TECHNICAL MEMORANDUM

A METHODOLOGY FOR ESTIMATING ECONOMIC IMPACTS IN SOUTH FLORIDA FROM AGRICULTURAL DROUGHT
(Research Project - Program No.8007)

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ABSTRACT

The purpose of this research is to develop a methodology for analyzing the economic impact of a drought on agriculture within the boundaries of the South Florida Water Management District (WMD or the District). The study includes an analysis of drought effects on the following: celery, lettuce (Iceburg and Romaine varieties), snap beans, sweet corn, tomatoes, citrus (oranges used in the production of concentrated orange juice), fresh pink and white seedless grapefruit, sugarcane, and beef cow/calf operations.

A framework is developed which clarifies the types of impacts which might be expected and identifies the groups on whom the burden might fall. A careful separation is made between impacts within the District's boundaries and in the rest of Florida and the United States. Relationships and procedural guidelines are then developed for measuring the major southern Florida impacts which include revenue losses and/or cost increases to farmers, along with their cost reduction efforts to reduce losses and/or transfer the burden to other sectors of the local economy.

Government grants-in-aid and small business loans are also considered as instruments that could ameliorate the adverse effects of drought.

I. PURPOSE AND SCOPE

South Florida's normal annual rainfall exceeds fifty inches per year; however, this rainfall is not uniformly distributed throughout the year. The majority of the rainfall occurs during the summer and fall months (wet season) while the normal dry season extends through the winter into the spring months. This uneven distribution of rainfall taxes the water system during southern Florida's period of greatest economic activity. Tourism and agricultural activities are at their zenith during the dry season, causing major increases in the demand for water.

South Florida, under normal conditions, has a plentiful water supply to meet all of these demands because the area's water system can store enough of the wet season's rainfall for use in the dry season. Water is normally stored in Lake Okeechobee and in the region's three water conservation areas. Supplies from the water conservation areas are used to recharge the Biscayne Aquifer which, in turn, is used to supply the majority of the urban and agricultural water needs in the lower east coast of Florida - except for Palm Beach County. The Everglades Agricultural Area and the urban areas of Palm Beach County are supplied through discharges from Lake Okeechobee. During the dry season, discharges from the lake are also used for maintaining the water levels in the water conservation areas and for recharging the Biscayne Aquifer.

Normal dry season rainfall helps to relieve some of these supplemental water needs. This rainfall normally gives enough relief so that the water system is not over-taxed. During the 1970/71 dry season, however, rainfall was not sufficient to help recharge the system. Water supplies were dwindling to the point where some urban water utilities, such as Miami-Dade Water

Authority, had to place constraints on the use of water for lawn irrigation and/or automobile washing. Agriculture was not seriously affected by the drought. No loss in crop production was measured although agricultural consumption was ordered reduced by thirty percent. No information is available on the degree of compliance with this order.

The purpose of this research was to consider several theoretical and empirical economic ramifications of a short-term (i.e., approximately three months) drought within the District. The study focused on the direct economic impacts on the agricultural sector and on the total effect on the economy within the District's geographical boundaries.

The District will be able to beneficially use the methodology in and results of this report. Even though the probability of the hypothesized drought occurring in a given year appears to be relatively slight, there is, indeed, a real possibility. One has only to refer to the drought of 1970/71. The District, using its permit authority[1], has the ability to ameliorate adverse economic impacts due to a drought by means of restricting water use in areas of least impact.

These economic impacts include both the direct and indirect effects on the economy in southern Florida. The direct effects are those that fall upon farmers and appear as changes in their total revenue and in any increase in their total variable costs. The indirect effects include the amount of the impact which can be shifted to labor and other variable inputs. This shifting of the burden can be accomplished by using less labor and materials for

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[1]The study is concerned with an agricultural drought. This condition is a function of moisture and water-response plant behavior; therefore, the presence of this drought will have different effects on individual crops due to their different water-response characteristics.

harvesting and by reducing marketing efforts. In addition, further indirect impacts will be realized from a multiplier effect, i.e., a chain reaction of reductions in purchases of goods and services due to the initial impact to the farmers. When the farmers are forced to reduce labor expenses, the reduction in income for the laborers means that they have less to spend, forcing them to reduce their demand for goods and services. This scenario will be repeated again and again until it manifests itself in an additional significant economic impact. Thus, there are two types of indirect impact - the shifting of the initial (or direct) impact and the additional impact due to the multiplier effect.

The existence of government grants-in-aid and small business loans may influence the net total economic impact. The amount of the influence is determined by the percentage of the producers of agricultural commodities which qualify for assistance.

The following section consists of a discussion of the methodology and framework for the analysis. This discussion establishes the guidelines for data collection and analysis and for quantitative model definitions which appear later in the report.

The development of the theoretical framework and empirical tests were designed to be used as a reference for the District in anticipation of a drought in southern Florida. Consequently, for forecasting purposes, empirical tests were performed only in those areas where reasonable stability is expected to exist in the future and where no simple approach was available. Therefore, the empirical work was confined to the demand relationships of the five vegetable groups and of seedless grapefruit.

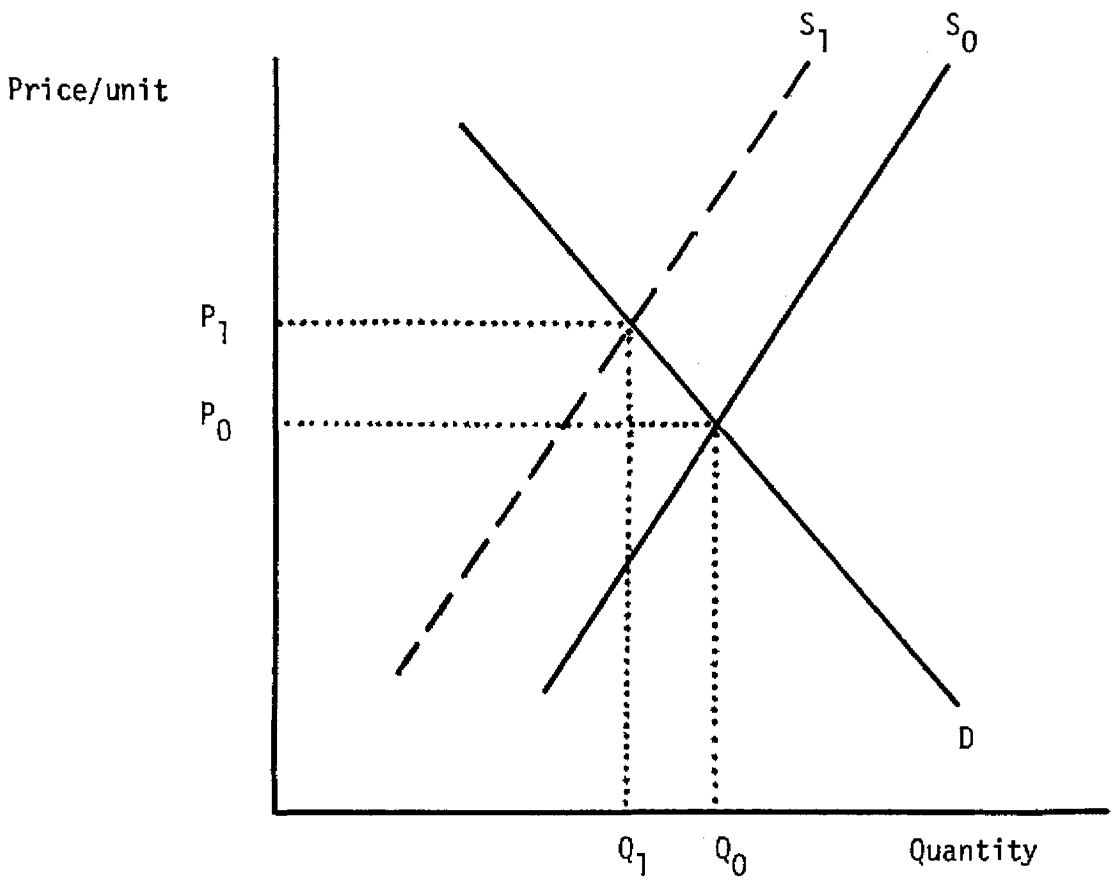
The report concludes with sections on results of these empirical tests and a summary of, and conclusions from, the research project.

II. FRAMEWORK AND METHODOLOGY

For purposes of this analysis it is assumed that droughts of two to three months duration have no significant effect on planted acreage from year to year because individual droughts are relatively infrequent and unpredictable. Furthermore, the probability of an occurrence of a drought in southern Florida, as indicated from historical experience, is highest between March and May. The determination of planted acreage for all annual crops is made many weeks before this time period. Most of the costs which make up both the short and long-run market supply curves should be largely unaffected by a drought. Thus, one may posit that, disregarding technological advancements, the intended short-run and the long-run supply curves are unchanged and a drought would cause an upward shift in the short-run supply curve only. The degree of shift would be a function of the severity of the drought.

Market supply is a schedule of prices per unit of output and quantities of output which suppliers in the market are willing to supply at those prices over some unit of time. This can be illustrated as a two-dimensional relationship between unit price and quantity (S_0 or S_1 in Figure 1). This relationship is the sum of the marginal cost relationships of the market suppliers. Using the assumption of profit maximization results in the supply function being synonymous with the marginal cost vs. output relationship because an additional unit of output will not be supplied unless the price of that unit equals its marginal cost.

The time frame considered is identified as short-run since a large portion of the factors of production is fixed, e.g., that portion consisting of planting costs and land rent; therefore, the market supply (marginal cost) curve reflects the production functions of firms with both fixed and variable inputs - fixed inputs being inputs which do not change with changes in output and variable inputs being inputs which do.



Short-run Market Supply (S) and Demand (D)

FIGURE 1.

The hypothesized drought will most likely affect only decisions regarding harvesting operations since that is the only process remaining in the crop cycle. To recover any crop losses, for example, producers must incur extra costs. The ability to recover the output loss from the drought is reflected in the slope of the supply curve after it has been shifted to the left by the drought (S_0 to S_1, in Figure 1). It should be noted that the shift in supply does not determine the direction of changes in revenues - if any. It is the elasticity of demand which indicates whether revenues will increase or decrease with a change in the quantity of output in the market (34).

Once decisions regarding the amount of acreage to be planted, intensity of planting, and soil preparation have been made, the short-run supply curve existing at the most likely time for a drought will be almost vertical. This situation, of course, is descriptive of both the individual producers and of the market levels. Normal harvesting practices are intended to reap all but a negligible amount of produce. Thus, the ratio of actual to potential harvest should be very close to unitary. Any variations from this level will be a function of the producer's production functions and their payment agreements with the inputs, i.e., labor contracts, transportation charges, etc. Consequently, when this ratio is equal to one, the supply is perfectly price inelastic. As this ratio decreases, the elasticity of supply increases.

In general terms, one may assume that farmers usually follow harvesting practices that allow them to harvest all but an insigificant amount of the planted crops. There are, however, possible labor contractural arrangements, for example, that would force the operators to leave additional amounts of crops in the fields. As an illustration, contracts which have payments for labor on a time basis (rather than piece-work) may force the farmers to forego harvesting areas in the fields where the crops' produce is sparse.

Thus, the ratio of actual to potential harvest is decreased. Furthermore, when the ratio is significantly less than one, there is the implication that the farmers are able to increase their harvest if the prices of the products being harvested are sufficiently high to cover the incremental costs. This allows for a more elastic supply than would exist if the ratio was close to one - i.e., essentially no residual crops left in the fields.

From the above comments, the conclusion can be made that demand will determine the market-clearing price once producers have made their planting decisions. Once a drought has occurred, its impact of reduced output will be felt in the market resulting in a shift in supply. Most producers should be able to reduce their harvesting and marketing costs from less labor hours, cartage, transporation costs, etc.

Market demand is analogous to market supply in the sense that it is a schedule of prices and quantities of output. Specifically, it is a schedule of prices per unit of output and quantities of output which buyers in the market are willing to buy at those prices over some unit of time. While quantities supplied have positive correlations with prices, quantities demanded have negative correlations with prices (D in Figure 1). As with the market supply curve, the market demand may be considered as the sum of the demand functions of the individual participants in the market.

As mentioned above, the price elasticity of demand determines the direction of revenue changes when there are shifts in supply. Price elasticity of demand is defined as the percentage change in quantity demanded from a one percent change in price. Since the demand function has a negative slope, an increase (decrease) in price will result in a decrease (increase) in quantity demanded. Thus, values for this elasticity are considered to be always negative. If the absolute value of price elasticity of demand is less than one, a decrease (increase) in quantity demanded will result in an increase (decrease) in revenue. When the value is greater than one, a decrease (increase) in quantity demanded will result in a decrease (increase) in revenue. When elasticity is equal to one, there is no change in revenue from a change in quantity demanded in either direction.

Once an estimate is made of the impact on agricultural revenue, the task remains to identify and evaluate the distributional effects on the factors of production. To adequately achieve this requires a substantial research on the producers' production function. This effort is worthy of future review. However, one may make intuitive observations of and approximations to these derived effects. Infrequent droughts will have an insignificant effect on acquisition of capital goods and land. Instead, the impact should be felt by labor, harvesting, supplies, and entrepreneural inputs.

In addition to the distributional effect on the factors of production is the consideration of the multiplier effect. This phenomenon appears from a series of economic transactions within the complex interactions of an economy. For example, when an agricultural producer has his income reduced from a drought, he will probably reduce his purchases of goods and services. The supplier of these goods and services will correspondingly have his income reduced from this reduction in purchases. This chain reaction will repeat itself throughout the economy.

To attempt to quantify this multiplier effect requires the estimation of the limit of this factor and the proportion of the transactions which are within the District's economy.

It is important to realize that the full multiplier effect will not be felt in the Florida economy. To the extent that purchases of goods and services would have been purchased from outside the state, the value of the multiplier should be reduced.

To illustrate the procedure to estimate the multiplier within the District's economy, assume that individuals in the economy spend 80% of any change in their income on consumption, the series of transactions can be represented by the following geometric progression:

$$\lim_{n \to \infty} (1 + .8 + .8^2 + \ldots + .8^{n-1}) = \frac{1}{1-.8} = \frac{1}{.2} = 5$$

The time period in which this effect will be realized will depend upon the time required for this series of transactions to work its way through the economy. Since this series is infinite, the multiplier is an upper limit which, theoretically, will be approached but never reached. If one assumes that fifty percent of all consumption expenditures result in following transactions outside of the District's economy, the above multiplier would have an effective value of fifty percent of its initial value. For the above illustration, the value would be 2.5. The direct impact calculated above is then multiplied by this factor to estimate the total economic impact.

The research completed for this project focuses on developing mathematical models which represent existing market demand functions for selected crops. These models were tested with empirical data for verification using the least squares regression techniques. The resulting evaluations of the structure of the models and their parameters provides a means to identify the relationships among market variables.

The purpose of these models is to evaluate the direct economic impact - identified as the reduction in revenue - on the major portion of the District's agricultural sector due to an hypothesized drought.

III. LITERATURE REVIEW

An extended effort was made to review the literature relevant to this project. The search was focused on studies of natural disaster impacts on crops and on price/quantity market relationships in the agricultural sector pertaining to both direct and indirect impacts on the agriculture and other sectors of the economy.

Studies on these topics would provide possible alternative or additional analytical techniques and data sources. The results from these research projects could test the effectiveness of specific techniques. Also, the data analysis should be helpful in avoiding misleading or inaccurate data. In summary, these studies can provide guidelines for the analysis and estimates for parameters being analyzed.

It is important, however, that the literature - to be useful - is relevant to this research. For example, estimates for the price elasticities which are based on national data should not be used as surrogates for price elasticities in the southern Florida area. However, these types of results have some value if they provide upper or lower limits to related variables appearing in this study. If estimates for price elasticities are based on the national market, for example, these estimates can be used as lower limits for estimates of corresponding elasticities for the southern Florida market - if other factors, such as the length of the time period, are the same.

Market research on price/quantity relationships for Florida vegetables is relatively limited. Two studies were conducted in the early 1960's at the Institute of Food and Agricultural Sciences (University of Florida). No other studies have been conducted on vegetables until recently, when funding for this type of study was resumed. The impacts of Mexican competition, for example, have influenced the perception of the need for market studies.

Brooke and Jung (2) studied the Florida celery industry in 1963. The purpose of the study was to analyze the impact of the creation of the Florida Celery Committee. The marketing order which created the Committee was adopted in 1961 as a response to three consecutive years of losses to the Florida celery industry caused by market over supply and consequent low prices. The marketing of celery, after 1961, was controlled by a central subcommittee comprised of growers appointed by the Secretary of the Florida Department of Agriculture. The committee was given the power to set prices received by members and the same basic market structure is still used. Price/quantity relationships were developed, although the regression results were not presented in the paper. The analysis showed that price elasticity of demand, in the short-run, was unitary at $2.00 per box at the mean levels.

Brooke and Bell (3) also studied the sweet corn industry for the 1960/61 thru 1962/63 seasons. They used weekly shipments and Friday FOB prices. They found two distinct marketing seasons - the winter season (ending around the second or third week in February) and the spring season. Demand was price inelastic in the winter (presumably because Florida was the only major producer of a winter crop) and price elastic in the spring (presumably because other regions of the country were beginning their harvesting season in April and May). The elasticities were computed at four levels of shipments - at the mean, the mean plus and the mean minus one standard deviation, and the level where elasticity was equal to one. The elasticities for the first three levels were -3.04, -1.34, and -13.15, respectively.

Shonkwiler (6) developed price/quantity relationships for celery in 1979. The study used average monthly data (December thru June) for the 1972/73 - 1977/78 seasons. He found that the Florida market was sensitive to prices received in California and to shipments from Florida during the preceding week. Demand shifters (dummy variables) were tested and those for the beginning and end of the season were found to have an effect upon the relationships. A dummy variable representing "year" was used and found to be significant also. The estimates for price elasticities for the quantity variable for the same week and lagged four weeks were -.481 and -.979, respectively.

Funds for citrus market research historically have been more abundant because citrus producers have been willing to tax themselves for this type of research by paying .1¢ per box to the Department of Citrus. Ward's (11) 1976 study was the most recent attempt to estimate demand for Florida Concentrated Orange Juice (FCOJ). The research estimated retail demand. Domestic retail price elasticity was -.501 and price elasticity of exports to Canada was -.523, showing that demand was inelastic. Exports to Europe were elastic, with price elasticity measured at -2.259 at the mean levels.

Edwards and Langham (9) estimated the demand functions for selected Florida crops. A distributed - lag model was used with annual state data for the seasons from 1955-56 through 1967-68. Estimates were made on an annual basis of both short - and long - run price elasticities at the means of the data for tomatoes, winter potatoes, snap beans, sweet corn, and squash. The short-run elasticities for tomatoes, snap beans, and sweet corn were estimated to be -.8920, -1.2490, and -.6444, respectively.

IV. PRODUCT SELECTION AND DATA ACQUISITION

To verify the postulated models, from which estimates of economic impacts of a drought can be derived, requires the collection of timely and quality data. In the case of the agricultural sector, a subset of the products which make up the total agricultural output was selected. A total of nine product groups represents a great proportion of the total agricultural sales from the region.

The five major winter vegetables selected had sales equal to or exceeding $20 million during the 1977-1978 growing season for crops grown within the District's boundaries. They accounted for $139.1 million of $190 million (73%)

of all vegetable sales in the District. Sales from citrus products grown in the District's region exceeded $95.7 million. This was heavily concentrated in the seedless grapefruit and orange markets with sales of $71.8 million and $23.7 million, respectively. As a result of this concentration, both seedless grapefruit and oranges were chosen for analysis. Finally, because the estimated gross annual sales of calves from Palm Beach County alone lies within the $15-18 million range, this livestock market was included in the study.

The livestock information was obtained from telephone interviews with agricultural professionals in south Florida. The general consensus among these individuals was that the dairy industry and the Seminole Sugar feedlot operation would be largely unaffected by a drought during the March-May period. These operations are designed to use supplemental feeding on a year-round basis and have facilities to store silage and high protein food supplements for long periods of time.

The cattle ranching industry in the Everglades Agricultural Area (EAA) is predominantly a "cow/calf" operation with sales of weaned calves to feedlots in Georgia, Texas, and Oklahoma. These operators, however, should be affected by a drought. Their options to reduce their losses are:

1. purchase extra supplemental feed, hold the calves to the normal weaning weights, and minimize damage to the grazing pasture;
2. continue normal amounts of supplemental feed to the brood cows, sell the calves, and minimize the damage to pasture from overgrazing; or
3. continue normal supplemental feeding to brood cows, keep calves to normal weaning time, and overgraze pasture.

All of the individuals interviewed indicated that the third alternative would be chosen. This would, instead of reducing their revenues, result in increased cost for repairing the damage to the pasture. These expenditures would offset some of the indirect income losses on the District's economy. Thus, the livestock operation is the only group in the analysis which is able to avoid revenue losses from a drought - but not without a cost.

In summary, the agricultural goods considered in this study were 1) celery, 2) lettuce, 3) snap beans, 4) sweet corn, 5) tomatoes, 6) seedless grapefruit, 7) oranges for frozen orange juice concentrate (FCOJ), 8) sugarcane, and 9) cow/calf livestock.

A. Cost Data

The data for vegetables and citrus can be acquired from various publications. All of the data from sources identified in the bibliography, according to the authors, were gathered by personal interviews with growers and processors of the designated crops. The number interviewed varied from year to year. In some instances, the respondents had suspended or sold their operations or refused to renew their participation in the program. Along with these comments, the authors did not guarantee that their samples were representative of the population of growers in their area.

Due to the uniqueness of the data and being under a time constraint, intensive evaluation of the data quality was not possible. This, however, is a worthy topic for future research.

All vegetable cost information can be collected from D. L. Brooke's annual publication Costs and Returns from Vegetable Crops in Florida (1) for numerous seasons. Brooke presents average costs per acre and per bushel by major group and sub-group categories. The two major categories are 1) growing costs and 2) harvesting and marketing costs. Harvesting and marketing costs include such sub-group expenses as picking and packing costs, container costs, hauling-to-market costs, and selling costs. Table I shows the unit costs appearing in Brooke's publication for the 1977-1978 season.

TABLE I.

Average Vegetable Harvesting and Marketing Costs/Unit for 1973-77

Vegetable	Unit	Amount
Snap beans	bushel	$ 2.02
Celery (Everglades area)	crate	2.34
Sweet corn (Everglades area)	crate	1.87
Cucumbers (Palm Beach-Broward Counties)	bushel	2.52*
Leaf crops (Everglades area)	crate	1.74
Tomatoes (Dade County)	30 lbs.	2.22

*1977-78 season

The farmer may incur additional growing costs if he decides to replant the lost portion of his crop. However, it is felt that there would be a low probability of his replanting the crop since the hypothesized drought would occur towards the end of the normal winter/spring growing season. Harvesting of most vegetable crops in southern Florida begins to taper off in April and May, and completely ends by the middle of July.

Preliminary cost data collection should include harvesting and marketing costs by sub-group. The summation of the component costs yields total variable costs which would be affected by the hypothesized drought. Data are available by crop type and corresponding growing area for snap beans, celery, corn, and leaf crops. These cost data can be used for snap beans grown in the Broward-Palm Beach area, and for celery, sweet corn, and leaf crops grown in the EAA for the aforementioned seasons. Information on costs for Iceburg and Romaine lettuce is not available, but costs for harvesting and selling leaf crops in general would probably be usable in the analysis.

Average total costs for harvesting and marketing can be collected separately for snap beans, celery, sweet corn, tomatoes, and leaf crops. The desired time period for tomatoes, however, should be chosen carefully because costs of this crop are not expressed in constant shipping units - i.e., container sizes. To avoid this problem, data for this crop should have a time frame beginning in the 1973/74 season, or later.

Harvesting and marketing costs for tomatoes grown in the Pompano growing area are not available. The Dade area costs more closely resemble costs for tomatoes grown in the Pompano area than would the data for Ft. Pierce for two reasons: 1) the majority of the tomatoes were grown along the eastern coast of Palm Beach County and in the interior of Broward County, and 2) the economic base in the study area more closely resembles Dade County than St. Lucie

County. It is therefore hypothesized that Dade area labor and fuel costs should be used as a surrogate for the Pompano areas.

Fresh grapefruit variable costs can be obtained from Estimated Costs of Picking and Hauling Fresh Florida Citrus, 1977-78 (13) and Estimated Costs of Packing and Selling Fresh Florida Citrus, 1977-78 (12). Both publications present time series data for the period beginning with the 1960/61 growing season and ending with the 1977/78 season.

The picking and hauling costs for oranges can be acquired from Estimated Costs of Picking and Hauling Fresh Florida Citrus, 1977-78 (13) and the processing and selling costs can be obtained from Estimated Costs of Processing Warehousing and Selling Florida Citrus Products, 1977-78 (14). Both publications present series data beginning with the 1965/66 season through the 1977/78 season.

The harvesting and processing variable costs for sugarcane can be based on Brooke's study for the 1975/76 season.

The additional cost for cattle ranchers to repair pastures overgrazed during a drought can be estimated. The sources used for estimates of the costs of inputs required for repairing the damaged pasture can be obtained from agricultural experts in south Florida (25-27,29).

B. Product Market Data

The data for snap beans, celery, sweet corn, lettuce, and tomatoes were obtained from the Marketing Florida Vegetables Summaries (4) for the 1972/73 through the 1977/78 seasons. Different areas of the country use different size containers for some or all of the vegetables. Thus, the "carlot" equivalent data was expressed in average number of containers shipped in a "normal" sized railroad car. Conversion factors were used to standardize the number of containers for each railroad car. Then, the data for out-of-state shipments were converted to units of 1,000 pounds to make it compatible with the data for Florida shipments.

All shipment data represented total recorded weekly shipments for an area such as California, Mexico, Florida, or regions in Florida. Data were available for Florida export shipments which passed through the Agricultural Inspection Stations along the Suwannee River in northern Florida. Some export vegetable shipments may have bypassed the inspection stations; however, these shipments probably represented less than ten percent of the total Florida shipments (8). There was no adjustment made in the data to account for these missed shipments. Also, these data do not account for intra-state shipments.

The time frame for the empirical analysis was from the 1973/74 season through the 1977/78 season - the last season for available data.

1. Celery

The value of celery production in the Everglades Agricultural Area (EAA) during the 1977/78 season was $40.9 million, accounting for all of the value of production within the District. Out of a total Florida production for that season of 6.4 million crates, 5.5 million were produced in the EAA. California production, however, was in the neighborhood of 19 million crates for the same time period, thereby dominating the national market production.

Data collected included weekly shipments from the EAA and California separately, starting with the first week in December through the second week in June, for each of the seasons mentioned. Price data included the Monday New York City wholesale price and the EAA Friday FOB price for the same week. Both prices were for the two-dozen head-per-crate size.

An average price for all celery sold was not available. The data source quoted two prices; one for the two-dozen per-crate size and one for the three-dozen per-crate size. Quantity data included all sizes shipped. The two-dozen per-crate price was used because previous studies had used this price (2)(6). An effort was made - without success - to obtain shipments by size.

2. Lettuce

Total lettuce sales from Florida amounted to $37.3 million in the 1977/78 season. Of that, $32.2 million was produced in the EAA. The major varieties grown in the EAA were Iceburg, Romaine, Bibb, Boston, and Leaf. The two varieties studied were Iceburg and Romaine, which had sales of approximately $11 million and $5 million, respectively. Even though these two varieties represented only half of the total sales, it was assumed that they were representative in market characteristics of the total lettuce crop.

California and Arizona production of Iceburg lettuce dominated the national market for the 1977/78 season. Florida's contribution amounted to only 3% of the total national market, although most of the national output of Romaine lettuce (8) is produced in Florida.

Weekly data collected included the Friday FOB price for southern Florida and Monday's New York City wholesale price, the combined total weekly shipments from California and Arizona, and total weekly shipments by variety from the EAA. The data covered the time frame beginning with the first week in December and ending with the last week in April for each of the aforementioned seasons.

3. Snap Beans

In the 1977/78 season, Florida produced almost $32 million of snap beans, of which $27.7 million was grown in south Florida within the District's boundaries. Palm Beach and Broward Counties' total was $20.7 million. The majority of this output was sold through the Pompano Farmer's Market (PFM) in northern Broward County. The data collected consisted of total weekly shipments of "round green" type snap beans from PFM from the first week in December through the last week in May for each of the five seasons. The shipments of this type of snap bean represented a major portion of total snap bean shipments from the District area. Data were also collected on exports from Mexico and estimates of total U.S. shipments. The FOB price for Friday of each week from the PFM was collected, along with that week's Monday New York City wholesale price. The Friday price was considered a good measure of daily prices for the week since snap bean prices did not vary significantly from day to day within the week (8).

No data were collected for "pole" type snap beans grown in Dade County because data were not readily available for all of the seasons and "pole" bean production was being phased out and being replaced with the "round green" variety. The latter is less expensive to plant and harvest (8).

4. Sweet Corn

Sweet corn production in the EAA was valued at $26.2 million, which represented 75.6% of the total value of sales within the District's boundaries during the 1977/78 season. Over $49 million of sweet corn was grown in Florida during that season. Yellow corn was the only variety studied, since the distribution of varieties within the EAA was assumed to be representative of the distribution within the District, and yellow corn production accounted for approximately 90% of the EAA's total sweet corn production.

Florida does not have a significant competitor in sweet corn during most of the winter growing season.

The data collected covered the period extending from the first week in November through the last week in May for each of the five seasons. Weekly quantities of sweet corn shipped from the EAA and all sweet corn shipped from California were collected along with the Friday FOB price for EAA sweet corn and the Monday New York City wholesale price.

5. Tomatoes

Data for tomatoes were collected from the Annual Reports of the Florida Tomato Committee for the 1973/74 through 1977/78 seasons. Data collected from this source included total weekly shipments and the weighted average FOB price for all "mature green", "mature green" large type, and "mature green" medium type tomatoes. Weekly Mexican shipments and the Monday New York City wholesale prices were also collected.

State-wide data were used as a surrogate for southern Florida data because prices for regions within the state were not available and because south Florida accounted for about 70 percent of all tomatoes grown in the state between December and the end of May for each of the five seasons.

6. Grapefruit

Data on prices and quantities for the Florida fresh grapefruit export shipments were obtained from the Grower's Administrative Committee's Annual Statistical Record for the seasons 1973/77 through 1977/78. The primary focus of research was the Indian River District since it has a significant portion of the Florida grapefruit market and because two counties - Martin and St. Lucie - are within the Indian River District and within the WMD. Indian River shipments of all grapefruit accounted for 35.6% of the total U.S. shipments for the 1977/78 season. The Florida Interior District accounted for another 32.1% of the U.S. grapefruit market. Thus the state produced at least 67.7% of the U.S. output.

The data included weekly shipments of white and pink seedless fresh grapefruit with the corresponding weekly weighted average FOB prices for the Indian River District. (Seedy grapefruit production was excluded because this type accounted for less than 17% of all grapefruit grown in Florida). Weekly shipments, by type, of fresh grapefruit grown in the Interior District of Florida, and total weekly U.S. shipments of all fresh grapefruit, were also collected.

7. Oranges

The data source for oranges was also the Grower's Administrative Committee's Annual Statistical Record (10). Ninety-five percent of all oranges grown in Florida during the 1977/78 season were used to make different types of orange juice. In fact, 75% of all oranges in Florida have been generally processed for Florida Frozen Orange Juice Concentrate (FCOJ) (15). Oranges grown in the Indian River District had a similar utilization distribution to that of the state. Furthermore, two counties - Martin and St. Lucie - located in both the Indian River District and in the South Florida Water Management District, annually produce about 75% of the Indian River oranges. Since the search for data of shipments of oranges for the FCOJ market was unsuccessful, the data collected was, instead, of the shipments of fresh oranges from these two counties.

8. Sugarcane

Due to the great influence on sugar prices from the futures market and the international supply fluctuations, the price of sugar is relatively unpredictable and volatile. Within this world market, the growers in southern Florida are price takers. Thus, the most practical approach to estimating revenue loss from a drought would be to use the current spot price for sugar. Consequently, no product market analysis regarding the demand function was necessary and data for this crop was not required.

9. Cow/Calf Livestock

As indicated above, the assumption was made that the cow/calf operators would opt to maintain their production levels and incur the increase in costs to repair their overgrazed pastures. Consequently, no significant impact should be felt in the product market and, thus, no market data was required.

V. DEMAND MODELS

A. Specifications

Regression models were specified and tested for the goods previously identified with the exception of sugarcane, oranges, and livestock. These models were hypothesized to be linear with price per unit, as the dependent variable, having functional relationships with several apparently relevant variables such as quantity, income, etc.

Florida's share of the nation's sugar market is small, indicating that the state's growers and processors are essentially price takers, i.e., facing horizontal demand curves. Revenue losses can,therefore, be based on the reduction of output valued at a projected sugar price - the current sugar futures price. The price received by Florida growers is based upon price quotes from the Savannah, Georgia Sugar Exchange which bases its price upon an adjusted world futures price. The normal level of production - to use in calculating output loss - could be based on the average annual output for the most recent three seasons.

Demand analysis of oranges used for FCOJ was made by Ward (11). He, using the FOB price per gallon of retail packed concentrate, estimated the elasticity to be -.501 for the national market. Since southern Florida supplies less than one hundred per cent of the national market supply but receives national market prices, the elasticity for local suppliers is correspondingly greater. The adjusted estimate can be used to evaluate the change in revenues from the reduced orange production.

A demand model for the cow/calf operation was not required since the assumption was made that the output would probably not be affected by the hypothesized drought.

The stepwise regression technique was used to analyze the hypothesized models for each of the remaining crops. The theoretically relevant variables in the demand function of the price of each commodity were considered to be 1) quantity demanded, 2) income, 3) prices of complementary goods, and 4) prices of substitutable goods.

An empirical analysis of the impacts from price changes of complementary and substitutable goods was not made. It was assumed that the net effect from these changes on each of the subject commodities would be insignificant.

The variables used in the stepwise regression technique should receive appropriate comments since each is theoretically relevant to the commodity price determination.

The Florida sub-area FOB price was used in the analysis because it represented the final price paid in Florida for the produce. The FOB price includes compensation for growing, harvesting, and marketing the produce plus profit for each stage of production up to the final distribution to wholesalers and retailers outside of Florida.

Shipments of a commodity from major competing regions of the nation and/or Mexico were tested when appropriate. Total U.S. shipments of a crop, less the Florida sub-area quantity, and shipments from competing regions were regressed in combinations with the weekly sub-area shipments against the Florida price in the hope of capturing the separate effects of these shipments on the FOB price.

The U.S. per capita personal income - seasonally adjusted - was used to estimate the effect that changes in income might have upon the variation in the Florida price. The monthly income variable used was a simple average of the current month's estimate and that of the two previous months. For example, the income for March was calculated by adding the monthly incomes for January, February, and March then dividing this sum by three. This variable was then adjusted by the CPI to measure the actual purchasing power of income, i.e., real income. The average income over three months was used - rather than monthly income - because much of the fluctuations in seasonally adjusted monthly income variables are due to measurement errors and errors in seasonal adjustments - all of which should have no effect on consumption expenditures.

The monthly Consumer Price Index (CPI) for the preceding month was used to estimate impacts from inflation.

To test for relationships within growing seasons, the first week of a given season was assigned the numeral "1" and each week thereafter was assigned a number in ascending order by one so that the fifth week in the season was assigned the number "5" and the thirtieth week "30", etc. This variable was used to show the time trend of price within each season. The variable was squared and used to test for any second order cyclical variations in price over the weeks of a season.

A variable was used to identify the year of the observation by giving it a two-digit number starting with "73" and ending with "78". This variable was used to identify an annual price level trend.

Dummy variables for months were also used. A variable was assigned the number "1" if the observation was for a specified month under study, otherwise it was assigned the number "0". For example, if the analysis was for January then the January observation was assigned a "1" and all other observations in the season were assigned a "0". The purpose of the dummy variables was to test for variations in the price/quantity relationships by month. It was also hypothesized that there is a different demand function for the winter harvesting season from that of the spring harvesting season.

The Monday New York City price was considered to be partially related to inventories of the particular crop on the national market carried over from previous weekly shipments. Inventories were hypothesized to have a negative effect upon Florida prices, i.e., the higher the inventories the lower the price and vice versa.

B. Results of Empirical Tests

Least-square regressions were run on the data sets encompassing the Florida growing and harvesting period - November or December through May or June, depending upon the crop. The results were generally disappointing since the calculations yielded low $\bar{R}^2$s. The data was then subdivided into a winter and a spring season, approximately duplicating Brooke's and Bell's seasons. Regressions on the spring season data yielded superior results for all of the vegetables, except for Romaine lettuce, with significantly higher $\bar{R}^2$s in all cases. In addition, the segmentation of the data eliminated or reduced the effects of serial correlation in a few of the results. The regression results reported are for the spring season - February through the end of harvesting-except for Romaine lettuce and both types of grapefruit where estimates were based upon data from January through May.

Tables II and III show the statistical results of the empirical tests on the hypothesized models. The summary statistics appearing in Table II are defined as follows:

1) "$\bar{R}^2$" is the coefficient of determination adjusted for degrees of freedom.
2) "F" is the equation's F-ratio.
3) "Standard Error of Estimate" is the estimated standard deviation of the theoretical distribution of errors about the estimate.
4) "Durbin-Watson" is the Durbin-Watson test for serial correlation.

To interpret the results shown in Table III, consider the snap bean model

$$P = \beta_1 + \beta_2 Q_a + \beta_4 X$$

Where,

P = The Friday FOB Pompano Farmer's Market (PFM) snap bean price,

Q_a = The weekly total PFM shipments of snap beans, and

X = The year number, i.e. 1975 = 75, etc.

As shown by the table, the estimates for β_1, β_2, and β_3 are -40.9290, -.0818, and .7143, respectively. Thus, the model can be specified as

$$P = 40.9290 - .0818\ Q_a + .7143\ X$$

The coefficient β_2, measures the change in price per bushel of snap beans from a thousand bushel change in quantity. If quantity were to be reduced (increased) by 1,000 bushels, for example, then its price would increase (decrease) by 8.19 cents per bushel. Consequently, this parameter can be used to calculate the change in revenues for snap beans. The coefficient, β_3, estimates the annual trend in price for snap beans to be 71.43 cents per bushel.

TABLE II

PRICE/QUANTITY REGRESSION SUMMARY

Crop Type	Dependent Variable	$\bar{R}^2$	F [α]	Standard Error of Estimate	Durbin-Watson [β]
Snap Beans	Pompano Friday FOB Price	.76	91.95	1.430	1.580
Celery	EAA Friday FOB Price	.66	91.83	1.303	.517
Sweet Corn	EAA Friday FOB Price	.70	86.91	.545	1.385
Iceburg Lettuce	EAA Friday FOB Price	.47	29.62	1.613	.995
Romaine Lettuce	EAA Friday FOB Price	.46	46.40	1.354	.367
Tomato	Fla. Friday FOB Price	.24	12.44	1.299	.846
Grapefruit - Pink Seedless	Indian River FOB Price	.55	41.86	.338	.562
Grapefruit - White Seedless	Indian River FOB Price	.23	16.30	.265	.366

[α] All tests are significant at 1% level

[β] All equations have significant positive serial correlations at the 1% level - with the exception of snap beans having an indeterminate DW level.

TABLE III

PRICE/QUANTITY REGRESSION COEFFICIENTS[1]

$$P = \beta_1 + \beta_2 Q_a + \beta_3 Q_b + \beta_4 X$$ [2]

Crop Type	β_1	β_2	Q_a	β_3	Q_b	β_4
Snap Beans	- 40.93 (-4.04)**	- .0819 (-11.56)**	Pompano Shipments (1000 bu.)			.7143 (5.39)**
Celery	- 88.93 (-12.40)**	- .0078 (-3.32)**	EAA Shipments (1000 bu.)			1.258 (13.31)**
Sweet Corn	- 16.44 (-5.03)**	- .0031 (-11.56)**	EAA Shipments (1000 containers)			.283 (6.55)**
Iceburg Lettuce	- 57.31 (-5.22)**			-.0045 (5.98)**	U.S. Shipments (1000 cartons)	.9415 (6.31)**
Romaine Lettuce	- 56.86 (-8.52)**	-.0366 (-3.08)**	EAA Shipments (1000 cartons)			.8085 (9.19)**
Tomato	- 19.68 (-2.48)*			-.0013 (3.64)**	Fla. Shipments (large mature green)	.3520 (3.37)**
Grapefruit Pink Seedless	- 3.745 (-2.06)*	-.0057 (-6.95)**	Indian River Shipments (boxes)	-.0019 (-7.32)**	U.S. (less Fla.) Shipments (all types)	.1187 (4.99)**
Grapefruit White Seedless	-.7854 (-0.526)	-.0020 (-3.768)**	Indian River Shipments (boxes)			.0528 (2.765)**

[1] The t-statistic appears in parentheses with each coefficient estimate.
[2] X = Number of Year
*Significant at the 5% level. Two-tailed for β_1 and β_4; one-tailed for β_2 and β_3.
**Significant at the 1% level. Two-tailed for β_1 and β_4; one-tailed for β_2 and β_3.

As shown by Table III, all hypothesized explanatory variables are highly significant. In addition, the coefficients for all of the quantity variables, Q_a and Q_b, had the hypothesized signs. The time trend variable, X, reflected the inflationary impact on the price levels of agricultural commodities.

The Durbin-Watson test for serial correlation revealed that positive serial correlations are quite evident in all equations - except for snap beans. These results indicate that one or more important explanatory variables are missing in each of the equations. Variations in the models were tested in order to reduce the serial correlation. All attempts, however, were unsuccessful.

Inventory impacts, which were not included in the regression, are a possible cause for serial correlation. Inventory changes may result in a cyclical pattern along the underlying demand curve. A less-than-expected quantity demanded, causing an increase in inventory, is followed by "dumping" of the perishable commodities over the following time periods. The analysis of residuals seem to indicate short cyclical patterns of six to eight weeks for most of the commodities.

VI. APPLICATION OF RESULTS

The models presented in the preceding sections can be integrated into an algorithm to calculate the change in total earnings. This algorithm can be used to analyse the direct impact of different levels of crop losses upon growers of the various crop types. The impact can be divided into two categories. The first measures the total changes in revenues (ΔTR) to 1) grower and 2) processors (where appropriate). The second category measures cost savings or increased (ΔC) to growers and processors. The total direct effect of the drought would be the sum of the changes in revenue and cost (ΔTE). Mathematically, the ΔTE equation is expressed as

$$\Delta TE = \Delta TR + \Delta C$$

The sign of ΔC may be either positive or negative. If the amount of cost savings from reduced production levels exceeds any increase in cost due to attempts to maintain production levels, the sign will be negative; otherwise, it will be positive. When applying this accounting procedure to the drought analysis, the only agricultural product which should exhibit a positive sign for ΔC is livestock. Here, production levels are assumed to be maintained by overgrazing of pasture (or possibly drilling for brackish water) resulting in repair costs.

The ΔTR represents the change in revenue to the growers and processors from the destruction of crops which normally would have been available for sale. The calculation summarizes two possible effects. The first effect is a change in income from reduced output - loss in quantity times the expected price with "normal" output levels. The second effect is the increase in income associated with the increase in price due to the reduced output - the increase in price times the reduced quantity. This can be expressed mathematically as:

$$\Delta TR = Q_L P + Q_R \, \Delta P$$

Where

ΔTR = change in revenue

Q_L = quantity lost

P = expected price with "normal" output

Q_R = quantity produced

ΔP = change in price due to reduced output

The estimated value of ΔTR for each commodity can be derived from the results of the analyses on vegetable and grapefruit crops appearing in Table III.

The variable for oranges should represent losses in quantities of boxes of oranges to the grower. Losses to processors of FCOJ should not be included because of the lack of data for the weekly shipments of and FOB prices for FCOJ. Thus, the ΔTE for oranges should underestimate the complete direct impact on the orange sector because losses to processors are ignored.

Estimates for the cost of repairing pasture for the livestock sector should be obtained from local agricultural experts as indicated in Section IV,A.

It is important to note that this analysis only attempts to present a methodology and estimated demand relationships to be applied to given output levels. The economic impact can be properly estimated only after estimates of crop water response relationships have been made. For example, hypothetical scenarios of uniformly proportional losses for each crop, with calculations of economic impacts, may be very inaccurate since the variance of crop water response for each crop may be quite large.

Furthermore, difficulties exist in making reasonably accurate projections of demand relationships from the use of historical data. The assumed relationships may change in the future, thus invalidating the models being used. Corn syrup, for example, may replace sugar as a sweetener in processed goods if sugar becomes too expensive. Mechanical harvesting might replace labor which would change the grower's production functions. These changes should affect ΔTR and/or ΔC. Therefore, one must be aware that the ΔTR and/or ΔTC calculations are only relevant if technology, people's tastes, etc., remain the same as in prior years.

The sum of all of the ΔTE's calculated for the above products will give an estimate of the direct impact on the major proportion of the agricultural sector. Since the commodities analyzed do not cover the entire agricultural output for the District, a quick approach to estimating the impact on the total agricultural sector within the District would be to divide the calculated value by the percentage of total sales for the above items to the total sales of the entire sector.

This adjusted estimate, when multiplied by the appropriate multiplier for the chain reaction of decreased spending within the District, will derive an estimate for the total economic impact on the District's economy. However, the value of this multiplier is unavailable, is extremely difficult to evaluate, and is beyond the scope of this project. The estimate, without the multiplier effect, can be considered as the minimum impact from the drought.

VII. SUMMARY AND CONCLUSIONS

More research should be conducted on the price/quantity and cost relationships. The effects of inventory changes on prices should be especially studied. Studies considering the impacts on costs in the District from technical innovations, energy, prices, and labor force availability and cost are necessary. In addition, research on the distributional effects caused by agricultural losses is imperative in order to adequately evaluate the distributed economic impact to the region.

Information on the marginal value of water is not available at the present time. However, the District is supporting research which would yield production functions for lettuce, celery, sweet corn, and sugarcane. These production functions will be useful in determining the marginal values of the irrigation requirements.

Government grants-in-aid and small business loans were determined to be ineffective in reducing the economic losses from a drought. Most of the aid programs for agriculture are limited to family type operations. Most of the agricultural enterprises which would be required to reduce irrigation withdrawals are large corporate or corporate type operations.

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