568
Dairy	3,922,384	3,922,384	0
Poultry	4,235,386	4,235,386	0
Sheep-Lambs	1,274,112	1,274,112	0
Calves[a/]	31,498,605	31,498,605	0
Cattle[b/]	109,997,655	39,081,328	70,916,327
Hogs and Pigs	4,911,478	4,911,478	0
Other	1,217,693	1,217,693	0
Total	$640,513,570	$150,163,675	$490,349,895

a/ Calf imports (feeders) $46,727,761, reflected in value of cattle sold.

b/ Source: Texas Commercial Livestock Slaughter, 1956-58, U.S. Department of Agriculture Statistical Reporting Service, Texas Crop and Livestock Reporting Service and Texas Agricultural Experiment Station. Bulletin 7, 1961. Prices from 1960 Agricultural Statistics.

APPENDIX C

DERIVATION OF SECONDARY BENEFITS TO IRRIGATION, TEXAS HIGH PLAINS

APPENDIX C

Derivation of Secondary Benefits to Irrigation, Texas High Plains

The following data and assumptions were utilized in determining local value added to basic agricultural production of the High Plains. The data were obtained from published information in the U.S. Department of Agriculture's "Agricultural Statistics, 1960," "Developments in Marketing Spreads for Agricultural Products in 1959, and 1963" (AMS-274 and ERS-14, 1964), "Railroad Freight Rate Indexes For Farm Products 1957-63," "Texas Grain Storage Statistics"; Texas Crop and Livestock Reporting Service, Bulletin 5, March 1960; and local High Plains businesses through interviews of company representatives. The data are summarized in Table C2.

Cotton

It was assumed that the High Plains cotton of the 42-county area was stored an average of 18 months per year, at a rate of $0.50 per bale per month, for 12 months; 6 months at $0.41 per bale per month with a $1.25 per bale warehouse receiving fee.

The assumed average transport cost was 800 miles at $0.92 per hundredweight, or $4.60 per bale with an intermediate assembly haul of 50 miles at $0.73 per bale and with two loadings and two unloadings costing a total of $2.00 per bale.

The total local value added to cotton would be the following:

Storage for first 12 months	$ 6.00
Storage for second 6 months	2.46
Receiving fee	1.25
Transportation and hauling	7.33
Total per bale	$17.04

With the farm price at $142.50 per bale, and the local value added equal to $17.04, the total local value of cotton lint is $159.54. The farmers' share of local value is 89 percent.

Other benefits from cotton are the by-products of cottonseed. The by-products with their respective prices are as follows:

Table C1.--Cottonseed by-product prices, 1959

By-product	Prices	
	U.S. average	Texas (when available)
Refined oil per pound	$00.1194	--
Meal per ton	59.15	--
Linters per ton	--	$19.25 per bale
Hulls per ton	5.00	--

Source: Agricultural Statistics, 1960.

An average ton of crushed cottonseed yields 338.92 pounds of crude oil, 0.46 tons of cake and meal, 0.30 bales of linters, and 0.23 tons of hulls, with respective values of $40.46, $27.20, $5.77 and $1.15.[1] The total value of the by-products from a ton of cottonseed is $74.58; however, the farmer receives $38.20 per ton for cottonseed. Thus, the value added is $36.38. The farmers' share is 51 percent.

Soybeans

The value added to soybeans is primarily due to the processing. It is assumed that 95 percent of the High Plains crop is processed locally; therefore, transportation and storage were not considered.

The value of soybeans is as follows:

(1) Unprocessed beans at farm price is $1.86 per bushel or $61.99 per ton;

(2) Processed crude oil per pound is $0.083, and meal per ton is $55.55.

One ton of crushed beans yields approximately 367.7 pounds of oil and 0.76 tons of meal. The processed value of a ton of soybeans is $72.74.

Since the seed used for the processing costs $61.99 per ton (farm price) and the value added is $10.75 per ton, the farmers' share of local value is 85 percent.

Wheat

The value added to wheat on the High Plains is due to storage and transportation. It is assumed that 1 year's production is in storage at all times and the average storage period is 18 months at $0.01 per bushel per month. Transportation costs average $0.22 per bushel for an assumed haul of 500 miles. At these rates the High Plains value added would be $0.40 per bushel. The total value of wheat leaving the High Plains would be $2.16, resulting in a farmers' share of local value of 81 percent.

Oats, Barley, and Corn

The assumption was made that total production of oats, barley, and corn is fed on the Plains. The average storage period was assumed at 6 months at $0.01 per bushel per month. The average haul is 50 miles at $0.135 per hundredweight.

Oats: Storage costs of $0.06 and transport costs of $0.04 give an added value of $0.10. With the farm price equal to $0.67, the total High Plains value is $0.77. The farmers' share of the total value is 87 percent.

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[1] Cottonseed and soybean yields of various by-products were calculated from 1959 national crushing and production statistics reported in "Agricultural Statistics, 1960."

Barley: With a storage cost of $0.06 and a transport cost of $0.06, the added value is $0.12. This $0.12 added value plus the farm price of $0.80 gives a total value of $0.92. The farm share is equal to 87 percent.

Corn: The per-bushel storage cost of $0.06 plus transport cost of $0.08 gives an added value of $0.14. The farm price of $1.13 plus the added value gives a total High Plains value of $1.27 per bushel. The farm share of the total value is 89 percent.

Rye: Rye is not fed in the High Plains like the other feed grains, so the transport distance was assumed to be 500 miles at $0.135 per hundredweight giving a transport cost of $0.24 per bushel. Storage costs of $0.06 per bushel were assumed. The sum of these two costs gave an added value of $0.30. The added value plus the farm price gave a total value of $1.22 per bushel. The farmers' share of the total High Plains value would be 75 percent.

Grain Sorghum

Of the total production, 1,661,379,681 pounds or $26,083,661 worth of grain sorghum was used on the High Plains in 1959. It was assumed that this locally used grain was stored an average of 6 months at $0.01 per month per bushel and hauled 50 miles at $0.105 per hundredweight.

There were 6,459,623,453 pounds exported from the 42-county area, with the assumption that 10 percent was shipped to the West Coast at $0.605 per hundredweight and 90 percent of shipped an average of 500 miles at $0.345 per hundredweight. Assuming that the grain sorghum exported from the High Plains was also stored an average of 6 months at $0.01 per month per bushel, the added value per bushel of grain going to the West Coast was $0.40 and total value was $1.28 per bushel.

The farm share of West Coast exports is 69 percent. For the grain sorghum that is exported an average of 500 miles the added value per bushel is $0.25 and the total value is $1.13 per bushel. The farm share of this latter portion of the 1959 crop was 78 percent. The composite farm share for the exported grain sorghum is 77 percent. The grain sorghum that is used locally has an added value of $0.12 and a total value of $1.00. The farm share would be 88 percent for locally used grain sorghum.

With 20 percent used locally and 80 percent exported, the farmers' share of value of High Plains grain sorghum is 79 percent.

Irish Potatoes

Ten percent of the High Plains produced potatoes was consumed locally and 90 percent was transported an average of 1,500 miles at $1.20 per hundredweight or $0.720 per bushel. There were no storage costs because the potatoes were consumed soon after harvest.

The value added due to transportation was $0.72, and this cost plus the farm price of $1.37 gave a total value of $2.09 per bushel for the 1959 crop. The farm share would be 66 percent for the potatoes exported and 62 percent for the total 1959 crop, assuming that farmers received a 27 percent share of potatoes used locally.

Vegetables

High Plains vegetables (onions and carrots) that were used locally amount to around 20 percent of the crop. The other 80 percent was transported an average of 1,475 miles at $1.25 per hundredweight.

With a farm price for onions of $2.95 per hundredweight, the transport cost raised the total value to $4.20. The farm share would be 70 percent.

The farm price for carrots--$1.05 per hundredweight--added to the transport cost of $1.25 per hundredweight gives a total value of $2.30. The farm share for carrots would be 45 percent.

The composite farm share for vegetables is 53 percent assuming the farm share of the locally consumed vegetables was 34 percent (same as the national margin).

Sugar Beets

The total processing of sugar beets was done on the High Plains; therefore, the national average farm share applies (Table C2).

Castorbeans

No specific information for castorbeans could be obtained; therefore, data for miscellaneous agricultural products was used. It was assumed that High Plains castorbean processors performed one-half the job of converting the farm product to the usable product; thus, the farm share would be 34 percent.

Livestock

It was assumed that 30 percent of local production was slaughtered on the Plains, and that 70 percent was transported 290 miles to Fort Worth at $0.69 per hundredweight. Livestock slaughtered locally was assumed to be transported 46 miles by commercial carrier and was included in marketing costs reflected by the farmer share of retail beef. All other livestock and livestock products were assumed to be transported at farmer expense since these products were processed and consumed locally.

The steer and heifer price at the farm in 1959 was $24.70 per hundredweight. This farm price plus the added value of transportation to Fort Worth ($0.69) gave a total value of $25.39 per hundredweight. Farmers' share of cattle shipped out would be 97 percent. Farmers' share of cattle slaughtered locally is the same as the national share (63 percent).

A composite local multiplier of cattle was obtained, consisting of local slaughter at full secondary benefits and exported cattle at value added from transportation. The farmers' share would be:

$$(0.30 \times 0.63) + (0.70 \times 0.97) = 0.19 + 0.67 = 0.86 \text{ or } 86 \text{ percent.}$$

Dairy, pork, and poultry produce of the High Plains is processed and consumed locally; therefore, national farm share rates apply to the High Plains situation.

Table C2.--National and Texas High Plains farm share of consumer expenditures on finished agricultural products, 1962

Item	Farmers' share of retail cost of finished products, United States[a] (percent)	Farmers' share of value of partially finished products, High Plains[b] (percent)	Expansion coefficient	
			United States	High Plains
Crops				
Cotton	0.15[c]	0.89	6.666	1.123
Cottonseed	.26	.51	3.846	1.961
Wheat	.12	.81	8.333	1.234
Grain sorghum[d]	[e]	.79	[e]	1.266
Oats	[e]	.87	[e]	1.149
Barley	[e]	.87	[e]	1.149
Rye	[e]	.75	[e]	1.333
Corn	[e]	.89	[e]	1.123
Irish potatoes	.27	.62	3.704	1.612
Soybeans	.26	.85	3.846	1.176
Vegetables[d]	.34	.53	2.941	1.886
Sugar beets	.34	.34	2.941	2.941
Castorbeans	.17	.34	5.882	2.941
Livestock				
Beef	.63	.86	1.587	1.163
Dairy	.44	.44	2.273	2.273
Poultry	.60	.60	1.666	1.666
Pork	.53	.53	1.886	1.886

[a] Developments in marketing spreads for agricultural products 1959, Marketing Economics Research Division, U.S. Department of Agriculture AMS-374, 1959.

[b] Many High Plains products are shipped out of the area for processing and marketing. Values presented here are a composite of farmers' share of retail cost of locally processed commodities and farmers' share of value of partially finished commodities leaving the area. The procedure used to obtain the percentages considers equivalent quantities at each marketing level. For example, a bale of seed cotton is valued at the farm, and the products of a bale of cotton (lint and cottonseed products) are valued after local High Plains processors, warehousers, and transporters have finished adding each respective service. Farmers' share is obtained by calculating the ratio of farm value to total value after local services are added.

[c] Composite of 25 products at U.S. level with locally based warehousing and transportation.

[d] Weighted according to percent used locally and percent exported from the area.

[e] Not available.

APPENDIX D

DERIVATION OF TERTIARY BENEFITS
TO IRRIGATION, TEXAS HIGH PLAINS

Table D1.--Purchases of production inputs for major crops of the composite irrigated acre, Texas High Plains, 1959

Irrigation-input items	Composite irrigated acre production costs[a]		Wholesale markup[b] (percent)	Farm purchases (per dollar)		Farm purchases for composite acre	
	Total costs	Percent of total		Wholesale cost[d]	Payment to local handlers	Wholesale costs per dollar of purchased inputs (col.2)x(col.4)	Payments to local handler per dollar of purchased inputs[e]
Variable materials	$12.17	45	0.33	$0.75	$0.25	$0.34	$0.11
Labor	2.91	11	[c]	[c]	1.00	[c]	.11
Harvesting, hauling, and ginning	8.18	30	[c]	[c]	1.00	[c]	.30
Irrigation equipment[f]	2.29	9	[c]	[c]	1.00	[c]	.09
Irrigation equipment	.57	2	.18	.84	.16	.02	.01
Farm machinery	.76	3	.26	.79	.21	.01	.01
Total	$26.88	100	--	--	--	$0.37	$0.63

[a] Additional costs for irrigation-inputs per acre irrigated (see text Table 3).
[b] Reported by High Plains dealers and manufacturers.
[c] These items are produced and marketed locally; therefore, a major portion of their total value accrues to local area resources.
[d] [1÷(1 + wholesale markup)].
[e] Payment to local handler, weighted by percent of total outlay (column 2, this table).
[f] Eighty percent of irrigation-inputs manufactured in the High Plains.

Table D2.--Consumption expenditures, Texas High Plains, 1959[a]

Items	Retail sales (thousands)	Composite retail dollar (percent)	Whole sale mark-up[b] (percent)	Wholesale value of retail dollar[c]	Wholesale value of composite retail dollar[d]
Food	259,108	18.0	20	$0.83	$0.15
Eating and drinking places	58,580	4.1	50	.66	.03
General merchandise	116,348	8.1	33	.75	.06
Apparel	78,176	5.4	35	.74	.04
Furniture and house apparel	61,010	4.3	40	.71	.03
Automotive	293,676	20.4	30	.77	.16
Gas stations	104,472	7.3	25	.80	.06
Lumber, bldg., and hardware	153,318	10.7	45	.69	.07
Drugs	42,984	3.0	45	.69	.02
Services[e]	143,429	10.0	[f]	[f]	[f]
Other	124,286	8.7	33	.75	.06
Total	1,435,387	100.0	--	--	$0.68

[a] Reported by "Sale Management Magazine."
[b] Reported by Lubbock wholesaler.
[c] Wholesale value of retail dollar equals retail dollar divided by unity plus wholesale markup.
[d] Wholesale value of retail dollar weighted by percent of composite retail dollar.
[e] Source: City County Data Book, 1960, U.S. Department of Commerce, Bureau of Census. Includes hotels, personal services, miscellaneous business services, auto repair, motion pictures, etc.
[f] Mainly labor for which total payment is retained by locally employed labor.

Table D3.--Labor employment, Texas High Plains, 1959

Sector	Number of workers	Wages (thousands of dollars)
Agricultural production[a]	24,580	61,016
Agricultural services	6,380	1,286
Mining (oil and gas)[b]	26,804	146,515
Construction	26,487	52,162
Manufacturing[c]	20,963	73,735
Transportation and public utilities[d]	19,215	67,194
Wholesale trade[e]	15,458	66,774
Retail trade	42,846	112,181
Finance, insurance, and real estate	11,721	34,809
Services (repair, etc.)	13,721	36,129
Professional services[f]	104,707	1,000,002
Unclassified	9,805	4,197
Total	322,687	1,656,000

[a] Hired labor only; 1959 Agricultural Census.
[b] Census of Mineral Industries, 1958.
[c] Census of Manufacturing, 1958.
[d] Excludes railroads; "County Business Patterns" reports 3,884 railroad employees.
[e] City County Data Book.
[f] Teachers, physicians, barbers, dentists, lawyers, farm owners, etc., self employed; 23,020 farm operators, 77,803 professional, and 3,884 railroad workers. Source: County Business Patterns.