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Impact of Climate Change on Agro-Economy of Eritrea, Africa

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Abstract

Because of the global warming, now-a-days the sea level is rising significantly, warm sea water is expensing, drought is increasing, and the higher temperature causing high evaporation, consequently altering global eco-systems. In Africa, about 75 to 250 million people are projected to be exposed to increased water stress; rain fed agriculture could be reduced by 50 per cent due to climate change by 2020. Extreme levels of (WBGT max 320 C) temperature occurs Saharan countries across the Africa west coast to the east and in parts of Ethiopia, Somalia, and Eritrea. The increasing intensity of global warming and the erratic nature of climate change followed by land degradation have adversely affected the economies of many Sub Saharan African countries including Eritrea. The increasing intensity of global warming and the erratic nature of climate change leading productivity miserable in Eritrea. Agriculture is the main source of livelihood for about 80 percent of Eritrea`s population which depends mainly on rain. Zoba (Province) Maekel of Eritrea is one of the Zobas experiencing this type of climate change where the dominant determinants temperature and rainfall have influenced the crop production prominently. This climatic change is affecting to the crop cultivation pattern of the region. This present paper analyses the impact of climate change on agro-economy of Eritrea in general and Zoba Maekel in particular.

Key Words: *Climate, Rain, Agriculture, Eritrea, Zoba, Maekel, Agro economy*

Introduction

Climate change is an alteration of statistical distribution of weather over a period of time that ranges from decades to millions of years. In recent temperature rises above 2^0 C will be difficult for contemporary societies to cope with, and are likely to cause major societal and environmental disruptions through the rest of the century and beyond. The human activities that change the environment are having the greatest impact on climate and are the most destructive. Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. Based on past observations and projections for the future, some important findings have been provided in the (Forth Assessment Report, Pachauri, R K and Resisinger, A. (eds). 2007. Which need urgent attention and action to meet this growing challenge across the globe. Sea level is rising significantly. During the 20th century, and rose about 15 cm (6 inches) due to melting glacier ice and expansion of warmer sea water. Extreme drought is increasing. Higher temperatures

cause a higher rate of evaporation and more droughts in some areas of the world. Ecosystems are changing. As temperature warm, species may either move to a cooler habitat or die. Species that are particularly vulnerable include endangered species, coral reefs, and polar animals. Warming has also caused changes in the timing of spring events and the length of growing season. Continued Greenhouse Gas (GHGs) emission at or above current rates would cause further warming and include many changes in the global climate systems during the 21st century that would very likely be larger than those observed in the 20th century. For the next two decade, a warming of about 0.2□C per decade is projected for a range of emission scenarios.

As it happens, even if the concentration of all GHGs were to be kept constant at the year 2000 levels, a further warming of about 0.1□C per decade would be expected. Beyond that, temperature projections depend increasingly on specific emission scenarios (Karupa and Kickert, 1998).

The impact of this increasing intensity of global warming and the erratic nature of climate change is also observed on agro-economy of African countries in general and sub-Saharan countries in particular. Eritrea, a recently formed small country located in the Horn of Africa which is one of the major countries of this sub-Sahara where agriculture is the main source of livelihood for about more than 80% of people which purely depends upon the rain water. The impact of increasing intensity of global warming and the erratic nature of climate change in Eritrea has been found very significantly. This climatic change is affecting to the crop cultivation pattern of the region.

In this paper an analyses has been made to discuss the impact of climate change on agro-economy of Eritrea in general and the Zoba (Province) Maekel of Eritrea in particular. Both primary and secondary sources data are used in this present paper. The primary source encompasses practical observation of field and responses by the farmers and labourers based on questionnaires. The secondary data have been collected from different magazines, journals, books, different ministries, internet and unpublished projects. Methodologically, data calculation, computation, graphs, bar diagram and cartographic methods have also been carried out for the completion of this paper.

Nature of the Study Area

Eritrea is situated in the Horn of Africa and lies north of equator between latitudes 12^0 22' N and 18^0 02' N and longitudes 36^0 26' 21" E and 43^0 13' E. It has an area of 122,000 square kilometers. To the east, the country is bordered by the Red Sea, extending about 1,212 kilometers from Ras Kasar in the north to Dar Elwa in the southeast. Djibouti borders Eritrea in the southeast, Ethiopia in the South, and the Sudan in the North and West. Administratively, the country is divided in to six *Zobas* (province): Anseba, Debub, Debubawi Keih Bahri, Gas Barka, Makel and Semenawi Keih Bahri.

Eritrea is a land of contrasts with land rising from below sea level to 3,000 meters above sea level. There are three major

physiographic zones: the Western Lowlands, the Central and Northern Highlands, and the Eastern Lowlands (also referred to as the Coastal Plains). Temperature varies with altitude: the mean annual temperature ranges from 16^0 – 18^0 in the Highlands to 28^0 C in the low lands to more than 30^0 C in the Coastal Plains (Ministry of Land, Water and Environment, 1997). Most of the Western Low Lands and Coastal Plains are associated with hot and dry climatic conditions, while the Highlands are relatively cool. The presence of flat land, relatively fertile soil, and a milder climate makes the Central Highlands a center of rain-fed agricultural activity. Several of the major urban centers of Eritrea, including the capital city, Asmara, are located in the central Highlands zone. During good rains the Western Lowlands have a potential for cultivation and agro-pastoralism. The Coastal Plains is the location of the densely populated part of the country, while the Lowlands are sparsely populated.

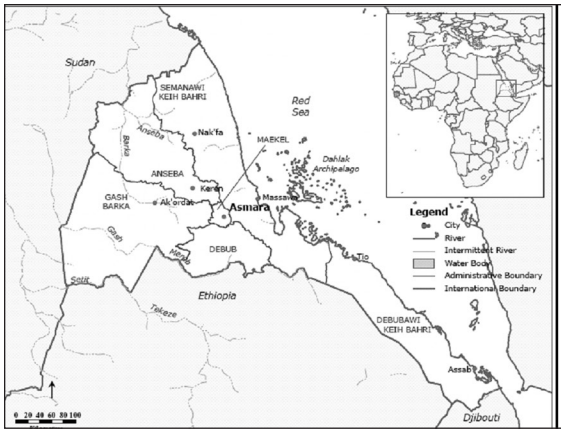

Fig. 1 : Location of Eritrea in Africa

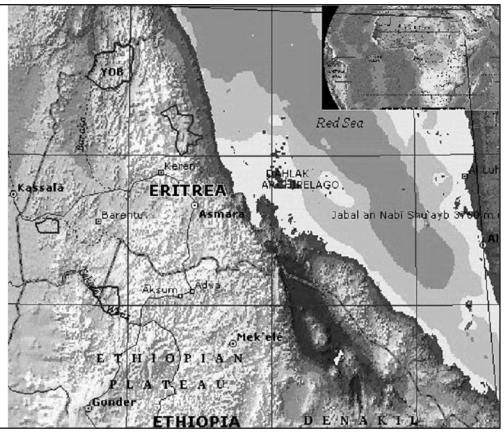

Fig. 2 : Physical Map of Eritrea

The diversified natural features of the country have resulted in growth of various kinds of cropping patterns pertaining to the prevailing climate conditions. Zoba Makel is one of the sixth Zoba of Eritrea which is located in the centre of the country where the capital of the country is in it and it is bordered with Anseba, Semenawi Keihbahri, Gash-Barka and Debob zone. It has a total area of 107,907.8 hectare of which 54,448 hectare is total potential area for agriculture, from this 33,000 hectare is cultivated through rain fed cropping, 3,000 hectare is cultivated using irrigation system and the rest is for grazing, forest plantation etc.

The altitude of the study area ranges from 1,600 meter above sea level, (which is Dirfo) up to 2,610 meter above sea level (that is Zagger). The rainy season is from June to August, but also too little rain showers during spring season. Moreover, forest occurs between October and February. Mean annual rainfall is 415.4 mm; maximum rain fall is 715 mm (as recorded in 1994) and the minimum annual rainfall is 194

mm recorded in 1996. The mean annual temperature of this zone is 15^0; with 25.5^0 C maximum temperature and 4.3^0 C mean annual temperature. Zoba Maekel has 89 villages with 114,627 numbers of households with total population of 518,412 of whom 27 percent engaged in agriculture, 23 percent in trade and service 18 percent in manufacturing and hand craft, 7.5 per cent in civil service and 24 per cent causal labourer (Ministry of Agriculture2007). So, it has its own importance in relation to agriculture. The farmers here practice mixed farming in which growing of crops and herding of animals in the major occupation. The crops grown are cereals which go into sustaining the farmer`s family and its proximity to the urban centre have promoted both vegetable and dairy farming.

Significantly, an underdeveloped region which is totally depends on agriculture for its survival. Climate change is already increasing the risk of exposure to hunger, malnutrition and food insecurity among the poorest and most vulnerable people. Natural disasters are becoming more frequent and intense, land and water are becoming scarcer and difficult to access in agricultural productivity is becoming more difficult to achieve.

Dominant Determinants of Agriculture

It is generally accepted that the elements of climate are the most important variables which play a vital role in agricultural production, even though technological advances and improvements in forecasting have made some possible adjustments in planting and harvesting schedule. The two most influential elements of climate on agriculture are (a) rainfall and (b) temperature which are described below.

(a) Rainfall

In general speaking rainfall has an upper hand in determining the success or failure of agriculture. Especially this is evident in countries like Eritrea, where agriculture is mostly dependent on rainfall. Although the total amount of rainfall (400 to 6000 mm) received each year seem to be sufficient for crop production most parts of Eritrea indeed suffer from chronic droughts over the years. The problem being that the rains are erratic and unpredictable. Moreover, there are also moments when the rains fails to come in time and sometimes are late resulting in the destruction of mature crops. This was witnessed in 1997 which was the El Nino year and the rain failed to occur in time, which in turn caused a lot of destruction (Hanssen, 2009). Historic metrological record reveals that the frequency of droughts have increased during the past 40 years. Eritrea has faced serious droughts from 1905-1915, from 1939-1945, from 1965-1978 and 1984, 1985, 1989, 1991, 2002, and 2008 and (Makel, 2009). Thus, the availability of rainfall is a necessary condition for the success of agricultural productivity. But excess abundance of moisture in the soil can have an adverse effect on agriculture as free movement of oxygen is blocked and compounds which are toxic to the plant roots can formed. The scarcity of moisture can also lead to plant wilting and dying (Scharpenseel e*t al;* 1990).

Zoba Maekel is a region located in the Central Highlands of Eritrea which have enough rainfall to support plant growth between June and September (summer season) and little rain showers in spring season (March and April). In this Zoba, out of 36,000 hectare cultivated land, the 33,000 hectare is rain fed cropping and remaining 3,000 hectare through irrigation. The rain fed crops and summer rainfall is important for the success of these crops. The table-1 gives a glimpse of spring and summer rainfall and their relation with crop production with selected years.

Table 1 : Spring and Summer Rainfall versus Total Production of Agricultural Crop in Tons

Year	Spring Rainfall	Summer Rainfall	Total Rainfall	Total production in ton
1992	10.6	286.5	297.1	21,000
1994	20	239	259	24,429
1996	42	147	189	9,559
1998	109.3	396.9	506.2	39,244
2000	100.9	366	466.9	23,090
2002	11.8	267.6	279.4	2,817
2004	61.4	184.2	245.6	6,089
2006	110	366.4	476.4	35,544
2008	86.4	154.7	241.1	3,170

Source: Department of Metrology and Ministry of Agriculture

The table-1 gives a strong positive correlation between the amount of spring and summer rainfall as well as crop production. For instance, the year 1998, 2000 and 2006 shows high crop production where there is high spring and summer rainfall. Whereas the year 2002 and 2008 recorded the lowest as both spring and summer rainfall was not sufficient to support crop production. The details of crop production based upon the rainfall in different season are given in figure: 3.

Furthermore, the above table shows that the occurrence of spring without summer rainfall and vice versa has negative influence on the productivity of crops. For example, in the year 2008 spring rainfall was significantly high but the failure of summer rainfall causes the decline of crop production. In addition, the distribution of rainy days and area coverage in the region has its own effect in crop production. Like the impact of rainfall on crop production, it has a similar effect on livestock, wildlife and forestry.

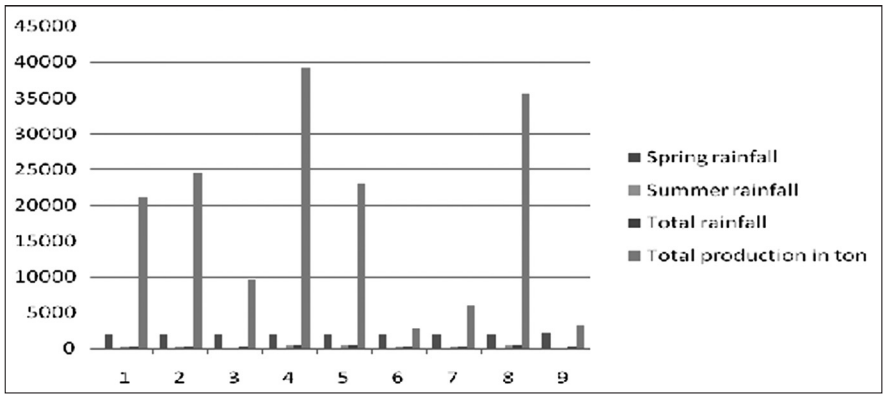

Fig. 3 : Spring and Summer Rainfall versus Total Production of Crops

(b) Temperature

Like rainfall, temperature also plays a significant role in the productivity of agriculture. Temperature could be defined as the hotness of a body. All crops have minimal, optimum and maximum temperature limited for each of their stage of growth. Generally speaking, a high temperature is not as destructive as a low temperature, if moisture supply is sufficient to prevent wilting.

High temperature can cause *sun scaled,* an injury caused by high radiation which leads to high evapotranspiration that can lead to plant drought. The mean minimum and mean maximum temperature of Asmara has been analyzed because most of the areas in Zoba Maekel have similar altitude. Since the months of January and July show the extreme temperature conditions of the year the temperature trend these months of past 18 years from 1992 to 2009 are analysed. The maximum temperature record of these two months for interval of two years difference is assessed in the graph below (Fig.4).

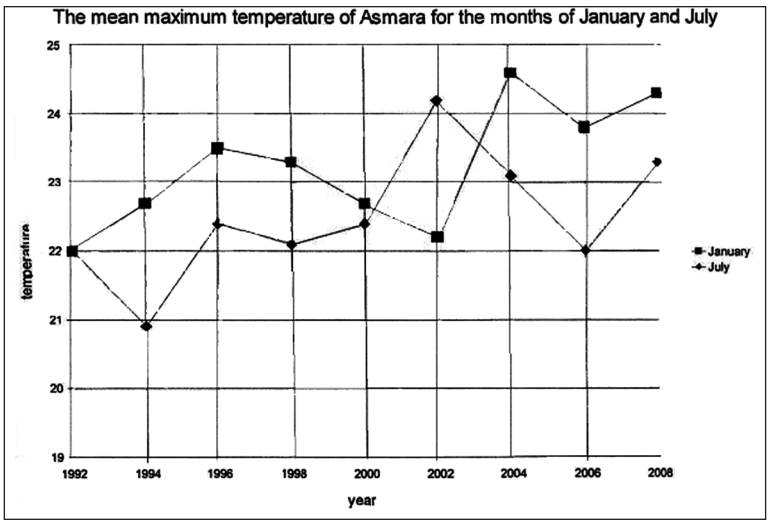

Fig.4 : Mean Maximum Temperature of Asmara for the months of January and July

For the month of January a general increase of temperature from 22º C to 24.3º C is observed from 1992 to 2008. Similarly, the mean maximum temperature in July escalates from 22º C in 1992 to 23.3º C in 2008. The mean maximum temperature of January and July show similar trend because the constant cloud cover of July reduce its maximum temperature by reflecting back most of the incoming radiation. Thus, from the above graph (Fig. 4) a general increase of temperature can be seen over the past 16 years.

The occurrence of low temperature has also far reaching impact on plant growth because plant growth stops when temperature falls below 6□ C. As for mean maximum temperature, the mean minimum temperature of Asmara for the month of July and January are also assessed in the graph below (Fig 5).

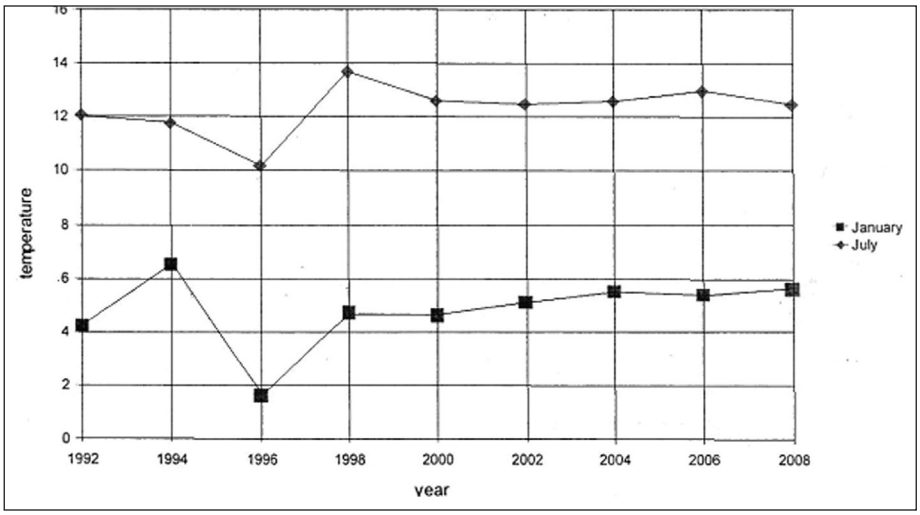

Fig.5 : Mean Minimum Temperature of Asmara for the months of January and July

In 2008 the mean minimum temperature of Asmara in January has risen from 4.2□ C (in 1992) to 5.6□ C. Similarly, the mean minimum temperature of July month shows an increase from 12.7□ C in 2008. From the figure - 5 it is evident that, the mean minimum temperature of July and January show great variation because the cloud cover in the month of July prevent heat loss through re-radiation. Thus a change in either rainfall or temperature can adversely affect the agricultural production.

Impact of Climate Change on Agro-Economy

As climate variation has direct effect on internal renewable water this climate change is also having indirect effect on irrigation crops. The internal renewable water is available from precipitation which is affected by climate change and in return it is affecting the irrigated crop production. Since, the global warming is a great threat in the twenty first century. This is also affecting the crop production by increasing water

requirement by a specific crop (Rosenzweig and Parry 1994).

The risk associated with climate change lies in the interaction of several systems with many variables that must be collectively considered. Agriculture (including crop agriculture, animal husbandry, forestry and fisheries) can be defined as one of the systems and climate the other. The issue is more global. It is now held as likely that human activities can affect climate, one of the components of the environments. Climate in turn affects agriculture, the source of all food consumed by human beings and domestic animals. It must be further considered that not only climate may be changing, but that human societies and agriculture develop trends and constraints of their own which climate change impact studies must take into consideration.

As expert meeting held at FAO Headquarters in Rome from 07th to 10th December, 1993 considered the direct effects of changing hydrological, pedological and plant physiological processes on agricultural production and concentrated on mechanisms. The increasing intensity of global warming and the erratic nature of climate change followed by land degradation have adversely affected on the economies of many Sub-Saharan African countries, particularly on their agriculture sector. Because of this, many of the countries have not yet reached the level of food security and has become a major food aid recipient. With increasing climate variability of cycle and duration, a major concern of many developing countries is on how mitigate the effect of looming in greater Horn of Africa, including Eritrea.

For people living in Eritrea, climate change is related to shortage of rainfall, extended rainy seasons, or late rains those results in decreased biomass production, yield loss, livestock death and therefore famine. Agriculture and pastoralism are the main source of livelihood for about 80 percent of Eritrea population. The agriculture sector depends mainly on rain, with less than 10 percent of the arable land currently irrigated. Consequently, productivity is low and the agriculture sector, including livestock and fisheries, accounts for only one fifth of the Gross Domestic Product (GDP). Eritrea is one of the poorest countries in the world, with GDP per capita of about US $ 200, well below the average US $ 270 for less developed countries (UNDP 2001).

Eritrea has abundant natural resources including arable land (26 percent of total area) of which only about 04 percent is under cultivation (World Food Program 2002). Although surface water is inadequate in Eritrea, there are adequate supplies of ground water, particularly in the Western Lowlands and in some part of the Coastal Plain that can be used for both household and industrial purposes. Eritrea is also believed to have varied and extensive mineral also exists in large quantities (Ministry of Land, Water and Environment, 1997). The Red Sea offers opportunities for the fishing industry, for expanding salt extraction industry, tourism, and possibly extraction of soil and gas. At present, most of these natural resources have not been fully exploited.

The population is essentially rural with about 80 percent of the people living in the country side. The urban population

is characterized by rapid growth, partly as the result of returning refugees from the neighboring and other countries, and partly due to high rural-urban migration. The population of Eritrea is not uniformly distributed throughout the country. The 50-60 percent of the population of Eritrea is living in the Highlands. The age distribution is typical of high fertility regimes in which a larger proportion of the population is to be found in the younger age groups than in the older age groups.

The climate is becoming more and more unpredictable and hence negatively affecting agricultural production of Eritrea. The Zoba Maekel is not free from such effect. The Central Highlands of Eritrea, in which Zoba Maekel is included, have an altitude of over 1600m, receiving an average rainfall of 500 mm to 750 mm and a growing period of crops ranging from 90 days to 130 days. The effect of climate in Zoba Maekel is reflected by the temporal and spatial variation of temperature and rainfall. These climatic variations have a significant influence on the people`s activities including crop production, livestock raising, forestry, horticulture etc.

The common crops grown in Zoba Maekel in order of their proportion are Barely, Wheat, Maize, Sorghum, Millet, Taff and Lentils. Most of crops depend on rainfall since the climate change cause decline of rainfall from year to year, the production of crops also decreased. The bar graph of the production of crops has given below from 1992 to 2008 in tons fig 6. In Zoba Maekel, as farmer`s heavily depend on rain fed agriculture; they are adversely affected by climate change. Over 27 per cent of the total population in Zoba Maekel makes their livelihood from mixed farming. These economic activities had been influenced by variations in elements of climate especially temperature and rainfall. As it is seen that the two important elements of climate rainfall and temperature which have been changing over the past 18 years

Types of crops grown in an area are largely influenced by type of climate in that particular area. Change in climatic condition of an area affect cultivation of crops. As already cited above, Zoba Maekel has been experiencing change in climate. The change in climate in return affects the region`s crop cultivation pattern. Although both temperature and rainfall are important, the influence of rainfall in Zoba Maekel`s crop production is most imminent. This is because large amount of Zoba Maekel`s farm land is rain fed. Climatic variations have direct effect on rain-fed crops. In the direct effect, rain fed yield changes are driven by both precipitation and temperature change. The irrigated yield effects are from temperature change alone because it has constant supply of ground water.

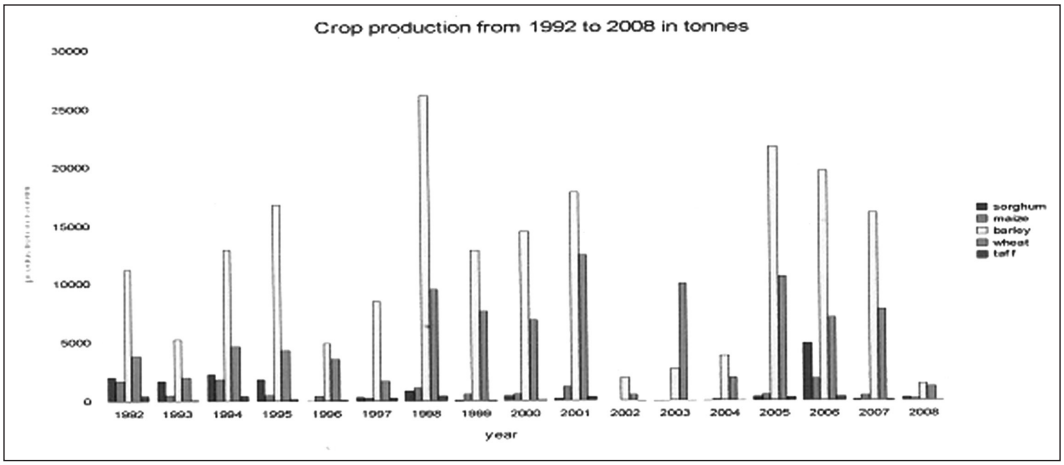

Fig. 6 : Crop Production from 1998 to 2008

Accordingly, production of Sorghum shows a decline from 2,000 tones in 1992 to 235 tones in 2008. Likewise, Maize production decreased from 1,700 tones in 1992 to 120 tones in 2008. On the other hand, the production of Barely and Wheat shows a slight increase because the land which was previously used to cultivate Sorghum and Maize were shifted to produce Barely and Wheat. This shift in land use has taken place due to the unreliability of spring rainfall, which has become very scare in some years (table. 1) and is not enough to support either Sorghum or Maize in the dry periods. The other years show alternative rise and fall of crop production. This means there are alternative 02 to 03 successive rises of production and 02 to 03 successive fall of production. This is because Eritrea is located in the region where drought occurs every 02 to 04 years.

Conclusion

Change in climate significantly affects a wide range of physical systems including water resources, agriculture, forestry and human settlement. Climate change has a greater impact on agriculture production of the world in general and Eritrea in particular. Zoba Maekel is one of Zoba in Eritrea having experience of climate change. Most important elements of climate are rain fall and temperature has been analyzed of about 20 years since 1992 to 2008. Rainfall and temperature are most important variables for determining the success and failure of agricultural production. Erratic and unpredictable behavior of rainfall creates uncertainties in the yield cropping. The year 1997 was witness of El Nino effect led to failure of rainfall. Historic metrological record reveals that the frequency of droughts have increased during the past 40 years. Eritrea has faced serious droughts from

1905-1915, from 1939-1945, from 1965-1978 and 1984, 1985, 1989, 1991, 2002, 2008 and 2009.

Positive co relations have been seen between the amount of spring and summer rainfall and crop production. The year 2002 and 2008 recorded the lowest as both spring and summer rainfall was not sufficient to support crop production. That has also been observed that the occurrence of spring without summer rainfall and vice versa has negative influence in the production of crops whereas in the combination of high spring and summer rainfall creates significant crop production.

Like rainfall, temperature also plays a significant role in the production of agriculture. High temperature can cause *sun scaled* an injury caused by high radiation which leads to high evapotranspiration that can cause plant drought. In the month of January the mean maximum temperature increased from 22□ C to 24□ C from 1992 to 2008. Similarly, mean minimum temperature of the month of July show an increase from 12□ C to 12 7□ C in 1992 to 2008. The effect of climate change in Zoba Maekel is reflected by temporal and spatial variation of rainfall and temperature. The climate is becoming more and more unpredictable negatively affecting agricultural production.

The common crops grown in this Zoba are Barely, Wheat, Maize, Sorghum, Millet, Tiff and Lentils. Most of these crops depend on rainfall since the climate change due to high temperature cause decline of rainfall from year to year the production of crops also decreases. The irrigated yield effects are from temperature change alone because it has constant supply of ground water. The production of Sorghum shows a decline from 2,000 tones in 1992 to 235 tons in 2008. Likewise, Maize production decreased from 1,700 tons in 1992 to 120 tons in 2008. On the other hand, production of Barley and Wheat shows a slight increase because the land which was previously used to cultivate Sorghum and Maize were shifted to produce Barley and Wheat. This shift in land use has taken place due to the unreliability of spring rainfall which has become very scare in some years and is not enough to support either Sorghum or Maize in the dry period.

The rainy season in the country in general and in highlands in particular is shrinking and farmers are continuously losing their long term crops, which take a maturity period of around six months. Eritrea, like other parts of the world, is under the grip of climate change. Successive drought and unreliable rainfall is prevailing in the country.

Global agriculture will be under significant pressure to meet the demands of rising populations using finite, often degraded, soil and water resources that are predicted to be further stressed by the impact of climate change. The ongoing building of green house gases in the atmosphere is promoting shifts in climate across the globe that will affect agro-ecological and growing conditions. Climate change has evolved from an 'environmental' issue into one that requires collective expertise in sustainable development, energy security, and the health and well-being of human being. This is a subject which needs to be addressed both at global, as well as the local level, and

creating knowledge and awareness on this issue would be of great value not only for sensitizing policy makers but also the public at large, particularly the younger generations whose future would be impacted by various dimensions of climate change.

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