WATER DEFICIENCY AND AGRICULTURAL DEVELOPMENT IN THE KETA DISTRICT OF GHANA

BY

VIDA ADJAPONG -AFRIFAH

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DECLARATION

I Vida Adjapong Afrifah, author of this thesis titled 'Water Deficiency and Agricultural Development in the Keta District' do hereby declare that apart from references of other people's work which have been duly acknowledged, the research work presented in this thesis was done entirely by me in the Department of Geography and Resource Development, University of Ghana, Legon from September 2000 to June 2002

This work has never been presented in whole or in part for any other degree in this University or elsewhere.

Vida Adjapong-Afrifah
(Student)

Professor E. Ofori Sarpong
(Major Supervisor)

Professor S.T. Addo
(Co-Supervisor)

DEDICATION

To the Almighty God, My Husband Jacob K.A Benson and My Son Ainslie Kweku Ameyaw-Benson.

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I wish to express my sincere thanks and appreciation to God for bringing me this far. I wish to also express my sincere appreciation to my supervisors, professor E. Ofori – Sarpong and professor S.T Addo for their patience and taking time of their busy schedules to give immense contributions and suggestions for this study.

My sincere thanks also go to Mr. Awadzi, Mr. Edward Ahiabor and Dr. (Mrs.) Awumbilla for all the contributions they made towards my work.

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Vida Adjapong- Afrifah

ABSTRACT

Agriculture is the backbone of most African countries. In Ghana it contributes immensely to the gross domestic product and it employs about 60% of the Country's labour force, however the agricultural sector in the country is underdeveloped and mainly rain fed. Hence variability of rainfall affects crop production in the country.

In spite of the variability of rainfall in the country and as a matter of fact, in the Keta District, farmers have resorted to some coping and adaptive strategies to overcome this problem. This study determined the nature of rainfall in the Keta District and its effect on agricultural production. The results obtained revealed that rainfall in the Keta District is scanty and variable and this has a great influence on production. For this problem to be solved, mechanized irrigation must be used by the mass though this technology has its accompanying problems. It was therefore recommended that future research should focus on the feasibility of extensive irrigation in the Keta District.

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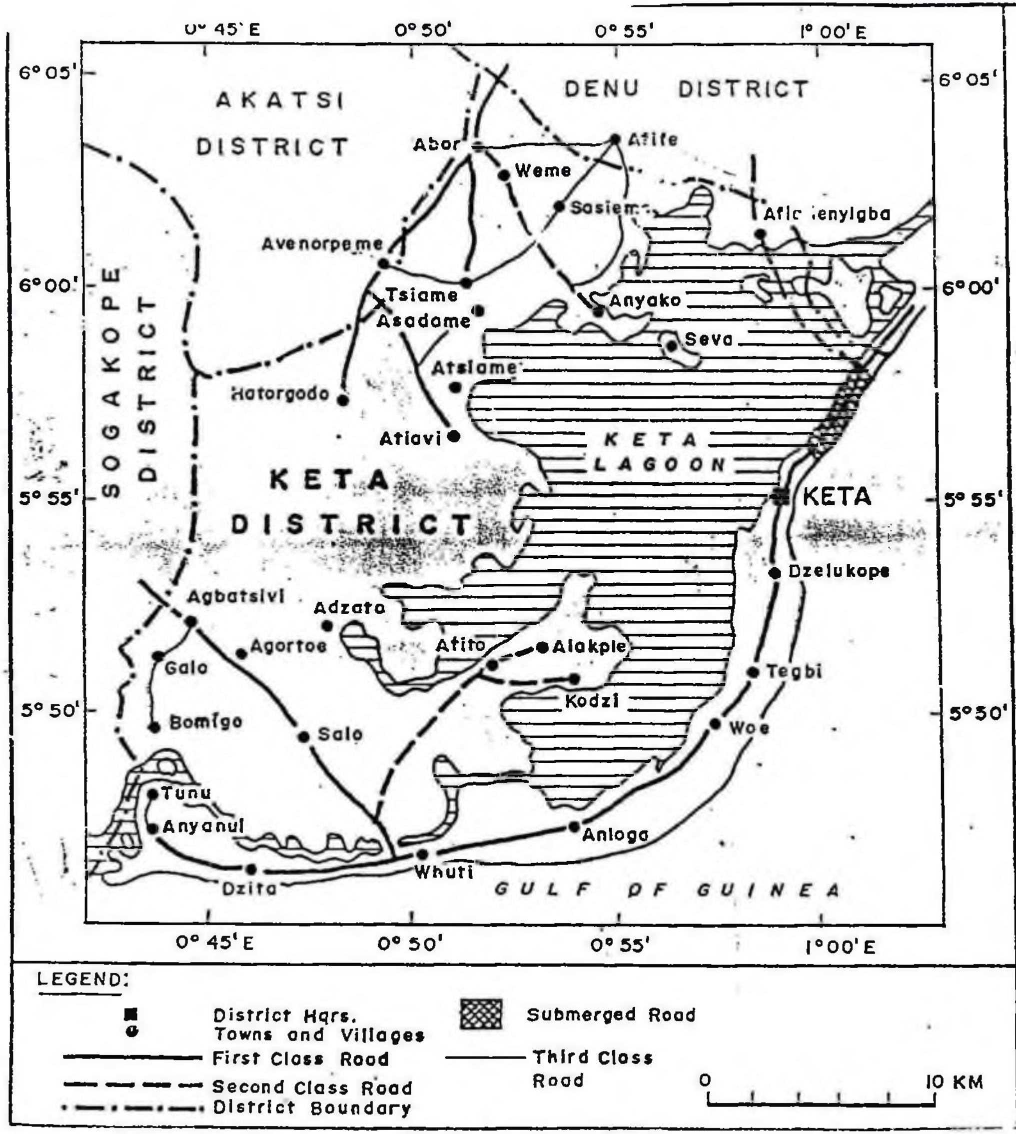
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AKATSI DISTRICT
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GULF OF GUINEA
Abor
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Bomigo
Salo
Woe
Tunu
Anyanui
Anloga
Whuti
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LEGEND:
District Hqrs.
Towns and Villages
First Class Road
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Submerged Road
Third Class Road
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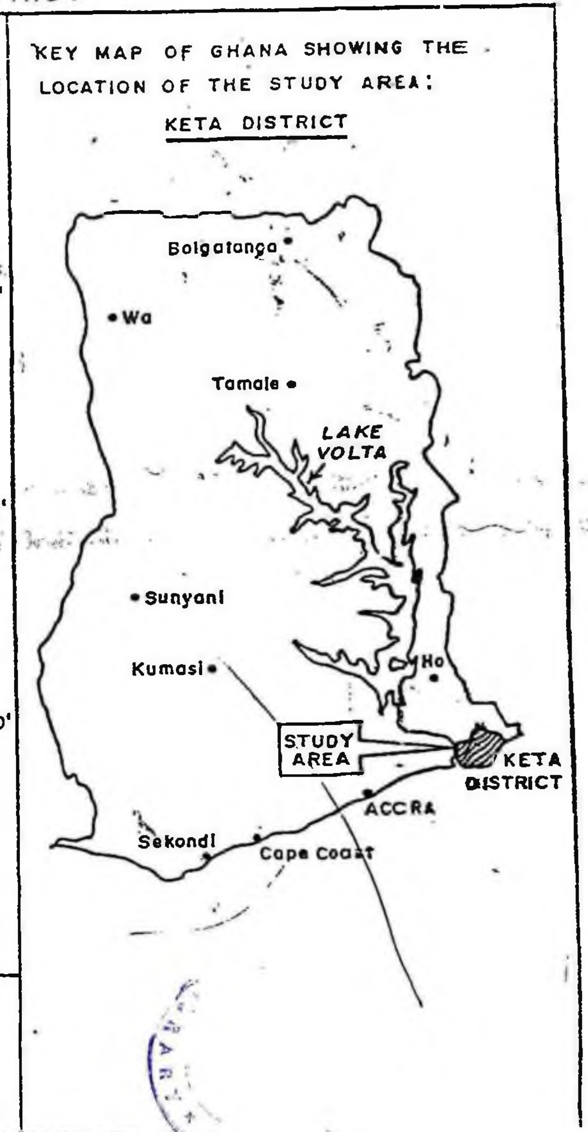

KEY MAP OF GHANA SHOWING THE LOCATION OF THE STUDY AREA:
KETA DISTRICT
Bolgatanga
Wa
Tamale
LAKE VOLTA
Sunyani
Kumasi
Ho
STUDY AREA
KETA DISTRICT
ACCRA
Sekondi
Cape Coast

CHAPTER ONE

INTRODUCTION

1.0 Background

Since time immemorial the issue of water deficiency has existed but the issue attracted many writers and conferences when the situation became very serious. Thus after thousands of years of human development in which water has been a plentiful resource in most areas amounting virtually to a free good, the situation is now abruptly changing to the point where, particularly in the more arid regions of the world, water deficiency has become the single greatest threat to food security. Slightly more than one billion people live in arid regions that will face absolute water scarcity by 2025 (Brown and Halweil, 1998).

The relationship between water deficiency and food production are epitomized by the current debate over the ability of China to feed its population without importing massive quantities of cereals. In a recent article, Lester Brown (Brown and Halweil, 1998) contended that primarily because of impending water shortages in the northern region of China, China would have to import as much as 210-370 million tons of grain per year to feed its population in 2025. This massive increase in imports could cause steeply increasing cereal prices and disruption of the world market.

The global 2000 Report (Council on Environmental Quality and Department of state, 1982) noted that land under cultivation is projected to increase by only four percent by 2000 because most good land is already being cultivated. In the early 1970s one hectare of arable land supported an average of 2.6 persons, by 2000, one hectare will have to support four persons. Hunger will affect more people by the end of the decade if there is no improvement of agricultural yield in developing countries. In Africa alone thirty out of fifty-one states may be unable to feed their predicted populations at the end of the century (Harrison, 1973).

Over the first three decades of the 21st century, the world's population is expected to increase by approximately 90 million people per year. Most of this growth will be in developing countries where agriculture plays a vital role in their development (United Nations, 1998). With this, the issue of agricultural development has become the primary objective of every country. Agricultural development although still concerned with the opening up of virgin land in few countries more often involves the improvement and increasingly, the rehabilitation of existing traditional agriculture and sometimes of failed development efforts. However, related to agricultural development is the issue of climate and soil fertility. Climate and soil play vital roles in agricultural development. Water deficiency limits soil moisture and this leads to low agricultural production. This is the case in the arid and semi arid regions of the world. Nevertheless few countries such as Israel have been able to overcome this problem through science and technology. In the sahelian part of Africa, large and small-scale irrigation schemes as well as settlement schemes have been provided to aid the development process, especially in agriculture. The Gezira and Kariba Schemes are cases in point (Nabila, 1996). Improvements in water management are essential to agricultural productivity and to reduce land degradation and water pollution. Critical issues concern the design of irrigation projects and efficiency of water use.

As in other parts of the world, Ghana, which lies in the tropics, faces the problem of water deficiency as far as agriculture is concerned. This has led to agricultural development in most part of the country and this problem attracted the attention of writers like Benneh and Addai in the 1970's. Moisture is a primary factor limiting crop production in the northern region of Ghana and the coastal plains of Ghana. Water deficiency imposes limitations on agricultural development. In the north and coastal plains of Ghana rainfall is erratic and unreliable and this has caused evapotranspiratation to exceed rainfall (Benneh, 1973). The main physical factors, which affect agricultural production in the Keta District, are climate and soil. In the Keta District where temperatures are uniformly high throughout the year, rainfall, which varies in time and space, is the most important climatic element. The Keta District is one of the driest areas of the country and as a result water is the life-blood of the district. It is a vital factor in agricultural development and without it agriculture is impossible, as plants cannot survive (Ofori-Sarpong, 1983). Keta has a mean annual rainfall of 897mm and forms part of the Southeast coastal plains. This area has two rainfall maxima but the dry season is more marked. Average annual relative humidities are higher in the rainy season than during the rest of the year. The relative dryness of the southeastern coastal plains requires an explanation. Several explanations have been adduced for the existence of this dry coastal zone (Walker, 1957, Ojo, 1977). One is the orientation of the coast, which makes the rain-bearing winds blow parallel to the coast.

There is an area of cold upwelling water eastward, which stabilizes the rain bearing winds moving over it thus causing a decrease in rainfall. This cold water may be associated with the northward extension of the cold Benguela current, which is deflected westward through the Gulf of Guinea. Alternatively, the wanton destruction of the vegetation has been found to contribute significantly to the drying out of the atmosphere (Charney, 1975).

Rainfall exerts its ecological influence not so much by its annual total as by its distribution in time and its reliability. Rainfall influences the nature of agriculture by its seasonal character, its duration and intensity. The seasonal distribution of rainfall therefore determines the cycle of farming activities. The mean annual rainfall is important because most crops require a certain minimum amount of seasonal rainfall in order to grow well without the aid of irrigation. The oil palm for example needs at least 1000-1250mm of rainfall per annum and will not thrive in areas where this requirement is not adequately met.

Much more important than the mean annual rainfall is the amount of rainfall within any particular year since this is related to flooding in the district. There is clear correlation between the heavy incidence of yearly rainfall and flooding in the Keta

District. The most outstanding years of rainfall have always been directly associated with the occurrence of disastrous floods in the Keta District and these were precisely the years when the agricultural production in the district was at a standstill.

Neither the mean annual rainfall nor the total annual rainfall indicates the character of the distribution of rainfall throughout the year. Farming however is a seasonal affair and farmers are much more concerned with the seasonal distribution of rainfall rather than its annual totals since their farming calendar and the length of the growing period depend upon that. Farmers however are much more interested in the reliability of rainfall since this, more than any of the other factors, directly affect agricultural production. Too much or too little rainfall in any season leads to floods or droughts. The amount of water present in the soil at any given time has a direct influence on the concentration of the soil solution and constitutes one of the main factors determining the ease with which water and soluble nutrients can be absorbed by the roots of plants. Soil moisture is not only related to rainfall but also to other factors such as the nature of rainfall and its seasonal distribution, run-off, the water-holding capacity of the soils and evapo-transpiration. Farmers of the Keta District generally show an awareness of the factor of soil moisture. The inland farmers in the Hevi (Figure 1) sector of the district for example respond to seasonal changes in soil moisture by farming in the valleys and near stream courses during the dry season.

The Keta District is located on a narrow strip of sand spit which is only a few kilometres wide. Its geographical location falls within latitude 5^0 46'N and 0^0 54'E of the equator as shown by Figure 1. Administratively, Keta is the district capital. It is bounded on the south by the Gulf of Guinea, north by Denu District, east by Avume and Sogakope on the west. For the purpose of this study, the whole of the district will be covered. The area experiences a bimodal rainfall pattern. The topography is relatively flat with gentle slopes. The surface soils are sandy, shallow and low in fertility.

The main road runs length-wise along the sand spit, connecting all the settlements situated on the sand-spit. The road may be regarded as a dividing line because it separates the lagoon area from the coastal area. The Keta District has a total population of 137,751 and a population growth rate of 3% (Ghana Statistical Service, 1984). The official current population is not known. However, the population of the area has increased considerably in the 1990s. It has been estimated at 142,700 going by the national population growth rate of 3%. Population density is over 500 persons per km^2 (Benneh, 1973) thus making the Keta District one of the most populous settlements in the Volta Region of Ghana.

The population in the district is predominantly rural with higher female percentage based on the 1984 population census reports. The social structure is such that, the males dominate. Patrilineal inheritance is a basic element of the culture. The males are the household heads. The major economic activity in the area is farming and it employs about 80% of the population. However, buying and selling, weaving, fishing are other activities engaged in by a smaller segment of the population. The presence of a few civil servants is noticeable.

Over 70% of its adult population are engaged in farming. However, only a handful of women engage in full time farming. The men do other jobs in addition to farming. Some engage in weaving of mats and trades like carpentry, masonry or blacksmithing. The Keta District falls within the tropical coastal savannah vegetation and as such exhibits the associated characteristics. Temperatures are high with a monthly mean of 27.7^{0}C. Rainfall is scanty and erratic. The area experiences a bi-modal rainfall regime. The first rains occur between April-June and the second in September and October. Total annual mean rainfall is 792.5mm. The amount of precipitation during the year is reflected in the volume of the lagoon waters and the underground water table. In years of persistent drought the lagoon waters evaporate leaving crystals of salt on the lagoon beds and the water table falls. Flooding of large areas may occur in months of very erratic rainfall though rainfall of the area is relatively low. This phenomenon usually causes destruction of crops on nearby cultivated areas.

The vegetation of the area is scrubland. Thorny shrubs and tuft grasses ---- *Imperata cylindrical* (locally called 'Be'), *Chrysobaiulus duriculars* (locally called Fortigbe), *Paspulum conjugatum,* (locally called gbekle), *Typha austialus*, (locally called avaa) and *Rhizophra racemosa* (locally called ketsi) are some of the common plants found there. But most of the vegetation has been cleared to allow space for farming in recent times (Dzokoto, 1993). The area has no surface stream or river. The main fresh water source is under-ground water. Each household has dug wells from which water is drawn for drinking and for domestic use.

The soils of the area are naturally unfertile for agricultural production, Ahn (1970). The soils in the Keta District show variations in colour, texture and humus content. Soils along the coast of Anloga are characterized by coarse texture and low content of clay, silt and humus. The basins are characterized by soils of fine texture, dark colour and clayey soils, which become quite peaty, coated with salt and have pH value between5.0 and 6.0. On the level low lands the soils are generally lighter in colour and vary in texture from fine sand to course gravels. The general pattern of soil distribution provides a setting for the pattern of agricultural development in the district. A clear correlation can be found to exist between the types of soils in the district, the vegetation and crops supported by them.

1.1 Problem Statement

In years of their existence, humans have depended on water to meet their own needs in terms of industrial, domestic and agriculture. This life supporting resource was in plentiful supply and was therefore a free good. The dynamism of the environment with its reinforcing effects on climate has negatively affected water availability such that water deficiency has become the single greatest threat to humanity in his effort to ensure food security especially in arid and semi-arid regions (Brown and Halweil 1998).

Climate poses severe problems for the people of the tropics through drought related food shortages. The most significant climatic factor, which limits agricultural productivity in the tropics, is rainfall (Griffiths, 1972; Jackson, 1977). Poor distribution of rainfall may lead to a marked reduction in agricultural production. In crop production, moisture plays a vital role and where there is a deficiency in soil moisture, agricultural production tends to be low. On the other hand where soil moisture is in excess agriculture suffers giving it a double shock. Regular and adequate rainfall has the potential to maintain adequate and sufficient soil moisture for agricultural production. Unfortunately in most arid and semi arid regions, rainfall is erratic, insufficient and unreliable thereby posing potential threat to agricultural development (Walker, 1957). It is against such condition that in most arid regions of Africa where soil water is insufficient agricultural production is accompanied by irrigation technology to meet the water needs of modern agriculture.

In Ghana about half of the land area is located in the arid and the semi arid regions where soil moisture is inadequate hence agricultural development in most areas are associated with irrigation schemes. For example in the Upper East, Tono irrigation scheme was built to facilitate tomato production while Dawhenya dam was also built to provide sufficient water for rice cultivation and other agricultural production in the area. Keta District of the southeast coastal plains of Ghana is a semi arid area where soil moisture is grossly inadequate for any meaningful agriculture. This has attracted many research works including Benneh (1973) and Nukunya (1972) to throw more light on the extent of water deficiency in the soil. In spite of several writings no irrigation scheme has been provided to support agriculture in the area. It is estimated that although the Keta District constitutes just less than 1% of the area of Ghana, it supports about 4% of the country's total population (Dotse, 1969) and depends solely on agriculture for their livelihood. Given this scenario one is tempted to challenge the much talked about water deficiency of the area. Perhaps some pertinent questions that come to mind are:

1. First what is the extent of water deficiency in the District?
2. Secondly, if the area is water deficient why are the people still tied to agriculture? Is it out of sheer necessity or are they having some copping mechanisms and,
3. Lastly what is the extent of agricultural development in the area and is irrigation a possible solution to water deficiency in the District?

1.2 Objectives of the Study

The main objective of this study is to analyse the extent of water deficiency and its relationship with agricultural development in the Keta District. The specific objectives are:

1. To determine the nature and causes of water deficiency in the Keta District.
2. To examine why the people of Keta District are still tied to agriculture in spite of the environmental difficulties.

3. To examine how the farmers have adapted to the environmental difficulties.
4. To assess the extent of agricultural development in the Keta District.

1.3 Assumptions of the Study

In this study it is assumed that:

1. Water is a limiting factor to agricultural development of the Keta District and,
2. Agriculture is undeveloped in the District.

1.4 Research Methodology

The methodology looks at the types of data and their sources, means of collection and methods of analyses of data. In this study two main sources of data were used, primary and secondary.

1.4.1 *Secondary data source*

For the secondary data, both published and unpublished data were used. Data was obtained from the Ghana Meteorological Service Department in Accra. The main features of data were monthly rainfall, annual rainfall, raindays, temperature, humidity and evapotranspiration rate. Data collection seems to be a difficult task. Ghana is an area where meteorological and climatological conditions have received little attention. Due to inadequacy of data in terms of gaps, the following number of continuous monthly rainfall, annual rainfall, raindays and temperature were collected for the study area. (1945-1994). Only data from Ada and Keta meteorological stations were used. However evapotranspiration rate for the station was not available so that of Ada was collected and this is because Ada is nearer to Keta District and again compared to rainfall evapotranspiration rate is less variable. For evapotranspiration, a 15-year period (1967-1981) was obtained from the Meteorological Services Department Accra. Initially, the author intended to select several years in order to make the analysis more representative but to her surprise rainfall data from the early part of the twentieth century (1901-1930) was difficult to come by. I would like to take this opportunity to suggest to the government of Ghana to provide more funding which will go a long way to help the Meteorological Stations in Ghana to provide reliable and continuous data. When this is done, the work of future climatologists who may be using rainfall as well as other climatic data will be simplified.

In addition, much of the theoretical background information was collected through library research, agricultural reports and from both documented and undocumented sources. Data was specifically obtained from Food and Agricultural Organization (F.A.O) and topographical map covering the study area was obtained from the Survey Department. Rainfall and potential evapo-transpiration data was also collected from the meteorological services department at Legon.

1.4.2 *Primary data source*

The first part of the field data collection involved a reconnaissance survey, which aimed at identifying the communities in the study area. The methods used comprised focus group discussions, in-depth interviews with key informants including district officials and personal observation.

1.4.3 *Research design*

Formal questionnaires were administered to respondents. They were mainly open-ended questionnaires. Unstructured questionnaires were used to collect data through focus group discussion. The district officer and extension officers were interviewed through focus group discussion with an unstructured questionnaire. The main questions asked were on the nature of rainfall in the area and its relation to agricultural development.

Out of a total of 45 settlements with a population size of 137,751 based on 1984 population census, twelve settlements were sampled for data collection. These were Atiavi, Abor, Anyanui, Tegbi, Tsiame, Weme, Gu, Hatogodo, Sasieme, Anloga, Avenorpeme, and Woe.

Table 1.1: Community Identification

Name of Settlement	Number of Households	Total Population	Name of Settlement	Number of Households	Total Population
Atiavi	410	2033	Abor	488	3571
Anyanui	128	1333	Anloga	2881	18993
Avenorpeme	222	1259	Weme	94	912
Sasieme	258	1388	Hatogodo	136	1413
Gu	72	349	Tegbi	1540	7928
Tsiame	302	4932	Woe	960	5188
Total Population			49299		

Source: Statistical Service Department (1984)

The selection of these settlements was purposely based on what is produced, that is the crops grown. Other factors influencing the choice of the communities was proximity of the adjoining settlements that helped to minimise cost, time and energy considering the dispersed nature of settlements in the traditional area. Households were systematically selected. Two hundred respondents were selected from all the settlements. In each settlement a house was randomly selected and afterwards the nth house was selected to obtain the number of people to be interviewed in each settlement as shown by table 1.2 below. This was done to ensure fair representation in the sample. Crop farming activities are a male dominated economic venture. In view of this fact, more males were interviewed.

Table 1.2: Sample Size

Name of Settlements	No. Of People Interviewed	Name of Settlements	No. Of People Interviewed
Atiavi	8	Abor	14
Anyanui	5	Anloga	78
Avenorpeme	5	Weme	4
Sasieme	6	Hatogodo	6
Gu	1	Tegbi	32
Tsiame	20	Woe	21
TOTAL		200	

Source: Fieldwork 2000

1.4.4 *Method of data analyses*

Analyses of data was done both quantitatively and qualitatively but more emphasis was laid on quantitative analysis. Thus relationships were established between variables. For instance a correlation was drawn between scarcity of water and food production. A water balance diagram was computed using Ada`s potential evapotranspiration data, as it was the only rainfall station with data. Again histograms were used to present the mean monthly rainfall distribution, and lastly annual rainfall fluctuation graphs were prepared.

1.5 Justification of the Study

The study of water deficiency and agricultural development in the Keta District is important, timely and necessary for a number of reasons. The problems associated with water deficiency are of current, national and international concern. It is expected that this study will assist the extension officers in finding relevant answers and solutions to the several questions and problems surrounding water deficiency and agricultural development in the area.

It is again expected that the result will enable policy makers to formulate policies, which will effectively and adequately serve the needs of the small-scale farmers in these water deficiency regions. The study is also justified on the basis of the many problems associated with it. Some of the farmers in the study area are farming out of sheer necessity without having the vision of increasing production. They are either ignorant of the importance of mechanised irrigation or it is too expensive for them to embark on. They always stick to the traditional crops such as shallots, tomatoes, and okra but there are some crops, which will adapt to the dry conditions and produce more yields for the growing population. The magnitude of all these problems makes it important for such a study to be carried out.

CHAPTER TWO

LITERATURE REVIEW

2.0 Water Deficiency and Agricultural Development

Scanty literature exists on water deficiency and agricultural development in the Keta District of Ghana. The large number of books such as those written by Boateng (1966), Harrison Church (1961), and Fitzgerald (1950) which talk about the climate and its effect along the south eastern coast of Ghana do not address the relationship between water deficiency and agricultural development. Nevertheless the most important literature has been reviewed to cover the issues under investigation. The major things that were considered under this review include the issue of water deficiency, the importance of rainfall to agricultural development and adaptive and coping strategies.

Thornthwaite (1963) defines water deficiency as an area where precipitation throughout the year is less than potential evapotranspiration. Ofori-Sarpong (1983) also defines water deficiency as the situation whereby evapotranspiration exceeds precipitation. Jackson (1977) is also of the view that if the roots to compensate for transpiration loss cannot absorb water then water deficiency develops in the plants although certain xerophytic plants store water to overcome this.

Agricultural Development according to Jackson (1989) is still concerned with the opening up of virgin land in few countries but also involve the improvement and increasingly, the rehabilitations of existing traditional agriculture and sometimes of failed development efforts. The above indicates that apart from opening up of virgin lands which is very difficult in the present generation because of increased population, agricultural development is said to have occurred when there is an introduction of new technologies in the farming system and sometimes improving the existing traditional ones. Oliver (1965) gives the indicators for agricultural development. He is of the view that the agricultural sector is said to be developed when there are improved seeds, increase in income of farmers and also sustainability of the farming systems which is the ultimate because whatever the action that is taken to develop agriculture, be it introduction of new technologies, improved seeds, introduction of irrigation system and so on, it must stand the test of time.

According to Brown and Halweil (1998), water deficiency has existed since time immemorial but the issue attracted many writers and conferences when the situation became very serious. After thousands of years of human development in which water has been a plentiful resource in most areas, amounting virtually to a free good, the situation is now abruptly changing to the point where particularly in the more arid regions of the world, water deficiency has become the greatest threat to food security. Slightly more than one billion people live in arid regions that will face absolute water deficiency by 2025.

Jackson (1989) is also of the view that water is vital to life and development in all parts of the world. In some regions the characteristics of water supply and demand pose few problems, but with increasing requirements for agriculture, industrial and domestic purposes such areas are becoming fewer, meaning that even in areas which were previously not facing any problem as far as water deficiency is concerned have now been caught up with it. However, a particular set of physical, economic, social and political factors combine to make water especially significant in the tropics so any study of water deficiency must consider these factors. Water deficiency has a great impact upon many aspects of plants growth, development and functioning. Probably the most common cause of plant death is the lack of sufficient water to replace that lost to transpiration. Even a temporary water deficiency can sometimes be fatal. The above statement by Jackson explains what water deficiency is and its effect on agricultural production. Ofori- Sarpong (1983) confirms this by saying that the main physical factor which affect agricultural production in South-eastern Ghana is the climate. In the Southeastern coast of Ghana where temperatures are uniformly high throughout the year, it is rainfall, which varies in time and space that is the most important climatic element

According to Benneh (1973), water plays a vital role in agricultural development. Benneh continues to say that moisture is a primary factor limiting crop production. They are of the view that water deficiency imposes limitations on agricultural development. Their discussions point to the fact that before there can be development in any country's agriculture, there must be sufficient water to help in plant growth. Ofori Sarpong (1983) is also of the view that the south-eastern Ghana is one of the driest areas of the country and as a result water is the main life-blood of the region. It is a vital factor for agricultural development and without it agriculture is impossible, as plants cannot survive. The three writers give a vivid role of water as far as agricultural development is concerned and in Ghana scarcity of water is limiting crop production in some parts of the country particularly in the Keta District. In the district, rainfall varies greatly both in time and in space and the significance of the variability is of great interest in agriculture. To understand the nature of rainfall along the south-eastern coast of Ghana, one must have an in-depth knowledge about the coastal rainfall condition.

Many writers have come out with theories concerning the nature of rainfall in the coastal areas. Among the writers were Harrison Church (1961), who noticed that from the western frontier as far as Cape Three Points, the coast receives the full effect of the rain laden South West Monsoon winds, but thence eastwards, the coast bends up northwards and the winds are generally parallel with the coast which consequently does not receive as much precipitation. This was also noticed by Boateng (1966). In addition Boateng (1966) noticed that rainfall over Ghana as a whole is largely the result of interaction between the Harmattan winds and the south west monsoon winds which promotes cooling and condensation. Furthermore, he commented that conventional rainfall and line squalls account for much of the rainfall experienced over the whole country. Harrison Church (1961) however gives a contradictory view and has declared that it is rather inadequate to use the monsoon winds as explanations for the increasing rainfall where they blow directly against the land since not all rain-bearing winds are southerly. He observed that other parts of the Guinea coast for example are similarly aligned as the coast of Accra, yet it is not so dry. He believes that Accra plains should have more rains since temperature contrast over land and sea tend to be more powerful where winds are parallel to the coast, thus making afternoon rains possible. In other words, Harrison Church (1961) does not accept the assertion that the coastal alignment east of Cape Three Points has a major effect on the rainfall contributed by the South Westerlies. Benneh (1973) is also of the view that the mean annual rainfall on the coast is about 750 mm but increases to 1000-1250 m in the interior. Rainfall is not only scanty but also irregular. Keta in the extreme southeast has a relative variability of about 19 %. Annual rainfall fluctuations are very considerable in the southeast coastal plains where the Keta District is located. For instance the mean annual rainfall in Accra is 788mm but from 1976-1978 Accra recorded rainfall of 430mm, 457mm and 555mm respectively. In Accra the mean of 788mm is distributed over 78 days and at Akuse and Ho a mean of 1421mm is spread over 111days(Ofori-Sarpong, 1983). The distribution of the number of rain days over the plains shows that the number decreases from north to south with Keta experiencing the minimum number of rain days. November to February are the dry months throughout the country but the driest month in the Keta District is August. During this month Accra receives a mean monthly rainfall of 15.7mm, Keta records 16.3mm, Akuse 36.8mm and Ho 78.7mm. Very considerable variations are prevalent between successive rainy seasons in time of onset, duration and amounts obtained. In some seasons the rainfall is high and evenly distributed while in others it is scattered and infrequent. The main cause of rainfall variability in the southeast coastal plains is the irregularities in the movement and intensity of the Inter-Tropical Discontinuity (ITD). Both its advance toward the north and its retreat to the south are interrupted or temporally reversed. A second source of rainfall variability is the very localized nature of rainfall caused by the thunderstorms and disturbance lines (Eldridge, 1958). These produce heavy rain over small areas resulting in striking differences over short distances. This factor is especially important during the beginning and the end of the rainy season. Water deficiency varies from 308mm at Ho in the north of the plains to 973mm at Keta in the southeast. In the south, water deficiency increases from the west of the plains to the east. In Accra, it is only in June that mean water surplus of 70mm is experienced. The rest of the months are characterized by water deficit. At Akuse, 1mm of water surplus occurs in May, 24mm in June and 11mm in October. In all 36mm of water surplus is received in May, June and July as against a total deficit of 753 in the remaining 9 months. Mean water surplus of 167mm occurs in 5 months (May, June, July, September and October) at Ho. It is the only station in the southeast coastal plains with 5 months of marginal water surplus. In the southeast, Keta has a mean water surplus of 46mm, which occurs in May (10mm) and June (36mm). Similarly, Ada receives a mean water surplus of 56mm in two months (May and June) (Ofori Sarpong, 1983).

The district is marginal for agriculture that the number of years that harvest fail outnumbers those in which they succeed. In an average year, it is an area of permanent drought, defined by Thornthwaite (1963) as an area where precipitation throughout the year is less than potential evapotranspiration. Despite this, agriculture is today the principal means of livelihood, and in the past the area formed one of the earliest centres of agriculture in Ghana, supporting one quarter of the country's population. He asserts that the role of drought in Ghanaian history has been documented only relatively recently and the details of human adjustments to drought stresses have been only locally considered. This study was undertaken as part of a comparison between the adjustments to agricultural drought of crop and livestock farmers from a developed nation and an undeveloped nation over the period 1944-1970. To him "Agricultural Drought" is defined as a shortage of water harmful to man's agricultural activities. It occurs as an interaction between agricultural activity and natural events, which results in a water volume, or quality inadequate for plant or animal needs.

Montage (1941) report on the agricultural survey of the Keta and Ada districts discusses the general pattern of agriculture of the district as was about two decades ago. In his report, he shows how the interplay of all the relevant factors that influence agricultural production in the Keta District has resulted in the present day pattern of their agricultural regions and their characteristic features of farming systems. High rates of evaporation and the characteristic of tropical rainfall pose particular problems. In many areas rainfall is markedly seasonal in character greatly limiting water availability at certain times of the year. At other times these same areas may have excessive rainfall leading to a further set of problems. These wet season problems; such as flooding and soil erosion, are also shared by many areas which do not have a pronounced dry season. Flooding is an essential element of the agricultural system in some areas. There is also considerable variability from season to season and year to year. These temporal variations have a marked influence on water availability and hence on any form of human existence, growth and development. He expands his discussion to say that rainfall variability has been the subject of much comment, but in reality comparatively little quantitative analysis of this factor has been undertaken in tropical areas. Lack of such analysis has led to a number of generalizations being made from often insufficient evidence. Variability receives particular attention in semi arid areas where droughts cause havoc. Especially in such areas, rainfall is characterized by the occurrence of a few extremely high values in a skewed distribution. In dry areas, a few years of low rainfall can lead to deterioration in vegetation that is not always reversed in succeeding years of high rainfall.

Jackson (1989) is also of the view that drought occurrence is regarded as simply lack of rain and the problem ends with a return to wetter conditions. Drought must be considered as a water supply demand situation. Unfortunately land use is sometimes blamed for adverse environmental effects when the real culprit is the adoption of inappropriate management practices. Land use management has considerable impact on drought occurrence, severity and environmental deterioration. Drought in sub- Saharan Africa has received much attention and reference in some studies. It illustrates not only the severity of the situation but also its complexity. Exact delimitation of the spatial extent and period is difficult. Ogallo (1984) states that after droughts conditions from 1968 to 1973, and 1974-75 there were substantial rainfall increases in the drought areas of sub- Saharan Africa but that the drought returned in 1976 and continued in some parts to date. Daniels (1980) refers to drought from 1968-1973 in West Africa with a return of rain in some areas in 1974-75 but persistence of drought in others.

Ofori- Sarpong (1983) asserts that climate poses severe problems for the people of the tropics through drought-related food shortages. The most significant climatic factor, which limits agricultural productivity in the tropics, is rainfall. Kenya like most countries in the tropics is basically agricultural. Poor distribution of rainfall may lead to a marked reduction in agricultural production. According to the Drought Monitoring Centre in Nairobi, the poor spatial distribution of rainfall could be attributed to the fact that the Inter Tropical Convergence Zone (ITCZ) remained diffused over the central and east African sector, while the Arabian anticyclone maintained moist north-easterlies into Ethiopia and northeastern parts of Kenya. He continues to say that the drought condition was brought about by the diffusion of the ITCZ over Central and Eastern Africa due to the influence of ENSO.

Ofori- Sarpong (1983) talks of drought from 1970-1973, 1975 –1977 in the district. Evaluation of drought impacts is difficult. For the 1975-1977 he suggests that impact on livestock was especially severe. Production of Okra, maize, pepper and groundnuts fell about 40%. Large scale rural to urban and north to south migration occurred in 1970-1973.

Flooding can be of an irregular short- term nature associated with individual storms. Flooding can also be on a regular seasonal basis and in many areas is an essential part of the agricultural system. Even in such areas periods of excessive flooding cause loss of life and serious damage to crops, communications and settlement. He continues to say that regulation of river flows to combat problems of flooding and to create dependable water supply for a wide variety of purposes is obviously important in the tropics. Dams represent one answer but there are problems.

Dotse (1969) asserts that the main physical problem facing farmers is the frequent floods, which prevent farmers cultivating all their beds. Although floods in the area are associated with years of exceptionally heavy rainfall, their occurrence is mainly due to the relief and drainage of the area. The shallot producing area is generally low lying. The district is studded on the south with both fresh and salt-water lagoons; the largest of these are the Keta, Avu, and the Angaw lagoons. The Keta lagoon is between 120-140 square miles. The water level of the Keta lagoon rises very rapidly since there is no regulated discharge into the ocean and the bottom of the lagoon through heavy rainfall so flooding occurs. The farmers have no technique of solving this problem. Jackson (1989) is of the view that the main point emerging in seasonality in stream flow in the tropics to be highly variable in time is in response to rainfall characteristics. This is true over various time scales. Rivers are commonly very seasonal. Concentration of much rainfall in few large intense storms produces considerable short-term stream flow variability. Periods of high discharge with resultant danger of flooding and soil erosion alternate with spells of low flow and water shortage. This has implications for higher power generation, irrigation, river and estuarine transport and water supply for domestic and industrial use.

According to Dotse (1969) there is a clear correlation between the heavy incidence of yearly rainfall and flooding in the Keta District. The most outstanding years of heavy rainfall (43inch) have always been directly associated with the occurrence of disastrous floods in the Keta District and these were precisely the years when agricultural production in the district was at a standstill.

Hamilton (1985) discusses concern about possible effects of deforestation on flooding. Evidence exists that forests provide protection against local flash flooding but Hamilton provides convincing arguments against the possible significance of deforestation alone for large –scale floods in the lower reaches of major rivers. Mattei (1979) also discusses the significance of flood retreat cultivation to traditional agriculture found over small areas along the main African rivers. Various crops such as sorghum, maize and cowpea are maintained by soil moisture along watercourses after flooding. The seasonal rainfall pattern over the catchments concerned determines the pattern of land use.

In addition to physical factors such as climate, land is also a major problem as far as agriculture is concerned. According to Dickson (1969) land is the fundamental resource of agriculture. It is more than any other factor of agricultural production. It determines what is produced, how much it is produced and how it is produced. On it thus depends the welfare of the rural people and the place of social and economic development.

The efficiency of any system of land tenure however depends on the extent of security it gives to the farmer because security of tenure gives the necessary incentive to the farmer to improve his land. It is only when the farmer feels that he has permanent rights over the land that he may think of important long-term beneficial practices such as crop rotation, soil conservation and adequate use of fertilizers on the farms. Previous study by Dotse (1969) showed that land tenure is a hindrance to agricultural development. He is of the view that some farmers just refuse to improve upon their parcels of land because it is not their personal property and again strangers and reliable people find it difficult or have to pay huge sums of money to acquire a parcel of land to work on. According to him in other Ewe sub-tribes for example, Anlo and Glidyi, individual property is transmitted matrilineally, a man's heir being his sister's son'. He rejects this assertion because according to him cases which have come to the courts have always been decided on the basis that succession is patrilineal and the paramount chief's tribunal has emphasised this in it's opinion to the courts. He also asserts that although the sale of land is not a common practice, it does occur and there are recognised procedures, which differentiate a sale from a gift and other forms of alienation. According to him there is a custom involving the offer of spirits by the 'vendee', it's acceptance by the vendor and the participation of both as well as a witness in drinking. This is known as 'ahatutu- anyigbadzi'. Other requirements include a formal demarcation of the boundaries in the presence of neighbours and the planting of boundary trees known as 'anyati' at the corners. Boundary pillars with the name or initials of the 'vendee' inscribed on them are now preferred. The head of the lineage and the elders must always approve of the sale of the land.

Other literature relevant to the system is the coping and adaptive strategies to environmental circumstances. Faced with the nature of rainfall discussed above and other social problems, the farmers have adopted some strategies.

Dotse (1969) is also of the view that the source of fresh water for both farming and human use on the whole of the sand bar in the south eastern coast area of Ghana is a shallow perched ground water aquifer overlying a salt-water lens. With intensified cropping under the low rainfall regime and high evapo-transpirative demand, farmers have resorted to increased irrigation by sinking wells. This in turn has increased exploitation of ground water. The natural ground water recharge system appears able to support the current level of increased exploitation. To add to this argument, Dotse (1969) says that problems of inadequate water resources are met by providing irrigation channels and wells, as the ground water is fresh to a great extent. Soil conservation practices are well developed. All kinds of fertilizers including fish, vegetables or green manure and bat droppings are used to enhance the fertility status of the soils. Inside the rooms of houses special constructions are made on the ceilings and rooftops for storing farm products. The traditional implements such as the hoe and the cutlass form the main basis of cultivation. He asserts that faced with problems of land shortage, poor and sandy soils and inadequate rainfall the people have evolved a system of farming based on the cultivation of early maturing short-season crops under hand irrigation from shallow wells, heavy manuring and continuous cropping.

In irrigation schemes, water quality as well as quantity is important. Different crops show different tolerance to salinity for example. Rawlins (1981) discusses the principles of salinity control in irrigation that involve providing water above evapo-transpiration requirements to leach salts from the root zone and drainage to remove the leached water. Hussain (1981) describes a simple technique for using highly saline water involving mixing irrigation and drainage water. The effectiveness of irrigation varies with soil type. Thompson, Gosnell and De robillard (1967) compared irrigation effects on sandy and clayey soil and found a marked difference in response. The general conclusion arrived at was that where available irrigation water was limited, heavy soils should be irrigated in preference to sandy soils. Other problems associated with irrigation include water logging, salinisation and contamination. Over irrigation is a common failure and this together with seepage from unlined canals causes the ground water table to rise if drainage is inadequate, leading to water logging and salinisation. Grove (1985) discusses the problem of water logging and salinity in arid areas pointing out that as much as land is going out of cultivation because of the problem as is being introduced by irrigation in areas affected by salinisation the fate of irrigation water used to flush out salts is important. If it percolates into the ground water the salinity of the latter increases. If the water is drained off from the area then its salinity can create problems downstream.

According to Sinnadurai (1970) crop farming is an important economic activity in Anloga and the major source of income for many households. Faced with problems of land shortage, poor and sandy soils, and inadequate rainfall the people have evolved a system of farming based on the cultivation of early maturing short season crops under hand irrigation from shallow wells, heavy manuring and continuous cropping. The system is so intensive that virtually no cropland is without growing crops at any time. This cropping system based on shallots, with minor modifications of other vegetables, has been in existence since the 19^{th} century. The shallots are grown either monoculturally or intercropped with other vegetables such as okra, pepper, tomato and cowpeas.

In the past a greater variety of crops were cultivated but as the population increased and the land holding became smaller and fragmented, emphasis shifted to high value vegetables such as shallots, pepper, okra and garden eggs. In the vicinity of the Keta District, traditional crops are grown and the farming patterns appear well adjusted to the environment. Drought is a minor hazard, but edaphic conditions promote differential impacts among farmers in the same village. Policy recommendations focus on the economic development rather than efforts to relieve drought.

Concerning the opportunities for adjustment in the area, farmers were asked what they would do to mitigate the damages of a drought event. Virtually all of them indicated that they would bear the losses that mean to suffer and starve until better times come along. An equal proportion would turn to God and pray to the traditional gods for help. Beyond bearing the losses, 59% believe they could get help from relatives, 55% might look for work in the city of Accra, but not further afield, 84% would try to enhance their income by selling handicraft items, cut fire wood, or grass for sale in the market, and 75% would aim to increase their food supply by fishing. One possibility of warding off hardship is the storage of food crops from one year to the next. Variability of rainfall and the marginality of the area for dry farming have provided an extremely uncertain environment for peasants who have few reserves of capital or food. Without aid from the community, harvest losses from drought or flood would reduce many families to starvation each year. Village society in Oaxaca has therefore evolved a more formal system of providing mutual insurance than might be expected in a situation of less uncertainty or greater reserves to meet losses. Wolf (1999) asserts that in Malle there had been a silent battle, which had been going on ever since the first Anglo- Australian settlers moved onto their farms some 60-70 years ago. Official statistics showed that between 1944 and 1970 the number of farms in the area declined by 14-40%. Only the northern fringe where irrigation lands were opened up in post 1945 was any increases in rural holdings noted. Most people claimed to have witnessed several droughts. Forty-three per cent (43%) claimed to have experienced four or more droughts and this tally with the 42% of the farmers who had been in the area. Throughout the periods 1944-1970, at least 92% had experienced the last major drought of 1967 and only 4% claimed no drought experience. These are experienced men well aware of the impacts of drought and were not overly concerned by it. That is if it does not last more than one season. Virtually all farmers agreed that the effects of drought depend upon its length. The majority claimed that the worse length of time for a drought to last was between one and three years and effectively over two seasons. One seasons drought losses could be borne but further failure in the second season posed greater problems because finances had been absorbed by the first year's losses, and their own supply of seed would have become exhausted so that seed would have to be bought for the third seasons sowing.

Dotse (1969) is in the view that in the face of unfavourable physical conditions and the scarcity of agricultural land the Anlo have developed a very intensive system which involves irrigation, manuring and rotation of crops in the narrow drainage ditches which run almost parallel to the coastline from the east of Attite through Dzita, Whuti, Anloga, Avume to as far as Tegbi. (Figure 1) The main crop cultivated under this system of farming is the "Sabala" system introduced into the area about the eighteenth century. He continues his argument by saying that shallot industry of Anloga has been in existence now for several decades but it was only during the last 30 years that the crop has been grown on commercial basis. Due to scarcity of land and the nature of the crop itself, intensive cultivation, heavy manuring and irrigation have become part and parcel of its cultivation. Scarcity of land no doubt affects the system of tenure and therefore the system of cultivation.

2.2.Conceptual Framework

The United Nations Conference on Desertification in 1977 has brought to global attention the geometric rate of desertification in the spread of desert-like conditions of low biological productivity into areas outside the previous desert boundaries.

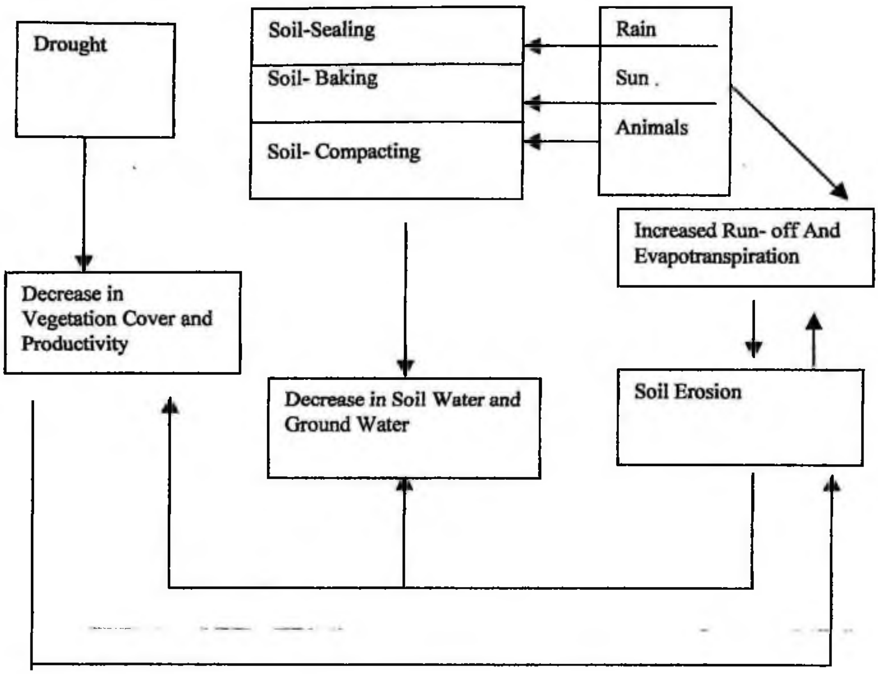
As a matter of concern, a large-scale international research programme was initiated to analyse the causes, to understand the process of desertification and to seek remedies. The emerged concern was that desertification is a result of climate change: - decrease in rainfall. In recent years, there is a new concern that desertification is the result of factors, which are multivariate and complex although climate change and misuse of land resources are much talked about.

Some studies have confirmed that high variability and drought risk are inherent characteristics of semi arid regions (Tivy, 1990). Further evidence suggests that from the quaternary era above average rainfall has alternated with below average rainfall. It is now obvious that desertification is a man-induced process resulting from the expansion and or the intensification of land use during agronomically favourable humid periods to an extent or degree that cannot be maintained during ensuing droughts.

Desertification according to Tivy (1990) is a man-induced process resulting from intensification of land use for agronomic purpose. The effect is soil moisture deficit, which has affected further agricultural development and the climate in a complex way. The process may have a positive feed back, increase in surface albedo as a result of land exposure may increase loss of heat and this could reinforce the atmospheric subsidence thus inhibiting precipitation and increasing climate aridity, loss of soil moisture and limit agricultural development. This may also have deleterious impact on hydrological cycle as presented diagrammatically by Tivy (1990) as cycle of soil degradation as a result of prolonged drought and overgrazing below. This is the original model by Tivy (1990) which looked at the cycle of soil degradation as a result of prolonged drought and overgrazing but since the author is looking at water deficiency and agricultural development this model has been modified to analyse the linkage between water deficiency and agricultural development in the Keta district.

The ecological and socio- economic factors combine to affect production in the area so that response to these factors will determine the nature of crop production in the area. According to the modified model, a negative response implies land degradation, a decrease in vegetation cover, and the use of unsuitable farming systems, low yields and food scarcity, which can collectively be described as agricultural underdevelopment. On the other hand, when the response is positive, farming would be characterised by the use of sustainable farming systems, which ensures conservation of land, increased productivity and a good supply of food. However the conditions prevailing in the tropics, such as lack of rainfall, unfavourable land tenure system and increasing population ensures that only the negative response is witnessed.

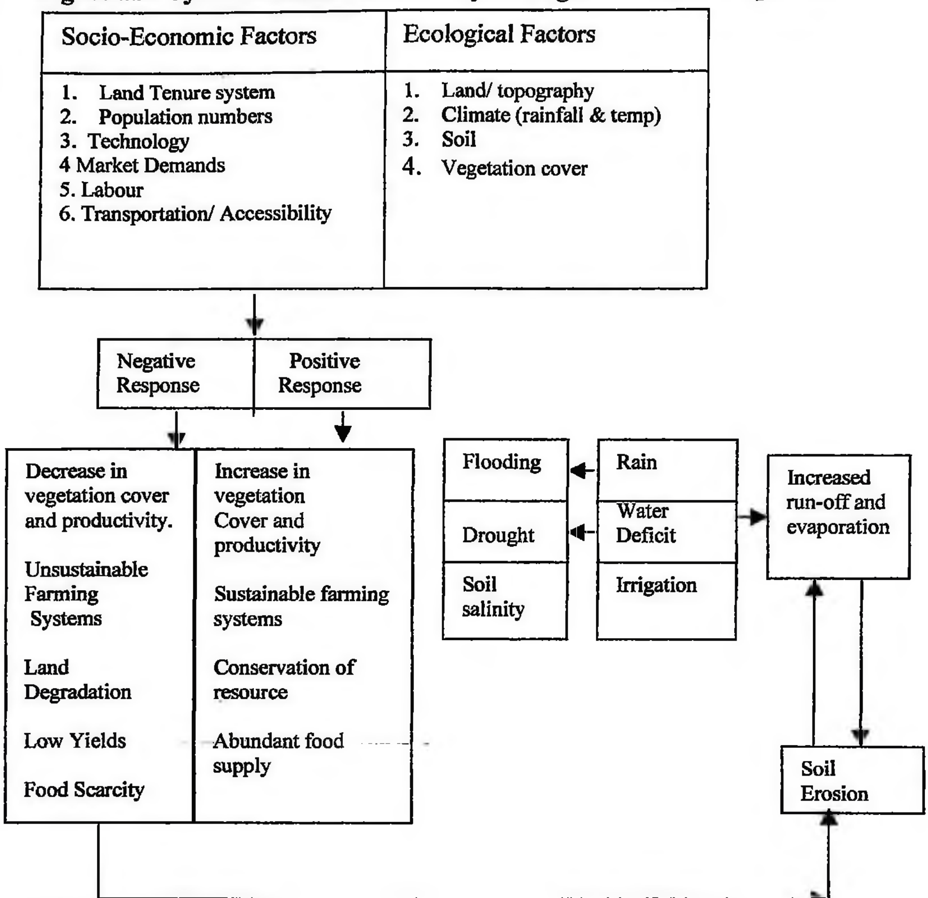
Figure 2.1: Cycle of Soil Degradation as a Result of Prolonged Drought and Overgrazing.



SOURCE: TIVY J 1990

When the vegetation cover is removed, there is erosion, which is followed by an increase in run-off and evaporation. Again the area is such that if there is an abundant or excess of rainfall in a particular season, it leads to flooding whilst the lack of it also leads to drought. Fresh water is perched on salty water so that though irrigation is much more important there is always the problem of salinity any time the water table is reached.

Figure 2.2: Cycle of Moisture Deficiency and Agricultural Development



Source: TIVY J 1990 Modified

CHAPTER THREE

THE CLIMATE OF THE STUDY AREA

3.0 Introduction

This chapter's focus is on the analysis of the nature of the rainfall situation in the Keta district. Due to lack of long-term data, a 50-year rainfall and temperature data are used in the analysis. It was not possible to acquire potential evapotranspiration data for the Keta District because it is not available. However potential evapotranspiration rate for Ada has been used in the analysis to calculate water budget in the study area. The reason behind the use of Ada evapotranspiration data is that Ada is nearer to the Keta District and again as compared to rainfall, potential evapotranspiration rate is less variable.

3.1 Seasonal Distribution of Rainfall

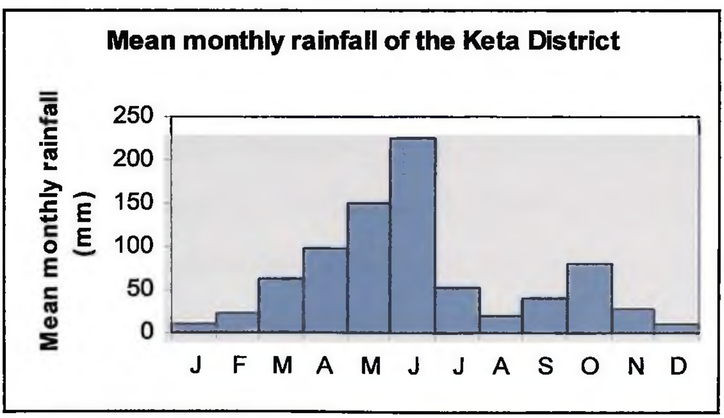
Keta District lies within a double or bimodal rainfall regime. Mean monthly rainfall increases from March until it peaks in June as shown by Table 3.1 and Figure 3.1 below. March has a mean of about 61.4mm and June 223.9mm. There is a sharp break in rainfall in July and August for about six weeks. July and August therefore constitute a short dry season in the study area, which separates the major rainy season (March-June) from the minor rainy season (September-October). The study area has two wet seasons and two dry seasons. The first wet season lasts from March to June. About 75% of the total rainfall occurs in these four months of the year. In this four-month period the maximum rainfall occurs in the extreme southwest at Anyanui and also towards the northeast of Ehi (Figure 1). In the central portion of the district, rainfall decreases gradually from northwest to southeast in the Abor, Hatogodo, and Keta area (Figure 1).

Table 3.1: Mean Monthly Rainfall for Keta District (1945-1994)

Months	Rainfall (mm)
January	11
February	21.4
March	61.4
April	96.8
May	150.2
June	223.9
July	53.1
August	20.1
September	39.1
October	80.3
November	26.5
December	10.9

Source: Meteorological Service Department, Accra (2000).

Fig: 3.1: Histogram of Mean Monthly Rainfall for Keta District



Source: Meteorological Service Department, Accra (2000).

The first dry season is between the months of July and August during which less than 40mm of rainfall is recorded. The second wet season lasts for two months with the second peak in October during which 80.3 mm is recorded. The main dry season is from November to February. During this time too low rainfall values are recorded and there are even some months with no amount of rainfall recorded in some years. December has the lowest rainfall followed by January as is shown by Table 3.1. For instance, in the years of 1983, 1985 and 1992 the study area recorded no amount of rainfall between the months of December and February. When asked about the peak of the rainy season, 189 of the respondents representing 95.4 percent said June whereas 11 of them representing 5.5 percent said May. All the farmers however gave December as the driest month in the year and this confirms the secondary data. The above discussion indicates that the area has a double rainfall regime with about six months of dry season.

The study area is characterized by seasonal variability of rainfall. Crop yields depend largely on the extent of intra-seasonal rather than the inter-annual variability. For instance a mean monthly rainfall of 36mm was recorded in 1985 however in the same year no amount of rainfall was recorded in January, February and December, 30.2mm in March, 38.1 in April and a high value of 161.8 in June. This is a clear indication of seasonal variability in the study area. Generally insignificant amount of rainfall is recorded between November and February. This means that the only months favourable for effective crop production in the study area are from March to June, and then from September to October. The mean annual rainfall in the Keta

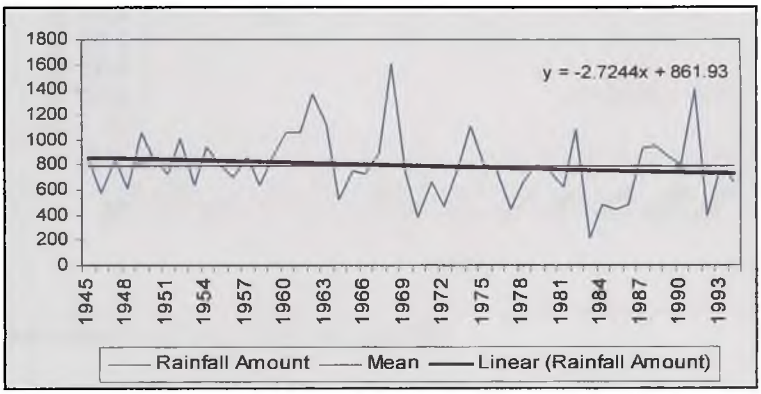
District is 792.5mm. Though the mean annual rainfall is important, it is the seasonal distribution that influences the agricultural cycle for the area. The mean annual rainfall decreases from north to south. The area with the heaviest rainfall is the north of Ehi and the area with the least rainfall is situated in the east of Whuti in figure 1. Averages can be markedly affected by the extreme values and this is particularly true of the arithmetic mean, which was obtained by totaling the individual values and dividing by the number of occurrences. For this reason a 50-year period was used for the determination of the mean values. Farming activities are synchronized with seasonal rainfall distribution so that farmers are much more particular about the seasonal distribution rather than the mean. In the Hotorgodo, Tsiame, Weme, Avenorpeme, Atsiame and Abor area (Figure 1) where no system of irrigation is practiced, farmers depend totally on seasonal rainfall to produce their crops. The highest annual rainfall ever recorded in the district occurred in 1968 with rainfall amount of 1613.25 mm whereas the lowest annual rainfall ever recorded for the 50-year period occurred in 1983 with rainfall amount of 220mm.

In the extreme south-west at Anyanui, Dzita, Whuti, Anloga, Woe, and Tegbi (Figure 1) farming is done all year round because the farmers depend on irrigation for their farming activities but in the central portion of the district at Abor, Hatogodo, Atiavi etc planting is synchronized with the seasons. In some seasons (1963, 1968, 1962 and 1982) the rainfall is high, reliable and evenly distributed but in other seasons (1977, 1983, 1985, and 1992) it is scattered and infrequent. Farmers also gave their views on the seasons. To add to how the farmers are able to synchronize activities with the pattern of the season, 196 respondents (98 percent) said that when the rain starts very early it means that it will favour crop production in a particular year whereas 4 of them (2 percent) said it is determined by the intensity of the rain at the beginning of the growing season.

3.2 Annual Rainfall Fluctuations and Variability in the Keta District

Fluctuations and trends are very important with the occurrence of drought conditions in the district. Rainfall fluctuations have implications for water resource agriculture, and early warning prediction of climate. Large-scale variations of rainfall exert a great influence upon agricultural production in the area. In the Keta District there are peaks centred on 1962, 1963, 1968, 1985, and 1990 and troughs centred on 1983, 1997 and 1998. Not only do amounts depart from average condition in individual years but also vary from area to area. For a particular period, rainfall can be well above average in one year but below average in another. The rainfall fluctuation diagram below (Figure 3.2) illustrates the differing pattern of fluctuations. Though the mean annual rainfall is 792.5mm, the area received rainfall amount of 1613.25mm, 632mm and 220mm in the years of 1968, 1969, and 1983 respectively. Fluctuations in rainfall intensity, duration, frequency and time are also of great importance in agriculture. A number of factors act to create fluctuations and the result will be a composite of their influence. There are variations from year to year, which tend to mask fluctuations over longer periods. Climatic change is critical in the district, which is classified as a marginal area. The annual mean for the district is 792.5mm and, the mean line shows this. All the years below the mean line give drought years and those above it give wet years. In this study, out of the 50-year period, 28 years are below the mean line whereas only 22 years are above the mean line. From the diagram it is seen that the district is an area prone to drought as more of the years are below the mean line. The trend line also gives an idea of the rate at which rainfall is decreasing. The equation shows that rainfall in the district has been decreasing at a rate of 2.7mm annually.

Figure 3.2: Annual Rainfall Fluctuations for Keta District (1945-1994)

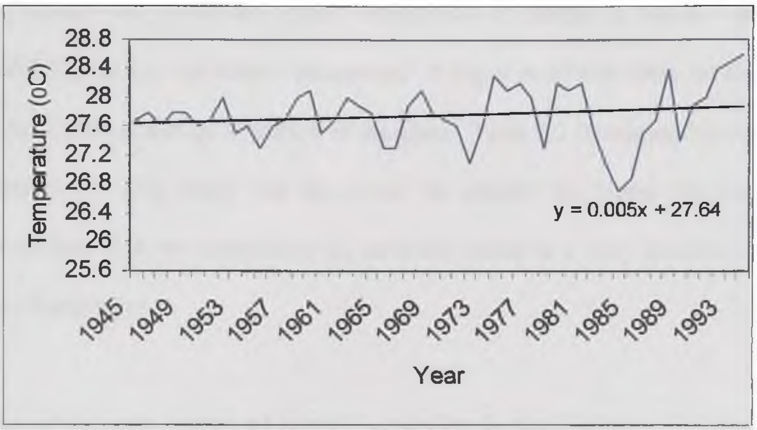


Source Meteorological Service Department, Accra (2000).

The inter-annual variation is therefore a problem as far as crop production is concerned. Rainfall variability in the district has been the subject of much comment. A frequently asserted claim is that rainfall in the district is more variable than in the other areas of the region. The economic situation in many of the communities makes it difficult to cope with variability. In areas where water supply is marginal, any variability has greater significance on agriculture and water resources. In areas with marked seasonal regime, variability at the start and end of the rains is important since variability imposes a degree of uncertainty (Ofori-Sarpong, 1983).

Though rainfall is decreasing in the study area, temperature however is increasing as is shown by Figure 3.3. The rising temperature and declining rainfall over the years, is an indication of climate change. The increase in temperature is giving rise to increase in evapotranspiration rate.

Figure 3.3: Annual Mean Temperature Fluctuations for Keta (1945-1994)



Source Meteorological Service Department, Accra (2000).

This is affecting ponds, streams and rivers thereby making water a scarce commodity in the district. Figure 3.3 shows how temperature in the area has been fluctuating. Temperature is less variable compared to rainfall and the trend line shows that temperature has been increasing at a rate of 0.005. Table 3.2 shows the standard deviation and co-efficient of variability for the area. The standard deviation is expressed in real or absolute terms. In this research, the standard deviation is 267.8 and this shows how the rainfall data for the fifty years in the district deviate from the annual mean and helps to reduce the variance to the original unit of measurement. This measure is not efficient because it tells us nothing about the distribution of rainfall. The coefficient of variability therefore becomes very important. Coefficient of variability is the percentage deviation from the mean. This relative measure is just to express the standard deviation as a percentage of the arithmetic mean. Coefficient of variability is normally greatest for the areas with the low rainfall. The coefficient of variability in the district is 33.9 and this shows that the district has one of the highest variabilities of rainfall in Ghana. Such a high variability makes agriculture precarious. It has a profound effect on the period of onset, duration and the cessation of the rains. Table 3.2 illustrates the coefficient of variability. It is found that the lower the rainfall the higher the coefficient of variability. It is not uncommon for an entire month in a rainy season to be without significant rains.

One of the main causes of rainfall variability in the district is the very localized nature of rainfall caused by thunderstorms and disturbance lines (Eldridge, 1958, Hamilton 1954). These produce heavy rain over small areas, resulting in striking differences over short distances. This factor is especially important during the beginning and end of the rainy season. Large-scale variations of rainfall in space exert a great influence upon agricultural systems and water supply. Not only do amounts depart from average conditions in individual years but also the way in which they vary from area to area. For a particular period, rainfall can be well above average but below average in another. Though the seasonal distribution of rainfall is very important, parts of the district are so marginal for agriculture that the number of years in which harvest fails outnumbers those in which they succeed.

Table 3.2: Standard Deviation and Coefficient of Variability (1945-1994)

Year	Rainfall Amount (mm)	Year	Rainfall Amount (mm)	Year	Rainfall Amount (mm)
1945	841.2	1962	1364.5	1979	810.0
1946	576.8	1963	1125.5	1980	750.0
1947	487.3	1964	517.5	1981	630.0
1948	614.0	1965	753.3	1982	1080.0
1949	10063.5	1966	723.5	1983	220.0
1950	846.8	1967	899.0	1984	480.0
1951	721.8	1968	1613.25	1985	450.0
1952	1007.5	1969	743.3	1986	480.0
1953	637.8	1970	385.8	1987	930.0
1954	942.3	1971	658.0	1988	960.0
1955	789.8	1972	470.8	1989	870.0
1956	707.5	1973	776.3	1990	810.0
1957	865.0	1974	1109.0	1991	1410.0
1958	636.5	1975	797.0	1992	390.0
1959	879.0	1976	750.0	1993	810.0
1960	1062.8	1977	441.0	1994	660.0
1961	1055.5	1978	660.0		
Sum	39622.8		Standard Deviation		269.1
Mean	792.5		Coefficient of Variability		33.59

Source: Meteorological Service Department, Accra (2000).

SD – Standard Deviation. CV = Coefficient of Variability

Despite this, agriculture is today the principal means of livelihood, and in the past the District formed one of the earliest centres of agriculture in Ghana supporting about 4% of Ghana's total population (Dotse, 1969). Because of the marginality of rainfall in the area the farmers are much more interested in the reliability of rainfall since the reliability affects agricultural production directly. In the Keta District, farmers are more concerned about the variability of rainfall and sometimes pray to the gods because they assume that the gods control rainfall in the area. The delay of rainfall in the district has a serious consequence as far as agriculture is concerned. This is because the central part of the district depends entirely on rain fed agriculture so that the delays in rainfall prevent farmers from increasing their acreage. During the minor season the land becomes so hard that farmers find it difficult to weed. Needs vary with crop type, evaporative demand and soil type. For annual falls of more than 750mm normality is a reasonable assumption and this is often true for wet season falls. For falls less than this, the possibility of non normality is greater and it has been found that for annual falls less than 635mm there was a 45% chance of data being non-normal (Dotse, 1969).

3.3 Rain Days

Rainfall amount is stated in inches or millimeters for each month of the year. It should be borne in mind that the months are not of equal duration; thus unless allowance is made by weighting the monthly totals, January with 31 days, may be expected to have rainfall some 10% higher than February with 28 days, other things being equal. But in addition to the monthly and annual totals some information is desirable on the nature of the rainfall, its persistence and its intensity. This is provided by data concerning the number of raindays. Table 3.3 and Figure 3.4 show the total raindays for the period 1945 to 1994. The total amount of rainfall received in the district gives only a general impression of the degree of wetness. Its distribution in time may be irregular within a season and this impairs the healthy growth of plants. The distribution indicates that almost all the years received rainfall during the period under study. The year 1947 was the year with the highest number of raindays, followed by 1968. The year with the least raindays was 1983.

Table 3.3: Annual Raindays for Keta District (1945-1994)

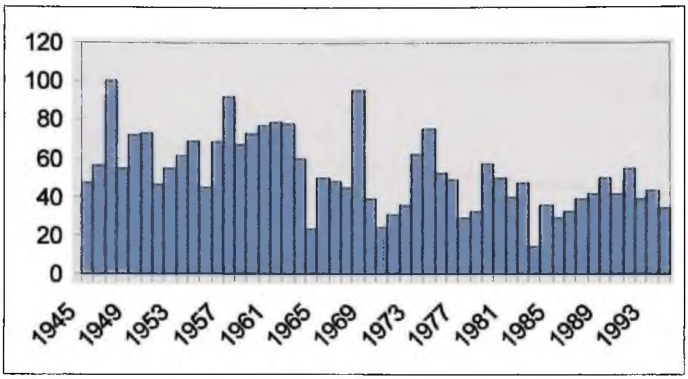
Year	Annual Raindays	Year	Annual Raindays	Year	Annual Raindays	Year	Annual Raindays
1945	47	1958	67	1971	31	1984	36
1946	56	1959	73	1972	36	1985	29
1947	100	1960	77	1973	62	1986	32
1948	55	1961	79	1974	75	1987	39
1949	72	1962	78	1975	52	1988	41
1950	73	1963	60	1976	49	1989	50
1951	46	1964	23	1977	29	1990	41
1952	55	1965	50	1978	32	1991	55
1953	61	1966	48	1979	57	1992	39
1954	69	1967	45	1980	50	1993	43
1955	45	1968	95	1981	40	1994	34
1956	69	1969	39	1982	47		
1957	92	1970	24	1983	14		
Annual Total		**2611.0**		**Mean**		**52.0**	

Source: Meteorological Service Department, Accra (2000).

This is in line with annual rainfall data because in 1968 the region recorded 1613.25mm of rainfall being the highest recorded in the area, and recorded 220mm of rainfall in 1983 being the least amount of rainfall recorded for the study period.

However this is not to say that the higher the rainfall amount the higher the raindays. The annual raindays is also important as it determines whether a particular year experienced enough raindays or not.

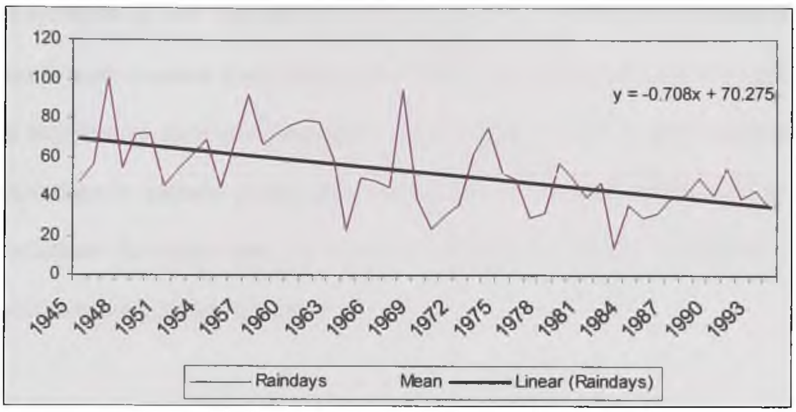
Figure 3.4: Histogram of Annual Raindays



Source: Meteorological Service Department, Accra (2000).

Keta's mean annual rainfall of 792.5mm is distributed among 52 mean raindays. For instance there are about 365¼ days in a year so if the annual mean raindays is 52 then the situation here is very serious because a farmer has to make use of only 52 raindays for planting in the whole year. This is woefully inadequate and unreliable so farmers here have to resort to irrigation. The figure below (Figure 3.5) shows the annual raindays fluctuations for the study area. The figure shows that raindays have been decreasing at a rate of 0.7 and this indicates the seriousness of the situation. For the first 10 years, that is between 1945 and 1963 there were fluctuations of raindays but the decrease was not much, however there was a sharp decrease in 1969 and this decrease continued till 1994. The mean line also gives the annual average raindays, which is 52, and this gives the years below and above average raindays for the study period. Those below the mean line are drought years whereas those above are wet years. Since 1977, there has been a steady decline in the number of raindays, which corresponds with the annual rainfall data.

Figure 3.5: Annual Raindays Fluctuations



Source: Meteorological Service Department, Accra (2000).

3.4 Potential Evapotranspiration

The mean annual rainfall of the district, its seasonal distribution in time and space and its variability has been examined in an attempt to assess the adequacy of water supply for plant growth. Rainfall is the main source of soil moisture. Rainfall may be lost through evaporation and run off. Of the proportion that enters the soil, some may percolate to greater depths beyond the root zone. The slope of the land on which it falls, the water holding capacity of the soil and the impending stratum in the soil are significant factors affecting the adequacy of water for plant growth. In a vegetative area, part of the water, which enters the plant, is returned to the atmosphere through the process of transpiration. Soil moisture is therefore dependent upon the relationship between rainfall, evaporation and transpiration. Potential Evapotranspiration (PE) is the maximum quantity of water capable of being so lost by continuous stretch of vegetation covering the whole ground when water supply to the soil is not limiting. The large amount of energy available for evaporation in low latitudes is a dominant factor. Potential evapotranspiration is much more constant from year to year than is rainfall because of the small variation in key factors such as temperature and radiation. The seasonal variation reflects variations in altitude of the sun, cloud cover, wind speed and humidity. Diurnal variations in evaporative demand in relation to diurnal variations in rainfall occurrence are also important.

It has not been possible to calculate the evapotranspiration rate for the Keta district, because figures are not available for the various stations. However potential evapotranspiration rate for Ada has been calculated. The reason behind this is that Ada is nearer to the Keta District and again as compared to rainfall, potential evapotranspiration rate is less variable. Table 3.4 and 3.5 show the distribution of mean monthly and mean annual potential evapotranspiration. Evapotranspiration rate is high in the dry season and low in the wet season. For instance though the mean annual evapotranspiration rate is 80.5mm for the 15-year period (1967-1994), June, which is the peak of the wet season recorded evapotranspiration rate of 66 whereas December, which is the driest month in the district, records 96.3mm. The reason behind the discussion above is the transparency of the atmosphere. Transparency of the atmosphere has an important effect on the amount of insolation reaching the earth's surface. During the wet season the skies become cloudy and this cloudiness absorbs, scatters and then reflects solar radiation therefore bringing about less direct insolation.

Table 3.4: Mean Monthly Evapotranspiration for Ada (1967-1981)

Month	Amount	Month	Amount
January	91.6	July	59.6
February	91.8	August	58.2
March	91.7	September	68
April	87.9	October	81.3
May	82.9	November	90.6
June	66.0	December	96.3

Source: Meteorological Service Department, Accra (2000)

Table 3.5: Annual Evapotranspiration for Ada (1967-1981)

Year	Yearly Total	Year	Yearly Total
1967	1022.5	1975	942.0
1968	987.5	1976	912.4
1969	977.5	1977	929.7
1970	1035.0	1978	908.9
1971	1045.0	1979	889.3
1972	1007.5	1980	908.4
1973	1030.0	1981	964.4
1974	985.0		
Total	**14445.1**	**Mean**	**963.0**

Source: Meteorological Service Department, Accra (2000)

The opposite is true for the dry season. When the skies become clear there is more direct insolation.

3.5 Water Budget

It should be realized that storage capacity varies with texture and structure of the soil. Computing water budget over a larger number of geographical zones, it is not possible to take into account all of the different water holding capacities which may occur in different areas. On the basis of comparison it was necessary to assume one constant value of water holding capacity over the district (Thornthwaite and Mather, 1955). It was assumed that the soil moisture storage within the root zone was 200mm. A comparison of monthly mean potential evapotranspiration (PE) and mean rainfall amounts gives some indication of the extent to which the theoretical water needs of crops are met. In other words, it enables water budgets to be computed. A method of depicting rainfall-potential evapotranspiration relations used by Franquin and Cocheme (1967) in agro-climatological investigations of West Africa was adopted for the study of water budget as well as the availability of water periods. It was also assumed that, up to half the amount in storage at the end of any month could be used in the next month.

The following parameters were obtained in computing the water budget for the Keta District:

a. Water deficit, which occurs when potential evapotranspiration exceeds rainfall;

b. Water surplus, recorded when rainfall exceeds potential evapotranspiration;

c. Evapotranspiration loss, which is the amount of rainfall falling early in the season on relatively dry soil and returned to the atmosphere without being utilized by crops;

d. Ground charge, referring to the amount entering the ground;

e. Ground storage, which is the amount stored up to the assumed maximum

f. Runoff, referring to the surplus water left over after the soil has reached its field capacity and

g. Effective rainfall, which is the amount of water, deemed to have been available to crops.

The comparison of mean monthly rainfall and mean monthly potential evapotranspiration makes it possible for water budget to be computed when the storage capacity of the soil is known. Each month the amount of potential evapotranspiration is subtracted from soil moisture storage while the precipitation is added. Water surplus occurs whenever mean monthly rainfall exceeds the potential evapotranspiration rate, whilst deficit occurs when the potential evapotranspiration exceeds the mean monthly rainfall.

Seasonal variations in rainfall and evapotranspiration can be illustrated by means of simple water-balance studies of the kind used by Thornthwaite and Mather (1955). When rainfall exceeds potential evapotranspiration, water surplus is recharged.

When soil moisture capacity is reached (a value varying with soil type as well as with rooting characteristics), any further rainfall is classed as surplus, either surface runoff or drainage beyond root range.

When rainfall is less than potential evapotranspiration, soil-moisture reserves are utilized. Once soil moisture drops below field capacity, however, water may not be freely available. Thornthwaite and Mather (1955) assume that evpotranspiration is proportional to available water. Thus, with only 50 per cent of maximum available water between field capacity and permanent wilting point, evapotranspiration is assumed to drop to 50 per cent of the potential rate. In dry areas, rainfall at all times may be less than potential evaporation and actual evaporation equals rainfall. At other stations, such as Keta the minor rainy season is about two months during which rainfall exceeds potential evapotranspiration, allowing some soil-moisture recharge followed by utilization of this in succeeding months.

Table 3.6: Water Balance Table at Keta (1945-1994)

	J	F	M	A	M	J	J	A	S	O	N	D
PE	91.6	91.8	91.7	87.9	82.9	66	59.6	58.2	68	81.3	90.6	96.3
P	11	21.4	61.4	96.8	150	224	53.1	20.1	39.1	80.3	26.5	10.9
WD	80.6	70.4	30.3	0	0	0	6.5	38.1	28.9	1	64.1	85.4
WS	0	0	0	8.9	67.3	158	0	0	0	0	0	0

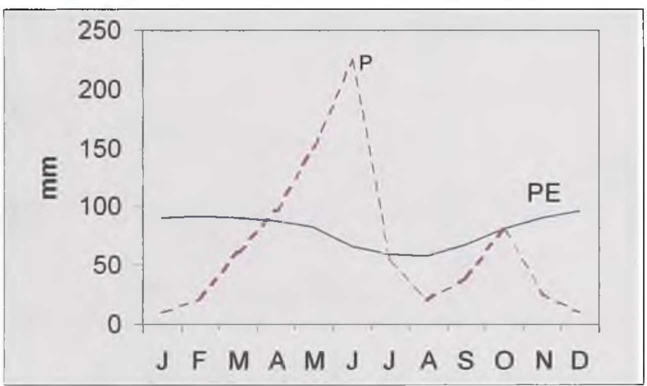
Source: Meteorological Service Department (2000) Accra

PE = Potential Evapotranspiration WD =Water Deficit P = Precipitation

WS =Water Surplus

Figure 3.6 indicates only three months of water surplus whereby the monthly rainfall over the period understudied exceeds the potential evapotranspiration. These months are April, May and June with water surplus of 8.9mm, 67.3mm and 157.9 mm respectively. This implies that there are nine months of water deficit. This is shown in Table 3.6 and Figure 3.6. This situation makes Keta area precarious for rain fed agriculture. It is during the water surplus periods that active plant growth and development take place. It is also the best time for flowers to develop particularly the cereals. It should be noted that farming is a yearly affair in the district where annual crops are grown; the length of the growing season is about ninety days. In times of drought, the length of the growing season can reduce to two or one and a half months (Ofori-Sarpong, 1983).

Figure 3.6: Simple Water Balance Diagram at Keta (1945-1995)



Source: Fieldwork 2001

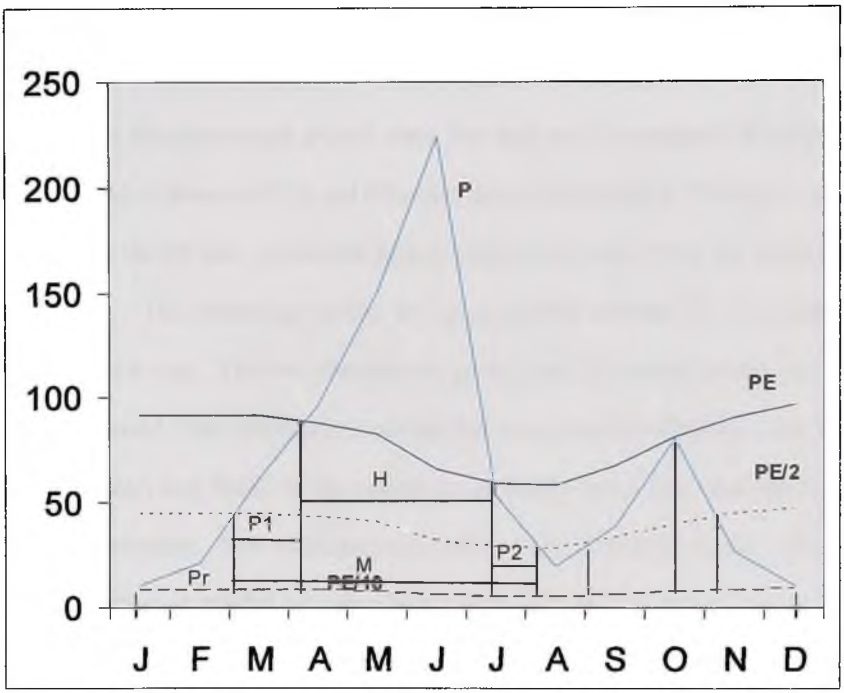
So if there are only three months of water surplus then it means the area is characterized as one of the most marginal areas as far as water is concerned.

The water balance diagram has therefore confirmed the fact that the district is faced with the problem of water deficiency.

3.6 Availability of Water Periods

Cocheme and Franquin (1967) have used an alternative method of depicting rainfall-evapotranspiration relations in agrometeorological investigations of parts of West Africa. This method depicts the availability of water periods. An illustration of their approach is shown in the figure below.

Figure 3.7: Availability of Water Periods in Keta (1945-1995)



Source: Fieldwork 2001

P1= PRE HUMID H = HUMID PERIOD M =MOIST

ET=EVAPOTRANSPIRATION Pr = PREPARATORY PERIOD

P = PRECIPITATION P2= POST HUMID

The duration of the periods during which rainfall exceeds selected levels of evapotranspiration is probably the most useful index of agricultural potentials. In making use of the graphical interpolation of monthly mean potential evapotranspiration and rainfall in conjunction with lines for the values of PE/2 and PE/10, the periods during which rainfall equaled or exceeded PE, PE/2 and PE/10 were determined for Keta District. The availability of water periods were named as Humid: when rainfall exceeds PE, Moist: when rainfall exceeds half PE, Pre-humid and post-humid (intermediates): the transition between moist and humid and preparatory: the period between the points PE/10 and PE/2 at the beginning of the season (Cocheme and Franquin, 1967). The period when rainfall lies between PE/10 and PE/2 is the preparatory period when the land may be prepared for planting. When rainfall is between PE/2 and PE is the intermediate period. When the rainfall line crosses the PE line, the humid period starts and it ends where the rainfall line crosses PE. The following period, to where rainfall crosses PE/2 is a second intermediate period. The two intermediate periods and the humid period constitute the moist period. The intermediate periods take account of the fact that crop-water use at the start and finish of the season is commonly much less than open-water surface evaporation. The moist period is followed by a reserve period. This is a time when although rainfall has fallen below PE/2, soil moisture reserve can be used, creating Cocheme's moist plus reserve period. Two assumptions are made:

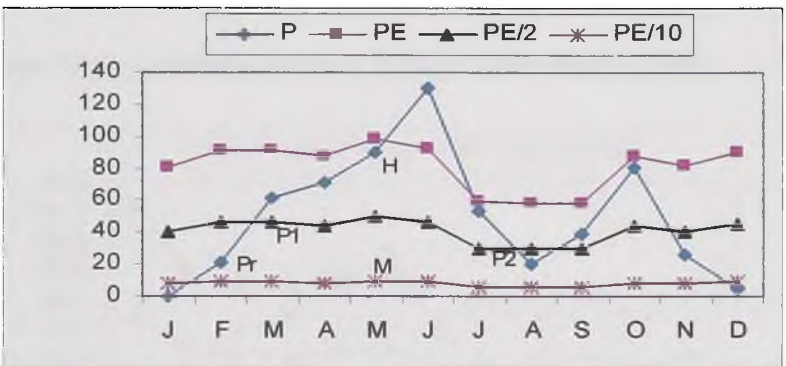
1. That soil-moisture storage within root range is limited to 200mm.
2. That up to half the amount in storage at the end of any month can be used in the next month. Thus if 200mm was in storage at the end of one month, 100mm could be used in the next month.

The figure above (Figure 3.7) illustrates the mean availability of water periods for Keta District. Keta has three months of humid period. It must be noted that it is during the humid period that active growth development takes places. It is of course during the humid period that water surplus and run off occur. Crops grown in the district are vegetables such as tomatoes, pepper, shallot and okra, which do not take less than two months to reach maturity. If the length of the growing season reduces as a result of drought, crop yield will fall and may lead to food insecurity. It should be noted that the minor rainy season according to Figure 3.7 is non-existent, as PE is higher than rainfall. It is characterized by water deficit and quick maturing and drought resistant annuals can survive in the area.

Water-balance studies such as those discussed are of considerable value in delimiting seasonal conditions, growing periods, times of deficit and excess. However, such, simple analyses based on average monthly data are often inadequate for agro-climatic classification systems and a variety of other purposes due to the complexity of the system. The availability of water periods enables the delimitation of seasonal conditions, growing periods, times of deficit and excess. Almost every process in plants is affected by water availability. The relationship varies with plant characteristics, stage of development, soil and climatic conditions (Chang, 1968). Water is absorbed by the roots of the plant and lost through the process of transpiration. If the roots, to compensate for transpiration loss, cannot absorb water then water deficit develops in the plants. Water deficit has significant impact on plant development and it can lead to reduction in photosynthesis. Chang (1968) finds that the rate of photosynthesis declines sharply when there is reduction of about 30% in water content of leaves. Ashton (1956) states that in a crop like sugarcane, photosynthesis appears to be slightly affected until the soil moisture drops to permanent wilting point.

Figures 3.8(a)-3.8(c) illustrates the state of availability of water periods for the Keta District during 1972, 1977 and 1992 drought years.

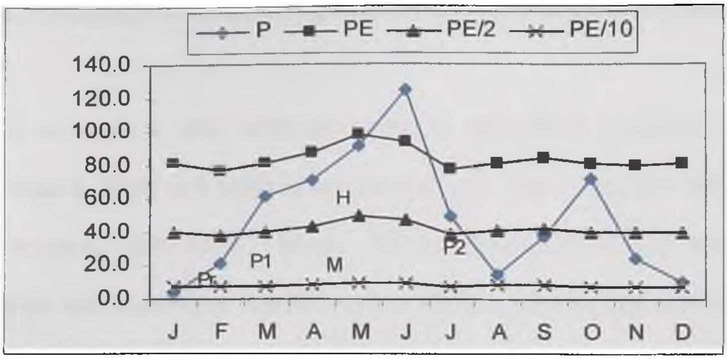
Figure 3.8(a): Availability of Water Periods in Keta District (1972)



Source: Fieldwork 2001

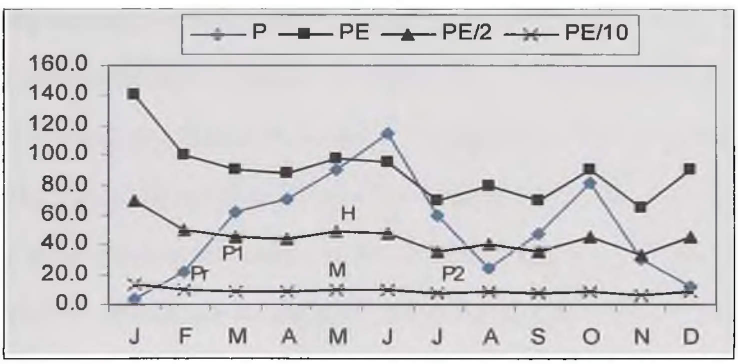
Throughout the drought period, (1972, 1977, and 1992), the district witnessed a decrease in the length of the growing season. The mean growing period begins from April to June. In 1972, the period reduced from three months to about one and half months (mid May – June).

Figure 3.8(b): Availability of Water Periods in Keta District (1977)



Source: Fieldwork 2001

Figure 3.8(c): Availability of Water Periods in Keta District (1992)



Source: Fieldwork 2001

P1= Prehumid P2= Posthumid M= Moist H= Humid

PE= Potential Evapotranspiration Pe= Preparatory period P= Precipitation

The minor rainy season was completely wiped out as it was characterized by large water deficit with even PE/2 greater than rainfall. A similar situation occurred in 1977. In 1992 however the humid period was between the end of May and the end of June. Not only was the growing period affected but also all the availability of water periods necessary for the growth of plants confirming the assumption that water deficiency is hampering agricultural development in the Keta district.

Soil moisture is very important as far as agricultural production is concerned because it affects soil solution and the ease with which water and soil nutrients can be absorbed by the roots of plants. Soil moisture is a function of the nature of the rainfall and its seasonal distribution, run-off, the water holding capacity of the soils and evapotranspiration. Loamy and clayey soils will hold more moisture than sandy soils. Because sandy soils contain no humus they have poor water holding capacity. The type of soil in a particular area is very important because soils with high water holding capacity are very good for agriculture all things being equal. The soils of the Keta District show variations in texture, colour and humus content. Along the coast are found the regosols soil. Around the Lagoons and the creeks are the sodium vleisols, which are dark grey clays, which become sticky when dry. Found at the north of the Lagoons and creeks are the savannah ochrosols, which are brown and red and well drained, porous and easily penetrated by plant roots. In the north west of the district is the regosolic groundwater laterites, which are humus-stained at the surface and consist of yellow brown loamy course sand. A clear correlation can be found to exist between the types of soils in the district and the vegetation and crops supported by them. The red earth found in the north of the lagoons and creeks are suitable for the production of oil palm, cassava and maize. Sandy soils are good or suitable for the production of shallot and cassava.

The analysis of the meteorological data collected shows that rainfall, the single most important climatic factor, has been diminishing in both amount and variability over the years just as temperature and evapotranspiration figures have been increasing. The result of these actions has been a deficiency in water for agricultural production. The above discussion is therefore a negative response from the ecological factors as seen in the conceptual framework leading to decrease in vegetation cover and productivity, unsustainable farming systems, land degradation, low yields and food scarcity.

CHAPTER FOUR

EFFECT OF WATER DEFICIENCY ON AGRICULTURAL PRODUCTION

4.0 Introduction

Climate poses severe problems for the people of the tropics through drought-related food shortages. The most significant climatic factor, which limits agricultural productivity in the tropics, is rainfall (Griffiths 1972, Jackson 1977). The Keta District in Ghana like most areas in the tropics is basically agricultural. Poor distribution of rainfall may lead to a marked reduction in agricultural production. This chapter outlines the importance of water to crops and the effect of its deficiency on agricultural production in the study area.

4.1 Importance of Water to Plants

Before one can talk about the influence or impact of water deficiency on agriculture, it is necessary to discuss the importance of water to plant growth. First of all water is a major constituent of plant protoplasm and it makes up more than 90% of the total weight of plants. Secondly water directly takes part in a number of chemical reactions. It is the medium through which substances move between soils and plant and again between cells and from organ to organ. Again, the presence of water in plants serves as maintenance of turgidity of cells and plants as a whole. Thus every process occurring in plants is affected by water availability though the relationship is very complex. The relationship varies with the nature, the stage of development, the climate characteristics and sometimes the characteristics of the soil.

Leaves have thousands of microscopic openings called stomata, through which water vapour is lost from the plant. This continual loss of water called transpiration causes the plant to wilt unless a constant supply of soil water is provided by absorption through the roots. The total water requirement is the amount of water lost from the plant plus the amount evaporated from the soil. These two processes are called evapotranspiration. Evapotranspiration rates vary and are influenced by day length, temperature, cloud cover, wind, relative humidity, mulching and the type, size and number of plants growing in a given area.

Apart from the ecological factors, socio-economic factors such as land tenure and population density also influence drought and moisture deficiency as seen in the conceptual framework. The issues of land tenure and land reforms are often at the centre of debates over how best to develop the rural sector and meet the needs of the population. One area in Ghana where land has undergone successive fragmentation over the generations leading to diminishing size of individual holdings and rigorous adherence to diverse systems of land tenure is the Anloga area in the Keta District (Figure 1) (Grove, 1966). According to Kufogbe (1997), the annual population growth rate of 1.7% for the Volta region (which is far below the national average of 2.6%-3%) would seem to apply to the Anloga area. Much of the population is concentrated on a narrow coastal strip with a density of 138 inhabitants per km, compared to the national average of 72.2 (Kufogbe 1997, VPRP 1996). The area is thus fairly densely populated. As land becomes fragmented due to increasing population, there is pressure on the existing resources such as water making water a scarce commodity in the district.

4.2 Effect of Water Deficiency

The Keta District is so much affected by water deficiency that the number of years in which harvests fail, are becoming unbearable. Despite this, agriculture is today the principal means of livelihood, and in the past the district formed one of the earliest centres of agriculture in the Volta Region supporting about 4% of Ghana's population (Dotse 1969). The two most important characteristics of rainfall for the Keta District are:

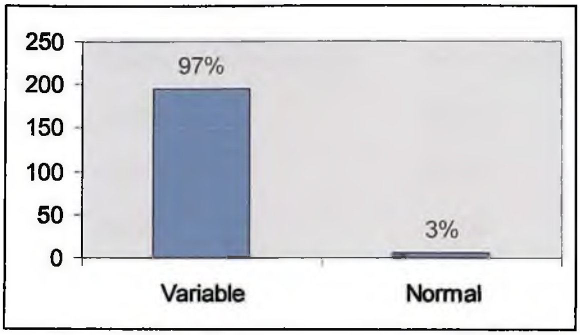
1. Total rainfall is only marginal for crop production in an average year and
2. That this marginality is aggravated by high variability of rainfall totals between years and their distribution within years.

Farmers' perceptions on the nature of rainfall were also gathered through fieldwork. The farmers were again asked about the adequacy of rainfall in the district and with this, all the 200 respondents said rainfall is inadequate.

They were again asked to give the characteristics of rainfall in the area and the answers are shown by Figure 4.1 below. Whereas about 194 of the farmers representing 97% said rainfall in the area is variable about 6 of them representing

3% said it is normal. The variability of total annual rainfall and the distribution of rain within the growing season are also of vital importance. The amount and distribution of rainfall in any year are crucial to peasant agriculture because arable farming is the basis of the economy in the district and water availability is the most important single factor affecting crop yield.

Figure 4.1: Histogram Showing the Nature of Rainfall in the Study Area



Source: Fieldwork 2001

Thus water is the key to increased agricultural production. Rainfall variability affects the time of planting, the location of crops, and the ultimate success of the harvest.

Water deficiency directly affects production in the Keta District. Plants need water to grow and produce food. Deficiency brings about a reduction in productivity. The crops grown in the district are shallot, maize, pepper, okra, tomatoes, cassava, potatoes, garden eggs and recently cabbage and then lettuce. Both documented and undocumented data show that these crops are affected by water deficiency. The farmers who were interviewed also gave affirmative answer to the question "does water deficiency affect crop production"? All the 200 respondents interviewed were of the view that, production figures would have been better than now if there had been sufficient water for farming in the district. Documented records on shallot (main crop production) in the district show that production figures have never been the same for the past ten years. Table 4.1 below shows a ten-year shallot production in the area.

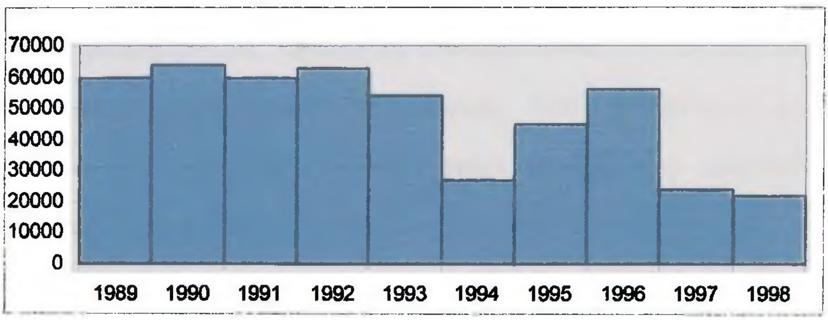
Table 4.1: A Ten-Year Shallot Production Figures (1989-1998)

Year	Estimated Area in Acres	Annual production in Tons
1989	4,000	60,000
1990	4,000	64,000
1991	4,000	60,000
1992	4,000	63,000
1993	4,500	54,000
1994	4,500	27,000
1995	4,500	45,000
1996	4,500	56,000
1997	4,500	24,000
1998	4,500	22,500

Source: Ministry of Food and Agriculture, 2000

Figure 4.1 shows how shallot production has fluctuated over the years. The year 1998 records the lowest shallot production figure followed by 1997 and then 1994. According to the respondents, the low production in these years is due to the low amount of rainfall recorded confirming the assumption that water deficiency is hampering agricultural development in the district. According to the chief farmer in the district, in 1998 about ¾ of all farmers lost everything on their farmland. One farmer who lost massively in this year (1998) said that in 1996, he got about 150 bundles of shallot from his shallot farm but had nothing at all in 1998.

Figure 4.2: Histogram of A Ten year Production Figures (1989-1998)



Source: Fieldwork 2001

What the farmers said was in line with meteorological data because in 1977 the area recorded 540mm of rainfall and 660mm in 1994. These are all below the annual average of 792.5 mm recorded in the study area.

With okra production the story is the same. Anytime low amount of rainfall is recorded, low okra production is also recorded. Though there is no documented record on okra production, farmers were able to give their views on production figures for low and heavy rainfall seasons. An average okra farmer gets about 150 big baskets of okra in a normal year but in times of low rainfall years, this is reduced to about 30 baskets. The farmers were asked about the years in which they lost their crop production to low amount of rainfall and with the 200 farmers interviewed, 156 representing 78% of the respondents said they lost massively in the years of 1977, 1983 and 1998. The rest of the farmers representing 22% of the respondents rather gave 1982, 1984, 1997 and 1999 as the years in which okra production fell massively. This information is in agreement with the author's view. By looking at meteorological data for the years mentioned, it was realized that low amount of rainfall were recorded. The rainfall figures recorded are as follows; 441mm for 1977, 480mm for 1984 and 220mm for 1983 respectively. These annual records are woefully inadequate. With the other crops such as pepper, maize and cassava, the chief farmer provided some undocumented production figures for 1999 and 2000.

Table 4.2:Production Figures for 1999 and 2000 (Maxi bags)

Crop	1999	2000
Pepper	10	12
Maize	5	7
Okra	40	43
Cassava	6	9

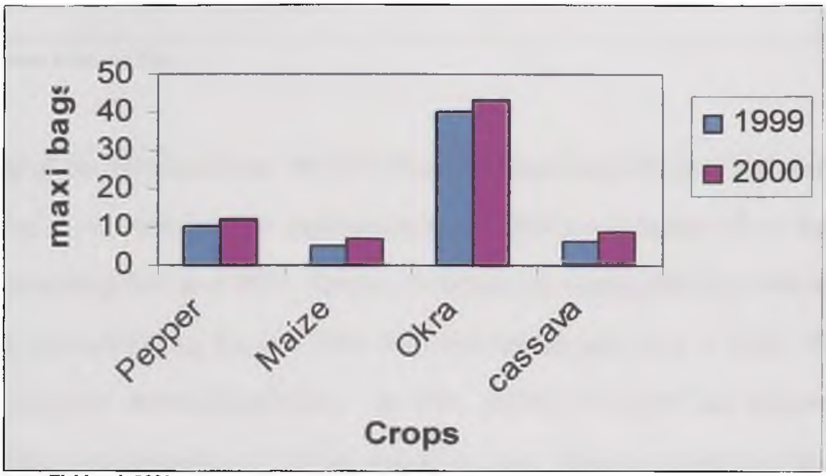
Source: Fieldwork 2001

Table 4.2 above shows on the average what individual farmers obtained from their cropping in 1999 and 2000.

Figure 4.4 shows that for all the crops, production was low in the year 1999 though the effect differs from one crop to the other. The respondents attributed this to the low amount of rainfall recorded in that year which confirms the assumption that water deficiency is hampering agricultural development in the District.

Apart from direct effect of water deficiency such as reduction in production, there are indirect effects such as hunger or food insecurity, increase in prices of consumer goods, poor nutritional status of the people, low standard of living and out-migration. Through data analysis it was realized that years of low rainfall (1977, 1983, 1986, 1998) coincided with years of hunger and food insecurity.

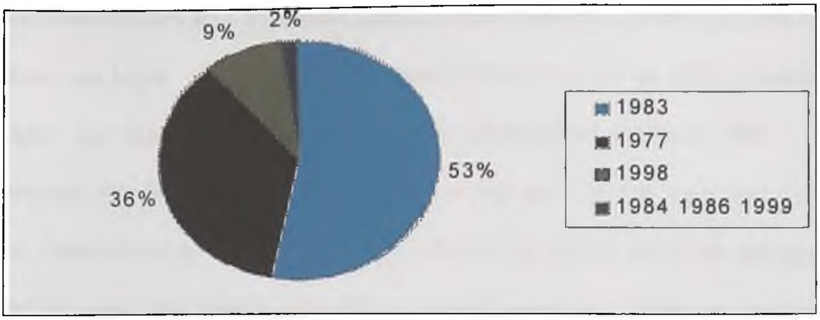
Figure 4.3: Graph of 1999 and 2000 Production Figures.



Source: Fieldwork 2001

The respondents were asked whether they experience hunger and food insecurity in the district and with the 200 respondents interviewed all of them answered affirmative to the question. They were then asked the years in which they experienced hunger and food insecurity and the results are shown in Figure 4.5 below.

Figure 4.4: Graph Showing Years of Hunger and Food Insecurity



Source: Fieldwork 2001

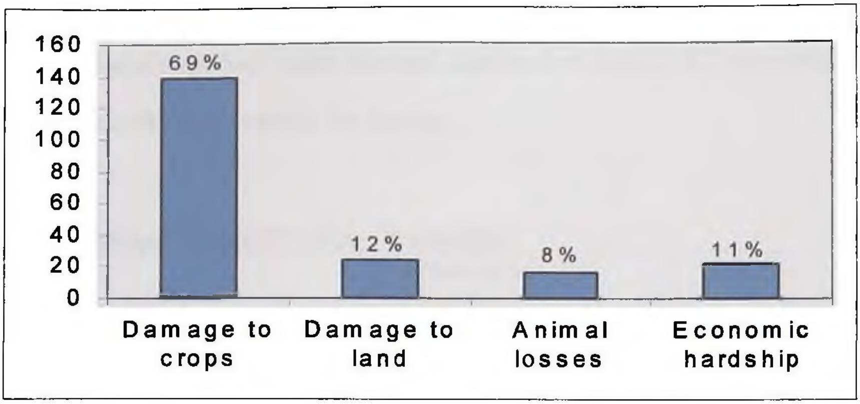
Out of the 200 respondents, 106 of the farmers representing 53% gave 1983 as the year, in which the district experienced severe famine and hunger, 72 of them representing 36% gave 1977. Another 18 farmers representing 9% gave 1998 and the rest representing 2% gave 1984, 1986 and then the early parts of 1999. This agrees with meteorological data. In 1983, 220mm of rainfall was recorded. 441mm was recorded in 1997 and 480mm in 1986. Analysis of both secondary and primary data here shows that there is a positive relationship between water deficiency and agricultural development in the sense that when high rainfall values are recorded there is food security and vice versa confirming the assumption that water deficiency is hampering agricultural activities in the Keta District. During a focus group discussion with some elders in the district, it was realized that in the past, the farmers had food in abundance but the situation is different now. According to the farmers when there is hunger, there is a vicious cycle of unfavourable conditions such as commodity price increases, poor nutritional status and low standard of living.

The farmers were of the view that sometimes when there is low rainfall, prices of food commodities such as shallot, okra, pepper, tomatoes, garden eggs and many others can triple. The farmers were also of the view that in 1997 a bundle of shallot was being sold for ¢3000 but this increased to ¢5000 in 1998. They attributed this to the low rainfall recorded in that year. In that same year, (1997) four fingers of okra were being sold to retailers for ¢50.00 but in the subsequent year the same four fingers were being sold for ¢100.00. There was not even a single commodity whose price remained the same in 1998 when low rainfall was recorded. With cassava production, the situation was different. Though the price shot up in 1998, it was even scarce to come by so that the farmers had to buy from neighbouring villages adding to cost because of the transportation involved. Because of the high cost of living in times of low rainfall, the standard of living becomes low and farmers become vulnerable. According to the farmers, their income levels become so low that they rather adopt eating twice a day instead of three and their nutritional value also becomes poor.

Another indirect effect of water deficiency is out-migration for greener pastures. Documented records show that about 70% of the youth migrate to the cities for other jobs (Dotse, 1969). This has an adverse effect on the economy of the district. Farming activities are kept in the hands of women and the aged who can produce just a few acres of land therefore producing a small yield even in times of heavy rainfall. Furthermore water deficiency increases cost of input. Because of the nature of the soil in the Keta District, the farmers have to cart loads of sandy soil from the seaside for preparation of beds. This task becomes unbearable for farmers when there is water deficiency. The farmers have to hire more labour, which is very expensive in the district. With the 200 farmers interviewed, only 102 of them representing 51% use family labour, the rest hire labour so that the district is described as a labour intensive one. An average labourer collects about ¢10,000.00 a day but in times of insufficient rainfall, he can charge more as they have to water crops all day long.

A long period of water deficiency can lead to agricultural drought, which is defined as a shortage of water harmful to man's agricultural activities. It occurs as an interaction between agricultural activity (i.e. the demand) and natural events (i.e., the supply) which result in a water volume or quality inadequate for plant needs. Drought is seen to have many varied associated impacts, ranging from environmental to economic, social and demographic. Farmers in the Keta District similarly saw drought impact as wide-ranging. For most however, the impacts were on crop production. The effect, according to the farmers is as follows: sixty-nine percent (69%) said the major effect is on crop production, 12% of the farmers however saw the major effect on damage to land by erosion. Eight percent (8%) of them saw the major effect on losses of animals and the effect on people of economic hardship noted by a further 11%.

Figure 4.5: Graph Showing the Effect of Drought on Crop Production



Source: Fieldwork 2001

According to the farmers, they sometimes loose all their crops on occasions or substantial amount in times of drought. Thirty-five percent (35%) of the farmers interviewed said that, in 1983 they lost the whole crop on occasions while 65% claimed that their losses had been substantial. Comparing a normal year with a drought year, it was realized that farmers' produce is reduced drastically in times of drought.

Table 4.3 and Table 4.4 below give crop production figures for the average farmer in the Keta District for a normal year (1997) and then a drought year (1998). Comparing "Normal" year (1997) production figures with drought year (1998) figures, it was realized that for shallot there was a drop of 62.5%, 60% for pepper, 40% for maize, 63% for okra, 70% for tomatoes and 50% for cassava. Water deficiency therefore has an influence on agricultural development by causing drought in some years.

Drought or water shortage is the most important hazard of this area. On being asked to volunteer the disadvantages under which they labour when there is drought, farmers mentioned water shortage, damage from locusts and other pests and shortage of the best farmland for clearing.

Table 4.3: Normal Year (1997) Crop Production

Crops	Quantity per year
Shallot	160 big bundles
Pepper	20 maxi bags
Maize	10 maxi bags
Okra	240 baskets
Tomatoes	20 boxes
Cassava	124 Bags

Source: Fieldwork 2001

Table 4.4: Drought Year (1998) Crop Production

Crops	Quantity per year
Shallot	60 big bundles
Pepper	8 maxi bags
Maize	6 maxi bags
Okra	90 baskets
Tomatoes	6 boxes
Cassava	12 bags

Source: Fieldwork, 2001.

Although other factors are highly contributing to low agricultural productivity, the major one is shortage of rainfall. Because of lack of rainfall and low productivity per unit of land holdings, farmers are forced to encroach into depression and marginal areas to gain more land for compensating low yield from their actual holdings. As a result of such land clearing activities, which involve deforestation and burning of vegetative cover, more land and sometimes even a whole catchment is exposed to excessive erosion and land degradation. Such chain reaction of soil degradation leads to complete drying out of wells, rivers, creeks and streams ending up in famine.

Shortage of water due to low and scanty rainfall makes the average crop yield per unit land area extremely low. As a result of continuous low crop yields, the total produce of most farmers is not even enough for their annual consumption. Because of these situations, the economic condition of most of the population has been gradually affected, leading to poverty. Productivity and agricultural sustainability can decrease and if the present trend in rainfall pattern continues, yield will also decrease. According to the farmers, this will cause reduction in return from capital investment and labour inputs. They were also of the view that when production is reduced, farmers' income is reduced or lowered and the small-scale farmers are forced to work on other farms.

Climate variability, which is the annual variation in the level of precipitation that may fluctuate around particular trends of cyclical long run patterns (Halme, 1992), has contributed to water deficiency. Climate variability becomes critical in economic terms when shortfalls in water availability are beyond the recurrent seasonal rainfall pattern that farmers consider as benchmark for selecting their cropping system and activity pattern. Consequently, farm household livelihoods become more vulnerable to shocks and stress and possess less means to cope with losses. Variability in rainfall is considered as one of the major causes of risk that threaten livelihoods in the Keta District where farm household income is strongly dependent on rainfall and labour intensive agricultural production. Implications of rainfall variability become visible at three different levels (World Bank 2000).

(i) Changes in yield level

(ii) Changes in prices and

(iii) Adjustments in disposable income.

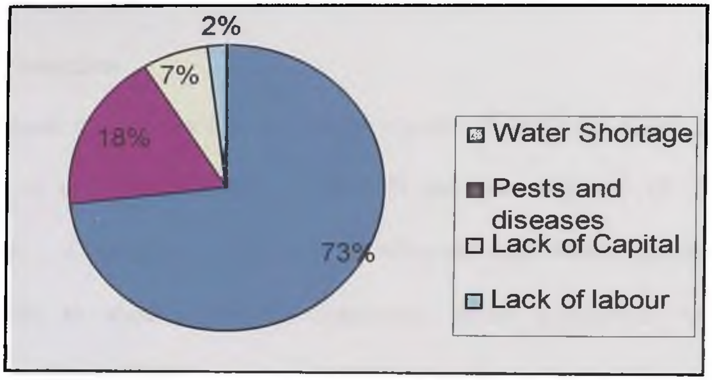
The farmer in the Keta District knows that he must cultivate sufficient foodstuffs in the short wet season to last the year round. What the farmer cannot control is the incidence of rainfall. Any significant variation in the district may spell disaster. According to the farmers interviewed total or partial crop failure is partly a function of delay in the onset of the rains or early rains followed by dry spell or later rains being too light. The seasonal distribution of rainfall determines the cycle of farming activities. Since water is the lifeblood of this area and a limiting factor to agricultural development, nutritional consequences of food shortages become very grave during drought period, (Ofori-Sarpong, 1980). The respondents were of the view that the poor rainfall distribution during the rainy season in 1977, 1983 and 1998 disrupted the agricultural calendar and resulted in poor crop yields, particularly shallot and maize. Again the respondents were of the view that in 1983, an estimated 3000 farmers suffered a lot because of water deficiency in the district. The district is expected to soon become the most popular district in the region because of its supply of vegetable crops such as shallots, okra, pepper and presently lettuce and cabbage. With about two-thirds of its population being farmers, conservative estimates indicate that the need for water will increase by 75 percent by the year 2005 (Ministry of Food and Agriculture 1996).

The extreme vulnerability to rainfall in the area and the poor capacity of most soils to retain moisture result in almost 60% of the district being vulnerable to drought and 30% being extremely vulnerable. Since the 1950's rainfall in the district has been significantly below normal. When the farmers were asked to state their views on the trend of production and productivity concerning indicators such as output, marginal returns and cost/ benefit, the farmers indicated that there has been a downward trend in shallot production since the 1990s. Though the researcher could not get documented records to substantiate the downward trend of shallot production in the 1990s, farmers' testimonies from the interviews, case histories and focus group discussions confirmed the fact that shallot production is on the downward trend. The chief farmer Mr. Vonoe testified that in the 1980s, he could harvest over 3000 big bundles of shallot per year from his 200 farm beds but since the 1990s the number of bundles he has been harvesting per year have been on the decline. In 1977 he harvested 200 bundles and in 1999 he harvested less than 150 bundles. Another elderly female respondent aged 75 years complained bitterly about her 1998 harvest. According to her she did not get even one bundle of shallot from 50 beds. The entire shallot seedlings wilted to the root and before harvest time. On the basis of these testimonies one could cautiously say that the future is bleak for the system. Unfortunately most of the respondents did not keep any valid records of accounts to enable the researcher come out with an appropriate balance sheet to determine profits and loss of individual farmers. Rather a few respondents kept record of the number of shallot bundles obtained per season and total for the year. Because they did not keep financial records, a greater number of the farmers could not tell the losses they incur every season. Nevertheless, it is clear from the testimonies that the farmers are incurring heavy losses. A farming system that does not pay its rent could not be said to be sustainable.

The above discussion shows that agricultural production is seriously affected by water deficiency. This is perceived by the farmers as about seventy-three percent of the farmers interviewed perceive water shortage to be the most important problem in the region followed by pests and diseases, lack of capital and lack of labour as shown by Figure 4.7 below. The discussion above also conforms to the conceptual framework that negative response from socio-economic factors lead to agricultural underdevelopment in the district.

In conclusion it can be said that climate poses severe problems for the people of the tropics through drought-related food shortages. This situation has also been seen to be true in the study area. The Keta District like most areas in the tropics is basically agricultural. Poor distribution of rainfall may lead to a marked reduction in agricultural production.

Figure 4.6: Pie Chart Showing Problems Facing Farming Activities in Keta District.



Source: fieldwork 2001s

CHAPTER FIVE

COPING AND ADAPTIVE STRATEGIES

5.0 Introduction

Agricultural development in semi-arid regions of Western Africa takes place in a context of extreme variability of rainfall and poor capacity of the soil to retain moisture. Consequently farmers' livelihoods and local economies are highly vulnerable to shocks that simultaneously affect production and consumption conditions (Davis 1996).

Water deficiency has become a serious problem to most communities in the Keta District. The poor people are the most affected group particularly those with small land sizes. Low productivity per unit of land is a salient feature of the district. Limited rainfall, inputs, small and highly localized surface water resources and scanty or non-existent vegetation combine to place constraints on the total productive capacity of the district. The traditional farmers who are the traditional food producers living in such fragile environment are ecologically, geographically and economically marginalized. They remain the poor who have developed certain coping and adaptive strategies to reduce water deficit vulnerability.

The farmers rely on a series of particular cropping and land use practices for managing yield risk. Coping strategies refer to built-in mechanisms that permit rural households to overcome chronic and transitory food shortages (e.g. cropping and planting practices) whereas adaptation means a permanent change in the activity mix and/or adjustments in local rule systems. Coping and adaptive strategies can be grouped broadly into indigenous strategies employed at the local level and based on traditional native technologies, and introduced or introduceable modern strategies that have been tried in or proposed for a number of different socio-economic settings. Accordingly, this chapter focuses on coping and adaptive strategies of the poor to water deficit vulnerability and other physical constraints in the district.

5.1 Coping and Adaptive Strategies

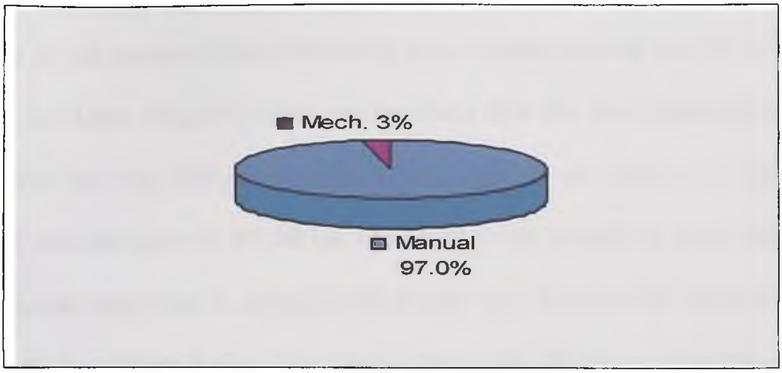
The survey has found out that about 80% of the selected farmers for the interview, living in the Keta District are characterized by fragile environment, sparse plants cover, low amount of rainfall, high rainfall variability, water deficiency, frequent rainfall failure and prolonged drought as in 1983 and 1998. People living under such fragile risky environment where rainfall is a major determinant factor of their food security have adopted certain strategies and mechanisms to water deficit vulnerability. The objective behind these are to reduce vulnerability in order to ensure short-term food security and long term livelihood security.

In the face of the unfavourable physical conditions, the farmers in the district have resorted to several coping and adaptive strategies. Such strategies include intensive farming system which involves irrigation, manuring and planting of crops in the narrow drainage ditches which run almost parallel to the coastline from the east of

Attiteti through Dzita, Whute, Anloga, Aveme to as far as Tegbi (Figure 1). The main crop, which is cultivated under this system of farming, is shallot. The farmers depend much on irrigation due to low amount of rainfall and low water holding capacity of the soil. The source of irrigation water is from wells, which are dug in between beds. The high water table makes it easy for farmers to construct shallow wells on the farm. The wells are about 1.5 – 2.0 meters deep and watering is done twice a day or the whole day depending on the season and the type of crops grown. This is done throughout the growing period of the crops. There is one well to about five beds. Irrigation is done manually with drawing buckets. Though mechanized irrigation is practiced in the district, it is not on a larger scale as it is expensive and can only be afforded by the few rich people in the communities. The pie chart below (Figure 5.1) shows the number and percentage of farmers who use pump or mechanized irrigation as against those who use manual irrigation. The farmers have been compelled to do this due to water deficiency in the area confirming the second assumption that water deficiency has compelled the farmers to adopt some copping strategies.

As at the time of the research, only six farmers representing 3.0% of the total number of farmers interviewed were using pump irrigation. Respondents using the pump came out with the advantages of irrigation. Forty-eight of the respondents representing about 24% of the total number of farmers interviewed were of the view that it saves labour and energy; 76 of them representing 38% said it makes water available in all the seasons. Again 69 of the respondents representing 34.5% said it saves time. The rest of the respondents, 7, representing 3.5%, said it enhances agriculture in the area.

Figure 5.1: Use of Mechanized and Manual Means of Irrigation



Source: Fieldwork 2001

Though the pump or mechanized irrigation was suggested by many of the farmers as a means which can lead to agricultural development in the district, it was realized that the fragmented and scattered nature of land holdings do not permit the use of mechanized irrigation. Again because fresh water is perched on salty water, the use of mechanized irrigation could disturb the equilibrium between the fresh water lens overlying the deeper saline water. In the north and central parts of the district such as Abor, Hatorgodo and Atiavi (Figure 1), where there are no dug wells because the water table is very high, the farmers irrigate the land by using creek and Lagoon water. Since the shallot farmer irrigates his land, the rhythm of rainfall distribution does not exercise much influence on his farming calendar. He is able to cultivate the same piece of land for a long time.

Due to the low fertility of the sandy soil, all kinds of fertilizers (both organic and inorganic have been resorted to by farmers to enrich the fertility of the soil. These are fish guana, cow dung, bat droppings, chemical fertilizers and green manure. The main source of fish manure is from fishermen in the coastal areas such as Woe, Tegbi, Keta, Kedzi and Denu (Figure1). Farmers buy them from the Keta market on market days. The price per bag varies from season to season. At the time of the survey a small basket was selling at ¢3,000.00 but according to the farmers the price increases in the lean season sometimes to about ¢6,000.00, per bag. A bag of fish manure is applied to about twelve shallot beds. The farmers were also of the view that in the past fish manure could be derived from all kinds of fish such as "Abobi", "Deyi", and "Aboludzibe" or small lobsters. The farmers assert that these manures which used to be relatively cheap or free have become more expensive as manure sources have diminished while demand has increased.

The main centres of bat droppings (drumi) production are Afife, Avenor, Kpenor, Abor, Dekpor and Lome (Figure 1). Middlemen at Anloga sell it in bags. At the time of the survey a bag was selling at ¢6,000.00 and this would be used on about five shallot beds. Cow dung is obtained mainly from Ada, , Dabala, Atiavi and Lome. A bag of "nyimi" cost about ¢3,000.00 at the time of the survey and a bag is applied to only one shallot bed.

Organic manure like chemical fertilizers have also been used by farmers. These are N.P.K., urea and sulphate of potash. With the green manure, crops, which might not have matured and weeds are ploughed into the soil with a big hoe and allowed to rot in order to increase the nutrient status of the soil. Mulching of crop residues is also used to improve soil organic matter content. The use of organic fertilizer has the ability to increase the water holding capacity of the soil.

Again the traditional producers in order to reduce the risk of rainfall failure and to ensure some agricultural yields adopt the strategy of early sowing of crop seeds. The farmers usually start sowing their crops in late February and March before the rains begin. The reasons behind early sowing of seeds are as stated by the respondents as first of all to benefit from early rains. The first rainy season in the district starts in March and peaks in June and through experience farmers have become aware of the variable nature of the rains so they do not wait till the peak season to plant their crops. Secondly, they were of the view that early sowing of seed helps them to have sufficient time to repeat sowing in case the first seeds fail. The first seeds fail when the rains fail to come at the expected time and this becomes a big blow to farmers especially the poor ones. Thirdly, crops succeed and mature before the end of the rainy season and give better yields. Accordingly, they avoid the risk of drought that occurs frequently towards the end of the rainy season. The degree of success of crops depends on the continuity of rainfall. If the first rain is followed by an early dry spell, the seeds often fail and the farmers have to repeat sowing their fields. Generally, this strategy to reduce drought vulnerability is essential for good crop germination and good yields. About 162 of the respondents representing 81% of the farmers interviewed practice this sort of strategy. The rest of the 38 farmers representing 19% of the respondents were of the view that their intention of planting their crops in March is not to curtail the problem of failure of first seeds, but they do so because the month of March is the beginning of the rainy and planting season. They said seeds are very expensive so they don't think they would have enough to re-sow when the first ones fail to germinate.

Moreover, one other strategy is what the farmers term as wide spacing. About 184 of the farmers representing 92% of the total number of farmers interviewed argued that they plant their crops in wide spacing; that is the spaces between crop rows are wide unlike some years back. For instance in shallot cultivation, the interval between the row is about 0.5 feet while in the past (about 20 years ago) it was only 0.3 feet. The respondents argued that the wide spacing reduces crop competition for scarce water and nutrients and make good aeration. They have observed that the trend of widening the spaces has recently increased mainly as a coping mechanism in the face of scarcity of water confirming the assumption that water deficiency has compelled the farmers to adopt to some copping strategies. Out of 90% of the respondents, who practice wide spacing, about 47% gave an added advantage to the reason for the wide spacing. They are of the view that it makes harvesting very easy.

Farmers again sow large quantities of seeds per hole thus increasing the density of plants per hole to reduce the possibilities of blowing seeds. When the rains fall the crops germinate as bush especially maize and sorghum. The large number of germinating seeds per hole results in competition on the scarce water. In order to reduce this competition the farmers practice a method of pulling and taking out some of the germinated seeds after some few days of its growth. About 174 people, representing 87% of the respondents practice this phenomenon.

Another strategy is the intercropping system. From the field survey and analysis of the questionnaire, intercropping system is extensively practised. For instance intercropping potatoes and watermelon, maize and cassava, tomatoes, okra and pepper and many other crop combinations. The objectives behind this strategy are that different plants exploit different layers of the soil as well as different strata of the ground using available nutrients, water and light with maximum efficiency. Again, because of this there is an added advantage of the remains of the crops previously harvested becoming manure for the newly planted crops. Also farmers do not loose totally when one crop fails. Lastly through intercropping the farmer can take advantage of the limited areas they can cultivate.

The next strategy is shifting to early maturing short season crops such as okra, maize, shallots, pepper and garden eggs. The traditional producers, through experience have become aware of the variable nature of rainfall. Scarcity or concentration of rainfall in short periods (mainly in June and October) is well comprehended. In order to overcome this vulnerability, the farmers have resorted to using improved seeds confirming the assumption that water deficiency has compelled the farmers to adopt some copping strategies. The respondents boasted of some improved seeds of maize and okra, which could take 30 days to mature.

Land in the district is scarce, fragmented and scattered. Because of this, plot sizes and land holdings are very small and these are calculated in the number of beds. Respondents were of the view that the average number of beds owned by a farmer was 25, though some even had one bed. Access to land is by inheritance of family lands or by hiring beds for a growing season of two months. As a result of land shortage, the farmers have adopted an intensive cropping system to maximize the use of land, virtually no land is left uncultivated since the farming system is very intensive.

Cultivation of vast areas in different directions is one other strategy adopted by peasant farmers. They have excavated the land at the sea side area of the town to avoid the risk of crop failure. This only not increases cropland but increase access to groundwater by increasing proximity to the water table.

The farmers again improve soil moisture through various traditional ways. In an attempt to reduce plant moisture needs or to eliminate moisture wastage, there is an early intense weeding. Dry planting which is the introduction of drought resistant crops or planting many varieties with different water requirements are other common examples used by the farmers.

Another strategy is crop rotation. With this method, the land is divided into plots and each plot is planted to a particular crop. Crops are then rotated after a season or two of cropping. The crops are carefully chosen and rotated in such a way as to allow replenishment of soil nutrients.

One other strategy is soil liming. This is done by the incorporation of lime produced locally from oyster shells into the soil and has the effect of neutralizing acidic soils. When this is done the soil becomes good for growing crops.

Due to the scarcity of land in the area, fallow periods, where it is practiced, have been reduced. Farmers are forced to return to fallow land at shorter intervals. The restoration of the fertility of the soil is therefore not attained and this may lead to lower and lower yields year after year, if some form of fertilization is not applied. However it allows a greater acreage of cropland to be used in a year.

Planting material for shallots is another major farm input and it is one that constitutes the largest drain on farmers' production capital. The planting materials are small to medium sized bulbs saved from the previous harvest. It was learned from the group discussions that about 25-30% of the previous crop is usually saved for planting the next planting season. One farmer, however, is trying to use the actual seed imported from Holland. It is however too early to speculate on the success rate of his trial. If it succeeds, then it would be one of the greatest adaptation mechanisms in the study area.

Again to eliminate or control pest in the study area, there is a strategy known as ‘close of season’. With this strategy there are specified periods within which shallots can be planted and periods within which no one must have shallots on his bed and this is practised on the seaside of the study area.

Again to get maximum returns from their farming activities, farmers have been cultivating high value vegetables dominated by shallots, okra, lettuce, cabbages, melons and maize. Intentionally, the farmers have eliminated crops such as groundnuts, potatoes etc because as compared with the others they are less profitable.

The next strategy includes raising of income through off farm work, labour work, diversification of income, remittance as well as consumption modifying mechanisms through cutting down the number of meals, changing of main meals, food substitution and use of famine food. These mechanisms reflect the awareness of the local people about their surrounding environment.

Another coping strategy found was out migration. In the Anloga area, where land is very scarce, most of the farmers have moved to the city of Accra for greener pastures so farming is done by the aged instead of the youth. Also due to flooding, the condition at Keta town is so bad that many people most especially the youth have migrated to the nearby towns, whereas others have resorted to fishing at places far away from the district.

Drought is caused by a long period of water deficiency and this is harmful to agricultural development. The concept of drought is very complex. No single definition can be universally accepted. That is the concept of water deficiency varies enormously over both space and time. However, two definitions were identified. These are the conceptual and operational ones. Conceptually, drought is defined as deficient in precipitation resulting in damage to crops. Whereas the operational definition of drought identifies the beginning, end and drought severity and the operational one is used by the author. In the study area, 140 respondents (70%) out of 200 perceived drought as decrease in rainfall. Their perception involves timing of the arrival of the rains and the amount received. This perception is supported by some indigenous methods of predicting drought e.g. delay in arrival time, long dry spell, and increase in prices of grains. Traditionally when locusts are usually more one can expect drought. Farmers perception about drought and drought type are shown in Table 5.1 below. Concerning the opportunities for adjustment in the area, farmers were asked what they would do to mitigate the damage of drought event. Virtually all of them indicated that their response would be simply to bear the loses, that is to suffer and wait until the end of the drought.

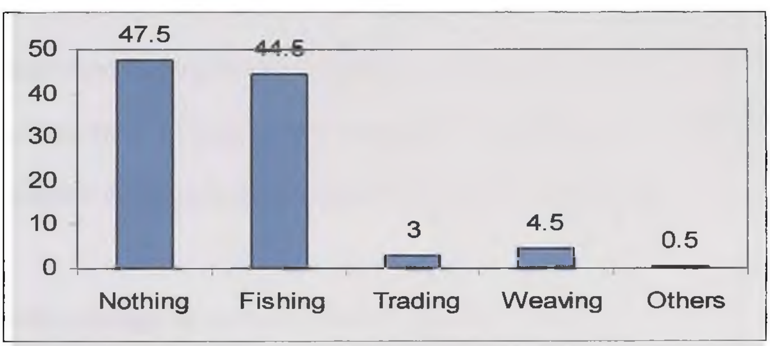
Table 5.1: Farmers Perception About Drought

Drought Perception	Type of Drought	Number of Respondents
Decrease in rainfall	Agricultural	98
Late onset of rain	Agricultural	36
Long dry spell	Agricultural	24
Heavy locusts	Agricultural	42

Source: Fieldwork 2001.

Beyond this 4.5% said they might enhance their income by selling handicraft items, 44.5% would aim to increase their food supply by fishing, and 3.0% will enter into trading. Forty-seven percent said they would do nothing whereas the remaining 5% said they would find other things to do. Figure 5.2 below shows this.

Figure 5.2: Other Activities Engaged by Farmers in Times of Drought.



Source: Fieldwork 2001

Most crops are planted in March with the onset of the rainy season. Timing is crucial because short drought after the planting time may lead to partial or complete loss of the germinating seed or young plants. Such an event necessitates not only replanting, but also generally results in a decrease in the total crop harvested.

One possibility of warding off hardship is the storage of food from year to year. Ways by which plant growth can be fitted into the existing rainfall condition is very important here. This involves questions of differences in water requirements of the different varieties of crops. The aim of every farmer is to increase production from the available physical resources that are always the same. Crops such as cowpea and sorghum have life cycles adapted to the short length of the period of water availability and also adaptation to climate sometimes helps them to escape unfavourable conditions. The farmers are critical about the time of planting of the crop in relation to soil moisture. The climatologist recognizes this by the atmospheric circulation pattern, but the peasant farmer recognizes and forecasts in terms of rain occurrence. Peasant knowledge is very important. Locally farmers in the district have built up an immense store of local experience and this helps in the understanding of local agriculture decision-making process and has a role in planning.

Another strategy is to ensure that the produce from the district finds ready markets. To ensure this, the dates on which sowing of seeds begins have been fixed by farmers in the area. The dates were selected after studying the times when shallots from the other Anlo villages are ready for the market. The beginning of the sowing period, which lasts for about four weeks, is announced by the beating of 'gong gong'. It is an offence for any shallot farmer to sow seeds after the period. This is done to ensure that all the shallot seedlings in the district will mature about the same time and thus prevent the spread of the pests known as "yoe" on the farms from the maturing seeds to the germinating ones. The first shallot season known locally as "Fenu" starts from 15th April and ends by the end of July. The second season "Kele" begins on 1st September and ends in November. This is followed by the third season "Fedomi" which starts from the 1st of January and ends in March.

Though coping and adaptive strategies are adopted to overcome certain barriers to production, they usually come with a cost, which sometimes could be detrimental to the environment. Measurements taken showed that the depression excavated is usually at least 1-1.5m deep, resulting in the complete removal of the scanty topsoil characteristic of the area. The main purpose of these excavations is to get close to the water table to enable the use of traditional irrigation methods. This has resulted in increased vegetable cropping on the seaside area, which in turn is increasing reliance on chemical fertilizers to raise soil fertility. Increased use of chemical fertilizers will increase the rate of leaching of fertilizer materials particularly nitrates into the ground water. This may result in contamination and reduced water quality for human use. The source of fresh water for both farming and human use on the whole of the sand bar is a shallow perched ground water aquifer overlying a salt-water lens.

With intensified cropping under the low rainfall regime and high evapotranspirative demand, farmers have resorted to increased irrigation by sinking more wells. This in turn has increased exploitation of ground water. Sinking larger and deeper wells to support the use of electric water pumping and use of sprinklers is likely to result in excessive exploitation of the aquifer.

Despite the coping and adaptive strategies being undertaking by the people of Keta District, agriculture is influenced greatly by rainfall. The study area has recorded declining levels of yields, productivity and food scarcity has been common. The nature of the land tenure system also makes the long-term investment on the land unattractive.

It can therefore be seen that the interaction of the socio-economic and ecological factors produces a negative response leaving agriculture in the area undeveloped as seen in the conceptual framework. Hence the first and second assumptions that water is a limiting factor to agricultural development in the Keta District and that agriculture is undeveloped in the district are true.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

This study has attempted to examine the effect of water deficiency on agricultural development in the Keta District of Ghana. In this regard the usefulness of rainfall as a climatic index in assessing the importance of water in agricultural activities has been examined. In addition this research has unearthed the environmental problems facing agricultural production in the district and how these problems could be solved. The Keta District is one of the driest areas in the region. Rainfall is scanty, unreliable, and woefully inadequate. However agriculture is the main stay of the economy of the district. Though the area forms about one percent of the total land of Ghana, it supports about 4 percent of its total population. Despite this the people of the Keta District are still tied to agriculture. The people not only adapt to the environment but they shape it as well. In times of low rainfall and degrading environment, the farmers developed ways of coping, which have been fairly successful. Other developments have been the introduction of mechanical irrigation. The expansion of vegetable production and a growing market in Accra, for example suggest a need for careful monitoring of developments in the area. The dependence of farmers in the district on cropland and ground water resource within a complex production system provides a case for the application of integrated management strategies in order to optimise resource use.

Moisture is the basic factor limiting crop production in the Keta District. The evapotranspiration rate is so high that rainfall in the rainy season is not able to offset the potential evapotranspiration. This means that the people of the Keta District are prone to environmental hazards because of annual and monthly variability of rainfall. The farmers have resorted to strategies such as heavy manuring to improve soil fertility and both mechanical and manual irrigation are used to replenish shortage of moisture in the soil. Though irrigation has a lot of advantages, it is very costly and excessive use of it too leads to overexploitation of fresh water.

Farmers in the district see themselves at the mercy of the elements of climate and in the hands of God. They know that drought can come again in any year and that its occurrence cannot be predicted early enough. The range of adjustments is narrow. Beyond their present agricultural strategies to conserve all available moisture, the Keta District farmers tend to see further adjustments being initiated and provided by the government and other non-governmental organizations.

Agriculture is a very important economic activity in the district and its development would go a long way to improve the income status of the people. To develop agriculture in the district will require irrigation. However the water resources in the district fall within a complex system, and calls for a multi disciplinary research. It is recommended that issues of ground water exploitation and sustainability of the aquifer or water lens to support increased demand for irrigation needs to be researched into.

Other sources of irrigation water may have to be found. The traditional farming system appears well adjusted to the environment. Disturbance of this adjustment by modification of the farming system or the introduction of pump and drip irrigation in the district should be considered only with great care. This recommendation aims at increasing the effectiveness of farming in the district.

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APPENDIX

DEPARTMENT OF GEOGRAPHY AND RESOURCE DEVELOPMENT, UNIVERSITY OF GHANA LEGON

QUESTIONAIRE FOR WATER DEFICIENCY AND AGRICULTURAL DEVELOPMENT IN THE KETA DISTRICT OF Ghana (M.PHIL THESIS 2000)

A:IDENTIFICATION

1.Name of respondent...

2.Region....................District......................Settlement.....................

Ethnic group............................

B: BACKGROUND INFORMATION

3.How old are you? [ ]

4.Sex a) Male [ ] b) female [ ]

5.Educational Status

a) Non formal[ ] b)Primary or Elementary[ ] c)Secondary/ Vocational/ Commercial[ ]d)Post Secondary Tertiary[ ]

6.Marital Status

a) Never Married [ ]b)Married[ ]c)Divorced[ ]d)Separated[ ]e)widowed[ ]

7.What is your occupation?.........................

C.PEASANT CULTIVATORS\S PERCEPTION OF RAINFALL VARRIABILITY INCLUDING THE MEMORY OF PAST WET AND DRY YEARS.

8.How do you find rainfall in this area? Is a) adequate[ ] b)inadequate [ ]

9.Does the rain come in time?

a)Yes[ ] b)No[ ]

10.What time do you begin to plant your crops?.......................................

11.What do you do when the rain fail to come at right time?...

....

12. Does it rain throughout the growing season?

a) No[ ] b)Yes[ ]

13.When is the peak rainfall season in the area?...

....

14. Has there been any change in the rainfall pattern for the past 30 years?

a) Yes[ ] b)No[ ]

If yes please explain ....

....

....

15.Was rainfall amount higher in the past than today?

a) Yes[ ] b)No[ ]

16.What do you think are the causes of rainfall variations in this area?.................

....

17.Is the rainfall situation having any negative effect on farming activities in the area?

a) Yes[ ] b)No[ ]

If yes explain your responds..

18.In your opinion do you think the rainfall situation is likely to worsen in the future?

a) Yes[ ] b)No[ ]

Please explain your response...

....

19.What do you think can be done to improve the rainfall pattern in the area?

....

20.Do you usually experience serious drought in this area?

a) Yes[ ] b)No[ ]

If yes explain your response...

....

21. What crops do you cultivate?

a)...................... b).................... c).....................

d)......................... e).........................

22.What happens to your crops when there is drought?

....

....

23.What do you think causes drought in this area?

....

....

24.Do you plant other crops (different) from what you plant if it does not rain

a) Yes[ ] b)No[ ]

If yes what are these crops

a)..........................

b)..........................

c)..........................

d)..........................

e)..........................

25.Can you remember some bad drought years?

a) Yes[ ] b)[ ]

If yes explain your responds………………………………………..

……………………………………………………………………….

26.What happened to your crops during these years?

……………………………………………………………………….

……………………………………………………………………….

27.During bad (drought) years what are the major problems that farmers face?

……………………………………………………………………………………….

……………………………………………………………………………………….

28.What are the major problems facing crop production and farming in general?

……………………………………………………………………………………….

……………………………………………………………………………………….

29 What do you think can be done to improve upon the rainfall pattern the area?

……………………………………………………………………………………….

30.Is farming activities in the area as vibrant as it used to be?

a) Yes[ ] b)No[ ]

Please explain your responds

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

31.How many types of soil do you have in this area? Please name them

a)......................

b)......................

c)......................

d)......................

e)......................

32.Which one is good for which crop

Type of soil Name of crop

a)..

b)..

c)..

d)..

e)..

33.In general what problems do you face as far as the saline soils are concerned?

....

....

34.What do you do to improve the soil fertility?

....

....

35.Have you heard about irrigation?

a) Yes[ ] b)No[ ]

36. If yes what form of irrigation have you been employing in this area?

37.Is there the need for intensive irrigation in this area?

a) Yes[ ] b)[ ]

38.What is the general importance of irrigation?

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

39.Why are you not into intensive irrigation despite its numerous advantages?

………………………………………………………………………………………

………………………………………………………………………………………

40.Do you measure your yield yearly

a) Yes[ ] b)No[ ]

41.Does drought reduce your yield?

a) Yes[ ] b)No[ ]

42.Can you estimate the average total number of bags derived from your crops during

a) Normal rainfall………………………………………

b) Drought…………………………………………….

43.Is there any relationship between food production and water scarcity?

a) Yes[ ] b)No[ ]

If yes explain your response…………………………………………..

44.Why are you still tied to agriculture though you are facing these problems?

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………

45. Is there the need to modernise or improve agriculture in this area?

a) Yes[ ] b)No[ ]

If yes who are the groups\organizations/institutions that can improve it and what are the roles you expect from them

GROUPS/ORGANIZATIONS/INSTITUTIONS ROLES EXPECTED FROM THEM

a)……………………………………………………………………………………..

b)……………………………………………………………………………………...

c)……………………………………………………………………………………...

d)……………………………………………………………………………………...

e)……………………………………………………………………………………...

THANK YOU