Development of Institutions and Their Innovations to Reduce Permanently the Effects of Droughts on Agriculture.

(With Implication for Ethiopia)

By

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PART I

A. Introduction and Statement of Problem

Drought is a natural hazard that cannot be avoided significantly within the present level of scientific development. Studies and experiments to overcome drought have not yet reached the stage of development where the world can depend on the available scientific technology to avoid droughts. As a result, both scientifically developed and the developing nations face the problem equally. The recent droughts of the Sahel and Northeast Africa and the current drought of the Great Plains of the United States show how diverse the distribution of the problem is and the range of possible effects that might be sustained in the poor regions of the world such as the Sahel and the more developed regions like the Great Plains.

The ability to absorb the vagaries of drought varies from one country to the other depending on the level of dependence on agriculture for the livelihood of the people and contribution to the overall economic activity and most importantly on the level of dependence of agriculture on rain. Those countries in Africa, Asia, and South America, where agricultural employment is the principal occupation for the majority of the people, are highly vulnerable to effects of drought not only because agriculture is sensitive to the weather but also most of the people are in absolute poverty that they do not have the ability to sustain the effects of loss of income. An important region where such a situation is common is the drought areas of India, which cover over 600,000 square kilometers (World Bank, 1975) and have a population of 66 million. The bulk of this population is engaged in a perennial struggle to overcome

the effects of drought and meet subsistence needs in generally harsh environment. Within this region drought has occurred in three or four years out of every ten and as a result the successions of drought years have affected harvests and resulted in absolute poverty to tens of millions of people. A similar extreme situation exists in the Drought Polygon of Northeast Brazil, affecting more than 20 million people. These two regions are good examples of regions that have constant problems of drought and have significantly failed to withstand the effects.

On the other hand in countries like the United States where the economy is mature, diversified, and dependence on agriculture for livelihood has significantly been reduced, the effects of drought become modest. The ability of the economy itself is so strong that the regions and individuals affected can be assisted and rehabilitated without much difficulty. Thus, the whole effect of drought has been put under control in the developed countries because of their strong economies.

For those countries that are highly dependent on agriculture and at the same time trapped in deep poverty like that of Ethiopia or India, the question of drought becomes a matter of life and death. Reduction of the effect of drought calls for less dependence on rain for agricultural activities and also less contribution of agriculture to the economic activity. This transformation requires capital, technical knowhow, and other resources to change the country from a subsistence agricultural economy into a dynamic industrial nation. The reality, however, is the less developed countries have great difficulty in obtaining the capital and knowhow within a reasonably short period of time under the existing conditions. Therefore, the problem of drought

will continue to be a big challenge and the devastating effects on the people of these countries will continue for some time to come. The remaining alternative is to try to reduce the effects of the drought temporarily within their existing capacities and at the same time start national development programs that would improve the economy. This requires the creation and development of proper institutions to carry out short term and long term programs. The creation of institutions and starting of programs still becomes a big hurdle due to the shortage of resources and technical knowhow and lack of experience. The available meager resources and the scarce trained manpower can be wasted if the institutions created are not appropriate or do not function the way they are supposed to. One possible way to increase efficiency and save resources is by using the experiences of countries that have developed such institutions for a long time and have successfully met the challenges of drought. The lessons obtained can enable them to reduce the expenses of some costly mistakes that might be made as a result of lack of proper direction and at the same time will enable them to minimize the effects of the drought because the institution will be better organized to take action on time.

The creation of the necessary institutions and the successes that would be expected greatly depend on proper understanding of the nature of the problem itself. In most of the less developed countries the nature of drought and the related economic and social problems had been conceived within a narrow scope and the solutions and institutions sought were much more ineffective as a result. Where drought is a recurring problem, the situation feeds back on itself and drought and poverty backup each other and easily deceive the decision makers.

Trying to solve the problem of drought separately without at the same time finding solutions to the general economic problem of poverty, will meet very limited successes. Therefore, it should be realized and understood that the problem of drought is part of an overall economic problem and any solution should be looked within broader perspectives and the institutions, programs, and policies should be geared towards this objective. The dynamic nature of the problem calls for looking at the situation from many angles including economic, political, and social frameworks. In this research attempts will be made to look at the problem from such a broad view and then develop recommendations that can enable Ethiopia to overcome its current and future drought problems.

B. Objectives of the Study

There is a large body of experience on drought problem and how to handle it in many countries today. Despite this, some less developed countries, though they had faced the problem from time to time, have not looked at it as a serious national problem requiring organized national efforts and planned action until very recently, late after they have seriously suffered the consequences. As a result of this unpreparedness they have suffered serious losses whenever they are attacked by drought and the confusion and inefficiency that follow have caused great damages both to human life and property beyond repair in most cases. Even worse, there are some countries today that have not set up any national institutions to look after this problem even though they have faced drought several times. A good case was the situation in Ethiopia in 1973. Therefore, what is attempted in this research work is to look at the incidences of droughts in some countries with different economic, social, and political backgrounds at given periods in their history and

evaluate how they developed their drought combating institutions and carried out their different programs. And then use some of the useful experiences that can be drawn from these institutions to make recommendations for Ethiopia that would help her organize the necessary institutions to reduce the effects of droughts.

Specifically, the objectives are:

1. To give a historical background to the droughts that had occurred in Northeast Brazil, India, and the Great Plains of the United States;
2. To describe the physical, economic, and political environment of the areas and countries in which the droughts occurred;
3. To explain the extent of damage done and/or social dislocations sustained by the Indian droughts between the 1880's and the 1960's with emphasis on the colonial period; the Northeast Brazilian droughts from 1877 to the 1950's; and the droughts of the Great Plains in the 1930's and the subsequent periods;
4. a) To obtain a better historical perspective of the institutions created to handle the problems of droughts;
   b) To obtain understanding of the favorable and unfavorable conditions surrounding their existence and performance;
   c) To identify their innovations; and
   d) To identify their realized achievements;
5. To evaluate the effectiveness of the innovations and compare the patterns of adjustments of the three regions to the drought situation, particularly with respect to:
   a) Stability of yield;
   b) Development of irrigation;

c) Adjustment in land use pattern;

d) Adjustment in livestock population;

e) Adjustment in cropping pattern;

f) Adjustment in size of holding; and

g) Conservation practices.

6. To draw important lessons from the experiences of institutions for drought relief and examine their usefulness to the drought problems of Ethiopia and make some recommendations.

C. Review of Literature

Works on the global outlook on drought greatly concentrate on temporary relief efforts and engineering aspects rather than institution building. Few works look at drought as a broad problem involving economics, politics, institutions and human factors. As a result, the literature useful for institutional evaluation and buildup becomes very limited.

Northeast Brazil

The Northeast Brazilian drought has been documented by native Brazilians in Portuguese but cannot be used for this research because of language problems. Two major works in English are available for use. The first is Albert O. Hirschman's Journeys Towards Progress in which he lengthily describes Brazil's actions to strengthen the economic positions of its drought-ridden and stagnating Northeast Provinces. He looks at the problem beginning from 1877-79 Great Drought and analyzes the consequential actions taken by the government and the underlying economic, political, and social influences that entered the process. He points out that the natural claimants for federal aid to

the Northeast were the political representatives of the area itself. These representatives secured appropriations of relief funds and were responsible for the establishment of first federal agencies and the large public works programs in the area. He brings out that there had been apparent inefficiency in the way in which federal funds had long been spent in the Northeast and this had led to concern outside the Northeast and this later led to coalition of Northeast reformers with groups in the Center and South and resulted in reorientation of the programs from narrow drought program to general consideration of economic development of the region.

The second major work on Northeast Brazil is by Stefan H. Robock published in 1963. In his Brazil's Developing Northeast: A Study of Regional Planning and Foreign Aid he evaluates the region against its own situation in the past and gives more weight to the development of institutions and their achievements. He analyzes the issues of the drought problem by merging various professional disciplines such as economics, politics, administration, ethics and all other relevant areas and sees the problem in broad perspectives. He believes that the Brazilian Northeast embraces the full range of issues confronted by most underdeveloped countries in their effort to achieve economic, political, and social progress. He clearly develops how the Northeast drought problem was for a long time perceived wrongly as a problem of periodic drought area and how later circumstances gave way to thorough understanding of the basic problems in their right perspectives involving economic and social problem, over-population, low economic productivity, unemployment, and widespread poverty that are separable from and more basic than the drought. But he also shows that drought is still

a strong natural phenomenon and would in the future continue to influence the development of institutions and the official ideas that guide the economic future of the Northeast.

India

The droughts of India, the great vulnerability of the people to weather changes, and the subsequent poverty have been greatly misunderstood and a wrong name, famine, had been given to the problem. This is clearly the result of the British colonial policy which had been in effect for over 200 years. As a result the literature on the Indian droughts has become the literature of famine. The work on this line is quite extensive and a large number of documents are available. Among the large volumes, B. M. Bhatia's Famines in India 1860-1965 accounts the famines and scarcities that have occurred over the last hundred years and the severity of the droughts that caused them. He dealt with the problem from the context of uneven development of the country resulting from foreign rule and the inadequacy of government measures to deal with the basic problem of poverty which made the people highly vulnerable to droughts. He points out that the public works programs undertaken to combat drought had laid greater emphasis on such things as railroads, which served commercial interests of Great Britain, than on canals and irrigation works which could have enabled them to overcome the horrible effects of drought. The failure to develop permanent institutions for drought relief is the result of colonial rule complicated with poverty and the frequency of the drought occurrence.

A very useful work is by Hari Shanker Srivastava entitled The History of Indian Famine, 1858-1918 published in 1968. Srivastava

analyzes the effects of drought and famine on the Indian people and systematically relates the problem to the colonial administration and the way the whole economy was managed. He separately discusses each of the famines that have occurred until 1958 in detail and evaluates the damages and measures taken. At last he concludes that the different programs and policies such as building railroads, irrigation works, land improvement programs, and creation of the Department of Agriculture had been failures in checking the effects of drought and thus no useful institution was developed by the British.

The Great Plains

The literature on the droughts of the Great Plains are very extensive and exhaustive. Detailed engineering, soil, grazing, and demographic studies are available at the MSU library. Because of the need to limit the research to manageable size, only a few sources are considered. A survey of U.S. farm policies including those formulated to overcome the 1934 Dust Bowl had been compiled and analyzed by Murrey R. Benedict, Farm Policies of the United States, 1790-1950. This work discusses the different policies and laws enacted by Congress and the various departments, states, and counties regarding agriculture and agricultural institutions. With respect to the Dust Bowl he asserts that the most important policies were those that created the Soil Conservation Service and the Division of Grazing (Taylor Grazing Act). He attributes most of the other policy measures that emerged in the 1930's mostly to the droughts of 1934 and 1936.

Charles M. Hardin's The Politics of Agriculture: Soil Conservation and the Struggle for Power in Rural America examines politics and exhibited by agricultural policy in the United States. He states that the

Dust Bowl of 1934 enabled the creation of the Soil Conservation Service and as a result altered the Great Plains from barrenness to bounty, from an area where dust storms scandalized the nation to an area with bumper crops year after year. The demonstration programs of the Soil Conservation Service, creation of soil conservation districts, and the cooperation of farmers enabled the achievement of concrete results in soil conservation.

The report of the Great Plains Committee in 1936 entitled The Future of the Great Plains, analyzes the general physical characteristics of the area, the use and misuse of land, etc., and draws recommendations that are essential for successful readjustment in land use and the necessary government (federal, state, and county) programs to be taken to solve the problem. The committee recommends permanent changes in agricultural pattern of the Plains, the carrying out of conservation works, improvement of the grazing conditions, resettlement, and development of other resources.

D. Research Method

The paper will be divided into four parts. The first part includes the introduction and methodology. Part two, which is divided into three sections, discusses each of the three cases of drought affected areas with respect to historical, physical, economic, and political and social backgrounds; introduces the drought problems, and identifies the institutions created and the innovations made.

Part three compares the performance of the three regions in stabilizing yields, developing irrigation, and adjusting the land use, holding size, etc. Part four introduces Ethiopia and the drought problem in that country and draws important lessons from the experiences

of the three countries to make recommendations for managing the Ethiopian droughts.

The sources of data for this study include various books, reports, statistical publications by Indian, U.S., and Brazilian Governments, periodicals, and bulletins. The part three, where evaluation of the performance of the institutions is made, there is a large number of missing information which cannot be filled because of the lack of data. Particularly information on irrigation development in Northeast Brazil and livestock numbers and farm size data for India greatly reduce the level of comparison of the adjustments. Every care has been taken to interpret the parts with missing data accordingly.

Due to the inadequacy of data and in order to be able to give detailed discussions, a single state that is representative has been taken from each of the three regions to make the various comparisons of effectiveness of innovations and the patterns of adjustments. Thus, the States of Punjab, Kansas, and Ceara were selected to represent India, the Great Plains, and Northeast Brazil respectively. General conclusions were drawn on the regions from the performances of these states.

The analysis in part three employs absolute quantity figures, indices, and percentages to present the results. Evaluation was made by comparing the patterns of adjustment and changes in the three states with respect to the seven important areas of interest - yield, irrigation, land use, etc. In case of conservation programs, where Kansas is the only one to carry out conservation on a large scale, the performance of this state was used to present the results in this area.

The period used for measuring the performances in the three states, and the three regions where appropriate, is divided into two. For those programs that require relatively long time to show changes in their size or adjustments, i.e., irrigation, land use pattern, livestock size and holding size, the period between 1900 and 1970 was used but where data are not available the period has been limited to that period for which data are available. But for evaluating yields and cropping patterns, the period 1947 to 1970 was used.

Part II

Development of Institutions and Their Innovations

A. India

1. Historical Background

Beginning from the 18th century, in 1707 the Mogul Empire ended two centuries of their brightest period in the Indian history. The feud for power after the fall of the Mogul Empire resulted in breakup of the central authority into small independent kingdoms which brought with them uncertainty and insecurity of life and property and weakened the sub-continent. In 1757 the British won the battle of Plassey in Bengal and this victory became the beginning of the Indian British Empire. The company that started in India in 1600 to do business thus made a war and became the ruling power in 1857. Between 1858 and 1947, a member of the British cabinet ruled India assisted by the Indian National Congress which was founded in 1885. For the major part of their colonial rule, the British were busy with trade, keeping law and order, and collecting revenues.

In 1919 the First World War brought a landmark in the Indian history. Because of its contribution to the war it was given more responsible government which gave some power to the provinces. Between 1937 and 1939 full responsible government was granted to the provinces making them autonomous in their internal activities. In 1947, India finally gained independence on 15th August, but this was accompanied by the country's partition, which created Pakistan out of the area in the north-west and the east; Burma was already separated a decade earlier. The partition created serious economic problem for independent India

because the large irrigation works in Sind and West Punjab went to Pakistan including the jute regions of East Bengal.

2. Physical Environment

The present India is 1,261,597 square miles and the second largest in Asia next to Mainland China. The country comprises three broad and well defined geographical regions. These are the mountain wall of the Himalayas and associated mountains which stretch across northern India from west to east, the Indo-Gangetic Plain which is 1,500 miles long and 150 to 200 miles wide and is formed by the basins of the sub-continent's three great rivers--the Indus, the Ganges, and the Brahamaputra--and the Deccan Plateau which is separated from the Indo-Gangetic Plains by mass of mountain and hill ranges. There are three principal watersheds in India. These are the Great Himalaya which forms a gigantic watershed to the north, the Vindhya Range which constitutes the second principal watershed and is in the central part of India, and the Western Ghats which is directing most of the Deccan rivers.

The soils of India are of varying nature. The Andhra Pradish is rich in black soils and red soils which spread throughout the state and form good agricultural soil. Mahershtra and Manipur have good black soils while Tamil Nadu has wide tracts of red soils. Laterite soils exist in Karela, Tamil Nadu, Maharshtra, and West Bengal. Arid soils are found in Punjab, Rajasthan and Kashmir. By and large the soils except for the deeper alluvial and regular, are not very fertile and over wide areas they have been ruined by erosion or by continuous cropping without much rotation or fertilizer application. As a result much of the valuable plant nutrients have been exhausted.

The climate of India, in general, is governed by the tropical monsoon winds. There are four recognized seasons: cold weather season, hot weather season, rainy season, and season of retreating monsoon. The rainy season is from June to September. Rainfall and temperature show wide variations in the country and as a result there are four broad climatic regions based on rainfall: The heavy rainfall area with average of 425 inches annually in Assam and West Coast of India; the moderately high rainfall region which receives 60 inches of rain and covers the Indo-Gangetic Plains; the low rainfall area which receives less than 30 inches of rainfall a year and constitutes the Vindhya Mountains, the Deccan Plateau, Mysore, Hydrabad, Uttar Pradesh, Rajputana, Northern and Southern Punjab and Sind; and regions of low precipitation which receive only minimal amount of rain and include the Rajasthan desert, the rest of Punjab, Kashmir, and Giligrit. The third and fourth regions constitute the drought striken areas of India.

Temperature varies as much as rainfall in the different parts of the sub-continent. The Himalayan region has the lowest temperature with averages around 50°F. The Indo-Gangetic Plains have average of about 79°F and in the coastal are of Bombay in the west and Madras in the east the average temperature is around 83°F. Because of India's great climatic variations, it is difficult to get the right picture from regional averages of rainfall and temperature.

India, as a result of its wide range of temperatures, rainfall, humidity, and other physical factors, produces a rich and varied vegetation, which differ according to regions and maintains a large variety of animal life. Palms of different kinds, commercial crops like coconuts, nuts, pepper, ginger, rubber, bananas, coffee and tea; forest products

like rosewood, ironwood, and tack; and thousands of species of other plants and flowers thrive in the rich tropical and other climates. The animal life ranges from the big game like elephants, tigers, panther, and cheetah to small life like mosquitos, bees, silkworm and coceuis lecar, which yields shellack.

3. Economic Environment

India is experiencing relatively slow economic progress compared to other developing countries. The per capita income in 1971 was US $75, one of the lowest per capita incomes in the world. The national income rose by about 26% between 1960 and 1968. With the population increase of about 2.4% per year, this growth rate is completely neutralized and as a result the average Indian was no better off between 1960 and 1968.

Agriculture is the biggest industry and accounted for about 50% of the total value of output in 1971. The country's food as well as vital industrial raw materials and large part of its exports originated in agriculture. About 45 percent of the entire land is under crops, 19% is forest, and the rest is uncultivated. Crops make about 85% of the total agricultural output by value. The emphasis on crops is due partly to religious aversion to meat-eating and the relative costliness of livestock products for the poor people.

Availability of water largely determines the kinds of crops grown, the yields obtained, the number of crops planted per year, and the seasons of harvest. About one-fifth of India's farmland was irrigated in 1966. The largest irrigated area is in the northeastern part, where the Himalaya-fed rivers flow all year round. The largest single crop is rice with 39 million metric tons of cleaned rice harvested in 1969.

Other major crops are wheat, millet and sorghum, barley, and among pulses chickpeas, beans, and peas. Tea, sugarcane, oil seeds and jute are important cash crops.

India has the largest livestock population in the world, 344,000,000 heads in 1971. However, the yields of milk, meat, and wood are very low due to poor quality of stock, inadequate fodder resources, limited grassland, and poor management practices. Specially the shortage of fodder is very serious and there are estimates that the present fodder is only enough for 60% of the livestock strength. Livestock accounts for about 5% of the GNP.

Since the beginning of the economic planning era in 1950 to formulate and secure the implementation of economic and social development, there has been greater emphasis on industralization. Both manufacturing and mining have increased substantially and by the late 1960's there was sizable and diversified industrial base. The industrial structure is dominated by consumer goods industries like cotton weaving, pharmaceuticals, and processing of tea and sugar. Capital goods industries are on the process of development and account for about 10% of the industrial output. Mining and quarrying have become important in the early 1970's.

4. Political and Social Environment

As pointed out earlier India had been a British colony for about 200 years and gained independence in 1947. The present constitution was put in effect in 1950 and allows a constituent assembly composed of elected representatives from each of the provinces and some representatives from the princely states. The union of India consists of 27 states, of which 10 are directly administered by the central government. The

president has the executive power and elects a prime minister who is the leader of the majority party.

The state government is under the executive power of the governor who is appointed by the president. Each state has chief minister and a council of ministers who are collectively responsible to the legislative assembly of the state. The state legislature consists of the governor, together with either one or two legislative houses.

In general the Indian government since its independence has been forging a socialist state, but the successes have not yet been as expected. Part of the explanation for the lack of this success is the large amount of government resources spent on the army due to the war with Pakistan. The other important explanation is the huge population that is growing fast despite the efforts to curb this by extensive family planning programs. India is the second most populous nation in the world and the 1971 census shows a total population of 546,955,945. The annual rate of growth was 2.4% and a density of 446 persons per square mile during the same year. The density varies with relief, climate, and degree of economic development. High densities are closely associated with good rainfall and alluvial soils and industrialization. Low densities are found in the mountains. Life expectancy is 42 years and birth control is highly promoted by disseminating information, by providing contraceptive devices, and by encouraging sterilization.

Eighty percent of India's population lives in villages, but as industrialization is progressing recently, there is a great tendency of increasing rural-urban migration. There are already nine cities with over one million people each and 2,900 cities with over half a million

each. The population is diverse on ethnic, religious, and linguistic bases with Hindu the largest tribe and Hinduism the largest religion. Religious customs and taboos prevent many Indians from eating some types of foods. "The people of India subsist for most part on vegetarian food, consisting of cereal grains, pulses, and vegetables, supplemented sometimes with dairy products. Consumption of animal food such as meat and fish is restricted to small sections of the population. The grain crops, which are the principal means of subsistence, are of crucial importance" (Bhatia 1963, p. 3.). India supports over 200 million sacred cows the contribution of which is very limited both to the diet and incomes of the people.

5. The Drought Problem

Droughts had been occurring in the Indian sub-continent even during the ancient times of greatness and glory. In the ancient times there were records showing that there were great droughts in 298 B.C. and 917-18 AD and subsequent periods (Srivastava, 1968). During medieval India there were droughts in 1291, 1326-27, 1334-35, 1362-66, 1412-13, and 1424. During the Mogul Empire there were severe droughts in 1595-98, 1630-31, 1659-60, and 1747. There had also been droughts in 1770, 1773, 1802-4, 1806-7, 1812, 1819-20, 1832, and 1837. During the British rule, droughts had occurred in 1860, 1862, 1865-66, 1868, 1873, 1876, 1877, 1880, 1884, 1888, 1891, 1896, 1899, and 1907. After independence there were no severe and widespread drought problems except one in 1965-66.

The nature of the Indian droughts is so diverse and the geographic coverage so changing that there is no specific pattern that can be followed. While many of the above mentioned droughts were limited to a

few low rainfall states, some others covered the entire sub-continent and resulted in great famines and distress to the people and at times claimed millions of human and animal lives. Complete failure or the untimely occurrence of rain had been existing side by side with heavy storms and flooding. Particularly in the low rainfall areas that receive less than 30 inches annually and include the Punjab, eastern half of Deccan, Rajputana, United Provinces, Hydrabad, Mysore, and Sind, the unreliability of rain is of great significance and these regions have been sites of periodic droughts in the last century. Though there were shortages and untimeliness of rain from time to time in the 20th century, the damage to human life has been minimized due to development of transportation facilities and better organization of the relief efforts. As a result there had not been major threats except during the 1965-66 drought period when large amounts of foreign grain assistance, particularly P.L.480 grain, was needed to save the lives of millions of Indians.

6. Development of Institutions and Their Innovations

The development of institutions to combat permanently the problems of droughts and the innovations made to this effect will be seen starting from the early British times. The British policy towards Indian drought problem has been misguided to the last time and the entire problem had been viewed within the narrow scope of problem of famine. Commissions were appointed after each famine, caused either by drought or otherwise, to examine the circumstances in which famine was bred and the nature of relief operation which might be undertaken. These commissions developed famine relief organizations and prepared

Famine Codes, which were constantly modified to meet new situations. Nothing important was done to develop institutions which will permanently seek solutions to the problems by creating the necessary infrastructure and making the necessary innovations. In the words of Srivastava, "But all that the government did was only to soften the pangs of hunger at the moment. Little was done in the way of insurance against the recurrence of famine. Palliatives were there, but not remedies and, up to the Independence in 1947, there was marked lack of irrigation and alternatives or subsidiary sources of employment for the teeming millions" (Srivastava, 1968, p. 4).

The British set up four departments to handle their general interest in India and the famine problem was secondary. These were the Civil Administration, the Department of Public Works, the Department of Agriculture, and the Department of Irrigation. As there was no definite plan to tackle the effects of droughts directly, the main responsibility for the famine and drought problem was given to the Civil Administration Department. This department organized relief programs and food distribution while seriously affected areas were excused of taxation in addition to relief assistance. The Public Works Department was a two-fold purpose institution whereby, in the first, destitutes from the famine who are able to work were engaged in construction programs mainly on railroads, roads, quarrying, earth work, metal collection, some irrigation and village improvement. Second, Public Works was the main department through which foreign investment was channeled to strengthen the transport system in order to expand the commercial interests of the colonizers. The Agriculture and Irrigation Departments, though not greatly effective as

they ought to be, they have done a few things with regard to fighting the drought problem and will be considered below in some depth.

a. The Agricultural Department

The Famine Commission of 1880 recommended the organization of the Agricultural Department for the promotion of scientific agriculture. In 1881 the Imperial Department of Agriculture was created as part of the Secretariat of the Government of India as recommended by the Famine Commission. The main function given to this Department was to supply periodic agricultural statistical information about crops and the state of the people in order to improve the efficiency of the famine relief program. Some responsibilities were given in research and education areas. In 1901 such responsibilities as promotion of mutual associations, investigation of crop diseases, provision of improved seeds, experimental introduction of new staples, improvement of cattle breeding, investigation of cattle diseases, and development of fodder supply were added to the list (Srivastava, 1968).

Departments of agriculture were established in the provinces between 1881 and 1886 with the main functions of collecting of agricultural statistics and other data necessary for dealing with famine problems, which in essence was the outcome of droughts in most of the cases. The progress of the development of agricultural departments was not equally rapid in the provinces because of the state of provincial revenues. Despite this, the Government of India Act of 1919 transferred fully the administration of agricultural departments to the provinces except in the area of research. The Royal Commission of Indian Agriculture of 1926 stressed the need for positive agricultural policy, coordination of

central and provincial sphere of work, integration of research work done at the Central Institute, provincial departments and universities, and the application of results to practical schemes of improvement (Thirumalai, 1954).

Thus, under the British administration there was only organization and reorganization of the agricultural administrative departments at the center and the provinces, but no definite actions in the area of improving the agriculture situation or devising ways of reducing the effects of drought by means of necessary adjustments as change in cropping pattern, land use, size of farms, etc. As Agrawal and Basil put it, "The achievements up to 1937 may be described as the creation of the Central and State Departments of Agriculture for agricultural research, and provision and intensification of facilities for research and education. In spite of considerable expansion in the staff and activities of agricultural departments, research and education facilities were very inadequate" (Agrawal and Basil, 1969, p. 13).

After independence, an era of planning was started in 1951, when the First Five Year Plan was launched. Second, third, and fourth five year plans followed and "On the whole, the country lacked any well defined policy of agriculture up to the end of the Second Five Year Plan. Many improvements have taken place since then" (Agrawal and Basil, 1969, p. 15). One of these improvements, often claimed to be the most successful of the plan outcomes, was increase in the production of food grains by reducing commercial crops and by intensifying the cultivation of land already under use. This was quite true specially in the sixties when irrigation, manuring, better management, and high yielding varieties of

crops gave good yields as was the case in 1967-68 when the country reaped 95.5 million tons of food grains, a record harvest in Indian history.

In the area of soil conservation, it was in the First Five Year Plan that need for taking up soil conservation programs on country-wide basis, in a coordinated way, covering survey, research, demonstration, training, and extension was recognized (Ministry of Food and Agriculture, 1966). A Central Soil Conservation Board was set up towards the end of 1953 with the responsibility to initiate, organize, and coordinate research in soil and water conservation programs, and spread education. "During the short period of the First Plan where only spade work was done, a sum of Rs 16 million was spent on soil conservation schemes" (Ministry of Food and Agriculture, 1966, p. 21). A large part of this amount was spent on anti-erosion measure like contour bunding and terracing of about 7,000 acres of agricultural land. During this First Plan period plans were made to establish 8 research-training-demonstration centers around the country in order to facilitate future conservation programs.

During the Second Plan, under the state schemes physical targets were set at 3 million acres, comprising 2 million acres of agricultural land for contour bunding and terracing and one million acres of other areas of afforestation and pasture development measures. About 2.5 million acres of agricultural land were protected with contour bunding and terracing (Ministry of Food and Agriculture, 1966). Work on this line continued during the Third Plan and 13 conservation projects were started throughout the country. In research area observation sites, aerial photography and its interpretation, preparation of watershed management plans, and small, but actual conservation work in the river

valleys were started particularly on crop, forest, and pasture lands. In general it had been recognized that 10% of the total land area might need some sort of soil conservation urgently, but by the end of the Third Plan only 1,450 square miles had some sort of conservation work done to it (India, Ministry of Information, 1968).

The above historical review of the Department of Agriculture clearly indicates the lack of definite programs under this department, either during the colonial era or after independence, to fully commit itself to solve the drought problems of the country. The narrow scope envisaged at the early stages of the department, research and education, continued through the plan periods. Recognition of the need for soil conservation and other agricultural practices that could reduce the effects of droughts were made late during the plan periods. The actual usefulness of these practices to reduce the effectiveness of droughts can be seen only in the future as the activities carried out so far start showing successful results.

b. The Department of Irrigation

India had large irrigation network before the British came to the sub-continent. Because of the fact that its agriculture depends largely on the monsoon, which lasts only about three months and sometimes untimely, irrigation was necessary for successful crop production. The value of irrigation to insure cultivation and increase yields had been understood by the ancient and medieval rulers of the country. Therefore, they paid great attention to irrigation works and dug canals, tanks and wells. But "In the early part of the nineteenth century, most of the irrigation works of the pre-British period had

fallen into despair due to the wars of the eighteenth century and absence of any strong political authority to look after them" (Srivastava, 1968, p. 5).

During the colonial era, the British participation goes back to the East India Company of 1773 where it started administering some areas in India. The Company restored a few old irrigation works on the Jumma, the Kavery, and the Koleroon; and built new ones on the Ganga and the Goderari (Dosai, 1968). Under the Crown, irrigation works were carried on with vigor for the first two decades. First private companies were employed, but due to their failure the work was taken over by the government. The most important works undertaken between 1860 and 1880 were the building of canals in Bengal, Agra, the Punjab, and the Bombay Deccan. By 1880 the irrigated area in British India had reached 29 million acres.

In 1880, due to the serious effects of the droughts of 1873, 1876, and 1877, the responsibility of irrigation works passed from the central government to the Famine Commission. The commission gave definite programs which were carried in the Punjab and United Province. In 1878 a Famine Relief and Insurance Fund was created which enabled them to build many protective works on the canals. In 1901, the Irrigation Commission was created which immediately started protective works on those canals found in regions liable to drought. As a result, between 1901 and 1921, 43 protective works were undertaken and increased the irrigated area in India from 44 million acres in 1903 to 46.8 in 1913-14 (Dasai, 1968). Though the achievement under the commission was not impressive, the value of irrigation for reducing the effects of droughts was properly understood at this time. "The commission drew

pointed attention in India and remarked that among the means that may be adopted for giving India direct protection from famine arising from drought, the first place must unquestionably be assigned to works of irrigation" (Bhatia, 1963, p. 127). The commission accepted that the measure of the value of irrigation should be different in that, first it has to be judged by direct protection afforded by them in years of drought; second, by the great services they render in imparting certainty to all agricultural operations, increasing the output per acre, and enabling valuable crops to be grown.

After the First World War there was reorientation of irrigation policy due to the government's recognition that the private sector should also be involved particularly in developing wells which would suit the small peasant farmers. As a result two major irrigation works developed, government works and private works, with the former divided into major and minor works. The government major works included both productive (new canals) and protective irrigation schemes. The very large irrigation works undertaken include the "Triple Canals" project in the Punjab, the Sukkor Barrage in Sind, the Sutlej Valley Project, and the Kavery Reservoir Scheme (Dasai, 1968). The protective schemes were those works intended to remove the fear of famine rather than built with the good intention of development of irrigation works to reduce the dependence of agriculture on the uncertain monsoon weather. Some of these protective works built between 1914 and 1929 were the Goderari Canals, Bhandardam and Bhatagar dams, and the Sarda Canal System (Dasai, 1968). The minor works undertaken by government were those works accomplished by local governments and included village tanks that require small expenditure.

In the private sector the government encouraged the development of wells, which were suited to serve the small peasants. Government assistance was provided through liberal assessment of taxes and protection of tenants against high rents. Until the beginning of the 20th century the privately owned irrigation facility had been important and thus in 1903 private works accounted for 58% of the irrigated area, the rest being government works. This proportion was reverted in the era after independence because of heavy government participation. In 1919 irrigation works became provincial responsibility and a Central Board of Irrigation was set up in 1926 to report on the irrigation schemes of the provinces. The growth of irrigation under this new arrangement was not impressive. Between 1913-14 and 1939-40 the growth in irrigated area was only 17% or about 7/10 of 1% per year (Dasai, 1968).

To summarize the development of irrigation under the British, the government adopted definite irrigation program only after a series of droughts in the 1870's and the emphasis was on public works. In line with the recommendation of the Irrigation Commission of 1901-03, protective works were given more attention. Between 1901 and 1911 the irrigated area increased by about 6%, and after the responsibility was transferred to the provinces in 1919, the growth of irrigated area was 17% in 25 years. The emphasis under the provincial arrangement was on large works and all irrigation projects were controlled by the Government of India. In 1939-40 the total irrigated area was 22% of the cultivated land, but under the partition in 1947 the great irrigation works of West Punjab and Sind went to Pakistan (Dasai, 1968).

There were some important problems with regard to the British policy towards irrigation that should be mentioned before going to the programs after independence.

1. The irrigation program had always been starved of funds because of the great emphasis of government expenditure in the area of building railroads which was the vehicle for promoting trade between the colony and the home country. Therefore, up to 1900, the total government expenditure for irrigation was £25 million and that of railroads £225 million (Dasai, 1968).

2. Those large irrigation works undertaken by the colonial government in the 20th century were concentrated in five regions with 92% of the total irrigated area in those regions. The Punjab had by far the most of it, with Burma the second, which is no longer a part of India after the 1935 partition. The other three regions were the Sind, Uttar Pradesh, and Madras.

3. There was neglect of minor works in favor of major projects and as a result the areas most liable to drought which offered the least favorable physical conditions for construction of major irrigation works were left out (Bhatia, 1963). Thus, for example, the area under irrigation from minor works increased by 1.3 million acres from 1878-79 to 1896-97 while the area irrigated at the same time from major works increased by 3.35 million acres.

To conclude, the situation of irrigation under the British, the size of the area cultivated and the proportion of the irrigated area from the different sources of irrigation in 1939-40 are shown below:

Table 1.

Position of irrigation in 1939-40.

Total area cultivated	224	million acres
Irrigated area	55	" "
" by government canals	25	" "
" by private canals	4	" "
" by tanks	6	" "
" by wells	13.5	" "
" by other works	6.5	" "

Source: Dasai, 1968.

Development of Irrigation After Independence

In the next few paragraphs the development of irrigation after independence will be discussed. Detailed discussion is not attempted because of the fact that most of the serious drought problems of India were concentrated in the period before independence and because of the reports consideration of the period under the British as the main focus of attention.

When India started its economic planning in 1951, the irrigated area was about 56 million acres or 22.6 million hectares, but at the end of the Third Five Year Plan in 1966, the irrigated area stood at 88 million acres or 25.61 million hectares, which gives a growth rate of two million acres per year (Indian Ministry of Information, 1968). Similarly, India had doubled its water conservation capacity in the same period. Out of an estimated river potential of 1,360 million acre feet, 450 million acre feet was estimated to be usable and out of this 76 million acre feet, representing 17%, was being used in 1951, but 1961 this utilization rate had risen to 150 million acre feet or 33% of the

usable flow (Indian Ministry of Information, 1968). The total effective storage capacity increased from 10 million acre feet in 1951 to 50 million acre feet in 1966. In sum, "At the end of the Third Plan the number of irrigation schemes completed and in hand stood at 465. Of these, 65 were major and 400 medium.---Out of the total of 465 schemes, 295 had been completed---by March 1966" (Indian Ministry of Information, 1968, p. 2).

Despite this tremendous achievement with 88 million acres under irrigation in March 1966, the Indian agriculture was once hit by a severe drought in 1965-66 due to the failure of the monsoon. As a result of this there were widespread crop failures and loss of life of both human and animal. There are two explanations for this. In the first place, although the figure of acre of irrigated land is among the highest in the world, the percentage of irrigated area to total cultivated area in the country was not so high. In 1966 it was less than 25% and thus three-fourth of the country was still vulnerable to the vagaries of the monsoon. Secondly, out of the 88 million acres of irrigated land more than half of it depended for its irrigation supplies on small wells, tanks, and small river diversions, which in themselves were dependent on rainfall, when rain fails, such sources failed and this had been the experience in 1965-66 (Indian Ministry of Information, 1968). In those areas where there were assured sources of irrigation production was not affected by shortage of rain.

To sum up the development of irrigation in India, it has been understood from the early times that the effect of drought can be overcome, or at least be reduced, by providing timely and adequate supply of

water for cultivation purposes. Land utilization and yield of crops are extremely dependent on rainfall and the most effective way of reducing the effects of failure of rain on agricultural production is to control the other sources of water supply, and increase to the maximum possible limit irrigation facilities to provide assured, adequate and regular water to fields throughout the year. And to this end out of the ultimate potential of 187 million acres of irrigable land, 88 million acres have been put under irrigation.

B. Great Plains

1. Historical Background

Before 1846 there were several expeditions to discover the Great Plains which are lengthy stories by themselves. Officially the Plains were accepted by the government as a socially, economically, and culturally unified and integrated unit following the Louisiana Purchase of 1803. After this, public interest in the region as a whole developed but commercial and military activity did not center in any one region, but extended throughout the north and south, and from the Mississippi to the Rockies. After 1846, this unified approach to and attitude towards the Plains began to disappear, and never since has the region been able to demand much national consideration as a geographical and historical unit (Kreavzel, 1955). After 1886, the region experienced the impact of having been a desert because it became only a base of operation for the war with Mexico and attachment with California.

The major settlement of the Plains started in the 1870's and spread gradually until it came to an end about 1910. After this period, new settlement was chiefly replacement of those who moved out mostly due to

the drought problem. In fifty years period from 1870 to 1920 population in seven Plains states increased twelve times from 556,969 to 6,031,968. This rapid settlement accounted for a great push of humid-area ways of living upon the Plains and finally resulted in heavy droughts which brought with them repeated hardships.

2. Physical Environment

The Great Plains encompasses 586,461 square miles of land area or 20 percent of the United States. Lying between the Rocky Mountains and the 98th meridian, it includes portions of ten states: Montana, Wyoming, Colorado, New Mexico, North and South Dakota, Nebraska, Kansas, Oklahoma, and Texas. About 6 million people lived in the Great Plains proper in 1960 or one-third of that of the Plains states population and 3.7% of that of the United States.

The Great Plains are a semi-arid land in general sense, but in actuality they are dry and even arid in some years and in other years they are wet. The major amount of the precipitation falls from May through July, which is also the growing season. If the limited moisture fell in the non-growing season, the region would be desert. The average annual precipitation varies from about 15 to 25 inches, though there are great variations from year to year and from place to place. The evaporation rate is another important factor in the climate of the region. The warm season evaporation is more than the precipitation received by more than ten inches annually and this contributes to critical situations in years of low rainfall.

The temperature variations are more extreme in the Plains than in other parts of the nation with few exceptions. There are great variations in

temperature within short periods and blizzards may be followed by warm winds that melt the snow everywhere. There are unexpected occurrences of precipitation and increases in climatic hazards significantly. The wind velocities are high and range from 10 to 12 miles an hour, but the average run as high as 16 to 18 miles per hour in some sections and thus cause excessive evaporation.

The soils of the Great Plains are among the most fertile to be found anywhere (Kreazel, 1955). The soil condition is related to the climatic conditions that have given rise to the Great Plains, and thus to the east of the Plains, the humid climate has led to the leaching of the soil, but at the edge where the Plains begin no leaching has taken place. Along the western edge, the chemicals are nearer the surface and make the subsoil less deep and lighter in color. The limiting factor of the area is moisture and the farming technique has to adapt to this situation.

There are no trees except on the water courses and short grass predominates the region. In areas where favorable moisture conditions prevail tall grasses grow and this is specially true in the eastern portion. The native grasses have become adapted to semi-arid conditions and some become dormant during drought periods and then revive when rain comes. Others have become so flexible that they can adjust themselves to the varying climatic condition that they can escape even the worst drought. The topography of the region varies from level to gently sloping.

3. Economic Environment

The basic income of the Great Plains is generated from livestock raising, crop production, forestry, and mining which includes petroleum.

All these income sources are tied to the natural resource base of the region. By the mid 1960's persons engaged in agriculture, forestry, and fishing constituted one-fifth of the employed persons in the area, wholesale and retail employed one-fifth, and manufacturing one-eighth.

The agriculture of the Plains has been greatly influenced by the availability of rainfall. In years of good rains the Great Plains area contains some of the larger, more prosperous farms and ranches in the country. But during drought years the effective size of farms will decrease and crop yields will fall and incomes will shrink. There is great risk and uncertainty in investment and income which sometimes contributes to inefficiency to the operations of farms. But this risk is being greatly reduced as new techniques of farming have aided farmers to use the available water supply more efficiently through conservation, irrigation, and other practices. This has helped in recent years to stabilize the agriculture of the area and incomes in general.

The annual income of American families is very high and has been rising markedly since 1930. The medium family income before taxes was $3,031 in 1947; in 1969 it had reached $9,433, and nearly 46% of all families had incomes of $10,000 or more. The per capita income was $3,360 in 1970. Differences between regions and occupations are not great and as a result the income for the Great Plains states is around this median.

4. Political and Social Environment

In the Great Plains, like anywhere else in the United States, "The individual farmer has throughout America's history been seeking to use political, economic, and social institutions to acquire temporal power" (Talbot and Hadwiger, 1968, p. 90). He always searches for means or

instruments which will help do for him what he cannot do for himself. Interest and pressure groups are formed everywhere wherever constitutional government exists to pursue their interests.

Some of the general farm organizations that developed from the interest groups are the American Farm Bureau Federation, National Council of Farmer Cooperatives, National Farmers Organization, National Farmers Union, and the National Grange. There are a number of commodity organizations such as American National Cattlemen Association, National Association of Wheat Growers, Soybean Growers of America, etc. There are also clientele type organizations like the National Association of Soil Conservation Districts, Soil Conservation Society, National Reclamation Association, which came to exist following federal farm programs. These and other general farm organizations understand and practice modern techniques of organizing internal administration, public relations propaganda, electioneering and lobbying (Talbot, et al, 1968).

Farmers have also been getting advantage through constitutional arrangements. Federal and state constitutions have certain built in political advantage towards farmers which give disproportionate weights to farmers votes in the elections. The equality of the representation of states at the Senate, as well of the election of the president by the electoral college have given the farmers a special advantage. In the voting process, farmers have been pursuing their interests rather than clinging to a political ideology. As Talbot and Hadwiger put it, "...the material interests are more powerful imperative to a voting decision than is ideology" (Talbot, et al, 1968, p. 81). Therefore, farmers have been voting for Democratic and Republican Parties depending on the advantage they seek.

As a whole farmers in the Great Plains and elsewhere in the country have been more inclined to social interactions, made economic cooperatives when there is a need, and maintained highly individualistic posture in their political dealings.

5. The Drought Problem

The drought problem of the Great Plains is the result of human modification of the natural conditions of the area. Prior to settlements of the area by the new immigrants, man did not alter conditions on the Plains. The Indians killed buffalo and sometimes set fire to the grass but these did not significantly influence the nature of the vegetation as they did not destroy the primitive grass cover. Nature has established the balance in the area but settlement by a large number of people disturbed this balance and caused wide erosion which had not occurred in the past at comparable rate.

There were dry periods between 1825 and 1865 but since the area was not densely settled the effect was minimal. Conditions started to change after 1866, the time settlement was greatly expanded. The period from 1886 to 1895 was one of disastrous droughts in the Great Plains, even though the forty years from 1865 to 1905 show average rainfall, in most parts of the Plains, above the critical level of 20 inches (The Great Plains Committee, 1936).

Favorable wet periods attracted great movements of settlers into the Plains and the great expansions of the cultivated and grazed areas have come during wet periods. The enlargements of the homestead tract from 160 acres to 320 acres in 1909 and the 1916 grants of 640 acres increased

plowing and grazing activities in the region and exposed the land to severe weather.

The coming of the tractor, the combine, and other powerful machinery after 1910 enabled an individual to plant and harvest more acreage and financial obligations to maintain these machinery and other factors obliged him to secure cash crop, wheat, and contributed to remarkable increase in area planted to this crop. These and other actions coupled with light rainfall, high summer temperatures, high winds, and fine grained soil which blow and drift when not held together by vegetative cover resulted in the severe droughts of the twenties, thirties, and subsequent periods. There were severe droughts in 1910-14, 1920-25, 1933-40, and 1952-56. Specially the droughts of 1934 and 1935, 1936 and 1937, 1941, and 1956 resulted in great human sufferings and economic distress. These depressing effects became a national concern and the Federal government recognized the need for creation of necessary institutions at all levels of government to devise measures that will alleviate the suffering and also prevent or mitigate the damaging effects of future droughts.

6. Development of Institutions and Their Innovations

The Dust Storm of 1934 and the subsequent droughts of the following years coupled with the general concern for the improvement of agriculture led to the need for large scale undertakings to conserve natural resources. The chief emphasis was on soil conservation and rebuilding soils and rehabilitation of rangelands in the Great Plains. Several new agencies were set up, the principal ones being the Soil Conservation Service, Division of Grazing, and the Resettlement of Administration. Prior to this, however, the Bureau of Reclamation had been set up for

reclaiming the arid lands by taking irrigation works in 17 western states, which includes the 10 Plains states.

The important features of these institutions are that they are organized and made to function at the federal, state, and local levels and organized within already existing administrative setups, i.e., under Departments of Agriculture, Interior, War, and Treasury, Farm Credit Administration, Interstate Commerce Commission, etc., and numerous types of districts such as conservation, irrigation, grazing, etc. Each of these institutions will be looked at below.

a. Soil Conservation Service

A temporary agency that would set up the erosion control program in the country, called Soil Erosion Service, was established under the Interior Department with bureau status in 1933 as part of the National Industrial Recovery Act of 1933. The program took the form of demonstration projects, mainly on public lands, the work being done by the Civilian Conservation Corps Personnel (Herdin, 1953). During 18 months of its existence, forty-one demonstration projects were established, hundreds of thousands of small check dams were constructed, vegetation were planted on eroding hillsides, firebreaks were opened up, and roads were developed.

On March 25, 1925 the soil erosion work was transferred to the Department of Agriculture by Administrative Order and as a result the various soil conservation activities of the department were combined with the Soil Erosion Service to form a new bureau called Soil Conservation Service (SCS). From the beginning the work of SCS was

based on good studies and strong public support both among the leaders and the general public. The problems of the Great Plains have been identified properly as inappropriate use of land resulting from undesirable practices and tenure. Specifically the problems were identified by the Great Plains Committee as follows:

I Undesirable tendencies in land use.

1. Overgrazing of rangelands--there was rapid increase of cattle from 1870, when it was 1,435,000 animal units, to 1935 when it reached 10,195,000 animal units in six of the Plains states. This stocking of the range portion of the six Plains states has been estimated to be close to 100% in excess of its estimated grazing capacity under any system which would provide adequate feed and still maintain the vegetation.

2. Expansion of arable farm into unsuitable areas--there was great increase in crop acreage in the region with less than 20 inches of rainfall.

3. Maladjustment of water utilization to land use requirement--failure to recognize land use and water use are joint problems and plan for both simultaneously.

4. Poorly balanced system of farming--heavy dependence is placed on one crop, wheat, in the agriculture of the area.

II Undesirable tendencies in land tenure.

1. Absentee ownership--promotes less care for conservation.

2. Uneconomic operating units--most units were small and scattered tracts which makes it difficult to gain control over and operate efficiently.

3. Extensive tenancy--it was 41% in 1935. Extensive tenancy results in determining types of crops and farm practices which were

mostly cash grain farming, increasing the degree to which the land is subjected to abuse.

4. Instability and insecurity of tenure--the consequences of this instability are that the tenant cannot plan his operations and develop a sound and efficient farming plan and thus lead to exploitation rather than conservation of soils.

With these problems identified the Soil Conservation Service was established with the main purposes of preservation and improvement of soil fertility, promotion of economic use and conservation of land, diminution of exploitative and wasteful and unscientific use of soil resources, promotion of rivers and harbors, and improving of parity of farm population's purchasing power. Specifically, land use planning, proper crop rotation, controlled livestock grazing, and application of other sound farm management practices were to be promoted. In 1937 the Water Facilities Act gave SCS expanded responsibilities to include construction of water facilities, developing of conservation plans, and providing technical assistance to farmers. "In 1956, Congress enacted the Great Plains conservation program which authorized the Secretary (of Agriculture) to enter into long term contracts with farm and ranch operators in designed counties of Great Plains" (Morgan, 1965, p. 166). This legislation permitted the department to enter into 10-year contracts with individual farmers who agree to make land use adjustments in accordance with a complete farm plan. For this cash payments are provided for following the practices agreed upon in the plan.

On May 13, 1936 standard soil conservation district law was published which recommended that state soil conservation committee be created with the function to encourage farmers to organize districts and to

conduct the proceeding required to establish them. State committees were set up to help the districts carry out their operations and coordinate their programs. The soil conservation districts depend financially on SCS funds from assessments and contributions, earnings, through equipment operations, and from state and county appropriations. By July 1, 1964 there were 2,928 soil conservation districts in 48 states, 11 subdistricts in Alaska, 8 work areas in Connecticut and 18 in the territories with total land area within the districts amounting to 1, 739 million acres; of this amount almost 1,060 were in farms (Morgan, 1965). Of these 857 districts were in the Great Plains covering 590,314,000 acres.

Some of the soil conservation program practices serviced by the SCS and soil conservation districts include contour cropping, tree planting, digging wells for grazing management, building dams, pits, and ponds for grassland management, preparing sod waterways to dispose of run-off, building terraces to control erosion and conserve water, building diversion terraces, protecting stream banks and channels, opening drainage ditches, building underground drainage systems, shaping land for drainage, reorganizing irrigation systems, leveling land for irrigation, etc. In 1962, 32.9% of the conservation practices were carried out in the Plains states with Kansas, Texas, Nebraska and Oklahoma having the biggest shares. In 1959, 627,324 farms had soil conservation plans in the Plains states alone.

In general, soil conservation has become a well established public policy and these are outstanding accomplishments. More than 98 percent of the land on the farms in 1965 was incorporated within soil

conservation districts and about half of all farm operators had conservation agreements with soil conservation districts (Morgan, 1965).

b. Division of Grazing

The serious condition of the overgrazed rangelands and uncontrolled eroding that followed led to the enactment by Congress of the Taylor Grazing Act in 1934. "The act was designed to regulate grazing on approximately 142, 000,000 acres of vacant, unreserved, and unappropriated public lands, almost all of which are within the boundaries of Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, and Wyoming" (Great Plains Committee, 1936, p. 176). There were small acres included in Washington, North Dakota, and South Dakota.

The purposes of the Taylor Grazing Act were:

1. To stop injury to public grazing lands by preventing overgrazing and soil deterioration;

2. To provide for their orderly use, improvement, and development; and

3. To stabilize the livestock industry dependent upon public range lands in such a manner that it will be possible for stock growers to plan their annual operations over period of years, with knowledge, based upon the average rainfall, of the amount of grazing that will be available.

The administrative authority of this Act was vested in the Secretary of the Interior, who created the Division of Grazing for administering this Act. The administrative procedure provides for creation of large administrative districts, the election of advisory officers who are authorized to make recommendations on such things as carrying capacity, determination of date of use of the grazing, determining priority of use,

issuance of grazing licenses, proper use of range practice, temporary range allotment, and seasonal use, and issuance of grazing permits to stockmen within or near the district. On this basis several districts were established immediately and by 1949 there were 37 districts in Montana alone covering 12,381,786 acres of range land.

The Secretary was also authorized to make reasonable changes for the privileges of grazing livestock within the districts. The Secretary was also authorized to rehabilitate overgrazed and eroded areas and to construct needed improvements such as wells, reservoirs, fences, and trails. For this task Civilian Conservation Corps were utilized and much of the work had been done in accordance with the recommendation of the local advisory board. To have some insight into the development of grazing districts, it is useful to look at the Montana State Grazing Districts, the first to be organized on this line.

The first state legislation in Montana providing for the incorporation of non-profit grazing associations was passed in 1933 "...to aid the conservation, restoration, improvement, and use of forage resources in the State of Montana" (Thompson, 1951, p. 7). For this law no administrative agency of any kind was provided, and the interpretation of the act and the development of policy was left entirely to such court litigations as might arise out of the operation of the act. About a hundred districts were organized in the state before legislative action in 1935 created the Montana Grazing Commission for the administration of the grazing districts organized under the 1933 law. The new Commission consolidated some of the smaller districts to help establish boundary lines and thus avoid overlapping boundaries and much confusion.

By May 1936, 13 districts were approved and operating and six were organized in the remaining of 1936. By 1950, 19 districts which existed in 1936 were still active, with some changes in boundaries, and 2 of the active districts in the same year were formed from a district in operation in 1936, so 21 of the districts in operation in 1950 have been operating 15 years or longer (Thompson, 1951). In 1939 the Montana Legislative Assembly passed the Grass Conservation Act to provide for the conservation, protection, restoration, and proper utilization of grass and forage resources of the State of Montana (Saunderson and Monte, 1936). This act provided for the incorporation of cooperative non-profit grazing districts called Montana Cooperative State Grazing Districts and creation of a State Grass Conservation Commission empowered to "Supervise and coordinate the formation and operation of districts which may be incorporated under the act" (Thompson, 1951, p. 8). As of July 1950, the 37 districts enclosing 12,381,786 acres had 1,572 members with grazing permits for that year to graze 200,858 animal units.

c. The Resettlement Administration

This agency was created by executive order on April 30, 1935, under the authority of the Emergency Relief Appropriation Act of April 8, 1935, to undertake the correction of certain chronic problems mainly associated with marginal agricultural areas. The three principal functions specified for this agency by the executive order were to aid in the settlement and housing of destitute or low income families, both rural and urban; to carry out certain land conservation projects; and to help farm families on relief to become independent by providing financial and technical assistance.

of the crop-growing season, and the flood run-off in spring was not dependable enough to justify storage reservoirs.

Thus in the early part, the States of Kansas, Oklahoma, and North and South Dakota have had only small irrigation schemes. The extreme droughts of the 1930's in the Plains areas forced thousands of farmers to leave the area for more favorable climate where they could earn living by dry farming or potential irrigation. A major breakthrough came when Congress realized the small irrigated acreage in this region following the 1930 droughts, and authorized the Missouri Basin project to develop scattered irrigation units throughout the basin, thus to help key segments of the population to have more secure economy.

In general to sum up the development of Irrigation in the Plains states from the time the Reclamation Service was established to the end of 1949, the following table shows the situation.

Table 2.

Development of Irrigation in 10 Plain States 1889 to 1949*

Year	Acres Irrigated
1889	1,629,703
1902	4,326,960
1919	7,968,318
1929	8,232,615
1939	8,814,187
1949	11,257,824

*Source: Golze, 1952, p. 42.

As can be seen above, there was great increase in the irrigated area in the Great Plains except during the 1929 to 1939 period, when most of

the work was retarded due to the drought problems and the Depression. One point should be clear here. All the increase shown on the table was not wholly due to the programs of the Bureau of Reclamation. There was substantial amount of irrigation development by private groups which had been accounted as part of the above figures. For example, in 1950 private irrigation facilities accounted for 17% of the total acreage irrigated in the 17 western states.

One important feature of this development is, although the primary Federal responsibility for conservation of water resources had been assigned to Bureau of Reclamation of the Department of Interior, there was strong support from the states and at least 24 other federal agencies. The Corps of Engineers of Department of Defense and the Department of Agriculture had been the greatest contributors. To coordinate the activities of these Federal agencies working to implement the development of water resources, there are several interagency committees like the Federal Power Commission, Missouri Basin Inter-Agency Committee, Colombia Basin Inter-Agency Committee and Pacific Southwest Federal Inter-Agency Technical Committee.

C. Northeast Brazil

1. Historical Background

Northeast Brazil, which consists of ten states, was the earliest settled region of Brazil. Sugar cane production started in this region as early as 1532 and it became one of the most important sugar producing areas in the world (Robock, 1963). As sugar industry developed in the Caribbean and world prices of sugar fell, the prosperity of the Northeast came to an end. Even though other agricultural activity like cotton

production had become important, the region did not regain its position of economic leadership in Brazil. As the national principal products shifted to gold, rubber, and coffee which are produced in the center and south, the economic gravity of the country migrated with these changes and as a result the Northeast lost its leadership.

The decline of sugar prosperity forced the growing population to shift to the semi-arid regions where subsistence agriculture and cattle raising became the principal economic activities. The growth of dependence on semi-arid region by a large population made the effects of the periodic droughts that occur in this region a significant national problem. The land area affected by this periodic drought is about 600,000 square miles and had a population of 22.4 million in 1960 (Robock, 1963).

The Northeast had been officially associated with drought problem since the great drought of 1877-79. The federal government recognized this region as a national problem and set up several institutions which had initiated large scale programs to build dams and reservoirs in order to reduce the effects of drought. Later the emphasis of the problem shifted from problem of drought alone to general problem of economic development and this view became strong in initiating a number of development programs starting from the 1940's.

2. Physical Environment

Brazil covers an area of 3,286,473 square miles, larger than the continental United States. Its population was 93,203,000 in 1972 and is increasing at 2.5% per year. Of this, Northeast Brazil accounts for 18 percent of the land area and 32 percent of the population.

The physical characteristics of the Northeast is dominated by high central escarpment that runs 2000 miles from Salvador to Bahia with few rivers that cut through these mountains and a semi-arid interior with insufficient rainfall and high tropical evaporation. During the long dry season lasting from June to December, most rivers except the Sao Franscisco and Parnaiba dry up. The rainy season is from January to April when about 27 inches of rainfall is received (Hirschman, 1963) but this is relatively low because of the high rate of evaporation.

This huge area is not homogeneous and has several elevated mountain areas where the rainfall is much higher than the average for the region and thus free of drought problem. The region around San Franscisco river in the south is less faced with the periodic drought. The severely drought affected regions are in the states of Ceara, Rio Grande do Norte, Pariaba, and Parnambuco and these states are relatively densely populated and force the population to the perennial river areas when the droughts come.

In general the Northeast can be divided into four relatively distinct subregions where within each subregion there is significant variation in topography, climate, and land resource base and use (Larcon, 1968). The first is the "Forest Zone" which is a narrow humid strip along the coast to the upper edge of the State of Pernambuco. This humid strip is about 40 miles wide and is covered with remnants of the dense tropical trees which originally covered the subregion. The region receives about 60 inches of rainfall annually, which is well distributed over the year. The soils are red or yellow which are highly leached and low in nutrients. In this region sugar cane is the principal crop. The second region is the transition zone from the low lying coast lands to the vast semi-arid, interior plateau called Agreste. It runs north and south and is about

40 miles wide. The rainfall varies from 30 to 40 inches annually and is fairly reliable. The region is hilly and the soils vary considerably and this variation allows greater agricultural diversification. Beans, rice, and manioc are widely cultivated and cattle are raised on large holdings.

The third region, the Seratao, is a semi-arid sub-region which receives an average annual rainfall of about 27 inches which is highly irregular and very seasonal in nature. A long dry season prevails from June to December and at times lasts all the year round. Here the soils are leached and eroded and the vegetation is sparce. The entire area of this sub-region which makes 70% of Northeast is under drought problem and is known as the "Drought Polygon," the official drought area that is designated in the Northeast. Agricultural production includes cattle raising and production of cotton, sisal, manioc, and rice. The fourth region consists of the tropical rain forest where the rainfall is heavy, averaging 60 to 70 inches annually. The area had been deforested by slash and burn agriculture and most of the area is sparcely settled. The principal crops are rice and cocoa and cattle raising is widely practiced. Maranhao and Southern Bahia are found in this region.

Largely the problem of Northeast Brazil has been that of irregularity of the dry weather and less of dryness. This has resulted in great uncertainty in the agricultural activity and risky life in general. Individual and governmental efforts made to reduce the consequences of major droughts and make life more tolerable have been met with limited successes.

3. Economic Environment

The Northeast's economy is heavily dependent on agriculture, particularly crop production. Thus in the composition of the regional product primary activities, mainly agriculture, contributed with 48%, industry 11% and services with 35% in 1965. During this time 66% of the region's population was in the rural sector and the population in general was young with 54% less than 20 years old. Due to large dependence on low value activity, agriculture, the income of the area is low and due to the periodic droughts there is sizeable out-migration of the population. The illiteracy rate is about 60% and transport and electricity are poorly developed.

The best lands of the Northeast are in the 50-mile-wide coastal strip where the population is mainly concentrated and where sugar cane had been traditionally cultivated in large properties under regime of monoculture. The interior which forms the Seratao, a semi-arid hinterland that makes 70% of the Northeast, is a relatively sparsely populated and periodically affected by drought; has a traditional activity of livestock raising. The main cultivated crops in the Northeast are cotton, sugar cane, manoic, beans, rice, sisal, tobacco and caster beans. Livestock and livestock products are second in importance contributing to 24% of the agricultural income. Crop production makes 70% while extractive agriculture accounts for the remaining 6% (Robock, 1963).

Within the Northeast there are great differences in resources, incomes, economic activity and urbanization. Average per capita income ranges from 29% of the national average for the State of Piaui to 60% for Pernambuco. Farm incomes also differ greatly within the region with the State of Bahia accounting for one-third of the total Northeast farm

income. Within Brazil, the Northeast is the lowest income region. "The best available estimates of Brazil's income in United States dollars indicate a per capita income in 1960 of $140 for the Northeast as compared to $410 in the South and $280 on the average for all Brazil" (Robock, 1963, p. 46). Thus the regional disparity in average income in 1960 ranged from 51 to 146 percent. The explanations for this low level of income in the Northeast, as given by most Brazilians, fall into two main areas. The first is the popular explanation which gives the traditional explanations such as problem of many decades of droughts which caused serious poverty and wide income fluctuations and inefficient capital investment by the public sector in unproductive projects, and the second is discriminatory federal politics which discriminate industrialization in the Northeast and poor policy with regard to fighting drought.

Robock, however, considers the following factors as the basic explanation for the economic poverty of the Northeast (Robock, 1963):

1. The physical resource endowment of the region, particularly the soils, is not outstanding.

2. The Northeast is specializing in relatively low income activity--agriculture.

3. A relatively small share of the Northeast population is economically active because of inadequate job opportunities.

4. Traditionally, the Northeast has never made substantial investment in its rich resource--its people.

5. Productivity is low in the Northeast due to serious lag in adopting technological innovations as well as to physical and human resource limitations.

4. Political and Social Environment

The Northeast is geographically removed from the main power center which has long been located in the Sao Paulo - Rio-Horizonte Triangle. The Northeast started losing its political and economic predominance around 1700 when the country's capital was shifted from Bahia to Rio in 1762. After this shift the major economic growth occurred in the Center and South where coffee production, European immigration, and industrialization dominated the scene. The Northeast region is also fragmented into numerous small size states and this has been a disadvantage because successful politicians from the region cannot deliver a large block of vote as the South or the Center and as a result the political power had largely been wielded by the South and Center politicians since the establishment of the Republic. Despite this, Northeasterners have often been attracted by political and military careers and as a result they have contributed powerful lobby at the seat of the power (Hirschman, 1963). In 1919, a Northeasterner, Epitacio Passoa, became the only President of Brazil from the Northeast. Ministerial positions have from time to time been held by Northeasterners which have contributed to the decisions at helping the drought problems of their region.

In general Hirchman puts that, "The region's size and large population, its historical and cultural importance, the assertive influence and pressure exerted by its elite, and, last but not least, the very deep misery and degradation into which a large part of its people are periodically plunged, have all made for a nationwide consciousness that the overcoming of backwardness and suffering in the Northeast is one of the principal tasks of Brazil as a Nation" (Hirschman, 1963, p. 18). On the other hand Roett takes the position that even though for a long time the

traditional culture and structure of the Northeast survived the colonial and imperial epoch with little alteration and minimum assistance from the south, the elite group retained their influence in the national affairs and dominant position in local society and economy by means of a system of bargaining that allowed them internal autonomy in exchange for political support of whatever government came to power in Rio de Janeiro (Roett, 1972). Political pressure even in the area of drought program became a manifestation of the needs of the desires of the regional oligarchy, which defined and distributed political power among the members of the oligarchy with no regard to public opinion or needs.

This tendency of political and social domination in the Northeast ended in 1945 when the military forced the withdrawal of the government from power and enabled social and political groups to assemble into loose coalition in preparation for political power. The 1946 constitution enabled organization of parties and as a result three major parties emerged. The effects of these parties started to show significant effects in the 1950's in the Northeast after a long gestation period.

5. The Drought Problem

Between 1877 and 1958 the Northeast had experienced eight major droughts in the periods 1877-79, 1888-89, 1900, 1915, 1919 20, 1931-32, 1951-52, and 1958. The failure of rain to come in 1877-79 had resulted in the worst disaster from which half a million people died due to hunger, thirst, eating of poisonous plants, and epidemic outbreaks. This tragedy resulted in the establishment of a Commission of Inquiry to look into ways of preventing similar disasters in the future. During this period relief assistance was limited and inefficient due to the poor

communications, slow reaction of different levels of government, inadequacy of funds, and corruption in handling the assistance.

The other seven droughts are as important as the one in 1877-79 but during these periods major institutional development had been undergoing and the effect on human life had been reduced as a result. Of all the droughts, the one in 1958 was the most severe and extensive one. It was particularly devastating in Ceara, Paraiba, and Rio Grande do Norte and brought a great exodus of people from the rural areas where crops were failing. The number of refuges employed by NDOCS, a drought fighting agency, at this time was almost 400,000 persons and by the Federal Highway Bureau 140,000 (Hirschman, 1963). This record number of refugees was able to escape the disaster due to good density of the road network and advances in motor transportation that had been made available by this time. However, the 1958 drought showed that all the previous attacks on the drought had been utterly futile and shattered the confidence in the drought relief agencies.

6. Development of Institutions and Their Innovations

In Brazil the important government decisions and institutions created with regards to drought are the results of official attempts to deal with the problems of the Northeast. Hirschman identifies two important features regarding the decisions (Hirschman, 1963).

1. A bad drought year usually results in some major new government effort; and

2. The presence of Northeasterner in key government position will produce forceful action.

Though these are usually the cases, both points are not regular in producing uniform results. The major drought years have in general

resulted in important government decisions which have necessitated the creation of institutions to carry-out the decisions. The institutions that were created over the years were the National Commission of Inquiry, the Inspectoria, the National Department of Works Against Drought (DNOCS), the San Franscisco Valley Commission and the San Franscisco Hydraulic Company, the Bank of Northeast (NBN), and the Superintendency for the Development of the Northeast (SUDENE). The creation, development, innovations and other aspects of these institutions will be discussed briefly below.

a. The National Commission of Inquiry

The federal government's official concern for the Northeast drought began in 1877 when an Imperial Commission of Inquiry was established to look into ways of preventing similar disasters in the future. The Commission's main recommendations were to improve transportation by building harbors and railroad lines and also build small and large dams. As a result of this, three dams were recommended for construction and the first dam, Cedro Dam in the Municipality of Quixoda, was started in 1884 with a capacity of 128 million cubic meter and completed in 1906 after many starts and stops. There was great inefficiency and waste in the construction of this dam which caused great dissatisfaction among the people.

b. Inspectoria

The dissatisfaction caused by the inefficiency of Quixida Dam led to the establishment of temporary federal commissions like Commission of Dams and Irrigation, Commission of Studies and Works Against the Effects of Droughts, and Commission for Perforation of Wells but these

commissions again turned out untidy and inefficient. In 1909 a unified permanent agency, the Inspectoria of Works Against Drought, was created to operate under the Ministry of Public Works. This federal agency remained in operation ever since with only slight changes in name. The Inspectoria's duty was to study systematically the drought area and to undertake the construction of works that would prevent or minimize the effects of droughts. The agency had broader power to build roads and railroads, drill wells, construct dams and reservoirs, and undertake other works as experience is built up. Natural scientists and engineers occupied all top positions and the principal solution to the problem was to be seen from engineering point of view.

During its early years of existence the Inspectoria prepared a number of scientific studies and organized data collection system on different aspects of the region. Shortly it was trapped in bureaucracy and inefficiency and politics started playing important role. The change of leadership, financial instability, lack of proper planning paralyzed the Inspectoria even as early as 1920. The problem of funds was especially an important matter and the fluctuation from year to year greatly limited the progress of several projects. According to Robock, the "Annual expenditure of the Inspectoria, for example, rose from 6 to 95 million cruzeiros from 1919 to 1922 and then dropped to 8 million in 1924. Likewise expenditures increased from 11 million cruzeiros in 1931 to 125 million in 1932 and then receded to 40 million in 1935" (Robock, 1963, p. 75).

The stability of funds for the Northeast projects, therefore, had been a very important requirement seen from the very beginning. The 1934

Constitution, to this effect, contained a special provision requiring that no less than 4 percent of the federal tax receipts be allocated for defense against the effects of droughts in the Northeast. This Constitution also provided that 4 percent of the state and local tax receipts be dedicated to economic assistance of this region (Hirschman, 1963). However, the revolution of 1937 disrupted efforts to implement these provisions and worst of all, the new Constitution that came about in 1937 itself dropped it all together. In summary by the thirties the Inspectoria had achieved to bring the number of dams in the region to 123 with a capacity of 2577 million cubic meters. In the area of highway construction 2000 kilometers of main highway and 1000 kilometers of secondary roads were built. The achievement in irrigation work was a failure and even by the 1960's the area irrigated by the reservoirs and dams amounted to only 7000 hectares (Hirschman, 1963).

c. National Department of Works Against Drought

In 1945 the Inspectoria was renamed National Department of Works Against Drought (DNOCS) with the responsibility to plan and implement hydraulic solution to drought problem and to carry emergency measures during prolonged drought periods and assist the people. Three percent of the federal tax revenues for defense against the drought and another three percent by the states in the region were to be allocated for construction of reservoirs and for other services necessary to assist the people (Robock, 1963). DNOCS completed two large dams that were started in the thirties. In the area of transportation and communication facilities, extensive works were undertaken which enabled to integrate the region with the rest of the national economy. About 12,000 kilometers

of dirt road, 2000 kilometers of paved road, 65 airfields, and 65 radio stations were built. Some research work in agro-industrial fields had been conducted by the agency. During the time there was a shift of interest from the northern part of the Northeast towards the southern part around the San Franscisco River.

From 1906 to 1959 the achievement in building dams, reservoirs, and irrigation channels resulted in completing 190 publically owned reservoirs with 6.6 billion cubic meters capacity, 470 small and medium storage reservoirs with 1 billion cubic meter capacity built on cooperative basis with landlords, and 5124 wells. As already indicated earlier, the result in actual irrigation was much limited with only 700 kilometers of irrigation channels to serve 6,000 hectares out of 250,000 hectares of possible irrigable land.

In the late 1960's DNOCS emphasized the construction of more dams, irrigation projects, well drilling, and agricultural extension activities. Its expenditure grew from 117,700 cruzeiros in 1950 to 2,100,900 in 1960, 28,624,400 in 1965 and 45,577,600 in 1968 (Anderson, 1972). The Department allocated an average of 52.7% of its budget to agriculture during the 1950-68 period and as opposed to its first phase. The DNOCS seems to play an important historical role in the agricultural development process in recent years.

d. San Franscisco Valley Commission and San Franscisco Hydraulic Company

There was transition in federal programs for the Northeast as a result of the creation of the San Franscisco Valley Commission and the San Franscisco Hydraulic Company in 1948 to develop the resource of the

region. These events took place without any serious drought emergencies and emerged out of events and policies largely unrelated to the traditional fighting of the drought problem. The purpose for creation of these agencies was to eliminate the vacuum that separates the Northeast from the Center and the South, giving an objective meaning to the force that will strengthen national unity and the funds for the project were earmarked before any specific program existed in 1946 (Robock, 1963).

The Commission's basic task was the regulation of the San Franscisco River flow for purposes of navigation, flood control, irrigation, and generation of electric power. Though the above tasks were set for the agency, it was later caught in undistinguished career (Hirschman, 1963). The commission in practice built access roads, infirmaries, and small hospitals and provided water and power for small towns.

The San Franscisco Hydraulic Company was also formed in 1968 and its functions were mostly power generation by building dams. It was a successful organization from an engineering point of view and its power generation capacity had expanded considerably over time.

Since 1957, the San Franscisco Valley Commission started concentrating on the agricultural sector and approximately 32% of its total expenditure during the period 1950-68 was spent on agricultural development (Anderson, 1972). The agricultural expenditure of this agency grew from 471,700 cruzeiors in 1957 to 25,927,000 cruzeiros in 1968 and it almost equalled the agricultural expenditure of the SUDENE in 1968.

e. Bank of Northeast Brazil

Created in 1952, the bank marked the first government acceptance of economic solution as federal policy for the Northeast drought problem

(Robock, 1963). The new policy of focusing on the economic welfare problem was a supplement to the hydraulic approach which was being carried out by DNOCS, particularly disbursing the constitutionally allocated shares of the federal revenue. The Bank of Northeast Brazil (BNB) obtained by the 1946 constitution one percent of federal tax revenues as special emergency relief fund for the Northeast drought which by special legislation in 1949 was authorized for use for agricultural and industrial loans.

As required by law to establish one bank branch for each 400,000 people, NBN opened 41 branches by 1960 with a total of 1500 employees. Its financial resources grew from 320 million to 6.4 billion cruzeiros (US $16 million to US $33 million) from 1954 to 1960. The main significance of this agency was that unlike other government agencies it maintained a reputation of non-political and businesslike practice. Thus it helped overcome the difficulties in a democratic setting of shifting from long established and politically controlled welfare and public works project to economically viable development program (Robock, 1963). In 1958 another drought came and DNOCS was stuck with another series of failures and scandals and this strengthened the economic development approach and resulted in a new federal agency to plan and coordinate all development efforts and drought fighting programs of the region. Thus the new agency, Superintendency for the Development of Northeast (SUDENE) was established in 1951 to coordinate the programs.

f. Superintendency for the Development of Northeast

The major policy changes in Brazilian government to the Northeast is directly related to the new national forces for economic planning and

development strongly supported in the 1940's. The various development organizations like DNOCS, CVSF, CHESF and BNB which were results of new regional initiatives of federal government resulted in additional agencies operating independently of each other and needed coordination at regional level. As a result of this and other pressure groups, a law was passed in 1959 to start SUDENE, and the first five-year plan of the agency was submitted in mid-1960. The philosophy, plans and performance of SUDENE are based on the concept that economic development must be political-economic development. As a result the politician and economist are joined in one person and political and economic strategy are combined in one plan (Robock, 1963). Thus, the strength of Furtado, the economist and politician, political considerations of federal deputies and senators from Northeast who became unwilling to give up their control over the allocation of federal funds in the region, Furtado's political support from state governors in the Northeast, federal legislators from the South, university student groups, Brazilian nationalists, and the United States aid program enabled SUDENE to apply economic development approach to the Northeast problem (Robock, 1963). The main policies of the SUDENE were:

1. Identification of industrial investment with the objective of increasing regional employment opportunities, reduction of the adverse flow of private capital out of Northeast, and reduction of the vulnerability of the region to drought.

2. Reorganization of agriculture for greater food production in humid areas, stabilization of food supplies, and transformation of the semi-arid zones to increased productivity and drought resistance.

3. Reallocation of population surpluses by redefining the Northeast to include the state of Maranhao to the north which, having moist soils, could absorb population surpluses created by a reorganization of the semi-arid agricultural economy. The actual five-year plan was limited in functional terms by requiring revision of plan every year and investment was based on yearly basis. Much of the priority went to creation of economic infrastructure like roads and electric power expansion which accounted for 70% of total planned investment in the first plan and about 76% of the first congressional appropriation (Robock, 1963).

The plan consists of agriculture as one of the important areas of planned expenditures with 15% of the total planned expenditure, with objectives of resettling farmers in Marhanao, reorganizing agricultural patterns in the humid sugar cane producing areas, making public farms available for family farms, irrigating 80,000 hectares in semi-arid interior, conducting agronomic planning, and river basin development programs. Though the first plan devoted 99% of the total planned expenditure on infrastructure, water and sewage projects, and agriculture, the second plan reduced this share to 80%.

SUDENE plans and implementation as of 1962 were not comprehensive regional development plans as stated in the policies for they included very little of the private sector, did not embrace total federal, state, and local expenditures, gave little attention to institutional and administrative needs, planning was top-down, and the main problem of the area which needed improvement in agriculture did not receive strong support and appropriation. In the agricultural field SUDENE invested substantial portions of its resources during its four phases, i.e., SUDENE I (1960-62) 11.7%, SUDENE II (1963-65) 19.3%, SUDENE III (1966-68) 12.6%, and SUDENE IV (1969-73) 11.8% (Anderson, 1972). The aggregate

growth rate in the SUDENE region was almost 10% per year during 1962-68 period, approximately double that of the country. The impact on agriculture even though not so great until 1960, was very significant during the post-1961 period. Compared to the other agencies, however, the direct impact of the SUDENE on agriculture was limited (Anderson, 1972).

To summarize the accomplishments of the above institutions, from the establishment of the first drought-fighting agency, the hydraulic approach was the only significant solution sought for the problem. This approach emphasized physical facilities like dams, reservoirs, and small wells as defense against the drought. Each new crisis resulted in building expensive dams and water storage reservoirs, the actual use of which were not put to irrigation in significant amount until the 1960's.

The basic philosophy of fighting the drought through water conservation projects gave way to economic development and planning by setting up BNB and SUDENE. This new "economic" solution focused on economic welfare problem mostly in industry and commerce with the subsequent neglect of agriculture in proportion to others and thus resulted in putting the main target of the drought phenomena and supporter of the majority of the population in second place. The various agencies involved so far did not stress the development of irrigation, practice to use proper soil conservation, adjustment in land use pattern, adjustment in cropping pattern, and adjustment in the sizes of farms.

Part III

A. Comparisons of Effectiveness and Pattern of Adjustment

In this section, the effectiveness of the innovations outlined in the programs of the various institutions discussed above will be compared. Since there is no direct measure of the impact of these institutions on the drought problem, indirect evaluation of their impact on stability of crop yield, development of irrigation, and adjustment of the farming practices to the drought condition will be looked at. Particularly adjustments in cattle population, land use pattern, cropping pattern, farm sizes, and the type and extent of conservation practices undertaken will be compared.

To make this comparison illuminating, a single state from each of the three regions was selected. The reasons for doing this are: difficulty of combining some of the measures like crop yield and irrigation facilities because of varying sizes of the states in a single region; lack of adequate data on all the states affected by drought, particularly those in India and Northeast Brazil; and because a typical state can present the conditions in greater detail. Therefore, the states of Punjab, Kansas, and Ceara were selected from India, Great Plains, and Northeast Brazil respectively.

The State of Punjab was selected from among the drought affected states in India because it is one of the highly drought affected states and relatively one of the most successful to make the necessary adjustments, particularly irrigation development. R. N. Dubey says, "There is no part of India which is so favorably suited as regards its waters, or so unfavorably as regards ~~to~~ its rainfall as the Punjab. By far

the greatest portion of it has less than 25 inches of rainfall per year. Even this amount is liable to failure" (Dubey, 1964, p. 66). Due to the great rivers with which it is fed, the Punjab is the most highly irrigated state in India and the Triple Canal system in the state is one of the largest in the country.

The State of Kansas was selected from the Plains States because its various regions have characteristics typical of the various parts of the region. Rainfall and vegetation vary greatly from one region of the state to another, representing the great diversity of the Plains region. For example, in 1961 rainfall varied from 22.7 inches in northwest Kansas to 54.57 inches in the southeast. The State of Kansas is the greatest wheat producer of the region and a good representative of the recent extensive cultivation which upset the ecological balance that had existed in that area.

The State of Ceara, like Punjab and Kansas, is a typical drought affected state in the region. It is among the first of the Northeast Brazil's states to get government attention from the beginning of the Inspectoria's hydraulic program. The Cedro Dam which was started in 1884 and completed in 1906 is located in this state. Geographically, the state has a small coastal strip and a huge drought ridden interior, typical of the Northeast.

With this introduction, the States of Punjab, Kansas, and Ceara will be taken up in the comparisons of the effectiveness of some of the innovations and the adjustments made in order to reduce the effects of droughts on the agriculture of the regions.

1. Stability of Yield

Adequate and timely supply of water is necessary for cultivation purposes and crop yields and intensity of land use are largely determined by it. Climate is one of the important determiners of the amount of water available for cultivation and hence yields. And "the most important effects of climatic variability are those on crops. They relate not only to current yields but also to extent of planting in the following years. Crop yields fluctuate notably in the Great Plains. Average corn yields range from almost nothing to 40 bushels per acre, while average yields of wheat vary from 5 bushels to more than 30 bushels per acre over entire states" (Great Plains Committee, 1936, p. 32). This indicates that climate has the dominant effect on the yields to be expected in areas of low rainfall.

The success in reducing the effects of droughts on agricultural activities through development of innovations like irrigation, soil conservation, and change in cropping pattern can be indirectly measured through the degree of fluctuation of yields with ups and downs of rainfall. To show the pattern of variability, crop yields in the three states during the 1947 to 1970 period were chosen for comparison. The pattern of yield fluctuation for the important crops grown in these areas are compared both in absolute terms and in comparison to the base year, 1947, along with the annual rainfall. The level of fluctuation of yield is then contrasted with the level of rainfall for that year.

Before going to the individual comparisons, one point needs to be clarified here. The annual rainfall used for comparison are the average rainfall for the state in the case of Punjab and Kansas. For

Ceara this is not the case because similar rainfall information was not possible to obtain. The only available rainfall data for this state was for Fortaleza, the state capital which is located at the coastal area and receives normally higher rainfall than the interior, and for Quixeramobim, a town located at the heart of the state where the rainfall is very low. The average rainfall of these two locations was used to represent the rainfall for the entire state. Since the rainfall for Fortaleza is very high, both in dry and wet years, the average rainfall will be inflated and the fluctuation from year to year will be reduced. Therefore, this limitation should be borne in mind when comparing the fluctuations of yield and rainfall. In the following paragraphs the patterns of crop yield and rainfall will be compared for Punjab, Kansas and Ceara for the period 1947 to 1970.

Punjab

Table 3 shows the pattern of crop yield in Punjab from 1947 to 1970. From the table it is clear that years of very low rainfall were 1949-50 with 21.38 inches, 1951-52 with 17.54 inches, 1963-64 with 17.25 inches, 1965-66 with 14.76 inches, and the three years of 1966-67, 1967-68 and 1968-69 with 21.88 inches, 21.21 inches and 18.39 inches, respectively. There was slight decline of rice and wheat yields in 1951-52 from 8.8 to 8.1 quintals and from 9.7 to 9.2 quintals, respectively and the corresponding index numbers are 92 and 95. Bajra and barley have also shown slight declines compared to the preceeding year. In 1963-64, though rainfall was only 17.25 inches, there was no reduction in yields compared to the year before when rainfall was 23.72 inches except for wheat and barley which fell from

Table 3

Pattern of crop yield and rainfall, 1947-1970 in Punjab

Rainfall in inches
Yield index 1947-48 = 100

Quintals 1 ha

Year	Rice		Bajra		Corn		Wheat		Barley		Gram		Cotton lint		Rainfall
	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index	
1947-48	8.8	100	3.6	100	8.2	100	9.7	100	6.2	100	5.4	100	2.5	100	26.40
48-49															26.70
49-50	9.5	108	3.7	103	10.0	122	10.9	112	5.9	95	4.1	76	-	-	21.38
50-51	8.9	101	3.8	106	5.6	68	9.0	93	6.5	105	6.0	111	2.5	100	33.90
51-52	8.1	92	3.6	100	9.0	110	9.2	95	6.2	100	6.1	113	-	-	17.59
52-53															23.14
53-54	10.1	115	4.3	119	13.3	162	10.6	109	10.2	165	9.1	169	-	-	25.15
54-55	9.4	107	2.4	67	11.1	135	11.2	115	9.6	155	7.8	144	2.5	100	27.62
55-56	7.2	82	3.8	106	7.4	90	8.8	91	7.6	123	6.6	122	2.0	80	37.59
56-57	9.5	108	2.5	69	16.2	198	10.3	106	9.2	148	7.9	146	2.5	100	30.66
57-58	9.4	107	3.1	89	13.7	167	10.1	104	8.5	137	7.3	135	2.4	96	29.58
58-59	9.3	106	2.9	81	10.1	123	10.7	110	8.4	135	9.3	172	2.1	84	32.14
59-60	10.5	119	3.5	97	13.2	161	10.2	105	8.1	131	6.5	120	2.6	104	27.43
60-61	10.4	118	4.8	133	11.3	138	12.4	128	8.0	129	8.2	152	2.7	108	27.77
61-62	10.4	118	6.1	169	13.8	168	12.3	127	8.5	137	8.2	152	3.0	120	24.79
62-63	9.8	111	3.9	108	9.1	111	13.5	139	9.5	153	8.1	150	2.8	112	23.72
63-64	11.5	131	3.9	108	13.9	170	12.0	124	7.8	126	5.1	150	3.0	120	17.25
64-65	12.8	145	3.6	100	13.2	161	13.8	142	11.7	189	7.8	144	3.1	124	25.36
65-66	10.0	114	5.5	153	16.7	204	12.4	128	10.3	166	6.2	115	3.1	124	14.76
66-67	11.9	135	8.2	228	14.0	171	15.1	156	8.6	139	8.0	148	3.1	124	21.88
67-68	13.3	151	10.0	278	16.5	201	18.9	195	10.0	161	9.2	170	3.3	132	21.21
68-69	13.6	155	10.5	292	15.6	190	21.7	224	8.5	137	6.8	126	3.1	124	18.39
69-70	14.9	169	11.0	306	14.7	179	22.2	229	10.0	161	8.9	165	3.5	140	24.06
70-71	17.6	200	11.8	328	15.5	189	22.4	231	10.2	165	8.0	148	3.7	148	29.10

Source: Statistical Abstract of India, 1947-1972 and Statistical Abstract of Punjab, 1966-1970.

13.5 to 12.0 quintals and from 9.5 to 7.8 quintals, respectively. But both wheat and barley have shown increases compared to 1947. In fact, rice, corn, and cotton lint have shown increases compared to the previous year, 1962-63.

During the four years of low rainfall between 1965-66 and 1968-69, all yields were higher than the base year, 1947, even in 1965-66 when rainfall fell to the minimum of 14.76 inches. Even when compared to the preceeding year of good rainfall, 1964-65, when rainfall was 25.36 inches, no significant decline in yield was observed. Only rice yield fell from 12.8 quintals (index = 145) to 11.4 quintals (index = 114) and gram (pulse) yield from 7.8 quintals (index = 144) to 6.2 quintals (index = 115). Surprisingly, there were some increases in yields of bajra (millet) and corn from 3.6 quintals (index = 100) to 5.5 quintals (index = 153) and from 13.2 quintals (index = 161) to 16.7 quintals (index = 204), respectively.

Despite this low fluctuation of yield during years of low rainfall, there had been years of decline of yields even though the rainfall was high. In 1955-56, when rainfall was 37.59 inches, the highest recorded for the state for the 24 years period, rice yield fell to 7.2 quintals (index = 82), corn fell to 7.4 quintals (index = 90), wheat fell to 8.8 quintals (index = 91), and cotton lint to 2.0 quintals (index = 80). The reason for this decline could be either flooding or unseasonality of rain. There were also reductions in the yields of bajra from 1956-57 to 1959-60 despite moderately high rainfall.

Kansas

Table 4 shows that the years 1952 to 1956, 1963, and 1966 were periods of low rainfall, ranging from 15.45 inches in 1956 to 22.16 in

Table 4

Pattern of Crop Yield and rainfall, 1947-70 in Kansas

Rainfall in inches
Yield index 1947 = 100

Quintals 1 ha

Year	Wheat		Rye		Corn		Oats		Barley		Sorghum		Hay		Rainfall
	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index	
1947	13.8	100	6.9	100	10.7	100	10.4	100	11.8	100	8.1	100	37.8	100	27.43
48	11.8	91	7.2	104	20.4	191	7.9	76	10.2	86	12.0	148	43.9	116	29.53
49	7.7	59	6.6	96	18.2	170	7.7	74	9.1	77	12.9	159	41.0	108	31.85
50	9.7	75	6.6	96	22.3	208	7.9	76	7.5	64	13.4	165	41.5	110	26.75
51	8.7	67	6.0	87	15.0	140	6.5	63	6.8	58	12.3	152	40.0	106	41.58
52	14.1	108	6.9	100	13.8	129	7.3	68	8.3	70	7.8	96	29.1	77	18.65
53	8.4	65	6.0	87	13.5	126	7.7	74	7.5	64	8.6	106	29.6	78	21.00
54	11.8	91	6.9	100	11.9	111	11.7	113	11.6	98	7.8	96	33.1	88	20.04
55	10.1	78	6.3	91	11.9	111	9.9	95	9.7	82	6.4	79	33.6	89	22.16
56	10.4	80	7.2	104	13.2	123	7.7	74	9.7	82	8.4	104	26.4	70	15.45
57	12.8	98	10.3	149	18.2	170	10.9	105	11.8	100	11.8	146	44.9	119	33.80
58	18.8	145	10.7	155	26.4	247	9.3	89	14.5	123	18.5	228	52.6	139	32.45
59	13.4	103	9.1	132	26.0	243	8.2	79	13.7	116	18.5	228	46.9	124	28.74
60	19.2	148	11.3	164	28.4	265	12.2	117	14.0	119	21.8	269	49.9	132	27.63
61	17.8	137	10.7	155	30.1	281	11.1	107	16.7	142	22.4	277	49.6	131	35.30
62	15.8	122	9.7	141	31.1	291	8.1	78	10.2	86	24.4	301	50.1	133	28.40
63	14.5	112	7.8	113	28.9	270	10.8	104	9.7	82	21.8	269	40.8	108	21.00
64	15.1	116	9.4	136	27.6	258	10.4	100	13.4	114	17.9	221	43.2	114	23.00
65	15.8	122	10.4	151	37.0	346	11.5	110	14.3	121	25.8	319	52.6	139	32.50
66	13.1	101	9.4	136	36.4	340	10.0	96	13.4	114	27.4	338	39.5	104	17.80
67	13.4	103	8.4	123	42.7	399	12.9	124	14.5	123	25.8	319	52.8	140	30.00
68	17.5	135	9.7	141	47.1	440	13.6	131	19.9	167	26.3	325	48.4	128	27.20
69	20.8	160	11.9	172	46.4	434	13.6	131	19.9	167	31.4	388	52.8	140	30.80
70	22.2	171	13.8	200	39.0	364	14.7	141	19.9	167	23.0	284	42.5	112	24.30

Source: Crop Production, Crop Reporting Board, Bureau of Agricultural Economics, U.S.D.A., 1950-70 and Agricultural Statistics, 1947-71.

1955. During these years most of the yields of the important crops have declined considerably. Wheat yield was 8.4 quintals (index = 65) in 1953, 11.8 quintals (index = 91) in 1954, 10.1 quintals (index = 78) in 1955, and 10.4 quintals (index = 80) in 1956. Rye, oat, barley and hay also experienced great declines during these periods with oats reaching a low of 7.8 quintals (index = 68) and hay 29.1 quintals (index = 77) in 1953 and barley 8.3 quintals (index = 70) in 1952. In 1963, despite the low rainfall, yields were above the base year but below the previous year (1962) in all cases except oats which increased from 8.1 quintals in 1962 when rainfall was 28.40 inches to 10.8 quintals in 1963 when rainfall was 21.00 inches. In 1966 all yields except for oats were above the base year but lower than the previous year. The yield of oat fell from 11.5 quintals (index = 110) in 1965 to 10.0 quintals (index = 96) in 1966. During this same year sorghum yield increased from 25.8 quintals in 1965 when rainfall was 32.50 inches to 27.4 quintals when rainfall was 17.80 inches.

There were decreases in yields in the moderately high rainfall years of 1948 to 1951 for wheat, rye, oak, and barley. Wheat yield reached its lowest level of 7.7 quintals (index = 87) in 1949, oats 6.5 quintals (index = 63) in 1951, and barley 6.8 quintals (index = 58) in 1951. During these years rainfall ranged between 26.75 and 41.58 inches.

Ceara

Table 5 shows that the worst drought years in Ceara during the 24 years period were 1951, 1952, 1953, and 1958. Cotton yield fell from 5.3 quintals per hectare in 1950 to 2.0 quintals in 1951, or

Table 5

Pattern of Crop Yield and rainfall, 1947-1970 in Ceara

Rainfall in inches
Yield index 1947 = 100

Quintals 1 ha

Year	Cotton		Rice		Sugar cane		Beans		Cassava		Corn		Rainfall
	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index	
1947	4.4	100	13.2	100	450.0	100	5.2	100	122.8	100	8.5	100	54.41
48	3.2	73	13.3	101	440.0	98	4.7	90	139.6	114	9.2	108	40.11
49	4.1	93	16.5	125	460.0	102	4.9	94	143.5	117	8.8	104	52.13
50	5.3	120	17.4	132	460.1	102	5.7	110	129.2	105	9.4	111	36.23
51	2.0	45	7.0	53	360.0	80	2.4	46	108.9	89	3.9	45	24.63
52	3.5	79	12.5	95	412.2	92	4.3	83	134.9	110	6.7	79	26.15
53	2.7	61	5.5	42	351.2	78	3.7	71	121.2	99	4.8	56	17.04
54	3.4	77	10.3	78	391.2	87	5.4	104	117.0	95	6.8	80	227.88
55	3.7	84	14.8	112	404.9	90	4.9	94	118.5	96	7.9	93	34.18
56	3.8	86	15.0	114	419.5	93	4.5	87	127.8	104	8.3	98	27.89
57	3.9	89	13.9	105	418.5	93	5.4	104	128.0	104	7.9	93	32.66
58	1.8	41	4.1	31	290.6	55	1.5	29	82.6	67	2.0	24	16.11
59	3.7	84	16.6	126	405.2	90	5.3	102	136.9	111	8.3	98	40.51
60	4.1	93	16.2	123	401.7	89	5.2	100	132.8	108	7.9	93	33.93
61	4.1	93	18.2	138	374.1	83	5.2	100	169.1	138	8.8	104	52.43
62	3.8	86	17.9	136	410.3	91	5.4	104	155.6	127	9.3	109	26.42
63	3.9	89	19.0	144	414.0	92	5.9	113	162.6	132	9.3	109	63.05
64	3.1	70	18.9	143	418.1	93	4.2	81	150.4	122	7.5	88	73.63
65	3.4	77	19.1	145	423.3	94	5.6	108	155.8	127	9.2	108	47.09
66	2.5	57	15.3	116	396.5	88	4.0	77	154.7	126	6.6	78	41.42
67	2.9	66	18.5	140	418.4	93	6.0	115	160.5	131	9.6	113	54.10
68	3.1	70	17.4	132	410.4	91	5.8	112	155.5	127	8.9	105	43.79
69	2.8	64	17.3	131	410.9	91	5.4	104	157.2	218	8.3	98	54.72
70	1.5	34	5.3	40	369.3	82	2.0	38	135.4	110	3.0	35	39.76

Source: Annuario Estatistico do Brazil, 1947-1971 and Manual De Estatisticas Boritas Do Nordeste, 1968. For rainfall: World Weather Record 1941-50, 1951-60, and 1961-70.

45% of that of the base year. Rice yield fell from 17.4 quintals in 1950 to 7.0 quintals in 1951, only 53% of that of 1947. Bean yield fell to 46% of that of 1947 and corn to 45%. Sugar cane and cassava yields also declined considerably in 1951. In 1952, cotton, beans, and corn yields fell by about 20% each compared to 1947 and rice and sugar by about 5 and 7% respectively. The 1953 drought was even worse than the two and as a result cotton yields declined to 2.7 quintals (index = 61), rice to 5.5 quintals (index = 42), sugar cane to 531.2 quintals (index = 78), beans to 3.7 quintals (index = 71), and corn to 4.8 quintals (index = 56).

The 1958 drought was also severe and all the yields of the important crops fell very sharply more than during the previous droughts. Cotton yield declined from 3.9 quintals in 1957 to 1.8 quintals in 1958, corn declined from 13.9 quintals in 1957 to 4.1 quintals in 1958; sugar cane from 418.5 quintals to 290.6 quintals; beans from 5.4 quintals to 1.5 quintal; cassava from 128.0 quintals to 82.0 quintals; and corn from 7.9 quintals to 2.0 quintals. Again in 1970, despite a high average rainfall for the two locations representing the state, there was great decline in the yields of cotton, rice, sugar cane, beans, and corn.

Except for rice and cassava, the general pattern of yields in Ceara declined over the 1947-70 period. Particularly cotton yields went down drastically even in years of good rainfall such as 1965, 1967, and 1969. Thus, the yield instability in Ceara was higher in comparison to the other two states.

2. Development of irrigation

The 1941 Year Book of Agriculture which was devoted to irrigation describes the importance of irrigation in the following words: "Theoretically irrigation affords an ideal form of husbandry wherein man attains a high degree of control over his crops through regulation of water, averts the consequences of drought, and takes the advantage of the long warm growing seasons and fertile soils of the semi-desert area to produce high yields in a variety of crops" (Year Book, 1941, p. 195). The need for irrigation is a requirement arising largely from climate but such factors as increasing population, growing cattle industry, and cultivation of specialized crops often require development of irrigation. Irrigation broadens the usability of the land, insures high level of yield, and upgrades the efficiency of other related factors of production such as soils, fertilizer, machinery, and good temperature.

The agricultural history of the three regions under consideration reveals that the main problem in successful agricultural production is that of providing adequate and timely supply of water for cultivation purposes. Since the amount of rainfall is severely limited during some years, irrigation becomes the remaining alternative for providing assured, adequate and regular supply of water to grow crops and raise livestock. Table 6 shows the development of irrigation from 1900 to 1970 in the states of Punjab, Kansas, and Ceara and for the entire regions of India, Great Plains, and Northeast Brazil.

As is clear from the table the data on irrigation development have several shortcomings. First, the areas under irrigation in India and Punjab have changed significantly due to changes in the size of the

Table 6

Development of Irrigation 1900-1970

Area Irrigated, Hectares

Year	Total India	Punjab	% of Cropland Irrigated, Punjab	Total Great Plains	Kansas	% of Cropland Irrigated, Kansas	Total N.E. Brazil	Ceara	% of Cropland Irrigated, Ceara
1900	5,000,000			709,233	11,709				
1910					15,174	.08			
1920	8,406,882	3,874,285		1,108,088	19,155	.09			
1930	10,778,334	5,146,995	48.9	1,349,411	28,862	.11			
1940	22,267,000	5,501,093	48.2	2,327,504	40,478	.17			
1950	21,749,000	1,780,889	36.8	3,739,172	57,082	.20			
1960	24,584,000	2,998,000	40.1	5,665,802	308,596	1.04	52,772	11,393	.72
1970	30,340,000	2,836,000	70.4	6,969,950	616,323	3.06	115,971	25,487	1.08

Sources: 1) Statistical Abstract of India, 1920-1970.

2) Agricultural Census of the United States 1900, 1910, 1920, 1930, 1940, 1950, 1959, and 1969.

3) Censo Agnicola De 19560, Volume II and Annurio Estatistico Do Brasil, 1975.

country and the state. Due to the partition of India with Burma in 1936 and with Pakistan in 1947, parts of the irrigation facilities had gone to these two countries. The 1947 partition had also given much of the irrigated land in Punjab to Pakistan and as a result the irrigated area in Punjab had fallen from 5,501,093 hectares in 1940 to 1,780,889 in 1950. Also in 1966, due to religion and language problems, part of Punjab was taken to form a new state called Haryana and as a result, there was another reduction in the irrigated area.

Secondly, the data on irrigation were not complete for Punjab before 1920 and for Ceara and Northeast Brazil for the period before 1960. Particularly the big data gap for Northeast Brazil and Ceara deprives of the picture much historical information. The censuses of Brazil available before 1960 do not contain information on irrigation and other sources are lacking in this area.

Given these limitations, the development of irrigation is considerably extensive in India but limited in the Great Plains and Northeast Brazil. Despite loss of large irrigated areas to Burma and Pakistan, India had managed to increase its irrigated area from 5 million hectares in 1900 to 30,340,000 hectares in 1970. In the Great Plains the growth for the same period was from 709,233 hectares to 6,969,950 hectares. The area irrigated in Northeast Brazil was only 115,971 hectares by 1970, and compared to the other two, it is very small.

On state basis Punjab is the most successful with 2,836,000 hectares under irrigation covering 70.4% of the cropland in 1970. Though the growth rate in Kansas was spectacular from only 11,709 hectares in 1900 to 616,323 hectares in 1970, and particularly after

1950, the area under irrigation reached only 3.06% of the cropland by 1970. Despite the lack of adequate data for Ceara, the development of irrigation had been very slow. Although the state is the second largest having irrigated land in the region, only next to Bahia, the area irrigated was only 11,393 hectares in 1960 and 25,487 hectares in 1970 or 0.73% and 1.08% of the cropland, respectively. Thus, while Punjab achieved great level of irrigation development, Kansas and Ceara were not able to expand their irrigation facilities on the same scale.

The important explanations for lower level of achievement in irrigation in Kansas and Ceara include lack of water for irrigation both rivers and underground resources, high cost of providing irrigation, shortage of funds, and other economic, physical, and political problems as indicated in the discussion of development of institutions. In India, though the present level of irrigation expansion is far greater than that in the other two regions, there is danger in the future expansion of further irrigation facilities as a result of the poor adjustment in land use and other farm practices. The cutting of timber trees that reduces forest, grazing of hillsides, expansion of roads and recreational facilities will alter the characteristics of the stream flows, tamper the long established physical and biological features of the watersheds from which the water is derived and reduce the potentially available water. This calls for proper water and soil conservation which at the moment has not obtained adequate attention.

3. Adjustment in land use pattern

In low rainfall regions like the Punjab, Great Plains, and Northeast Brazil, wide climatic fluctuations are to be expected from year

to year and over time. A stable economy, therefore, can be achieved only if agriculture is adapted to the entire range of climatic conditions that would prevail. Particularly the adjustment to low rainfall requires keeping as much of the land covered with vegetation in order to maintain the natural cycle of rain.

The natural vegetation of a region can be maintained and/or increased by maintaining and/or increasing the rangelands and the forests. Rangelands and forests are also very highly adapted to the climatic conditions of dry regions. "Range plants are adapted to contend with fluctuating precipitation and have remarkable recuperative powers to affect loss of stand as a result of drought. Adaption includes compaction or breaking up of grass tufts, production of fewer and stronger stems and leaves, the curling or folding of leaves to reduce transpiration, and even dropping of leaves by shrubs if conditions become too severe" (Year Book, 1941, p. 465). This greater adaption of range plants helps reduce the effects of short droughts on an economy largely based on the use of grazing.

Forests, like the grass, are highly adapted to dry conditions and provide greater stability. A dense forest acts as an umbrella with holes in it covering the land under. Naturally, the moisture, temperature and light under the forest are modified to provide favorable condition to the area under it. More than that, the climate near the vast umbrella provided by the forest is somewhat modified too. This shows that, even though man can do nothing to affect the climate in general, he can influence it to some extent locally by adding or taking away forests. In sum, the important localized effects of forests include considerable interception of precipitation by trees, reduction of

evaporation from the soil under the forest, reduction of wind velocities that carry soil and increase rate of evaporation, increasing the water storage capacity of the soil, and increasing the humidity within the soil.

Ideally the expansion of cultivation should be limited and over time the area under pasture and forests should be expanded. Reduction in the waste land should be made through appropriate reclamation and conservation measures. These land use adjustments are necessary from the standpoint of the drought problem, but in practice many other factors affect patterns of land use. Among these are technology (e.g. irrigation, machinery, conservation, etc.), price of farm products, and consumption habit of the people, a good example of which is the Indian food habit which is vegetarian. However, the comparison that will be made here is strictly limited to the adjustment pattern necessary from the view point of climatic requirement. Tables 7, 8, and 9 show the pattern of adjustment in the three states both in absolute terms (hectares) and relative terms, percentages, starting from 1930, 1910, and 1920 for Punjab, Kansas, and Ceara, respectively.

Punjab

Tables 7a and 7b show the land use pattern in Punjab for the period 1930 to 1970. Since the absolute sizes of the different land uses cannot be compared due to changes in the size of the state, comparisons will be limited to the change in proportion of the different uses over time. Cropland increased from 42% of the total land area in 1930 to 80% in 1970. Pasture land declined from 3% in 1930 to almost none in 1970. The area under forests fell from 3% in 1930 to 2% in 1970.

Fallow, land left to conserve moisture for next growing season, declined from 7% in 1930 to 3% in 1970. All these adjustments were undesirable from the view point of climate. The only desirable adjustment made in this state was the reduction of cultivable waste from 25% in 1930 to 2% in 1970.

The worst of all the undesirable changes made was the decrease in pasture land to almost zero percent despite a large number of cattle population in the state, 3,162,000 cattle and 2,933,000 buffalos in 1970. Though there seems to be great danger due to greatly exposing the land to drought by cultivating 80% of the land, this danger has been reduced by bringing 70.4% of the cultivated land under irrigation. Irrigation will enable most of the land to be covered with crops almost all year round and thus increase the vegetation of the area and consequently the natural cycle of rain. In general the reduction in the size of pasture, forests, and fallow are undesirable adjustments in land use and would greatly affect the ability of the state to stand future droughts.

Kansas

As can be seen from Tables 8a and 8b, the adjustment in land use in Kansas has mixed results. There is some increase in cropland from 8.055,298 hectares in 1910 to 11,272,470 hectares in 1970, an increase from 38% to 53% of the land area. There is also slight increase in pasture land from 7,565,759 hectares or 36% of the total land area in 1930 to 8,146,154 hectares or 38% of the land area in 1970. This increase in pasture land is a desirable adjustment from the view point of the drought problem and the increasing cattle population.

Table 7a

Change in land use pattern of Punjab, 1930-1970

Hectores

Type of Use	1930	1940	1950	1960	1970
Total land area	25,206,400	24,697,000	9,685,000	12,195,000	5,030,000
Land in farms	20,125,750	19,435,620	7,242,100	9,026,000	4,395,000
Cropland	10,532,390	11,405,050	4,837,200	7,490,000	4,032,000
Pasture	811,610	327,964	298,400	125,000	5,000
Forests	879,230	799,570	307,200	270,000	119,000
Fallow	1,684,200	1,240,500	761,000	480,000	150,000
Not available for cultivation	5,080,650	5,261,380	2,442,900	3,169,000	635,000
Cultivable waste	6,218,320	5,662,536	1,047,300	561,000	89,000

Source: Statistical Abstract of India, 1930 to 1971.

Table 7b

Change in land use pattern of Punjab, 1930-1970

Percentages

Type of Use	1930	1940	1950	1960	1970
Total land area	100	100	100	100	100
Land in farms	80	78	75	74	87
Cropland	42	46	50	61	80
Pasture	3	1	3	1	(.01)
Forests	3	3	3	3	2
Fallow	7	5	8	4	3
Not available for cultivation	20	22	25	26	13
Cultivable waste	25	23	11	5	2

Source: Statistical Abstract of India, 1930 to 1971.

Table 8a

Change in land use pattern of Kansas from 1910 to 1970

Hectores

Type of Use	1910	1920	1930	1940	1950	1960	1970
Total land area	21,188,405	21,188,405	21,188,405	21,276,243	21,274,947	21,259,401	21,192,308
Land in farms	17,564,696	18,390,761	18,757,889	19,503,524	19,680,715	20,308,449	19,995,959
Cropland	8,055,298	8,869,545	10,233,248	9,387,285	11,514,018	11,997,115	11,272,470
Pasture			7,565,759	7,866,397	7,501,021	7,988,700	8,146,154
Forest	488,223	531,617	449,193	287,877	469,660	322,634	187,854
Fallow			509,689	1,961,965	196,015		389,474
Other unimproved	4,969,564	5,470,172					
Others	7,675,320	6,317,071	2,430,516	1,772,719	1,594,233	950,952	1,196,356

Sources: Agricultural Census of the United States 1910 to 1970.

Table 8b

Change in land use pattern of Kansas from 1910 to 1970

Percentages

Type of Use	1910	1920	1930	1940	1950	1960	1970
Total land area	100	100	100	100	100	100	100
Land in farms	83	87	89	92	92	96	94
Cropland	38	42	48	44	54	56	53
Pasture			36	37	35	38	38
Forest	2	3	2	2	2	2	1
Fallow			3	9	1		2
Other unimproved	24	26					
Others	36	17	11	8	8	4	6

Sources: Agricultural Census of the United States 1910 to 1970.

Forest lands declined from 488,223 hectares or 2% of the total land area in 1910 to 187,474 hectares or about 1% of the total land area in 1970. This reduction in forests was undesirable and could greatly decrease the hydraulic cycle of the area. Land in other uses declined greatly and most of it was captured by crops and pasture. In sum, the land use adjustment in Kansas had mixed results but compared to Punjab it was better for at least pasture land had increased.

Ceara

Tables 9a and 9b show the land use pattern in Ceara. In this state there was a spectacular increase both in crop land and pasture between 1920 and 1970. Crop land increased from 183,590 hectares or 1% of the total land area in 1920 to 2,356,952 hectares or 16% of the land area in 1970. This was almost a 13 fold increase in cultivated area in half a century. Since the initial crop land in this state was very small compared to the other two states, this increase in crop land might not be as dangerous as in the other states. After all by 1970 only 16% of the land was cultivated; the comparable figures for Punjab and Kansas being 80% and 53%, respectively. However, strictly from physical point of view this increased cultivation reduced the vegetation cover in the area, since there was no other protection provided through irrigation and conservation.

Pasture land increased from 2,000,550 hectares or 14% of the land area in 1920 to 4,123,379 hectares or 28% of the total land area in 1970. This increase in pasture acreage increased the protection of the land from wind and water erosion and kept the normal moisture cycle in the area. The land under forest increased considerably

Table 9a

Change in land use pattern of Ceara from 1920 to 1970

Type of Use	Hectores				
	1920	1940	1950	1960	1970
Total land area	14,700,000	14,700,000	14,700,000	14,700,000	14,700,000
Land in farms	5,649,677	8,605,953	10,200,877	10,943,939	10,771,994
Crop land	183,590	1,312,825	777,002	1,565,328	2,356,952
Pasture	2,000,550	2,305,022	2,392,056	3,370,474	4,123,379
Forest	1,327,999	2,281,248	3,002,585	3,295,215	1,543,554
Unappropriated waste	2,137,538	2,700,858	4,029,234	2,712,922	2,748,109
Others	9,050,323	6,094,047	4,499,123	3,756,061	3,988,006

Source: Annuario Estatistico Do Brazil, 1908-12, 1937-1971.

Table 9b

Change in land use pattern of Ceara from 1920 to 1970

Type of Use	Percentages				
	1920	1940	1950	1960	1970
Total land area	100	100	100	100	100
Land in farms	39	59	69	74	73
Crop land	1	9	5	11	16
Pasture	14	16	16	23	28
Forest	9	16	20	22	10
Unappropriated waste	15	18	28	19	19
Others	61	41	31	26	27

Source: Annuario Estatistico Do Brazil, 1908-12, 1937-1971.

between 1920 and 1960 but declined between 1960 and 1970 almost reaching the level of 1920. But compared to the other two states Ceara was the only one that was able at least to maintain the original size of its forest. Much of the land that went to the increase in crop land and pasture was taken out of land under other uses. There was a slight increase in unappropriated and waste land over the years under consideration, indicating the lack of reclamation and conservation work in the state. Despite the high increase in crop land, Ceara showed relatively better land use adjustment compared to the other two states.

4. Adjustment in livestock population

Climate has indirect effect on livestock production through its marked effect on the amount and nutritive value of feedstuffs produced within a region. In a dry region where rainfall fluctuates considerably and where the dry years greatly reduce the ability of the land to produce crops, the proper economic adjustment calls for returning to grazing economy, in which pasturing of cattle on the natural and restored range is supplemented by the production of forage and feed crops in areas where irrigation is possible, and elsewhere in the rainy season on soils that are resistant to deterioration by wind and water (Year Book, 1941). Thus, proper pasture management to keep the maximum young nutritious growth and good animal husbandry go hand in hand.

In a semi-arid area where the stand of the pasture covers only a small portion of the soil surface, usually about 10%, the number of acres required to feed an animal increases. If the animal population

has then to increase over time, the acreage under pasture has to increase considerably more in order to support the increased animals. For this reason every care should be taken to control and limit the grazing of pasture land in accordance with the carrying capacity, with allowance for growth for natural seeding. If the acreage under pasture cannot be increased or has to be reduced, the number of animals should be adjusted accordingly. Table 10 shows the pattern of livestock and pasture adjustment for the three states under consideration.

Table 10

Change in cattle population and pasture land, 1900 to 1970

	Cattle numbers			Pasture land in hectores		
Year	Punjab	Kansas	Ceara	Punjab	Kansas	Ceara
1900		4,491,078				
1910		3,079,403	1,161,900			
1920		2,975,390	580,028			2,000,550
1930		3,223,772	800,000	811,610	18,687,425	
1940		2,928,000	991,904	327,964	19,430,000	2,305,022
1950	4,292,000	3,627,000	1,527,720	298,400	18,527,523	2,392,056
1960	6,095,000	4,429,000	1,446,000	125,000	19,732,090	3,370,474
1970	3,162,000	6,016,000	2,227,000	5,000	20,121,000	4,123,379

Sources: 1) Statistical Abstract of India, 1908-12 to 1971.

2) Agricultural Census of the United States, 1900 to 1969.

3) Annuario Estatistico Do Brazil, 1920 to 1971.

Punjab

Despite the incomplete information and the change in the number of cattle and pasture size due to the division of the state in 1966, the cattle population reached alarmingly high proportions compared to the available grazing land. The pasture land stood at 5,000 hectares in 1970 to feed 3,162,000 cattle, 2,933,000 buffalos and a large number of sheep, goats and donkeys. The decline from 1950 to 1960 was also very alarming. In 1950, there were 298,400 hectares of pasture for

4,292,000 heads of cattle but in 1960, there were only 125,000 hectares for 6,095,000 heads of cattle. There was not much forage available to supplement the pasture as almost all the crop land was under wheat, rice, bajra, gram, and cotton. This situation resulted in overgrazing the small pasture and forest land and as a result serious erosion threatened the land. Kaith puts this problem as follows, "Sheet erosion and gullying of overgrazed pasture lands are quite common sights in India. The number of animals which graze in the forest and on the village commons is far greater than the vegetation can support. The need for balancing the number of improved livestock to the feed available is urgent" (Kaith, et al, 1948, p. 11). He suggests that "The improvement of pasture and the livestock can be effected only if a bold and vigorous policy is followed. This involves the adoption of all practical measures to reduce the number of cattle, combined with improvement of pasture and increase the area under forage crops" (Kaith, et al, 1948, p. 11).

It is clear that the Punjab made undesirable increases in its livestock population compared to the availability of pasture land. The decline of per capita pasture from 0.07 hectares per animal in 1950 to 0.002 hectares per animal in 1970 was an ample evidence.

Kansas

There were slight ups and downs in the cattle population between 1900 and 1950 and a moderate increase thereafter. The cattle population which was 4,491,078 in 1900 declined and stayed around the 3 million mark until 1950, but increased to 6,016,000 by 1970. The area under pasture increased from 18,687,425 hectares in 1930 to 20,121,000 hectares in 1970--but declining on per animal basis from

5.8 hectares in 1930 to 3.4 hectares in 1970. Since there was a large amount of cultivated land devoted to the production of hay, 966,000 hectares in 1970, the loss in the pasture land could be partially offset by the forage available from the hay fields.

In Kansas a large proportion of the animals, about 70% in 1970, were fed in feed lots with concentrates (Livestock and Meat Situation, 1970). This reduced the pressure of the cattle on the pasture lands and left more pasture land for those animals not fed on feed lots. On the whole, the increase in pasture land and the availability of forage and concentrates made the adjustment in livestock number in Kansas better than that made in Punjab.

Ceara

The number of cattle in Ceara decreased from 1,161,900 in 1910 to 580,028 in 1920, almost a 50% reduction but this number gradually picked up until 1960 but sharply rose by 1970 reaching an all time high of 2,227,000 heads of cattle. During this time the area under pasture had been increasing gradually and doubled between 1920 and 1970 from 2,000,550 hectares to 4,123,379 hectares. On per animal basis there was decline from 3.4 hectares in 1920 to 1.9 hectares in 1970. This figure was lower than that obtained in Kansas, but the rate of decline of pasture land per animal was lower in Ceara. There was a decline of 2.4 hectares per cattle in Kansas between 1920 and 1970 as compared to 1.4 hectares per cattle in Ceara for the same period.

5. Adjustment in cropping pattern

Reasons for adjustment in cropping pattern among many things include adaption to weather conditions; balancing of different crops

in order to stabilize income, adapting to technological change such as irrigation, farm machinery, fertilizer and pesticides; change in size of holdings; changes in government pricing policy; change in relative profitability of different crops; and change in consumption habits of the people. Assuming here that all changes in cropping patterns are the result of adaption to weather conditions, we will look at how Punjab, Kansas, and Ceara adjusted their cropping patterns to the prevailing low rainfall in these regions. In order to have a good view of the kind of crops adapted to the various rainfall conditions, classification of plants according to their water needs is necessary. Generally plants are classified into three groups depending on their water requirements. The first are the hydrophytes, the water loving plants like rice, which can be grown only where water from either rainfall or irrigation is extremely abundant. The second group called mesophytes are plants adapted to medium rainfall conditions and include great proportions of the agricultural plants like wheat, barley, corn, and oats. The third group called zerophytes are highly resistant to drought conditions and greatly desired for their extensive adaption to low rainfall areas. Example of a zerophyte crop is sorghum. The basic characteristics of plant life adapted to semi-arid and arid regions include early maturation of plants; flexibility in growth and plant structure which assures the ability to take advantage of changes in the length of the rainy season; strong stem to insure resistance to wind and hail; flexible root system which makes it possible to get to the moisture, whether near the surface or at greater depth; the ability to enter rest stage, taking advantage of early rains; high yield in seed or roughage or both; and other drought resistant characteristics

such as low evaporation, small leaves, thick waxy covering, slow growth, and continued growth through period of dormancy.

Under a semi-desert condition where irrigation has not been developed to a great extent, drought resistant crops are desirable for cultivation. In areas where irrigation facilities are widely available like that in Punjab, the need for cultivating drought resistant crops will not be great. Tables 11, 12 and 13 show the change in the cropping pattern in Punjab, Kansas and Ceara during the 1948 to 1970 period.

Punjab

Tables 11a and 11b show the change in the cropping pattern of the important crops in Punjab for the period 1948-49 to 1970-71. The changes in the size of the state from 9,685,000 hectares in the 1950's to 12,195,000 hectares in the 1960's and to 5,030,000 hectares in 1966 make an effective comparison on absolute area terms difficult. But attempts have been made here to compare the pattern of change on relative terms. Table 11a shows the acreage under the eight principal crops grown in the area. These eight crops made 39% of the cultivated land in 1948-49 and almost 100% in 1970-71, excluding multiple cropping. Table 11b shows the proportion of these principal crops compared to the base year 1948-49. We will compare the change in cropping pattern before and after the 1966 division of the state separately.

During the 1948-49 to 1964-65 period, rice, corn, wheat, gram and cotton acreages increased considerably. Jowar (sorghum) increased by 57% during this time. Bajra (millet) showed small increases and decreases but remained in the range of 80% and 116%. Barley acreage

Table 11a

Change in Cropping Pattern from 1948-1970 in Punjab

1000 ha

Year	Rice	Jawar	Bajra	Corn	Wheat	Barley	Gram	Cotton
48-49	153	185	847	308	1112	166	1222	97
49-50								
50-51	225	256	818	311	1199	161	1179	181
51-52	208	237	719	296	1299	221	754	210
52-53								
53-54	234	289	893	315	1237	167	1123	238
54-55								
55-56	247	240	732	322	1419	138	1530	335
56-57	297	326	981	409	2082	216	2509	573
57-58	319	306	921	472	1073	486	2316	616
58-59	346	308	984	508	2151	236	2583	601
59-60	393	282	858	539	2069	190	2465	545
60-61								
61-62	457	310	862	537	2239	181	2405	590
62-63	471	321	832	582	2263	161	2248	586
63-64	476	311	812	582	2323	143	2185	651
64-65	522	291	935	564	2440	158	2156	664
65-66								
66-67	271	5	184	419	1647	116	629	432
67-68	295	6	198	469	1804	132	560	420
68-69	338	3	192	481	2086	82	317	444
69-70	384	3	210	563	2162	80	450	385
70-71	390	5	207	555	2299	57	358	397

Source: Statistical Abstract of India, 1948 to 1971.

Table 11b

Change in Cropping Pattern from 1948-1970 in Punjab

Index 1948-49=100

Year	Rice	Jawar	Bajra	Corn	Wheat	Barley	Gram	Cotton
1948-49	100	100	100	100	100	100	100	100
49-50								
50-51	147	138	97	101	108	97	96	187
51-52	136	128	85	96	117	133	62	216
52-53								
53-54	153	156	105	102	111	101	92	245
54-55								
55-56	161	130	86	105	128	83	125	345
56-57	194	176	116	133	187	130	205	591
57-58	208	165	109	153	96	293	190	635
58-59	226	166	116	165	193	142	211	619
59-60	257	152	101	175	186	114	202	562
60-61								
61-62	299	168	102	174	201	109	197	608
62-63	309	174	98	189	204	97	184	604
63-64	311	168	96	189	209	86	179	671
64-65	341	157	110	183	219	95	176	685
65-66								
66-67	177	3	22	136	148	70	51	445
67-68	193	3	23	152	162	80	46	433
68-69	221	2	23	156	188	49	26	458
69-70	251	2	25	183	194	48	37	397
70-71	255	3	24	180	207	34	29	409

Source: Statistical Abstract of India, 1948 to 1971.

increased dramatically in 1957-58 reaching 486,000 hectares (index = 292) but fell back to 158,000 hectares (index = 95) by 1964-65.

During the 1966-67 to 1970-71 period, rice, corn, and wheat acreages increased substantially from 177% to 255%, from 136% to 180%, and from 148% to 207%, respectively. Jowar, bajra, and cotton stayed almost at the same level as in 1966-67 but with little ups and downs. The acreage under barley and gram fell considerably during this period. Barley decreased from 116,000 hectares (index = 70) in 1966-67 to 57,000 hectares (index = 34) in 1970-71 and gram from 629,000 hectares (index = 51) in 1966-67 to 358,000 hectares (index = 29) in 1970-71.

Overall rice, corn, and wheat have increased in acreage despite the fact that they are not drought resistant. Part of the explanation is the availability of irrigation facility that can provide adequate water to grow these crops. The other crops have shown some increases and decreases but there was no great change compared to the three crops. Jowar and bajra, which are resistant to drought conditions, have been stabilized during the later periods.

Kansas

As shown on tables 12a and 12b, the acreage under the 7 principal crops in Kansas fluctuated for almost all the crops, and despite this the acreage under rice, sorghum, and hay increased between 1948 and 1970. On the other hand wheat, corn, oats, and barley declined in acreage. Wheat declined from 5,927,000 hectares in 1948 to 3,924,000 hectares (index = 66) in 1970. Rye first steadily increased until it reached 148,000 hectares in 1958, then slightly decreased for the following three years, and then increased to reach a

Table 12a

Change in Cropping Pattern from 1948-1970 in Kansas

1000 ha

Year	Wheat	Rye	Corn	Oats	Barley	Sorghum	Hay
1948	5927	36	1012	654	186	489	788
1949	6579	26	1052	419	108	465	806
50	5592	41	1056	616	258	787	821
51	5983	35	1130	480	139	1055	864
52	6103	37	1142	403	49	273	799
53	5798	41	993	500	68	776	873
54	4754	81	924	500	223	1303	963
55	4374	107	730	560	379	1171	1032
56	4417	113	686	560	326	659	921
57	2916	146	638	566	343	2490	968
58	4402	148	727	277	326	1583	878
59	4402	130	815	341	404	1641	775
60	4358	130	831	208	436	1690	811
61	4344	117	580	266	401	1131	855
62	3751	166	626	211	422	1199	897
63	4310	139	701	173	287	2052	915
64	4310	72	567	164	235	1744	991
65	4565	90	522	105	94	1639	1047
66	4474	82	553	113	89	1541	1035
67	5324	51	553	88	48	1757	998
68	4845	38	586	90	51	1810	973
69	4361	68	622	81	81	1647	967
70	3924	85	684	117	89	1778	966

Source: Agricultural Statistics, USDA, 1948-1971.

Table 12b

Change in Cropping Pattern from 1948-70 in Kansas

Index 1948=100

Year	Wheat	Rye	Corn	Oats	Barley	Sorghum	Hay
1948	100	100	100	100	100	100	100
49	111	72	104	64	58	95	102
50	94	114	104	94	138	161	104
51	101	97	112	73	75	216	110
52	103	103	113	62	26	56	101
53	98	114	98	76	37	159	111
54	80	225	91	76	120	266	122
55	74	297	72	86	204	239	131
56	75	314	68	86	175	135	117
57	49	406	63	87	184	509	123
58	74	411	72	42	175	324	114
59	74	361	81	52	217	336	98
60	74	361	82	32	234	346	103
61	73	325	57	41	216	231	109
62	63	461	62	32	227	245	114
63	73	386	69	26	154	420	116
64	73	200	56	25	126	357	126
65	77	250	52	16	51	335	133
66	75	228	56	17	48	315	131
67	90	142	56	13	26	359	127
68	82	106	58	14	27	370	123
69	74	189	61	12	44	337	123
70	66	236	68	18	48	364	123

Source: Agricultural Statistics, USDA, 1948-1971.

record high of 166,000 hectares in 1962. After 1962, it decreased gradually throughout except in 1970 when it picked up a little to reach 85,000 hectares, 236% compared to 1947.

Corn acreage increased between 1948 and 1952 and reached its maximum of 1,142,000 hectares in 1952 and decreased thereafter reaching 684,000 hectares in 1970, whichwas 68% of that of the base year. Oats declined gradually with few ups and downs from 654,000 hectares in 1948 to 117,000 hectares in 1970, which is only 18%. Barley acreage declined considerably between 1949 and 1952 except in 1950 and then increased until 1965. After this period it declined sharply. Most of the years of sharp decline in barley coincided with years of low rainfall or years following low rainfall indicating that the plant was not well suited to dry conditions. Good examples were 1952, 1953 and 1966.

Sorghum acreage declined in 1952 but for the rest of the period the general pattern was towards increased acreage from year to year. The increase was from 489,000 hectares in 1948 to 1,778,000 hectares in 1970. In fact, the sorghum acreage increased tremendously in 1957, the year following the 1956 severe drought when rainfall was only 15.45 inches, and in 1963 when rainfall was 17.8 inches. This shows that during dry periods farmers prefer to grow drought-resistant crops. In general, the increase in sorghum acreage is a healthy pattern in the adjustment of cropping pattern.

The acreage under hay increased only slightly reaching its maximum of 1,047,000 hectares in 1950 and in 1970, it had levelled off to 966,000 hectares or 123% of that in 1948. In sum, except the increase in the acreage under rye, whichwas a minor crop, the adjustment in cropping

pattern in Kansas was very highly desirable and consistent with the moisture conditions of the region. Reduction in the high moisture requiring crops like wheat, corn, oats, and barley and increasing the drought resistant crop, sorghum, made the change in cropping pattern consistent with the shortage of water in the area.

Ceara

Tables 13a and 13b show that all the six important crops grown in Ceara increased in acreage between 1948 and 1970 with cotton and cassava showing the highest rates of increase. The area under cotton grew from 325,000 hectares in 1948 to 1,172,000 hectares in 1970. Rice increased from 26,000 hectares to 47,000 hectares, showing 81% increase over the 23 years period. Sugar cane increased from 20,000 hectares to 58,000 hectares (index = 290) in the same period.

Beans and corn acreage increased almost two and half times; beans from 113,000 hectares to 291,000 hectares and corn from 147,000 hectares to 374,000 hectares. During the worst dry years of 1951 and 1958, the acreage under the moisture sensitive crops like cotton, rice, beans and corn declined sharply indicating that these crops do not stand dry years. The acreage under cassava grew from 41,000 hectares in 1948 to 138,000 hectares in 1970, and this is the highest rate of increase among the six crops. The six crops considered here represent 86% of the crop land in 1948 and 88% in 1970. All these crops, except cassava are sensitive to drought and yet the acreage under all of them had increased despite this fact. It is even worse that drought-resistant crops like sorghum and millet have not been introduced to the region in sizeable amounts and the trend looks that these non-drought

Table 13a

Change in Cropping Pattern from 1948-1970 in Ceara

1000 ha

Year	Cotton	Rice	Sugar Cane	Beans	Casava	Corn
1948	325	26	20	113	41	147
49	321	28	21	122	44	179
50	346	23	23	135	53	208
51	281	18	23	93	48	121
52	309	26	24	114	49	182
53	310	26	25	131	54	181
54	341	31	25	167	55	224
55	358	34	26	201	61	224
56	379	37	27	216	70	252
57	411	42	29	224	61	271
58	362	21	27	75	44	78
59	407	33	23	212	33	254
60	431	34	30	226	51	279
61	497	35	31	236	54	301
62	569	44	35	247	60	317
63	642	43	34	264	65	350
64	749	46	38	260	71	346
65	877	48	37	282	69	378
66	979	46	41	278	72	342
67	1007	53	52	348	85	435
68	1114	57	57	360	123	481
69	1201	60	60	351	138	468
70	1172	47	58	291	138	374

Source: Annuario Estatistico Do Brasil, 1948-1971.

Table 13b

Change in Cropping Pattern from 1948-70 in Ceara

Index 1948=100

Year	Cotton	Rice	Sugar Cane	Beans	Casava	Corn
1948	100	100	100	100	100	100
49	99	108	105	108	107	122
50	106	88	115	119	129	141
51	86	69	115	82	117	82
52	95	100	120	101	120	124
53	95	100	125	116	132	123
54	105	119	125	148	134	152
55	110	131	130	178	149	152
56	117	142	135	191	171	171
57	126	162	145	198	149	184
58	111	81	135	66	107	53
59	125	127	115	188	80	173
60	133	131	150	200	124	190
61	153	135	155	209	132	205
62	175	169	175	219	146	216
63	198	165	170	234	159	238
64	230	177	190	230	173	235
65	270	185	185	250	168	257
66	301	177	205	246	176	233
67	310	204	260	308	207	296
68	343	219	285	319	300	327
69	370	231	300	311	337	318
70	361	181	290	258	337	254

Source: Annurio Estatistico Do Brasil, 1948-1971.

resistant crops will dominate the area and continue to fluctuate sharply in years of low rainfall.

6. Adjustment in size of holding

The need for diversifying the agricultural activity from heavy dependence on crop production to more and more cattle production requires that farms in areas of low rainfall become larger and larger over time in order to support a growing number of animals and at the same time provide adequate income comparable to that earned in the other parts of the country where rainfall is abundant. Because of the decline of incomes in dry regions during years of low rainfall, farmers in dry areas should be able to earn greater incomes in years of good rainfall to enable them to go with little or no income in years of low rainfall. This also calls for larger farms than in regions where rainfall is assured. These and other reasons indicate that the desirable adjustment in the size of farms should be towards larger and larger farms until a point is reached where cultivation and grazing can be carried out more profitably and reasonable income growth compatible with the country's rate of development can be maintained.

Generally, the average and sometimes the absolute size of farms in a region are related to the agricultural land per capita. The relationship between farm size and per capita agricultural land somewhat vary between countries owning to differences in the share of farm work force in the total labor force (Johnston and Kilby, 1975). In a more developed region like the Great Plains, the nonagricultural labor force is larger relative to the total labor force and as a result the average farm size is larger relative to the agricultural land per

capita. But in a region like Punjab where most of the people are engaged in agriculture, the average farm size is smaller relative to the agricultural land per capita. The average farm size is used to look at some of the changing patterns of farm size in Punjab. In Kansas and Ceara different farm sizes are used to evaluate the pattern of adjustment in the sizes of farms in these regions.

Punjab

Table 14 shows that adequate data that can show the different size of farms in Punjab over time is not available. Due to lack of information it is not possible to make any significant conclusion about the changes in farm sizes in Punjab. The only available information which can give indication of the size of farms is the average size for 1924, 1950, and 1960 which were 9.2 acres, 11.8 acres, and 4.5 acres, respectively. From this it can be said that, generally, the farms in Punjab were very small in size. The average acreage in 1960 was much smaller than that in 1950 and 1924. In 1950 farms under 10 acres made up 49% of the total number of farms, but in 1960 they declined to 44%. Farms in the 10-49 acres category increased from 50% in 1950 to 53% in 1960. Similarly, the proportion of farms above 50 acres increased from 1% to 2% during the same period.

Kansas

Tables 15a and 15b show the absolute number and the proportion of farms under the different size categories in Kansas for the period 1900 to 1970. The number of farms under 10 acres increased between 1900 and 1950 but sharply declined in 1960 and again rose in 1970 to

Table 14

Change in farm size in Punjab, 1924 to 1960

Size of farm	Percentage of farms		
	1924	1950	1960
< 10 acres		49	44
10-49 acres		50	53
50+ acres		1	2
Unspecified			1
Average size of holding in acres	9.2	11.8	4.5

Source: 1) Statistical Abstract of India, 1953-54

2) Statistical Abstract of Punjab, 1971

3) Johnston and Kilby, Agriculture and Structural Transformation, p. 14.

reach 3,460 or 4% of the total number of farms. Farms in the 10-49 acres category declined considerably, decreasing from 15,677 or 10% of the farms in 1900 to 5,231 or 6% of the farms in 1970. The farms in the 50-99 acres category increased between 1900 and 1910 but declined thereafter to reach 8% in 1970 from its original of 16% in 1900. The 100-225 acres farms increased from 80,452 or 48% of the farms in 1900 to 85,011 or 46% of the farms in 1910 but declined thereafter reaching 19,467 or 23% in 1970.

The number of farms in the 260-499 acres category increased until 1930 but declined thereafter. This group of farms increased in relative terms from 17% in 1900 to 36% in 1960 but fell to 23% by 1970. The farms in the 500-999 acres category increased consistently both in absolute and relative terms from 8,895 or 5% of the farms in 1900 to 18,394 or 21% of the farms in 1970. Similarly, farms 1000 acres and above increased gradually and consistently from

Table 15a

Change in farm size in Kansas from 1900-1970

	Number of farms							
Size of farm	1900	1910	1920	1930	1940	1950	1960	1970
< 10 acres	3,598	4,441	4,042	6,728	7,564	7,861	605	3,460
10 - 49 acres	15,677	14,339	11,565	13,540	13,514	11,008	4,606	5,231
50 - 99 acres	26,151	32,103	20,287	19,226	17,394	11,973	7,265	7,217
100 - 259 acres	80,452	85,011	75,587	68,401	59,886	41,563	19,191	19,467
260 - 499 acres	28,182	34,696	37,504	38,385	36,298	33,874	34,321	19,675
500 - 999 acres	8,895	10,475	12,127	15,055	15,635	17,456	19,498	18,394
1000+ acres	3,360	3,559	4,174	4,707	6,036	7,659	9,855	12,613
Total # of farms	166,315	184,624	165,286	166,042	156,327	131,394	95,341	86,057

Source: Agricultural Census of the United States, 1900 to 1969.

Table 15b

Change in farm size in Kansas from 1900-1970

	Percentages of farms							
Size of farm	1900	1910	1920	1930	1940	1950	1960	1970
< 10 acres	2	2	2	4	5	6	1	4
10 - 49 acres	10	8	7	8	9	8	5	6
50 - 99 acres	16	17	12	12	11	9	8	8
100 - 259 acres	48	46	46	41	38	32	20	23
260 - 499 acres	17	19	23	23	23	26	36	23
500 - 999 acres	5	6	7	9	10	13	20	21
1000+ acres	2	2	3	3	4	6	10	15
Total # of farms	100	100	100	100	100	100	100	100

Source: Agricultural Census of the United States, 1900 to 1969.

3,360 or 2% of the farms in 1900 to 12,613 or 15% of the farms in 1970.

In general, the farms below 99 acres decreased from 28% to 18% from 1900 to 1970; those in the 100-259 acres category declined from 48% to 23%; and those 260 acres and above increased considerably, particularly those 500 acres and above. The general tendency was towards decreasing farms that are less than 260 acres and increasing those 260 acres and above. Also the total number of farms in the state had in general been declining through this period. The total number of farms fell from 166,315 in 1900 to 86,057 in 1970, a reduction of almost 48%. This reduction in the total number of farms had given the opportunity for the rest to increase in size.

Ceara

Though the size classification shown on Tables 16a and 16b are different from that for Kansas, both on unit of measurement and sizes of different categoreis, there is a clear pattern of adjustment in the sizes of the forms over the 1920 to 1970 period. The number of farms thatwere less than 10 hectares decreased from 25,948 or 28% in 1940 to 18,607 or 22% in 1950 but increased to 34,654 or 28% in 1960 and to 120,470 or 50% in 1970. The number of farms in the 11-100 hectares category decreased from 49,064 or 53% in 1940 to 46,870 in 1950 but increased in relative terms to 55%. In 1960 and 1970, this group increased considerably in absolute terms to 66,101 and 101,842, respectively, but declined in relative terms to 54% and 41%, respectively.

Table 16a

Change in Farm Size in Ceara from 1920-1970

Number of farms

Size of farm	1920	1940	1950	1960	1970
< 10 hectares	7594	25,948	18,607	34,654	120,470
11 - 100 "		49,064	46,870	66,101	101,842
101 - 1000 "	7534	17,266	18,832	20,694	22,114
1001-10,000 "	1075	904	1,343	1,284	1,272
10,001 + "	20	16	29	30	18
Undeclared	-	-			239
Total # of farms	16,223	93,198	85,681	122,763	245,955

Source: Annuario Estatistico Do Brasil, 1908-12 to 1973.

Table 16b

Change in Size of Farm in Ceara from 1920-1970

Percentages of farms

Size of farm	1920	1940	1950	1960	1970
< 10 hectares	47	28	22	28	50
11 - 100 "		53	55	54	41
101 - 1000 "	46	18	22	17	9
1001-10,000 "	7	1	1	1	(0.5)
10,001 +	(0.1)	(0.01)	(0.03)	(0.02)	(0.007)
Undeclared					(0.1)
Total # of farms	100	100	100	100	100

Source: Annuario Estatistico Do Brasil 1908-12 to 1973.

The larger farms in the 101-1000 hectares category increased in absolute terms from 7,534 in 1900 to 22,114 in 1970 but declined in relative terms from 46% to 9% during the same period. The number of farms between 1001-10,000 hectares remained around one thousand and those over 10,000 remained around the 20's. In general, the tendency for farm size in Ceara had been towards increased number of small farms below 100 hectares in size. These farms increased from 47% of the farms in 1900 to 91% in 1970. The larger farms above 100 hectares declined from 53% in 1900 to 9% in 1970. It is clear from this that Ceara did not make any desirable adjustment in the size of farms, in fact the situation deteriorated over the years.

7. Conservation practices

"An inch of water saved by cultural practice is as good as an extra inch of rainfall" (Year Book, 1941, p. 34). A major objective of a conservation program is to keep the rainfall where it falls as nearly as possible so that it may be absorbed by the soil, conduct excess water from the land slowly under control in order to reduce soil erosion, and then minimize the evaporation of the water retained in the soil. On already cultivated land conservation calls for complete program of soil conservation and management practices, some of these practices requiring expert engineering and agronomic practices.

Conservation programs in addition to conserving water and hence reducing the effects of drought, restore the ecological balance of the area which had been upset by expansion of economic activity into marginal lands and by poor cultivation practices. Soil conservation

also brings other beneficial effects such as giving opportunities for recreation, enables green and good looking countryside to be covered with vegetation, provides clean environment and streams, and preserves resources for future generations.

As discussed earlier in Part II, conservation had been vigorously carried in the U.S. beginning in the early 1930's and is still a very active program of the Department of Agriculture. On the other hand, in India and Brazil conservation programs are at their infant stages and largely concentrate on research, training, and demonstration and as a result large scale conservation works like that in the U.S. have not been started. For this reason, this section will concentrate on the type and size of the conservation work done in Kansas only. Table 17 shows some of the major practices, acreage covered under each practice, number of participating farmers, and proportion of crop land put under conservation for 5-year intervals between 1940 and 1970.

As shown on the table, the major conservation practices include terracing, contour farming, protective summer fallow, grazing land management, green manure and cover crops, and strip cropping. Other practices not shown are mulching, listing, rotation of crops, crop residue management, fertilizer application, liming, constructing ponds and drainage ditches, and minor irrigation works. The trend in conservation during the 30 years period was towards reducing the number of participating farms and the amount of farm land put under conservation practices. The relative proportion of the various practices had also been changing considerably.

Table 17

Selected conservation practices performed in Kansas and extent of participation

			Hectores					
Year	# of participating farmers	% of cropland	Terracing	Contour farming	Protective summer fallow	Strip Cropping	Grazing land management	Green manure and cover crops
1940	-	-	982	1,330	-	-	-	446,221
1945	64,408	62	13,061	151,665	902,900	23,833	628,532	122,394
1950	46,743	50	84,614	175,737	1,152,606	27,750	258,559	26,143
1955	27,609	32	72,659	103,363	36,696	21,479	1,180,704	33,026
1960	19,743	17	104,501	116,838	-	1,226	22,258	31,989
1965	20,616	19	116,599	141,101	-	12,874	23,887	44,939
1970	16,607	-	95,547	273,328	389,475	3,084	21,862	51,012

Source: Agricultural Statistics, U.S.D.A., 1940 to 1971.

It is interesting to note that the soil conservation program in the U.S. was combined with production control program beginning 1936. Farmers were paid to voluntarily shift acreage from soil depleting crops to soil conserving legumes and grasses and this made the soil conservation program a successful arrangement. In general the conservation program in the U.S. in addition to spending large amounts of money on various conservation programs, also gave farmers the incentives to use profitable practices not initially undertaken due to uncertainty and lack of knowledge. There is great potential for other countries to use the practices and programs developed in the U.S. with suitable modification to suit local conditions and save vast areas of agricultural land from erosion and deterioration and as well reduce the effects of droughts.

Conclusion

The type of institution developed and the specific innovations made to reduce the effects of droughts in India, Great Plains, and Northeast Brazil differ both in approach and content and this is largely due to the differences in the economic, political, social, and physical conditions existing in these regions. It is clear from the previous discussions that each region followed different approaches and the results have also been different. As the three representative states indicate, one region was successful in some areas but lacking in others. India largely concentrated on irrigation developments and this enabled it to expand the area under irrigation more than the other two regions. But it failed to make desirable adjustments in

land use patterns, cropping patterns, livestock size, farm size, and conservation of soil and water.

In the Great Plains the attempt to reduce the effects of drought by creating specialized institutions helped initiate a number programs in the areas of conservation, irrigation, pasture management, and farm size enlargement and as a result striking successes have been achieved. Particularly reduction in fluctuation of crop yields and expansion of pasture land stand out as very successful achievements. Other successful programs include conservation, enlargement of farm sizes, and improvement in cropping patterns from small grains to the drought resistant crop, sorghum.

The least successful of the three regions under consideration was Northeast Brazil as seen from the conditions in Ceara. The hydraulic approach followed in this region for half a century did not result in large irrigation facilities and the new economic development approach has not helped make desirable adjustments in cropping patterns, farm size, and conservation of soil and water. The only desirable adjustment made was the increase in pasture land to keep up with the increasing livestock population. Crop yields fluctuated sharply in years of low rainfall as was the case in 1951 to 1953 and 1958. The crop acreage also declined sharply in years of low rainfall. Irrigation was unsuccessful since only 25,000 hectares were irrigated in Ceara by 1970, and about 115,000 in the whole Northeast region. The cropping pattern and farm sizes moved opposite to what was desired and conservation was not started on large scale even by 1970.

It is thus clear the three regions have shown varying degrees of successes in the process of trying to reduce the effects of droughts on agriculture. Of the three, Kansas had made more desirable adjustments in most of the areas. The extensive irrigation in Punjab which enabled to reduce the fluctuation of yield more than the other two, puts it ahead of Ceara. The success of Kansas is not without adequate reasons. The political, financial, and scientific support behind the various institutions and programs, the large participation of the people of the state, and the organization of the various programs and institutions at all levels of government made the efforts successful. In addition, the high income of the people gave such great taxing power to the different levels of government that programs started or supported by these governments had huge amounts of money to spend on various programs as already seen in the discussion of soil conservation and reclamation programs. In the other two states, on the other hand, finance had been one of the important bottlenecks in most of the programs. Also in the case of Kansas and the Great Plains in general the political support, particularly from the elected officials of the Plains States, was so tremendous that financial requirements of the various programs were successfully met due to the pressure of these officials on the legislation and executive bodies.

Above all the scientific support made available to the drought related programs was extremely impressive. Besides the use of the already accumulated scientific knowledge in the various areas of activities, the Great Plains Agricultural Council made continued local studies for use in various programs. Because of its great contribution to the scientific studies and applications of various drought

related results to actually solving the problem, the background of this Council deserves some elaboration. The purpose of the Great Plains Agricultural Council is to analyze the problems of the region, develop possible solutions, promote adoption of research, extension, and action programs to conditions of the Plains. The Council is an advisory body which provides for exchange of ideas and was formed in the early 1930's as various agricultural leaders felt a need to work together on common problems. Since then, it has continued to function on the adaption of agriculture to the dry conditions of the region.

The Council carries out much of its activities through use of committees. These committees are: Controlled-climate plant growth committee which outlines the need for regional laboratory and areas of work in which research would be conducted; forestry committee to facilitate tree growing in the Plains; information committee to publicize the work of the Council; health committee to facilitate the adaption of health services and facilities to the conditions peculiar to the Plains; insect control committee to facilitate adjustment of insect control programs to the needs of the Plains; irrigation committee to outline research need on problem of irrigation farming and irrigation development; Plains research committee to activate regional research on problems of the Plains; program implementation committee to outline research needed in the field; soil moisture research laboratory committee to outline need for regional program and outline areas of work in which research would be conducted; and tenure, credit, and land values committee to outline research need and to facilitate in these and related areas. A number of these committees have functioned for many years and made important contributions in

finding solutions to the agricultural problems of the region.

The experience of Great Plains shows that to provide permanent and lasting solution to the problems of droughts in a region careful analysis of the potentials, needs, and constraints anchored in the economic, political, social, and physical environment of a country, irrespective of existing patterns, and then directing the necessary efforts in a coordinated way to better serve the purpose, it is important to recognize that the major and most difficult issues are not those of engineering nature, but those which involve questions of policy and interpretation and settlement of conflict of desires of competitive groups. If engineering were the solution to the drought problem, the 50 years of Brazilian hydraulic programs could have been successful. Therefore, it should be understood from the very beginning that the important issues are sociological and economic and not engineering.

Since the problem of drought is the shortage of water or its unseasonality, the ultimate objective of any action to overcome the problem needs to aim at balancing the economy of the region with respect to water availability and other economic segments. The first scientific approach to the balancing program is to have enough data to prepare a "water economic budget." This budget should provide an inventory of water resources as they are now and the water uses and needs with their shortages and surpluses. The budget should cover all types of water uses--domestic, municipal, industrial, irrigation, dilution of treated waste and agricultural runoff, and water from precipitation needed for crops and for range used for grazing--(Report of U.S. Government, 1958). The budget has to show not only the demand side but also the supply side

as accurately as possible. Present and future demands and supplies should then be developed for specific regions depending on their potentialities and other considerations that may be important. This water economic budget will serve as the basis from which the agricultural adjustments such as land use pattern, irrigation development, livestock number, holding size, conservation programs, and cropping patterns can be determined, consistent with the future economic development of the region. And lastly, the future adjustment in agriculture and the entire economic activity should be directed in a coordinated manner and should include the central government, local government, institutions, and above all, the people of the region.

Part IV

Implication for Ethiopia

In this section a brief introduction to the country, drought problems, and the existing situation will be made which will be followed by some recommendations to the problems of droughts from the experience obtained from the institutions and programs developed in the Great Plains, India, and Northeast Brazil. Since the drought problem in Ethiopia is a very big topic by itself, no detailed treatment will be attempted here. Only some practical lessons that can be useful to combat the problem are to be considered.

Ethiopia is 1,221,900 square kilometers and is divided roughly into two broad regions, the central plateau cut by numerous rivers and valleys and the eastern and southern lowlands which also include the Rift Valley. The climate is temperate on the plateau and hot in the lowlands. The weather is usually sunny and dry and there are two rainy seasons in a year. The small rainy season is around February to April and the big rainy season lasts from June to mid-September.

The population of Ethiopia was 27 million in 1975 and of this about 90% was rural and 10% urban. The main economic activity depends on agriculture, which supports about 90% of the population and makes up about 60% of the GNP. The per capita income was around US $80, GNP growth rate 1.2%, and population growth rate 2.4% in 1972. The foreign trade sector is very small and growing at a very slow rate and much of the exports are concentrated in a few agricultural commodities like coffee, hides, and oil seeds and pulses.

Religion has great social and economic impact on the daily life of the majority of the people and religious institutions command great power and resources. The urban sector is very small and is largely controlled by the bureaucracy, army, church and businessmen and is generally conservative. The small urban elite which is mostly Western-educated is opposed to this traditional conservatism and is struggling to maintain its identity in a surrounding based on tradition and patronage.

At present the country is run by a Provisional Military Government that assumed power in 1974 after overthrowing the government of Emperor Haile Selassie. The military government declared socialism as the political and economic guide for the future development of the country in early 1975 and since then urban and rural land, banks, industries, insurance companies and commercial banks have been nationalized. Recently, the Military Government has promised return to civilian government in the near future.

The Drought Problems

Historically, there had been several severe droughts in Ethiopia dating as far back as 1252. The two recent droughts that preceded the current one occurred in 1890-92 and 1958-59. The 1890-92 drought killed millions of people in the northern and central parts of the country. The 1958-59 drought which hit parts of Wallo, Tigre, and Eritrea killed at least 100,000 people in Wallo and Tigre alone (Greenfield, 1965). The current drought started around 1972 affecting the northern provinces of Wallo, Tigre and Eritrea and gradually moving southwards to Shoa, Harar, Bale, Sidamo, and Gemer Gofa. By 1975, 13 out of the 14 administrative regions in the country had been affected. The damage to human

life and economic activity was very severe. More than 100,000 people died in 1973 in Wallo alone and more than 4 million people were affected in 12 other administrative regions.

The failure of rain for three consecutive years in the settled agricultural area of the north and center and in the nomadic regions of the east and south caused great economic and social dislocations. The causes for the drought like that in India, Great Plains, and Brazil, were largely man-made. Centuries of careless land use and intensive cultivation in the fertile valleys stripped the soil and the vegetation, upset the ecological balance, and increased the vulnerability of the area to droughts. There were great human and animal pressures which pushed economic activities to marginal lands. Severe erosion of the highland occurred following destruction of forests and the natural vegetation and this resulted in exaggerating the shortages of rains on agricultural activities.

The effects of the current drought reached very high proportions because of various other complications that surrounded the shortage of rainfall. Maldistribution of land, lack of infrastructure, lack of social services, demographic imbalance, inefficient administration, decaying politics, and the general low standard of living failed to enable to meet emergency needs. As a result, great economic and social dislocations, which are beyond repair in the near future, were sustained by the country. The government effort that was organized lately focused largely on the short term emergency relief and rehabilitation programs. These programs were limited to provision of food, medical care, and shelter, distribution of oxen and seeds, construction of feeder roads and storage facilities, digging wells and

construction of ponds, and settling of dislocated individuals. Many of these short term programs will continue in the near future until good rains come and the victims are able to return to their old ways of life. But preparation should begin from now to find lasting solutions in order to avoid similar exposure of the people to this dangerous problem.

Steps Towards Lasting Solution to the Problem

The experience gained from the efforts made in India, United States, and Brazil has important implications to Ethiopia. Despite the great differences in the economic, social, political, and physical backgrounds of these countries and Ethiopia, some of the approaches, innovations, and knowledge accumulated can be transferred with suitable modifications to meet the Ethiopian conditions. The various scientific and organizational knowledge gained from carrying out the various adjustment programs in irrigation, soil reclamation, and adjustments in land use pattern, cropping pattern, farm sizes, livestock number, and conservation works can be transferred to Ethiopia to initiate suitable programs that can enable them to reduce the impacts of droughts. Large scale adoptive research is required to condition the accumulated huge scientific knowledge to suit conditions in Ethiopia.

Both for research and actual program implementation it is essential to recognize the two broad ecological zones in the drought affected areas of Ethiopia. The first zone is the highly populated, highly cultivated and severely eroded area with small-land-man ratio and covering the administrative regions of Wallo, Tigre, Northern Shoa and Eritrea. This region had been under cultivation for thousands of years and has highly subsistent economy. The second region is the

thinly populated, generally dry, high-land-man ratio and which supports a nomadic population largely dependent on livestock raising. This region is usually isolated from the rest of the country and the economy has not been integrated into that of the country. Therefore, future research work and actual programs should recognize these distinctions and work to meet differing needs and conditions. The organizational setups of future institutions that may be created should take the distinctions into account and two parallel subdepartments under the main organization may be needed to handle the problems of the two regions. With this short introduction, it is appropriate now to look at possible program recommendations for the problem. I have suggested two types of programs, short-term and long-term, and each will be discussed below:

Short-Term Programs

These programs include research, training, demonstration and education in all areas of drought and related problems and should start as soon as possible, preferably under the Ministry of Agriculture and assisted by the Relief and Rehabilitation Commission, the University and all foreign donors currently operating in the country in conjunction with the drought problem. The functions of the four separate programs should include:

1. Research - A capacity of scientific knowledge should be developed to do basic as well as adaptive research and already accumulated basic scientific data in countries like the United States and India should be used to find solutions to the problems of Ethiopia. The specific areas of research may include analysis of basic data, meteorological research on causes of drought, cloud physics, improved

forecasting, investigation for techniques of reducing evaporation, conducting surveys of availability, movement and use of underground water sources, studies of feasibility of artificial ground water recharge and storage studies of estimates of water use for various purposes, etc. Planning and development of water resource management, the type already started on the big river basins like the Awash, Blue Nile, Wabi Shebbeli and Baro should be greatly expanded. Collection and compilation of basic engineering data as well as research in economical use of water should be greatly expanded. Geologic surveys, soil studies, and comprehensive hydrologic studies and total potential water resources in the country should be determined. "Water economic budget" for the different parts of the country and for different economic activities should be prepared in accordance with future economic development of the country.

Studies in land resource management, which include geologic and topographic mapping and soil surveys, should be undertaken in order to justify and facilitate future programs. Specific studies in future program areas like run off and erosion control practices, agronomic adaptability of crops, irrigation management, nursery management, pasture and forage cultivation, grazing capacity, and adaptability of animals to drought conditions should be made.

Economic studies which can enable evaluation of the economic opportunities for adjustment in cropping patterns, land use, irrigation, conservation, holding size, and livestock development should be conducted under broad range of conditions. The scientific findings that are obtained from biological and physical scientists should be used to the fullest advantage in the economic studies.

2. Training - To conduct biological, physical, and economic research and to interpret the research results into meaningful programs, a large number of trained manpower is needed in various areas of studies. Qualified people ranging from top level scientists in such areas as agronomy, weather science, engineering, soils, geography, geology, animal husbandry, economics, planning, and sociology and anthropology to field levels, workers in extension, conservation, forestry, surveying, administration, and organization need to be trained in large numbers. Because of the limited scientific knowledge in the country and lack of trained manpower to start the initial programs, the need for training high level personnel becomes a top priority. The type of training and the timing should be planned in advance in order to be able to prepare the right type of people for the right job and at the right time.

3. Demonstration - Since it takes quite a long time to organize large scale government programs at the farm level, successful research results should be demonstrated as soon as they are made available and interested farmers should be encouraged to adopt them. Demonstration should also be used as a means for making the administrators and general public aware of the research findings, and make them ready for acceptance when the government is in a position to take them to the farms.

4. Information and education - Information and education have several useful functions. First, the immediate users of the programs will be informed of the research results and available government programs; the general public will be aware of the ongoing programs, and participating foreign donors will be aware of the activities

going on and how their assistance is utilized. Secondly, through the feedback process much can be learned from institutions doing similar work in other countries. Many things can also be learned from the farmers and the people in general.

The information program can also enable participation in international programs that are involved in similar program areas. Particularly regional and continental organizations are important for a problem like drought which has its causes and effects on wide geographical areas. As was clear from the past few years, the drought problem was a continental problem in Africa. The Sahel, Ethiopia, Somalia, Kenya, and Tanzania were hit by the 1973 droughts at the same time, and they should make coordinated effort to find a solution to the problem. A regional or continental research coordinating body on the line of the Great Plains Agricultural Council is appropriate. The smallness of the individual countries, the similarities in the regions, the high cost of research, and the continental nature of the causes of the problem justify this regional or continental level research program. The foundation should be laid now in order to do effective work in the future.

To these should be added the immediate rehabilitation programs which include:

a. Assistance to farmers for restoration of output. Many of the victims of the drought that fled their homes and entered the various relief camps need to go back to their farms and start farming once again. The proper assistance in the form of oxen, seeds, fertilizer, and food items that will enable them to restore their pre-drought level of production should be provided. Supportive programs in credit,

marketing, and production planning should start immediately in many of the regions in order to facilitate fast recovery.

b. Rebuilding herds -- the nomadic population that lost as much as 100% of its livestock in some areas needs to be restored to its traditional way of life until permanent settlement programs can be started on a large scale in the long run. This requires government assistance to replace the lost animals and to improve the watering and grazing facilities. The right number of animals that can be supported by the rangelands should be distributed to the farmers either freely or on credit basis or both. Supplementary assistance in the form of feeder roads, veterinary service, watering ponds, and marketing facilities should be provided.

c. Improving local administration capacity and greater decentralization -- the police, court, taxation, and general administration which are mostly filled with corrupt, incapable, and ineffective personnel that are obstacles to fast progress and development need to be replaced by honest and competent individuals. Promising young civil servants should be trained and put to work as soon as possible and in the future a high level of ethical and professional standards should be maintained in the civil service. Greater decision making and taxing power should be given to the administrative regions, districts, and peasant associations in order to make fast and effective decisions for local problems. The nature of drought problem which is diverse and urgent requires fast and localized decisions for most of the problems and this calls for greater decentralization.

These short range programs should be started as soon as possible and continue to function to meet new problems and new needs. The

success of long range programs are greatly determined by what is done in the short run.

Long-Term Programs

Long-term programs include policy, organization, and implementation of programs. The policy question can make use of some of the important experiences gained in the United States, India, and Brazil. The failures and successes of these countries should be closely studied in order not to repeat the mistakes and make use of the successful ones. Some of the policy considerations that may be useful to mention here are that the problem of drought should not be looked at separately from that of the general problem of economic development of the regions; institution and program development should not be aimed at solving problems in response to pressing situations, but should be planned and executed diligently and be guided by short- and long-term plans; the goals, objectives, programs, targets, and timing of implementation should be determined in advance and all alterations should be adequately justified; and the institutions created, the funds and leadership provided, and the legal and constitutional provisions should be separated from personalities and political interests and should be directed towards the general welfare of the people.

The organizational setup, staffing and expenditure for the various programs may be put under existing organizations like the Ministry of Agriculture and the Relief and Rehabilitation Commission or a new agency may be set up depending on research results. All decisions in organization, staffing and funding should be based on sound research and deliberations. One thing that should be clear at this point is that much of the success obtained in the United States, particularly in

soil conservation and grazing management, was largely because of the high level of cooperation and involvement of the people directly affected by the drought. Any program in Ethiopia should, therefore, make every effort to include the people in the programs both at planning and implementation stages. The present organization of the farmers into peasant associations will make this arrangement even more successful.

The specific programs to be carried out at the field level should largely be determined through research results. Since the Ethiopian drought problem is largely the result of human neglect of the land and poor agricultural practices, much of the research and field programs should be directed on this line. The main corrective factor should aim at restoring the water balance and the future use of the available water wisely. The following areas are part of a desirable program to reduce the effects of drought on agriculture:

1. Irrigation development - to reduce the effects of droughts on crops and livestock, adequate amounts of water should be provided through irrigation. Dams, reservoirs, ponds, wells, and ditches are needed to provide assured supply of water at least to some portions of the economic activities. Ethiopia has to make every effort to develop irrigation programs in those regions where adequate sources of water supply are available. Population shift from the currently rain fed agricultural areas to the big river valleys where there is great potential for irrigation development should be encouraged. And as there is no organization in the country to look at the development

of irrigation, a department of irrigation under the Ministry of Agriculture or Ministry of National Resources should be organized.

2. Proper adjustment in land use pattern - much of the cause for droughts in Ethiopia was the destruction of forests and the natural vegetation that keep the hydraulogic cycle of the region. Restoration of the normal cycle requires covering back the land with vegetation, both forests and grasses. Definite programs in tree planting and range restoration have to be started urgently in the northern and central parts of the country. Grazing associations, that may be part of the peasant association program and may include several of these peasant associations under one grazing association, should be organized. Government's technical and financial assistance must be provided in building ponds, restoring grasses and building feeder roads.

3. Soil conservation - this important program includes terracing, strip cropping, mulching, wind breaks, fertilizing, liming, contour farming, drainage, and weed and shrub management and should include all other practical steps to conserve soil and moisture. Soil conservation also helps restore the ecological balance upset by the action of man. Most of the soils in Ethiopia at present are greatly stripped of their natural vegetation and millions of tons of rich topsoil are washed into the sea annually. Unless definite and effective programs are taken, the situation will continue to deteriorate. Therefore, sound conservation programs that are based on scientific findings and are supported by the general public and the peasant associations in particular, should be initiated. Soil conservation associations may be set up or conservation responsibilities may be given to the peasant associations themselves. After all, the law that gave 10 hectares to

each farmer should be able to require that the land should be used under conditions that can restore the land. The law alone may not work and assistance of peasant associations and education of farms in

program until June 30, 1937, options were taken on about 17.5 million acres, and titles were acquired on about 12 million acres. The cost of the land acquired up to June 30, 1937 was $52,283,950" (Hardin, 1953, p. 325).

There was one big problem faced by the agency in the land purchase program with regard to the settling of families displaced. These families were mostly those long established with the problem areas, particularly drought area, and hence difficult to resettle. The families that were moved tended to hold the agency responsible for insuring success in the new location (Hardin, 1953). This led to opposition to the land purchase and resettlement activities and as a result the agency turned from this program to other types of aid to low income farmers and farm wage workers. Because of this and due to the fact that it was not originally authorized by Congress, the Congress passed the Bankhead-Jones Farm Tenancy Act in July, 1937 authorizing most of the activities previously carried on by the Resettlement Administration under executive order, plus some additional ones." On September 1, the Secretary of Agriculture issued a memorandum changing the name of the organization from Resettlement Administration to Farm Security Administration. All powers and duties of the Resettlement Administration had been transferred to the Secretary of Agriculture on December 31, 1936, under Executive Order 7530" (Hardin, 1953, p. 27).

d. Bureau of Reclamation

On June 17, 1902 Congress passed the Reclamation Act of 1902 for

Concentrating on the land aspect of this agency, the role dealing with the land was given to the Division of Land Utilization of this agency which was authorized to purchase land, work out adjustments on the economic use of such lands, provide for their conservation, and devise plans for the best size and type of farms and ranches adapted to this land. The part of this land program which attracted most attention in the early period was that involving purchase of submarginal lands, combining them into management units under government control, and resettling the families thus displaced, presumably on better lands (Hordin, 1953). This can be taken as a significant change in land policy of the government because before this the government's policy had looked to the alienation of any lands which people were willing to settle on except national forests, parks and certain mineral reserves. Much arid grazing lands, of necessity remained in government hands, and this was being brought under management through establishing grazing districts under government supervision.

There was some overlapping of responsibility with Soil Conservation Service and Division of Grazing with regard to soil conservation and grazing districts respectively. However, in setting up its program, the Resettlement Administration limited its activities largely to marginal and submarginal farm lands in order to concentrate on a given problem area. In the submarginal land areas, particularly those along the eastern fringe of the semi-arid region, the lands were relatively productive when rainfall was above normal, but virtually useless when it was deficient and as a result the agency concentrated on this region during the initial phase of its program. "From the beginning of the

5. Adjustment in livestock size - Most parts of Ethiopia are highly overstocked with cattle (26 million in 1972). Increased cultivation due to increased human pressure had taken much of the land used for grazing for cultivation purposes. On top of this, the belief among the nomadic population that cattle are status symbol and should not be sold, has increased the cattle population beyond the carrying capacity of the range land. Therefore, when droughts came in 1973-75, the cattle in the semidesert areas were almost completely wiped out. The present government restocking programs should, therefore, be carried out with the knowledge of the carrying capacity of the rangelands. Appropriate institutions should be set up to reduce the number of animals and to improve existing pasture lands and to coordinate the activities of grazing associations.

These and other programs and institutions that may be revealed through research results must be put to work in planned manner with definite objectives and programs. The results are obtained after a long time and the investment and other efforts should continue to be made in order to stabilize the agricultural economy in the long run.

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