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Institutional Factors Influencing Water Development in Texas

W.L. Trock

Texas Water Resources Institute

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INSTITUTIONAL FACTORS INFLUENCING WATER DEVELOPMENT IN TEXAS

Project Director
Dr. Warren L. Trock

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ABSTRACT

The development and use of land and water resources has been and will continue to be significantly affected by institutions--legal, cultural, economic, political and religious. Institutions are the organizing and directing mechanisms by which we achieve an organization of resources in productive activities which satisfy human needs. They are essential to individual and collective activity and thus must be understood and managed to achieve our purposes.

In this project, attention has been given to institutions which are important to (1) the implementation of the Texas Water Plan, and (2) the efficient use of water resources in irrigation in the lower Rio Grande Valley.

Numerous political and economic institutions must be changed or newly developed to provide for (1) the interbasin diversions proposed by the Texas Water Plan, (2) the creation and management of transfer systems and (3) distribution of water within importing areas and fulfillment of financial obligations. These will be expressed by individuals and groups various points of view relative to water developments and the administration of water supplies. Self interests will be forcefully expressed. Competing users of water will make themselves heard. Institutional arrangements to resolve conflicts, to provide for development of water systems and to insure efficient use of water will be critical to the success of the Plan. Numerous suggestions for institutional changes are made in papers and reports of the research of this project relative to these issues.

They cannot be reported in this abstract.

Institutions of particular importance to efficient distribution and use of water in irrigation in the lower Rio Grande Valley are the irrigation districts and their policies and operations plus water rights. While operations of districts could significantly be influenced by consolidation of districts, rehabilitation, and changed managerial policies, there are important barriers to such change. Present low costs of water in districts and the desire to maintain control of irrigation systems policies and procedures in local districts may not allow change to take place. Negotiable water rights are a possibility, and exchange of rights or annual allocations would improve efficiency of water use. District members need to be made aware of consequences of such a change in this institution. An informational program relative to water management would be helpful.

KEY WORDS: Institutions, Water Resources Planning, Irrigation, Water Rights, Irrigation Districts, Interbasin Transfers, Cost Sharing, Water Law, Water Administration.

ACKNOWLEDGMENTS

The research reported herein is the product of three very capable students in the Department of Agricultural Economics and Rural Sociology, a professor of Resource Economics, and the project director. Contributions of each were significant; each has earned the respect and the thanks of the project director for a job well done.

Thomas Casbeer initiated the study of institutions affecting land and water use in the lower Rio Grande Valley by identification of institutional arrangements most significant to the organization of resources in irrigated agriculture. Abdullah Thenayan and Roy (Mack) Gray were responsible for (1) estimating the impacts of institutional arrangements on choice of enterprises, use of land and water resources, and output of agricultural commodities and (2) developing the recommendations for change in institutions which would promote greater efficiency in resource use.

Dr. Clarence Jensen, of Montana State University, used his Sabbatical leave to work on the problem of institutional arrangements for the Texas Water Plan. This was a study which was not anticipated in the project proposal. Publication of the Plan made quite apparent the problem of appropriate institutional arrangements for water development, allocation and use; so Dr. Jensen was employed to develop the research.

Others who have given the researchers needed assistance are professional employees of the Texas Water Rights Commission, Bureau of Reclamation, Texas A&M Research and Extension Center at Weslaco, Soil Conservation Service and the Hidalgo Water Control and Improvement District No. 1 at Donna, Texas. Their cooperation in the research effort is deeply appreciated.

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CHAPTER 1

INTRODUCTION

The future growth and prosperity of the state of Texas is closely linked with the development and efficient utilization of its water resources. Water is important to several industries, including agriculture, transportation, recreation, commercial fishing and some extractive industries. Projections of Texas' needs far exceed the presently and potentially available supplies of water.[27] Numerous studies have been conducted and are in process to discover new supplies to supplement those available internally.

Other efforts have been directed to the problem of maldistribution of water throughout the state. Some areas have surpassed the level of water use that can be supported by the existing supply, e.g. west Texas (especially the High Plains and the Trans-Pecos) is rapidly depleting its underground water because of a rate of use which far exceeds the natural recharge.[11, 27] Other areas in east Texas have supplies which exceed even the projected needs. Intrastate redistribution and water quality improvement would alleviate the problem, but these measures are viewed as short-term solutions only. A significant increase in over-all quantity, improved distribution and quality improvement are needed for the longer term.

A significant planning effort was revealed when the Texas Water Development Board released to the public "The Texas Water Plan." It is an ambitious proposal to develop the water resources of the state,

to supplement these resources by an import of surplus water from the Mississippi River, and to distribute water supplies for a wide variety of purposes throughout the state via several coordinated transfer systems. Included also in the Plan are suggestions for improving the use of existing and prospective supplies of water. Possibilities for more efficient application of water in irrigation are noted; recycling and reuse of water in industry is suggested as a means of increasing the water supply; the destruction of non-economic plants which allow the escape of water via transpiration is advocated; and the reduction of evaporative losses from reservoirs by various means is promoted. The plan is fairly comprehensive in the proposals advanced for water development, water conservation, and water use.

It seems obvious that a plan of this nature should present many problems to those responsible for its implementation. Problems of engineering will be formidable; economic problems of feasibility, cost-sharing, financing and water pricing will be critical; and the development of appropriate institutional arrangements will be essential for the success of the plan. Institutions have often been formidable obstacles to resource developments. It does not appear that Texas water development will escape their effects.

This study represents an effort to identify the problems of institutions in water development and use. It is in one aspect a very broad study. Institutional arrangements necessary for the implementation of the plan for importing, transporting and distributing water supplies in the state of Texas are recognized and evaluated. But there is also a careful examination of the impacts of institutions on land and water use in a local area, the lower Rio Grande, where

irrigation is critical to the area's economy. Both of these research efforts should be useful to planners, developers, and users of water. They should provide helpful guidelines for changing institutional arrangements of developing new ones where it is necessary to accomplish our purposes of development and efficient utilization of water.

Institutions

Wherever man has developed a relationship with others, an institution has evolved to manage and protect that relationship, thus minimizing the frictions or conflicts that might arise from it. Minimizing frictions or conflicts does not mean eliminating them. Professor Young says it takes repeated problem situations or crises to generate institutions, and from these "groups come to develop certain standardized methods of performance. Any recurrent performance, associated with images, ideas, and attitudes and organized around fundamental life situations may be considered as institutional behavior. . ."[35]

Thus institutions provide a framework or environment, at whatever level of social grouping, within which our lives are regulated. Institutions involve habits and cultural organizations, traditions, customs, laws and legal requirements, leading to Commons' definition of institutions as being "collective action in control, liberation, and expansion of individual action."[16] Commons also attributes to institutions a life span greater than that of the individuals who are affected by them. He wrote, "Instead of isolated individuals in a state of nature they are always . . . members of a concern in which they come and go, citizens of an institution that lived before them and will live after them. . ."[5]

Such longevity suggests rigidity. Specific institutional needs change as the elements of society change; and as certain institutions are outgrown, they can be a hindrance to action in the public interest. [17] Institutional problems arise primarily because some guidance is looked for, or some change is proposed, that is contrary to the purpose of that institution. Such efforts cannot succeed until the framework within which that activity is to take place is changed.[1]

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[1]Visualize a change in land use, e.g. that runs counter to the institution of personal property with its attendant rights of ownership. That institution (with the court's backing) will be a barrier to change so long as it remains a viable and controlling force in the holding and use of land.

A specific instance of likely conflict in water rights is embodied in the 1931 Wagstaff Act of the Texas Legislature which states, ". . . all appropriations or allotments of water hereafter . . . shall be granted subject to the right of any city, town, or municipality . . . to make further appropriations . . . without the necessity of condemnation or paying therefor . . . ." This "right" is yet to be tested in court [28], but it has legislative sanction in spite of being directly contrary to the security of tenure inherent in the institution of property.

CHAPTER II

INSTITUTIONAL ARRANGEMENTS FOR THE TEXAS WATER PLAN

For a water development plan such as that proposed in the Texas Water Plan, institutional needs will be numerous and complex. Some significant changes of the present institutional structure may also be required. Institutional arrangements necessary for interstate diversions of water, for the management of improvements and transfer systems, for establishing and maintaining claims to water resources, and for developing repayment capabilities among water users and other beneficiaries will be essential to the implementation of the plan.

An institutional structure appropriate to the Texas Water Plan would logically be organized around the functions of the system. It would include specific institutional arrangements for each of three broad, separate functions: (1) diversion of water from rivers in east Texas and the Mississippi, (2) creation and management of the transfer system, and (3) distribution of water within importing areas and fulfillment of financial obligations.

Several institutional factors have been recognized as important to the diversion of water from the lower Mississippi River. This proposed source of supplemental water is an interstate stream; its waters are shared by several states through which the river flows. It is navigable for a considerable portion of its length. It supplies water for agriculture, municipalities, industries, power generation, and recreational uses. There are existing water rights which must be recognized and protected from any diversion. There is considerable

economic dependence on water within the Mississippi basin and its tributaries. For many people "Old Man River" has significant subjective value. There is and will be important personal and public resistance to any diversion of water. But to make a water transfer system functional, a diversion in perpetuity is necessary, the rights to the diverted water must be granted, and an agreement relative to compensation (if any) for the diverted water must be negotiated. The Congress will be called upon to judge the feasibility of the proposed diversion, to insure the rights to whatever flow may be diverted and to provide for federal participation in this phase of the total water development. To this end, studies of the flow of the river, the uses of water in the basin, and the existing institutional arrangements associated with uses are under way. Changes in institutions or new institutional arrangements to insure the diversion of water from the Mississippi, to construct and finance works necessary to diversion and to provide for administration of waters affected by diversion will be largely the responsibility of the Congress, though the states, local governments, private firms and individuals interested in this diversion will certainly affect congressional decisions.

If diversion is approved, the transfer system must be created. This will require consideration of other institutional factors. What will be the interests of federal, state and local governments in this system? How will they cooperate to design and construct its facilities? How will the system be financed?

The federal government will be concerned with such matters as (1) an equitable apportionment of "surplus" water among states and regions receiving it, (2) an equitable sharing of costs among states and the federal government, (3) the coordinated management of the system in the water transfer, flood control and conservation storage

which will be provided, and (4) the indiscriminate application of federal conservation and reclamation policy.

The state will be interested in such things as (1) allocation of water among various uses according to state established priorities, (2) the distribution and use of water without unwanted restrictions, (3) pricing and sale of water according to policies and procedures developed by the state, and (4) management of the system to serve the special interests of the state.

Local governmental entities, including special districts, authorities and county governments, will be interested in (1) maintaining their activities in water supply management, with a local interest point of view; (2) guarding their present and future investments in facilities and protecting their positions as debtors; and (3) preserving other interests for which they may have been specially created.

Some interests of these various governments may be harmonious; some may be conflicting. To the extent that each government represents different constituencies and different points of view, we can expect conflicting interests. There must be resolution of conflicts through negotiation involving legislators, agency heads, important interest groups and other concerned persons and groups.

For the purpose of creating and managing the transfer system, we have conceived of three alternative, cooperative relationships of federal, state and local governments. Each has precedence in various existing institutional arrangements; each is a possible relationship with respect to the Texas Water System.

One is a relationship dominated by the federal government. It would reflect the considerable federal interest and would give the

system a "project" orientation. Development would proceed within the framework of the Federal Reclamation Act, as amended. Design and construction of the transfer system would be a cooperative endeavor involving state and federal agencies. Costs would be shared in traditional ways, with the federal government assuming the responsibility for flood control while municipal and industrial water storage would be a responsibility of state and local government entities. Management will probably be characterized by that of the larger, reclamation projects of the western states which involve deliveries and sales of water to municipalities, industries and agriculture. The restraints of the Reclamation Act would be imposed on agricultural water users, unless the Congress specifically exempts them from the Act's provisions. [33] Emphasis would probably be given to the agricultural use of water, since this has been the orientation of reclamation projects.

A second, possible intergovernmental relationship would not reflect dominance by any particular government. It would provide for a "partnership" approach to the planning for and development of the system. It could be organized as an intergovernmental council or commission, with representatives from federal, state and local governments, and with advisory groups as required for the expression of various interests and points of view. Such an organization might develop some significantly new approaches to water development, e.g. cost-sharing arrangements based on projections of benefit accrual at all levels might be developed. This would be quite different from legislatively-defined interests in water developments. This approach should provide for management which would give more attention to municipal, industrial and recreational uses of water. A council or commission responsible for management may tend to question traditional

priorities in water use and base their allocative and pricing policies on concepts of multiple use and measures of value of water in various uses.[1] Perhaps the broader scope of interest and activity of a commission might serve to influence congressional decisions to provide for flexibility in management of this large water supply system.

A third method of organizing various levels of government in a planning and developmental effort would give the intergovernmental relationship a state-and-local interest bias. Texas has recently reorganized its state "water agencies" so that it has a relatively strong Water Development Board.[27] The Board, with some technical assistance from federal agencies, local authorities and districts, and technical consultants could take principal responsibility for the design and construction of the transfer system. Cost-sharing and financing would be worked out by federal, state and local governmental entities. It seems likely that this approach to the creation of the system might require the state to assume a greater share of costs than would a different approach, e.g. the first intergovernmental relationship described. Acquisition of the greater decision-making powers may require a larger contribution by the state. This intergovernmental

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[1] This will require some prior institutional change in that the 1931 Texas Legislature enacted (in the Wagstaff Act) an ordering of uses in the following priorities: (1) Domestic and municipal, (2) Manufacturing, (3) Irrigation, (4) Mining and recovery of minerals, (5) Hydro-electric power, (6) Navigation, and (7) Recreation and pleasure.

Such a statutory preference ordering ignores values in use and makes the economic system incapable of registering values properly with a resultant loss in the efficiency with which water is used. As stated in [16], a principle of "higher" - "lower" limits the "perfection of property rights in water applied to 'lower' uses, however productive such uses might be."

relationship would also provide for a strong state-local responsibility in management. The legislation prescribing the responsibilities of the various governments could even provide that the transfer system would be turned over to the state for operations and maintenance after all or a major portion of it were complete. There are state and local agencies which would welcome such a delegation of managerial authority because it would allow them to serve the state's interests as they see them.

These alternative, intergovernmental relationships have been suggested to stimulate thought about possibilities for organizing the efforts of various levels of government in implementing the Texas Water Plan. Each of them, plus some other alternatives perhaps, needs careful economic evaluation. Their effects have only been hypothesized so far.

At the user level, there are important problems of institutional arrangements to provide for the contractual purchase of water, its distribution and use. Prospective users of imported water have been forewarned of the need for quasi-governmental agencies -- master districts or import authorities --with powers to contract with state and federal governments, to tax beneficiaries and charge water users in various ways, to acquire lands for distribution systems and to sell water as retailers of that good.[34] Organizing master districts will not be easy in the established, irrigation areas of the state. One obstacle will be the existing organizations of water users.[30] These include irrigation districts, drainage districts, fresh water supply districts, navigation districts, etc. Each has special authority, responsibilities and a large degree of autonomy. Most will tend to guard their special interests jealously.

Many water users will be hesitant to give a master district the powers it will need to function as a retailer and distributor of imported

water. To give important rights such as eminent domain and the taxing power to another governmental entity will be difficult for some, yet existing governmental units might find conflicts in objectives if system responsibilities are added to their present duties.

Important to the users of imported water will be the resolution of the question of limitations on irrigated acreage. If the federal-state relationship for development and management of the transfer system is dominated by the Federal government, there will exist the very real possibility of limitations according to the Reclamation Act. But might there not be some minimum proportion of "federal water" below which the limitations would not be applied? One might expect a line to be drawn somewhere short of a blanket application of the Act.[1] A number of exemptions to the 160-acre limitation have been made and the state of Texas should expect similar treatment. Since no new irrigation project development is proposed as a part of the Texas Water System the entire new supply may legitimately be regarded as supplementary.[2]

Problems of concern at all institutional levels, but probably of greater importance at the state and local levels, involve questions of tax equity, water pricing and sharing in the water supply. An especially critical problem involves the rights to certain underground water supplies. Some important users of water in Texas pump it from underground aquifers, to which they have exclusive rights.[34] If

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[1] It is stated that "millions of acre feet" will be transferred through the system annually, while only 12-13 million acre feet are to be imported, from the Mississippi River.[27]

[2] And this may be sufficient; several irrigation projects in the West have been exempted from the 160-acre limitation on this basis. [17, 33]

imported water should be stored underground, these aquifers would be recharged and landowners would realize windfall benefits. It would seem necessary that the state or the master districts involved acquire these rights through exchange of permits to system water, purchase, or other equitable means. Such acquisition would permit control and management of underground and surface waters to achieve optimum economic use of both.

Even without underground storage of imported water, problems of rights and use may develop. Attempts to use public surface water and private underground water conjunctively may cause considerable conflict, especially for the water district that has contracted to purchase water from the transfer system and pay for it by sales to users and other charges to beneficiaries.

A further problem will be the definition and collection of appropriate charges for benefits accruing to individuals who are not direct users of imported water. For example, how could beneficiaries from reduced land subsidence be taxed or charged for a sometimes considerable benefit? The total value of this may be great in the heavily populated areas where underground water is a significant source of supply, and land subsidence becomes more and more prevalent to the detriment of surface land and property values. Regional Director Carey was both an optimist and pessimist when he testified, ". . . of course, most anything can be done. . . but we absolutely recognize the difficulty of putting water underground and earmarking where it is going to go. . . ." [6]

Important to managers of the transfer system as well as to users will be the adjustment of use rates and coordination of storage and release flows in all basins within the boundaries of the state.[34]

The need for such management will reach much farther too. The flow of the Mississippi River will have to be more closely regulated than it now is, meaning also adjusted storage and releases in the Missouri, Ohio and Tennessee rivers and their tributaries.

The institutional needs of the Texas Water Plan will not be easily satisfied. Implementation of the plan will require a great deal of just plain "bargaining" -- to get congressional approval, to determine the extent of federal participation, to organize the local interests. Bargaining will be easier if Texas gets its own "water house" in order. A bone of contention will likely be the 50-year protection for basins-of-origin against inter-basin water transfers. A predictable question is: "Why should they be given some of 'our' water when they are prohibiting efficient use of their present supply?"[1] Texans must face up to such obvious complaints and deal with them realistically.

If the Texas Water System ever becomes a reality, it is not likely to fail -- not in the usual sense of the word "failure." But it could fail to perform efficiently because of unnecessarily high institutional overhead leading to wasted manpower, inadequate services, excessively high taxes and tolls, disputes over the use of water and over institutional responsibilities, poor repayment experiences, and an overall rate of output below the system's potential. This kind of failure can be avoided by careful attention to the institutional arrangements established in implementing the plan.

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[1] Restrictions on the transfer of water (be it county-to-county, basin-to-basin, or state-to-state) make for inefficient water development and use. Where would we be, e.g. if we had the same institutional blocks in the development and use of our oil and gas resources, electric power resources, etc.?

An efficient system can be realized only after all factors involved are so organized that each does its job better than some alternative, with no more institutions than necessary to fulfill all the needs of the plan. There is evidence that the Texas Water Plan meets the tests of engineering feasibility and of economic possibility; it remains to be seen whether the plan is politically acceptable and can be implemented via the application of relevant institutions.

CHAPTER III

INSTITUTIONAL FACTORS AFFECTING LAND AND WATER USE, LOWER RIO GRANDE VALLEY, TEXAS

The lower Rio Grande Valley of Texas is one of the leading agricultural areas in the United States. It ranks third in citrus production in the nation and is important in the production of vegetable crops. Significant quantities of these commodities are marketed as fresh produce, but processing of fruits and vegetables is increasingly important and will extend the production opportunities for farmers in the Valley.[22]

While the region is very productive and applicable to many crops, there are unique problems of land and water use which must be resolved if an optimum allocation of these resources is to be achieved. The resource problems needing particular attention are (1) variability in annual supplies of irrigation water, (2) inadequate systems for diversion and distribution of irrigation water, (3) inadequate drainage of irrigated land, and (4) inefficient use of existing irrigation water supplies.

Physical conditions of supply affect the quantity of and time period that water is available for irrigation. The annual U. S. share of Rio Grande water (long-run average) is 1.7 million acre-feet, but variations in flow range from 3.5 to less than 0.6 million acre-feet per year.[26] The Soil Conservation Service has estimated that 1,175,000 acre-feet will be available to the three counties at points of diversion on the river, and that approximately one million acre-feet is available

for agricultural uses.[22] Because of the variability in flows of the river, this latter quantity fluctuates over time, but impoundments at Falcon and Amistad Reservoirs permit management of supply for regular and continuing uses. Demand for the limited irrigation water has increased in the past decade, as irrigation acreage has expanded by about 50 percent. This has resulted in a decreasing quantity of water per irrigated acre.

Contributing to the problems of water supply are the obsolete facilities of many irrigation districts. Unlined open canals allow seepage, excessive evaporation and losses of water to weeds and bushes along the canals. Some districts have no storage facilities, which could contribute to management of water diverted from the river and contained within the distribution system.

The need for improved management of the water supply goes beyond the distribution of water for irrigation and includes drainage of water following irrigations and removal of flood waters. Drainage problems are a result of too-frequent and excessive irrigations, naturally high water tables, and manmade obstacles to drainage (roads, canals, railways, etc.). Flooding occurs with large amounts of precipitation, because of inadequate outlets for water draining from relatively flat lands.

These problems of supply, distribution and drainage have received the attention of private and public agencies and individuals. The two reservoirs have been constructed on the river to regulate and conserve water. A drainage system has been proposed by the Soil Conservation Service, and a program for redevelopment of the irrigation systems is being readied by the Bureau of Reclamation. These works will contribute significantly to the solution of problems of water supply and

distribution in the Valley.

Not as obvious as the physical problems of supply, distribution and drainage are problems of institutions which condition and often control the use of land and water resources in productive enterprises of the Valley. Institutions prescribing rights, conduct and established ways of doing things are numerous in the Valley. They are the product of several nations, a mixture of cultures and a variety of people. They are often as significant to resource use as strictly economic factors such as product prices.

Efficiency in Resource Use

To identify the problem of inefficiency in land and water use in the irrigated agriculture of the Valley, and to suggest a solution to the problem, a model depicting optimum resource use in crops production was developed.[29] The total lower Rio Grande Valley was viewed as an agricultural operation managed for the purpose of the maximization of net revenue. There is a limited number of acres that can be irrigated, a certain quantity of water available for irrigation purposes and several alternative enterprises applicable to the region.[26]

Resources that are most restrictive in the Valley are land and water. Approximately 750 thousand acres are presently irrigated in the Valley. There are two principle soil types, loam and clay. On the loam soils, 19 different enterprises were considered and 14 alternative enterprises were considered on the clay soil.

Water from the Rio Grande used to irrigate the 750 thousand acres averages one million acre-feet per year. It was assumed for the analysis that water can be distributed through a technically efficient distribution system and managed on farms in a superior fashion.

Distributive efficiency was taken to be .852 and efficiency on the farm was estimated at .75.

In addition to land and water, labor and capital were also included as restricted resources, but buying activities were introduced to acquire labor and capital. Capital requirements were also reflected in the objective function; i.e., the objective function value, by activity, is returns net of production costs.

Other restrictions included in the model are market and institutional constraints. Because this was a regional study the usual assumptions of perfectly elastic demand for output did not apply to the vegetable and livestock production activities. Acreages of vegetables produced primarily in the Valley were limited to the 1964-68 average, since elasticities indicate an increase in acreage would depress price. Vegetables that are produced primarily in areas other than the Valley were assigned an upper limit greater than the 1964-68 average acreage. For example, cantaloups were allowed to increase in 20 percent over the 1964-68 production average. The allowable increase in acres of specific vegetables that would not affect price was developed in cooperation with other economists and vegetable specialists. All vegetable crops had an upper limit of acres permitted.

Institutional constraints include government farm programs and acreage allotments. Cotton acreage was restricted to the 1970 allotment.

Model development necessitated construction of enterprise budgets. Production costs were estimated based on publications and interviews with Valley farmers and specialists of Texas A&M University. The price per unit applicable to each of the crops is the 1964-68 weighted average and can be considered as a normal price.

The model was developed as a regional planning tool.[35] The optimum solution provides a comparison of the present use of available resources to an optimum allocation of existing land and water to crops. The results apply to the region (lower Rio Grande Valley) and are thus of limited value to the individual farmer in determining an optimum organization of farm firm resources.

Calculations withing the framework of the model indicate that an optimal allocation of resources to crop enterprises would require a reorganization of resources and enterprises in the Valley. Acreages of crops currently irrigated and the optimum acreages of irrigated crops are in Table 1. There are presently 760,235 acres irrigated in the Valley; the data indicate that with the assumed restraints on crops production and marketing and the present water supply, only 435,100 acres can effectively be irrigated. Those crops in the optimum solution are relatively high value crops and they are irrigated according to recommended requirements.[29] Net revenue for agriculture in the region is maximized with the combination of crops in the optimum solution.

Given the assumption underlying this study, the optimal plan with the present annual water supply indicates that not only is there insufficient water in the Valley to support the irrigation of 600 to 700 thousand acres, but inefficiency in selecting the proper crop mixes prevails. Some crops are planted which consume large quantities of water but have very low returns; e.g., cauliflower and watermelons. The returns would be increased significantly if such crops were eliminated and the water shifted to such high paying enterprises as citrus fruits, lettuce and cantaloups.

The comparison between acreages in the optimum solution with the

Table 1. Irrigated Crops Production in the Rio Grande Valley: Present Acreages and Optimum Acreages with Limited Water Supply

Land Use	Present Acreage	Optimum Solution[a/]	
		Acreage	Water Use
			(ac. ft.)
Snap beans	3,560	3,000	3,887
Beets	1,380	1,420	2,171
Broccoli	2,440	1,800	2,371
Cabbage	12,000		
Cantaloup	7,520	15,000	23,850
Carrots	22,120		
Cauliflower	580		
Sweet corn	3,200	3,000	4,442
Cucumbers	2,060		
Honeydew melons	1,200	2,500	3,975
Lettuce	4,000	3,700	5,715
Green peppers	3,140	7,200	13,715
Onions	10,360	19,200	29,603
Tomatoes	11,270		
Watermelon	3,000		
Potatoes	3,100		
Cotton	340,807	268,280	582,168
Grain sorghum	189,157		
Bermuda pasture	60,200		
Citrus fruits	79,141	110,000	319,791
Acres Irrigated	760,235	435,100	

[a/] Present average annual irrigation water supply available in the Rio Grande Valley.

present water supply and the acres of land actually used in the Valley raises a question about the rationality of decisions about land and water use. Yet there are some good reasons for the present allocation of resources to crops. First, farmers usually select crops with minimum amounts of risk. This is true in the case of cotton and grain sorghum. While the optimal plan suggests that only 268,280 acres of cotton should be planted, farmers in the area plant their full allotment (340,807) acres. It would be more profitable for farmers to shift part of the cotton acreage to such crops as cantaloups and honeydew melons, but prices for these crops are not supported, as is the case with cotton. While the optimum plan indicates that grain sorghum should be produced on dryland, the usual practice is to irrigate this crop. Shift of the water resource to other high value crops would be more profitable, but the typical farmer feels that grain sorghum is relatively riskless. He does not want to commit an investment to other crops which might be more risky, even though the operation results in higher average returns per acre. Secondly, cultural practices and traditions are strong in the area. The average farmer is accustomed to the existing crop mix, and he keeps growing the same crops every year. There are, in addition, preferences for certain crops like oranges and grapefruit. Acreages of these crops are relatively constant. There is little apparent inclination to change crop mixes. Third, it is well known that capital rationing, both internal and external, usually prevents the average farmer from carrying out plans for relatively efficient uses of resources in crops production. Often little can be done to change this circumstance.

These factors, and others, aggravate the problem of water shortage and produce an inefficient use of this resource. Total returns are

lower than those possible if they select optimal crop mixes and use water efficiently in crops production.

This analysis indicates that a "misallocation" of resources exists in the Valley. The results indicate the general direction necessary for an improvement of the organization of resources and enterprises.

Some Specific Institutional Problems

In an earlier study of institutions affecting land and water use in the lower Rio Grande, some specific institutional arrangements of singular importance were identified.[3] Among these were water rights, water supply districts, operational policies in districts and pricing policies for water. These were given further attention in this study to determine their influence and to suggest changes, if needed, in them.

An examination of the water right, as an institution, produced the conclusion that the efficiency of water use can be increased by making water rights or annual water allocations freely negotiable. With market exchanges of rights and/or allocations and the present water supply, there would be changes in cropping patterns and enterprise combinations that would virtually eliminate the use of irrigation water to produce low value crops, such as grain sorghum. Water released from such uses would be employed in the production of cotton and for more intensive irrigation of citrus, especially during years of low river flow.

An indication of changes in water use which would be brought about by market exchanges of rights is found in Tables 2, 3, 4 and 5. In these tables optimum uses of land and water in crop enterprises with various water prices is shown. In circumstances where water was sufficiently available that the market price of annual allocations was

Table 2. Enterprise Combination and Water Use by Crops When Water Price is $9.60 Per Acre Foot.

Enterprise		Acreage	Irrigation Water Use - Ac. Ft.
Snap beans	(loam)	3,000	3,887
Cotton-3	(loam)	268,280	582,168
Beets	(loam)	1,200	1,755
Cabbage	(loam)	7,500	13,206
Carrots	(loam)	15,000	18,150
Green pepper	(loam)	6,500	12,450
Lettuce	(loam)	3,500	5,232
Onions	(loam)	17,500	26,162
Sweet corn	(loam)	3,000	4,442
Broccoli	(loam)	1,800	2,371
Potatoes	(loam)	4,000	5,543
Honeydew melons	(loam)	2,500	3,975
Cantaloups	(loam)	15,000	23,850
Citrus	(loam)	90,000	261,825
Grain sorghum-1	(loam)	210,667	326,534
Citrus	(clay)	20,000	58,966
Cotton-3	(clay)	154,978	346,505
Grain sorghum-1	(clay)	161,422	245,765
Beets	(clay)	220	416
Pepper	(clay)	700	1,265
Lettuce	(clay)	200	483
Onions	(clay)	1,700	3,441
Sweet corn	(clay)	600	1,293
Broccoli	(clay)	750	1,355
Irrigated Acreage		990,017	

Table 3. Enterprise Combination and Water Use by Crops When Water Price is $18.65 Per Acre Foot.

Enterprise		Acreage	Irrigation Water Use - Ac. Ft.
Snap beans	(loam)	3,000	3,887
Cotton-3	(loam)	168,280	582,168
Beets	(loam)	1,200	1,755
Carrots	(loam)	15,000	18,150
Green pepper	(loam)	6,500	12,450
Lettuce	(loam)	3,500	5,232
Onions	(loam)	17,500	26,162
Sweet corn	(loam)	3,000	4,442
Broccoli	(loam)	1,800	2,371
Potatoes	(loam)	4,000	5,543
Honeydew melons	(loam)	2,500	3,975
Cantaloups	(loam)	15,000	23,850
Citrus	(loam)	90,000	261,825
Cotton-3	(clay)	154,978	346,505
Citrus	(clay)	20,000	58,966
Beets	(clay)	220	416
Pepper	(clay)	700	1,265
Lettuce	(clay)	200	483
Onions	(clay)	1,700	3,441
Sweet corn	(clay)	600	1,293
Broccoli	(clay)	750	1,355
Irrigated Acreage		610,428	

Table 4. Enterprise Combination and Water Use by Crops When Water Price is $27.90 Per Acre Foot.

Enterprise		Acreage	Irrigation Water Use - Ac. Ft.
Snap beans	(loam)	3,000	3,887
Cotton-3	(loam)	268,280	582,168
Beets	(loam)	1,200	1,755
Green pepper	(loam)	6,500	12,450
Lettuce	(loam)	3,500	5,232
Onions	(loam)	17,500	26,162
Sweet corn	(loam)	3,000	4,442
Broccoli	(loam)	1,800	2,371
Honeydew melons	(loam)	2,500	3,975
Cantaloups	(loam)	15,000	23,850
Citrus	(loam)	90,000	261,825
Citrus	(clay)	20,000	58,966
Beets	(clay)	220	416
Pepper	(clay)	700	1,265
Lettuce	(clay)	200	483
Onions	(clay)	1,700	3,441
Irrigated Acreage		435,100	

Table 5. Enterprise Combination and Water Use by Crops When Water Price is $32.46 Per Acre Foot.

Enterprise		Acreage	Irrigation Water Use - Ac. Ft.
Snap beans	(loam)	3,000	3,887
Grain Sorghum DL	(loam)	505,447	- 0 -
Beets	(loam)	1,200	1,755
Green pepper	(loam)	6,500	12,450
Lettuce	(loam)	3,500	5,232
Onions	(loam)	17,500	26,162
Sweet corn	(loam)	3,000	4,442
Broccoli	(loam)	1,800	2,371
Honeydew melons	(loam)	2,500	3,975
Cantaloups	(loam)	15,000	23,850
Citrus	(loam)	90,000	161,825
Citrus	(clay)	20,000	58,966
Grain Sorghum DL	(clay)	217,750	- 0 -
Beets	(clay)	220	416
Pepper	(clay)	700	1,265
Lettuce	(clay)	200	483
Onions	(clay)	1,700	3,441
Irrigated Acreage		166,820	

$9.60 per acre foot, all the irrigable land in the Valley would be irrigated and crops would be produced as in Table 2. If circumstances changed such that market prices for annual allocations were worth $18.65 per acre foot, only 610,428 acres would be irrigated (Table 3). If the price of water went on up to $27.90 per acre foot, only 435,100 acres would be irrigated and crop enterprises would be reduced to 16. With a price of $32.46 per acre foot only 166,820 acres are irrigated. Without such a marketing mechanism for water, the combination of water-using enterprises tends to stay very much like that of the present (Table 1), with 650 to 700 thousand acres irrigated. There is a misallocation of water because the right is fixed to the land, it is not negotiable, and water prices within districts are presently relatively low--about $9.60 per acre foot.

It was also found that there is little likelihood that area producers will radically change the organization or structure of existing water supply districts in the Valley. This conclusion was unexpected; it seemed obvious that consolidation of districts would be advantageous--that facilities could be improved and water distribution efficiency increased. For several reasons, such developments may not take place. First, the economies of size which could be realized by district consolidation and reorganization do not appear to be sufficient to encourage such changes. Second, the physical layout of the districts and the orientation of their facilities to the river would make consolidation very expensive in terms of initial investment for many districts. Third, there are tremendous differences in condition of facilities, sizes of debts, and levels of taxes among districts, which would make arrangements for consolidation very difficult. Fourth, the present organizational structure of the water

districts allows approximately 170 producers to be active as directors in the operation and policy of the water districts. Any reorganization or consolidation of districts would reduce the number of local producers who can serve as directors and would tend to centralize control of this Valley institution.

Attention was also given to possibilities for rehabilitation of irrigation districts. Many are obsolete, in terms of facilities that are necessary to an efficient distribution of water. Service to district members is, in some cases, relatively poor. There are problems in timing of water applications because of slow service. In addition, significant quantities of water are lost to weeds and trees along canals and by infiltration into the soil of unlined canals.

The analysis consisted of an evaluation of returns to land and management in the region with and without rehabilitation of water distribution systems. Five separate levels of rehabilitation were examined, the levels representing various quantities of irrigated land which might be involved. It was assumed that .507 additional acre feet of water would be available in rehabilitated districts, as compared with those not so improved. The water "saved" would cause output of rehabilitated districts to be greater. Costs of rehabilitation were assumed to be $166 per acre, typical of recent costs in the Valley.

Results of the analysis indicate that there is no one optimum level at which to carry out rehabilitation (see Table 6). If the decision-maker wishes to maximize the benefit-cost ratio or the net benefits per acre, these decision variables are maximized at level five, where irrigated acreage involved will be only 166,820 acres. If return to investment in rehabilitation is the variable to be maximized, the optimum level is four, where acreage included is 435,100 acres. At this point the

Table 6. Benefits and Costs Associated with Rehabilitation of Valley Irrigation Districts, Selected Levels of Water Use.

Acres Irrigation (Level)	Acre Ft. of Water Used	Cost of Rehabilitation @ $166/Acre	Present Value Benefits 3/ Discounted 5%	Present Value Benefits 3/ Discounted 7½%	Net Benefits 5%	Net Benefits 7½%	Net Benefits Per Irrigated Acre 5%	Net Benefits Per Irrigated Acre 7½%	Benefit/Cost Ratio 5%	Benefit/Cost Ratio 7½%	Return to Land & Management with Rehabilitation
990,017 1/	1,948,805 1/	$164,432,822	$ 70,877,544	$ 52,022,628	-$ 93,465,278	-$112,320,194	-$ 94.40	-$113.45	0.43:1	0.32:1	$72,642,620
665,316 2/	1,446,866 2/										
771,850 1/	1,609,065 1/	128,127,100	246,650,420	181,036,223	118,523,320	52,909,123	153.56	68.55	1.92:1	1.41:1	69,970,482
536,905 2/	1,217,738 2/										
610,428 1/	1,363,300 1/	101,331,048	258,930,835	190,049,789	157,599,787	88,718,741	258.17	145.34	2.55:1	1.87:1	67,745,689
463,588 2/	1,053,813 2/										
435,100 1/	990,120 1/	72,226,600	328,142,318	240,849,563	255,915,718	168,622,963	588.17	387.55	4.54:1	3.33:1	61,030,112
333,443 2/	769,524 2/										
166,820 1/	407,953 1/	27,692,120	196,204,199	144,009,757	168,512,079	116,317,637	1010.14	697.26	7.08:1	5.20:1	47,723,531
130,410 2/	323,376 2/										

1/ With rehabilitation

2/ Without rehabilitation

3/ Present value of benefits based on estimated 40 years useful life of district facilities

present value of net benefits is at a maximum. Another decision which could be made would be to maximize regional net returns to land and management, with the constraint that the present value of net benefits must be positive. The level of rehabilitation which would maximize this variable is level two, where 771,850 acres would be involved in rehabilitation.

Limitations and Need for Further Study

This study, like most, is subject to several limitations. While the study of water supply districts shed considerable light on district operations, an analysis of the data available from district audits and annual reports did not contribute very much to an understanding of several important facets of district operation. For instance, many services can be provided by a district with modern, efficient facilities and management which could not be provided by districts with less modern and efficient facilities. Such a district can provide more timely delivery of water than other districts but this does not show up as added efficiency in any analysis of per acre or per acre foot delivery cost. Another problem lies in the way in which district audits are conducted. Some districts report certain costs as annual operating expenses while others report the same costs as capital investment. A third problem with this part of the study is associated with the short time period of the analysis. Some districts appear to carry out only enough annual maintenance to continue operation and depend on occasional heavier outlays to maintain their systems. In a short term study, these outlays may not be isolated as annual operating and maintenance costs. Some of these maintenance costs were probably not accounted for in this study because of the relatively short period

for which data were available.

Because the Water Control and Improvement Districts which pump and distribute irrigation water in the Valley play an important role in water management and use in the area, it would be desirable to have additional information about them. The most practical way to get it, given the problem of securing meaningful data from thirty-four separate and independent entities, would probably be through the use of a case study approach, whereby selected district operations could be studied in depth, appraised and compared.

This study has been an attempt to conduct an in-depth analysis of a few of the more important institutions which affect water use and management in the Rio Grande Valley. The study has led to recommendations for change that should improve the efficiency of use of the scarce resource, water. But institutions do not change easily. The likely impacts of change must be well known and the effects must be positive and significant if the change in institutions is to be seriously considered. The need for research to identify and evaluate the impact of institutional factors which influence water development and use will continue to be of critical importance if the Rio Grande Basin is to continue to prosper as an important agricultural area.

PUBLICATIONS

The following publications were developed as a result of the research in this project.

"Institutional Factors in Water Development," Proceedings, 12th Water for Texas Conference, Warren Trock, Water Resources Institute, Texas A&M University, College Station, Texas.

"Institutional Factors and the Texas Water Plan," Proceedings, 42nd Annual Meeting, Western Agricultural Economics Association, Warren Trock, published by Oregon State University, Corvallis, Oregon.

"Institutional Factors Affecting Land and Water Development, Lower Rio Grande Valley, Texas," Water Resources Research, Warren Trock, Journal of the American Geophysical Union, Vol. 5, No. 6, December, 1969.

A Study of Institutional Factors Affecting Water Resource Development in the Lower Rio Grande Valley, T. Casbeer and W. Trock, Technical Report No. 21, Water Resources Institute, Texas A&M University, College Station, Texas.

"Institutional Factors and the Texas Water Plan," Water Resources Bulletin, W. Trock and C. Jensen, Journal of the American Water Resources Association, Vol. 6, No. 2, April, 1970.

Organization of Agricultural Resources in the Lower Rio Grande Valley of Texas With Limiting and Non-Limiting Water Supply, A Dissertation by Abdullah T. Thenayan, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

A Study of the Effects of Institutions on the Distribution and Use of Water for Irrigation in the Lower Rio Grande Basin, A Dissertation by Roy M. Gray, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

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