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ECONOMIC STRATEGIES
FOR DROUGHT VULNERABLE AREAS OF THE WORLD

by

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ECONOMIC STRATEGIES FOR DROUGHT VULNERABLE AREAS OF THE WORLD

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M.B.O.

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PREFACE

This dissertation is addressed to the problems of the constraints which the soil and climatic conditions of the drought vulnerable regions impose on agricultural production. From a socioeconomic standpoint, these problems find their expressions in the human tragedies - economic losses, malnutrition, famines and starvation deaths resulting from drought related crop and animal losses - which have plagued many arid land nations for millenia. Geological and historical findings also have furnished evidence of the rise and fall of empires according to the changing conditions of the climate of these regions. Today, in an age of unparalleled technological advancement, we are still faced with the occurrences of the socioeconomic disruptions which have often resulted from drought conditions.

The recent drought related human tragedy in the Sahel and the world wide food crisis which followed the occurrences of droughts in the U.S.S.R., China, India, Australia and Argentina during the early part of the 1970's have heightened the anxiety of many people about the world food/population problems. This anxiety has led to an upsurge in the literature pertaining to drought

conditions, world food/population problems and the nature and extent of international cooperation needed to arrest the worsening world food/population problems. This dissertation is a contribution to the subject matter of drought conditions and their socioeconomic impacts.

METHODOLOGY: This dissertation deals with the theoretical aspects and socioeconomic impact of drought on agriculture. Therefore, in our presentation there is no methodology characteristic of empirically oriented dissertations in which statistical and/or economic models are used in the analyses of specific problems or issues. Our methodology is a literary presentation consisting of statement of facts, critical assessment of relevant materials in the literature and the theoretical application of statistical and economic models and principles in the analyses of the socioeconomic problems which usually result from the occurrences of agricultural drought.

The first part of this dissertation examines the soil and climatic conditions of the drought vulnerable regions. Recent research findings relating to the climatology, geomorphology and hydrogeology of these regions is highlighted. In the second part, which deals with the socioeconomic impacts of agricultural drought, statistical and economic models and principles are made

use of in a theoretical setting. Also in this part, the concepts of general equilibrium and stability conditions are used while placing emphasis upon empiricism as a means of furnishing information upon which agricultural production planning should be based on micro and macro levels.

OBJECTIVE: This dissertation is centered upon the crucial role of resource endowment - land, mineral, water, h8man and capital resources, the state of technology and the socioeconomic institutions which have bearings on resource allocation in the agricultural development of the nations of the drought vulnerable regions of the world. The author realizes that a theoretical exposition of the issues of agricultural production in these regions could be approached from many perspectives. For example, some writers have placed emphasis on the need for irrigation while others have emphasized conservation needs. In adopting a resource based approach our aim is to demonstrate that: (1) The rates of agricultural development of the nations of the drought vulnerable regions are largely dependent on the levels of their nonclimatic resource endowments, especially technological levels: and (2) The levels of agricultural development, on the other hand, determine, to a large extent, a specific nation's

abilities to moderate the disruption which the occurrences of agricultural droughts can cause in the socio-economic life of their people. In other words, the aim is to compare arid land nations at different levels of technology and to demonstrate that (1) in economically advanced arid nations the advanced state of technology enhances agricultural production and moderates the socio-economic disruptions which usually follow the occurrences of drought, and conversely, (2) in the poor nations of the drought vulnerable regions, technological backwardness accentuates the impacts of soil and climatic constraints in depressing agricultural productivity, while the low level of agricultural development aggravates the disruption which drought occurrences can cause in the socioeconomic life of the peoples of these nations as we have recently witnessed in the Sahel.

The Sahelian tratedy was, in fact, moderated by international cooperation. Without the food made available for distribution by international donors starvation deaths would have been considerably greater than the estimated 200,000. An examination of food aid programs in relation to the issue of incentives in domestic food production in the poor arid land nations suggests that international assistance should place emphasis on measures aimed at accelerating the agricultural development of the poor

nations of the drought vulnerable regions. Research pertaining to soil and water resources of these regions constitutes a significant aspect of such measures.

Because of the severe limitations placed on agricultural production by the soil and climatic condition of the drought vulnerable regions, chapters one through three of this dissertation have been devoted to an extensive examination of the landscape and water resources of the arid and semi-arid lands. The aim here is to demonstrate that a deep knowledge of the soil and climatic conditions of these regions could contribute to an enhancement of agricultural production. One other reason for this approach is that in economic analyses of production processes the underlying production functions assume technology as given. Research could furnish knowledge which could represent innovations. Innovations, on the other hand, could represent new technologies with considerable impact in temrs of increased agricultural productivity.

CHAPTER 1

WATER NEEDS FOR AGRICULTURAL PURPOSES AND THE DEFINITION OF DROUGHT

A cursory examination of the water content of the earth seems to suggest that it is paradoxical to talk about water storage for human consumption. The seas and oceans alone contain a vast amount of water covering about 75 percent of the earth's surface. Yet throughout mankind's history, water shortages, especially for agricultural production, have caused considerable suffering and even death. Before going into a detailed examination of the nature and causes of agricultural drought and its socioeconomic aspects it might be of some interest to look briefly into the water supply potential of the world in relation to man's water needs, especially for agricultural production. The last two sections of this chapter will be devoted to a broad examination of the hydrologic cycle and the definition of agricultural drought.

It has been estimated that the earth contains some 336 million cubic miles of water 98 percent of which lies in the seas and oceans. The oceanic water represents about 7 percent of earth's total mass. The remaining 2 percent of the earth's water content is largely locked up in ice.

Mankind draws his needs (for industrial, domestic and agricultural uses) from only a minute trace, 0.027 percent, existing in rivers, lakes and ground water. This minute portion is continually being replenished by an even smaller trace of .000053 percent of moisture moving around the atmosphere.

1.1 Man's Water Needs

Estimates of per capita consumption of water for industrial domestic and agricultural purposes are readily available for the advanced industrialized countries but not for many of the developing countries. Therefore, it is not possible to compile an estimate of the world's water consumption for agricultural purposes from published data. However, many indirect methods, such as the estimate of water requirements for world's major crops and water use for irrigation purposes have been suggested. The indirect method which is probably most accurate is the one based on the amount of water needed to produce man's daily requirement for food in terms of dry matter.

The daily food requirement of an adult has been estimated to be 2.5 pounds of dry matter. The amount of water required to produce wheat bread that could furnish 2.5 pounds of dry matter is about 300 gallons. Assuming that all men are vegetarian, eating wheat bread, (and

that no distinction is made between adult's and non-adult's food requirements) the daily water requirement for producing wheat sufficient to feed a world of 4.5 billion people is one thousand three hundred and fifty billion (1,350 x 10^9) gallons. If we substitute one pound of animal protein for half a pound of the 2.5 pounds of dry matter the daily water requirement for producing one man's food jumps to 2,500 gallons (water required to produce one pound of animal protein is estimated to be 25 times the water required to produce one pound of bread). With the introduction of animal products, the world's daily consumption of water for agricultural purpose would be eleven thousand two hundred and fifty billion (11.250 x 10^9) gallons. Even if we double this amount to give allowance for domestic and industrial consumption it is clear that man's water needs constitute an insignificant fraction of the earth's water content. Also significant is the fact that most of the water used by man somehow finds its way back into the earth's water pool.

1.2 Effects of Location and Quality on Water Availability

On the basis of their location and water quality, most seas, rivers, lakes, ice caps and aquifers are not available for dryland farming. The largest source of water, the seas and oceans, cannot be used for irrigation

agriculture without desalination, a very costly process at the present time. The largest source of fresh water in the world is that locked up in the ice, a total of about 2.1 x $10^5 km^3$. Yet this vast source of fresh water is not readily available for human consumption. In fact, in view of the increasing world demand for fresh water, some people have suggested towing icebergs to areas where fresh waters are needed. "Thus it has been calculated that of an iceberg measuring 2,700 x 2,700 x 250 m, towed at a speed of half a knot from the Amery ice shelf to Australia, 30% would arrive intact. The water would be worth $5.5 million, i.e., about 10% of the cost of a similar quantity of desalinated water, compared with a towing cost of $1 million." (Franks, 1972)

The lakes, rivers and aquifers all provide sources of fresh water. Fifty percent of all lake water is fresh while the remaining 50 percent is saline. Ground water generally exists in three layers. The topmost layer is unsaturated soil with moisture held by capillary forces. The next zone is saturated soil and it is from here that ground water reservoirs are recharged. The zone immediately below the saturated layer holds about half of all ground water and is highly mineralized.

1.3 The Hydrologic Cycle

In the hydrologic cycle water that moves into the atmosphere through evaporation from the soil and water surfaces and through transpiration from plants comes back to the earth in the form of precipitation. On balance total world precipitation is equal to total world evaporation but there is excess of precipitation over evaporation on the land. It is this excess of precipitation that makes for a continental runoff of fresh water into the seas and oceans. Evaporation from bodies of water results in natural desalination. Three hundred and eighty billion acre-feet of rain and snow fall on the earth each year of which 80 billion acre-feet fall on the land. Only 92 percent of the water evaporating from the sea falls back to the sea.

About 27 billion acre-feet of water is carried by glaciers, rivers and coastal spring to the sea annually. Thirteen billion acre-feet are carried by thousands of small rivers over a drainage area of about 11 billion acres. Water is also carried into the sea through underground flow drained from about 8 billion acres of continental land.

Only a small portion of the enormous supply of water in the hydrologic cycle is used by agriculture, man's principal consumer of water. Irrigation, for

example, uses less than 4 percent of total river flow. About 310 million acres of irrigated land, constituting about 1 percent of total land surface, requires only about 1 billion acre-feet of water. Therefore, most rivers flow to the sea untapped by man. For example, the Amazon River, the largest river in the world, whose powerful current drives the sea fresh for 200 miles, has been described as less significant to man than the tiny Jordan river on the basis of the extent to which these two rivers have been tapped by man. The larger portions of human food and fibre come from dryland farming being carried out on part of the 3 billion acres of land that receive about 10 billion acre-feet of precipitation annually.

If evenly distributed in time and space the 80 billion acre-feet of precipitation falling annually on land is sufficient to make all the 52 million square miles of the world's land areas flourish with vegetation. It would have been possible to practice dryland farming over all the land areas of the world without the difficulty that has often arisen from precipitation deficiency in the more than 18 million square miles constituting arid and semi-arid zones. Because of this process of uneven rainfall distribution that constitutes the major cause of drought, the definition of agricultural drought in the

following section is based on the concept of the hydrologic cycle.

1.4 Definition of Agricultural Drought

Many definitions have been advanced for drought, reflecting the diversity of research interests and disciplinary background of those involved in drought related investigations. Most of the definitions given for agricultural drought depict a drought coming upon crops already existing in the field. Some writers try to distinguish between meterological and agricultural drought. Also some writers would like to eliminate the true desert from areas of drought occurrences on the grounds that rainfall there is permanently small and irregular so that man does not bother to cultivate it. The central theme in all these definitions, however, is precipitation deficiency. In agricultural production the deficiency is in relation to crops. Through research and cultivation experience, the optimum water requirements for most crops are fairly well known and a useful definition of agricultural drought must be related to the water requirements of crops. Therefore, for the purpose of this dissertation, agricultural drought will be defined as all cases of deficiency in temporal distribution of precipitation in any given spatial location leading to the availability

of less than the empirically determined optimum water requirement of a given crop. This definition is based on the notion of the functioning of the hydrologic cycle in relation to the known optimum water requirement of crops. It deals with relative rather than absolute quantities of precipitation in relation to optimum water needs of a given crop or plant in time and space and, hence, permits us to examine the issues of drought in all the land areas of the world, ranging from the most arid region to the most humid region. Also, the definition, by making precipitation subject to availability, takes into account the adaphic features of the spatial location. Because we are examining the issues of agricultural drought in time and space, the true desert has been included to reflect the significance of climatic change. Research findings in many scientific quarters suggest that many of the deserts of today were once humid. From the standpoint of contemporary climatic patterns, however, the desert can be regarded as an area of permanent drought. The foregoing broad view about agricultural droughts has been adopted to enable us to examine the overall socioeconomic impact of drought in time and space, with particular reference to the nations of the arid zones where, historically, the consequences of drought have been very grave.

Once more the significance of the temporal