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Climate Change Effect and Crops Adaptations in Ethiopia: A Comprehensive Review

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Abstract

Climate change is one of the serious problems in crop production. The increase in carbon dioxide level from 280μg/g to 387μg/g is associated with the global temperature. Human activities release greenhouses gases into the atmosphere. Projected increases temperature, changes in precipitation pattern, changes in extreme weather events, and reduction in water availability may all result in decline crop productivity. The IPCC estimated that a global temperature increases by 1.1 to 6.4°C and also, precipitation, wind shift and other measure of climate change will be occurred in the future. These changes are direct, indirect and socio-economic impacts on crop production. Different study showed that climate change impacts on fruit growth, crude initiations, bulb development, grain yield, biomass formation are direct effect on physiological, morphological, phenotypic changes which may results on crop productivity. Adaptations strategies involve in climate change such as shifting planting time, using improved varieties such as drought resistance, new in Janation, precious management, integrated weed management, pit planting of sugarcane, in addition to these other strategies like improving existing cultivars and new crops and devising new systems and method of managing crops. The main review this paper to summarize that understanding the physiology, morphology and molecular level of plant in climate change, using new knowledge translate, working in collaboration between research and development and using genetic engineering approach will improve further to adopt climate change.

Keywords: Climate change; Crop production; Adaptation strategies

Introduction

Climate change is rapidly emerging as a global critical development issue affecting many sectors in the world and is considered to be one of the most serious threats to sustainable development in the world and is considered. Globally, an unprecedented increase in greenhouse emissions has led to increased climate change impacts agricultural activities have been shown to contribute immensely to climate change as it ranks third after energy consumption and chlorofluorocarbon production in enhancing greenhouse emissions. In fact, emissions from agricultural sources are believed to account for some 15% of today's anthropogenic greenhouse gas emissions. Land use changes, often made for agricultural purposes, contribute another 8% or so to the total [1].

The increase in carbon dioxide level from 280μg/g to 387μg/g in preindustrial times to the current concentration is clearly associated with a worldwide increase in temperature particular over the last five decades. The linear warming trend over the 50 years from 1956 to 2005 of 0.13°C (0.10–0.16°C) per decade is nearly twice that for the 100 years from 1906 to 2005 [2]. The temperature increase is greater at higher northern latitudes, and land regions have warned faster than the oceans [2]. The temperatures in areas at the center of continents have increased faster than those near coast Bhattacharjee et al. suggest that the countries in the Nile Basin have experienced a warming trend of 2-3 per century, while in Rwanda in central Africa has been 7-9 per century. This confirms a similar trend regional diversity by [3].

While some of the increase temperature may be related to urbanization in the more densely populated regions of the world, the changes in sea surface temperatures and in rural Africa, for example, indicate that the warming trend is a global phenomenon that the intergovernmental panel on climate change (IPCC) concludes is most likely the result of human activity [2].

Additional, from 1900 to 2005, different regional trends in precipitation amount have been observed. Precipitation has increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia, whereas precipitation has decreased in the Sahel, the Mediterranean, southern Africa, southern Australia, and parts of southern Asia [2].

Some extreme weather events have also changed in frequency and/or intensity over the last 50 years: cold days, cold nights, and frosts have become less frequent, while hot days and hot nights, heat waves, and the frequency of heavy precipitation events have increased over most land areas [2]. The variability in temperature altered the phenology of crop, i.e., leaf development, and thesis, harvest, fruit production and in asynchrony between an thesis and pollinators. The variable temperature range resulted in high respiration rates, reduction in pollen germination, shorter grain filling period, lesser biomass production and low yields [4]. High temperature above 35°C in combination with high humidity and low wind speed caused a 4°C increase in temperature, resulting floret sterility in cereals and fruits [5]. Climate change impact assessment provides the scientific foundation for the development of adaptations to offset the negative impacts of climate change. Therefore, this paper reviews the impact of climate change and adaptation strategies for crops.

Review of the Literature

Main projections for climate change at global level

The projections of future climate patterns are largely based on

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computer-based models of the climate system that incorporate the important factors and processes of the atmosphere and the oceans, including the expected growth in greenhouse gases from socio-economic scenarios for the coming decades. The IPCC has examined the published results from many different models and on the basis of the evidence has estimated that by 2010 are:- the global average surface warming (surface air temperature change) will increase by 1.1 - 6.4 °C, the sea level will rise between 18 and 59 cm, the oceans will become more acidic, It's very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent, It's very likely that there will be more precipitation at higher latitudes and it is likely that there will be less precipitation in most subtropical land areas. It's likely that tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and heavier precipitation associated with ongoing increases of tropical sea surface temperatures.

Climate change and its consequences

Certain activities create greenhouse gases, which capture heat and energy in the atmosphere and alter long term cycles; this phenomenon is called the greenhouse effect. The Earth's greenhouse effects, in fact, a natural phenomenon that helps regulate the temperature of the planet. When the sun heats the Earth, some of this heat escapes back into space. The rest of heat, also known as infrared radiation, is trapped in the atmosphere by clouds and GHGs, such as water vapor and carbon dioxide (CO2).

If all these GHGs did not exist, the planet would be approximately 60 degrees (Fahrenheit) colder than it is today. The primary GHGs emitted by human activities are CO2, methane (CH4), and nitrous oxide (N2O) which trap heat in the atmosphere and steadily increase the temperature of the Earth above natural levels. The levels of these gases are increasing at a rate faster than at any time during the past 100,000 years and are causing subsequent increases in global surface temperatures Eleven of these years 1995 to 2006 set new annual global surface temperature records. The cumulative effects of increased GHG emissions and their role in the atmosphere and in weather patterns are known as climate change. In a warming climate, extreme events like floods and droughts are likely to become more frequent. More frequent floods and droughts will affect water quality and availability.

A. **Increased temperatures have several direct impacts on crop production as well.**

1. Higher temperatures will cause more evapo-transpiration, drying soils more rapidly and raising the humidity of the atmosphere, which can decrease crop water uptake. The implications of decreased crop water uptake and variable soil moisture level are not generally well-understood but crops rely on water uptake to supply essential nutrients so, anything that decreases water uptake will need to be considered for its consequences on crop productivity.

2. Increased temperatures will reduce organic compound levels in the soil via oxidation, which can further reduce crop productivity soil moisture levels and subsequently impact.

3. Increased temperatures may impact germination and senescence of some crops.

4. Reduced frost risk and warmer winters in many regions could allow earlier planting but could also expand the range of various agricultural pest and disease.

B. **Increased atmospheric CO2 levels have the potential to increase crop productivity for two reasons**

1. Warmer temperatures may make many crops grow more quickly but could also consequently reduce yields of some crops. Crops tend to grow faster in warmer conditions, but for some crops, such as grains, rapid growth reduces the seed maturity and nutrition and can ultimately reduce yields.

2. Greater CO2 concentrations increase plant respiration rate. As part of the carbon cycle plants use energy from sun to photosynthesize carbohydrate from CO2, and greater CO2 concentrations can result in greater carbohydrate production. A small amount of warming coupled with increasing CO2 could benefit certain crops, although the impact on crops depends also on the availability of water and nutrients.

Climate change affects crop production by means of direct, indirect, and socio- economic effects as describe in Figure 1.

Impact of climate change on crop production

Rate of plant growth and development is dependent upon the temperature surrounding the plant and each species has a specific temperature range represented by a minimum, maximum and optimum [6-8]. The expected changes in temperature over the next 30–50 years are predicated to be in the range of 2- 3°C Intergovernmental Panel for Climate Change [9]. Heat waves or extreme temperature events are projected to become more intense, more frequent, and last longer than what is being currently been observed in recent years [10, 11]. Extreme temperature events may have short-term durations of a few days with temperature increase of over 5°C above the normal temperatures [12].

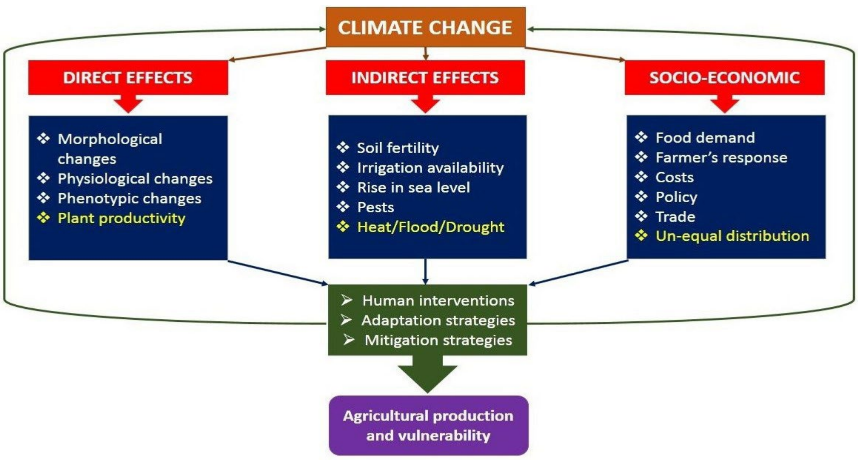

Figure 1: Direct, indirect and socio-economic effects of climate change on agricultural production.

Extreme events occurring during the summer period would have the most dramatic impact on plant productivity.

A recent review by Barlow et al [13] on the effect of temperature extremes, frost and heat, in wheat (Triticum aestivum L) revealed that frost caused sterility and abortion or formed grains filling period. Analysis by [14] revealed that daily minimum temperatures will increase more rapidly than daily maximum temperatures leading to increase in the daily mean temperatures and a greater likelihood of extreme events and these changes could have detrimental effects on grain yield. If these changes temperature are expected occur over the next 30 years than understanding the potential impacts on plant growth and development will help develop adaptation to offset these impacts [15, 16].

Previous studies of climate change impacts on agriculture, using crop yield simulation models [17-19]. Or statistical models suggest that climate change will substantially affect productivity of major staple food crops such as maize, because growth and development of crops are mainly dependent on sunlight, temperature, and water [20- 22].

Climate change may modify precipitation, soil water, runoff, and my reduce crop maturation period and increase yield variability and could reduce areas suitable for the production of many crops [23-25] climate change might limit crop production (the amount of a crop that is harvested in a farm, region state, or country in kilograms or tones) in many areas [26-27].

[28] Used a modeling approach to show that doubling the CO2 increased peanut (Arachis hypogaea L.) yields by 8% on average over 50 years of simulated yields, while increasing the temperature by 3°C decreased yields by 31% across all seasons and a 10% reduction in rainfall decreased yields by 7% on average. Clearly, the increase in mean temperature had a marked effect on yield.

The decrease in yield with higher mean temperatures arises from a speeding up of phonological development and a shortening of the period from emergence to flowering and from flowering to maturity with a consequent reduction in leaf area, a reduction in the radiation intercepted and a reduction in biomass. A rise in mean temperature of 3°C decreased the days to maturity by 6 days (7%) in pearl millet and 19 days (16%) in peanut, reducing grain yield by 33-39%.

The observed effects of past climate trends on crop production are evident in several regions of the world [29], with negative impacts more common than positive ones, including several periods of price spikes following climate extremes in key producing regions. There is evidence that climate change has already negatively affected wheat and maize yields increased frequency of unusually hot nights in most regions is in many regions and also at global level [30].The increased frequency of unusually hot nights in most regions is damaging for most crops, with observed impacts on rice yield and quality.

Several methods and many distinct crop models and model types can be used to estimate how future climate change will affect crop production. Convergent research results from globally consistent, multi-model climate change assessment for major crops with explicit characterization of uncertainty show that climate change will fundamentally alter global food production patterns. Negative crop productivity impacts from climate change for wheat, rice and maize – everything else being equal given present day agricultural areas, levels of management and technology - are expected in low latitude and tropical regions, even at low levels of warming Impacts in the mid to high latitudes are expected to be more mixed, especially at lower levels of warming.

Some high-latitude regions are expected to benefit sometimes substantially – from warmer temperatures and longer growing seasons; however, other environmental conditions, such as soil quality issues in the far north, will likely constrain expansion [29].

Spatial differences are also observed at regional and sub-regional scales, particularly where there are substantial differences in elevation. Contrasted impacts between high and low-latitude regions indicate that climate change is likely to exacerbate existing imbalances between the developed and developing world. Overall climate change will also increase variability in crop yields in many regions. Effects of temperature are generally well understood up to the optimum temperature for crop development. Effects above these optimum temperatures are much less known. Studies also show a large negative sensitivity of crop yields to extreme daytime temperatures around 30 °C to 34 °C depending on the crop and region.

Maize, Sorghum and millet occupy the highest crop areas for all Africa, but with considerable variation across regions. An International Food Policy Research Institute (IFPRI) climate change impact study on crop yields significant geographical variation of impacts, indicating that, while most direct climate change impacts will be negative, there will be positive impacts on yields in some areas with projected increases in precipitation, and in some elevated areas that will be able to be cultivated due to warmer temperatures.

The impact on other crops and higher nutritional value products (such as roots and tubers, pulses, vegetables, fruits and other horticultural products) than the major stable Crops has been much less studied, despite their importance for nutrition and livelihood opportunities. Earlier flowering and maturity have been observed worldwide for grapes, apples and other perennial horticultural crops. Some recent studies suggest that cassava could benefit as it is characterized by high optimum temperature for photosynthesis and growth and a positive response to CO2 increase. Winter chill accumulation, which is important for many fruit and nut trees, is expected to continue to on apples and cherries in the United States of America. Reductions in suitability for grapevines are expected in most wine producing regions. In Brazil, sugarcane and coffee are expected to move to more favorable zones. Suitability for coffee in Costa Rica Nicaragua and EI Salvador is expected to be reduced by 40%.

Climate change is also one of the key diverse of the erosion of genetic for food and agriculture, the raw materials that local communities and researcher rely up on to improve the quality and output of food production. The crop varieties that will be required for charging climate condition will have to come from existing pool of the genetic resources for food and agriculture. Increase tolerance to a biotic stresses (eg. Heat, drought, flooding, frost, rising water temperature) will be needed to new varieties adopted to higher production temperature and to increase or decreased the amount of rainfall are already being developed around the world. However, climate change also threatening the strategic reservoir of crop genetic resources from which to the varieties that will be needed to adapt production system to future challenges. As conditions change, varieties may be a bonfoned by farmers and may be lost forever. Catastrophic extreme weather events such as flood and droughts which in many parts of the world are expected to become more frequent because of climate change, can pode an immediate threat to the survival varieties that are raised only in specific small geographical areas.

Citrus is cultivated in more than 140 countries and is an important natural resources of vitamin C. Predication for the Mediterranean Basin indicate the reduction in annual rainfall, high temperature and increase of salinity and droughts resulting from climate change will seriously threaten Citrus.

In tomato, water stress accompanied by temperature above 28°C induced about 30-45°C flower drop in different cultivars chills also suffer drought stress, leading to yield loss up to 50- 60%. Onion is also sensitive to flooding during bulb development with yield loss up to 30- 40%. Under climate change scenario the impact of these stress would be compounded. These stresses are the primary cause of yield losses worldwide by more than 50% plant and the response of plants to environment stresses depends on the development stage and the length and severity of the stresses. Cauliflower performs well in the temperature range of 15-25°C with high humidity. Though some varieties have adapted to temperature over 30°C, most varieties are sensitive to higher temperature and delayed crud initiations are observed.

The study revealed significant changes in weather elements and has had significant impact on the production of spices crop such as small cardamom, seed spices and black pepper Temperature has a big influence on the rate of fruit growth, thus use of bunch covers, which are tough, to warm the fruit, increase the growth rate. Higher temperature (31-32°C) in general increases the rate of plant maturity in banana, thus shortening the bunch development period. The horticulture crops having C3 photosynthetic metabolism have shown beneficial effects indicated the increase in onion yield by 25-30% maturity due to increase in bulb size at 530ppm CO_2.

Crop adaptation strategies

Climate change adaptation is the action to global warming, which helps to reduce the vulnerabilities in social and biological system. The main objective of adaptation strategies is to build the resilient in society against climate change.

Agriculture sector is highly vulnerable to changing climate. Extreme weather conditions and changing patterns of precipitation affects the crop development, growth and yield of crops. High temperature at critical growth stages could reduce the grain filling duration caused the grains sterility and consequence yield reduction. To avoid the risks in agricultural associated with climate change(CC) adaptation is the key factor that could help to mitigate the negative of climate change. Adaption strategies provide an opportunity to address the CC challenges and to sustain the crop production.

In the recent year, climate change adaptation has been explored by the farmers in many ways. For example, in Pakistan and Barzil farmers has adopted the climate change variability by adjustment of planting time and optimizing of plant population. Adjustment of planting date is important to explore the full potential of crop. High temperature at grain filling stage, reduce the time for grain filling that lead to decrease the yield. Adjusting the planting time with onset of rains and heat waves would decrease the yield losses. Numbers of plant per unit area plays a vital role for higher yield in crops especially wheat.

The number of productive tillers dies or remains unproductive due to variation in temperature and moisture stress. The optimum plant population compensates the yield loss. The development of improved varieties such as early maturing drought and heat tolerant necessary to sustain the productivity under changing climate. The new cultivars would increase the production per unit area under moisture stress and extreme temperatures.

Methane gas is produced from the flooded rice. Flood water in rice blocks the oxygen to penetrate in soil that creates the favorable conditions for bacteria that emit the methane gas. So new methods of planting like direct seeded rice and system of rice intensification with Alternate wetting and draying reduce the methane emission and increase the water use efficiency.

Precision management of nutrients can increase the resilience in the crops by increasing the efficiency of fertilizer. Precision management of fertilizers in crops especially maize reduced the use of fertilizer that would enhance the production and soil health that lead to decrease the emission of greenhouse gases (GHGs). Ratoon crop of sugar cane is more adaptive to climate vulnerabilities. Fuel consumption is less for tillage practices, and less soil is disturbed that lead to reduce the GHGs emission. Pit planting is new evolutionary method in sugarcane in this method sugarcane seedling are grown in small pit under field condition. This method improves the aeration and solar radiation that lead to increase the quality of cane juice and number of cans for milling. A weed is serious issue in the chickpea cultivation. Weeds compete with the chickpea plants for water and nutrients that reduce the growth and yield of chickpea. So integrated weed control improves the yield. GHGs emissions are also reduced due to less use of synthetic weedicides.

The common agricultural adaptation strategies by farmers were the use of drought resistance varieties crops, crop diversifications, changes in cropping pattern and calendar of planting, conserving soil moisture through appropriate tillage method, improving irrigation efficiency afforestation and agro-forestry.

The climate has always been in state of flux, but the current rate of change is much faster, and the range of wheat variables much broader than ever seen before in modern agriculture. Today, two primary approaches for adapting crops to these conditions exist: (i). improving existing crops to these conditions exist: and (ii) devising new cropping systems and methods for managing crops in the field.

These approaches include the specific strategies discussed below:-

i. Strategies for improving existing cultivars and developing new crops

Integrate beneficial traits into existing crop through use of germplasm collections, related datasets, and breeding. Historically, crop scientists have identified and selectively adapted crops to exhibit desirable traits that allow them to achieve optimum yields while withstanding stresses, such as drought, heat, and water-logging. The success and speed of breeding efforts depend, however, on the ability of breeders to access optimal germplasm and quality information about grrmplasm material. Today's breeders rely on genetic and environmental information in germplasm collection. To support continuous improvement of germplasm that can be used to develop cultivars adapted to climate change, there is cultivars adapted to new environmental a faster pace, broadening the options for farmers needed to acquire, preserve, evaluate, document, and distribute plant genetic resources for a wide range of crops and their wild relatives, In addition, biotechnology methods that allow scientists to screen crop traits are already changing how germplasm banks are used. Expanded use of these resources and method will help researchers more quickly identify adaptive traits, represented by genes or groups of genes, which contribute to stress resistance.

Identify crop germplasm that tolerates stresses related to climate change. Yield drops when crops experience drought, excessive heat, or surplus water deviating from the optimum for growth during key stages, including pollination, flowering, and filling periods, when carbohydrate and nutrients assimilate inside grain, tubers, or fruits. Cultivars are now being developed that tolerates excessive heat during pollination for cowpea and corn and flooding early in the growing season for soybean and rice. Maize hybrids are also being developed that show better synchronization of pollination and flowering under heat and water stress. Even so, we have only accessed a small portion of the vast information available about a biotic stress tolerance because information and research is often limited to the most prominent crops; broader investigations and datasets are needed.

Employ new mapping and cataloging techniques Rapid, high-throughput screening of crops genetic material and other new methods are now possible because of imaging, robotics, and supercomputers. These technologies allow researchers to identify adaptive traits expressed in different environments more quickly and increase the probability of finding key clusters or groups of genes that control traits for resistance to drought and other a biotic stresses.

Develop new crops. New crops will likely play a key role in maintain and increasing agricultural production. Domestication began only 5000 to 12000 years ago for our oldest crop such as maize, wheat, potatoes, and sorghum while blueberries and wild rice were domesticated more recently. Development and domestication of crops has enabled us to modify them to optimize yield and nutritional qualities.

Today, some scientists are crossing perennial relative's crops such as maize, millet, rice, sorghum, sunflower, and wheat with their annual, domesticated counterparts for use in developing perennial grain crops. Additional a growing interest in bio-energy has also encouraged the domestication and breeding of new crops is a long-term solution, requiring many years of effort before formal testing can be forms.

Expand field-level evaluation of crop germplasm. The modern crop breeders toolkit which provides access to global genetic resources and technology, combined with large- scale field–level research ,will help uncover previously unknown genetic resources regions on DNA associated with a biotic stress tolerance will enable both applied and basic researchers to develop long-term strategies that maximize delivery of new improved cultivars. Therefore, field-based research programs and related breeding efforts must be supported, integrated, and expanded to engage the full spectrum of crop development scientists, including breeders, physiologist and geneticist.

ii. Strategies for devising new systems and methods to managing crops

New management systems are being developed to increase crop resilience toward climate stresses and maintain ion of location-specific recommendations, will likely help minimize the negative economic impacts that can otherwise accompany ad hoc, untested changes in cropping systems.

Use crop models in decision–making: Crop models integrate important information about processes and allow scientists to estimate the impact of changes in crop genetics and crop and soil management methods. Crop models can also be used to compare crop management strategies, helping producers weigh both economic and environmental considerations as they make decisions about crop varieties, cropping dates, and management practices.

Apply remote sensing and precision agriculture technologies: Remote sensing using both satellite and on-the-go field equipment scanners can reduce the resources needed to measure crop characteristics like cover, leaf greenness, to measure crop characteristics like cover, leaf greenness, growth rate, and biomass across a broad range of cropping systems and environments. This information then allows researchers to assess the effectiveness of modifications in cropping systems and can help producers make precision agriculture production decisions. These tools will be of great use in understanding the effects of a changing environment at the field scale and the appropriate agronomic methods needed to respond to such changes.

Monitor crop condition: Short- and long-term monitoring of factors such as pathogens, changes in field conditions, crop productivity, and weather patterns is essential for building an information base on which future decisions and inJanations can draw remote sensing of crop, weather, and pest conditions, for example, can be used by farmers for adaptive management or by governments as an early warning signal for climate-based food security crises. Databases also permit modeling of both biotic and a biotic climate change effects on crops in specific regions. In short, long-term monitoring is needed to develop strategies for crop/cultivar deployment and associated management practice that offer farmers the best chance for a productive harvest.

Optimize water-use efficiency: With climate change, water supplies are expected to become threatened in certain regions of the world, but water management strategies, such as drip irrigation, can conserve water and protect vulnerable crops from water shortages. To evaluate the effectiveness of these practices, agronomists often calculate the amount of crop yield per unit of water, or water productivity. Also known as achieving "more crop per drop' water productivity can be improved through advances in cultivars, plant nutrition, irrigation practices based on real-time crop need, and better drought and heat tolerance in crops grown in rain-fed systems.

Optimize land use: Sustainable yield intensification use existing arable land more efficiency and avoids bringing new land into production. Higher yields have also been shown to reduce greenhouse gas emissions, thus helping minimizing agriculture's contribution to climate change

Summary

From an agronomic perspective, favorable conditions for crops and other species will move geographically optimizing this condition will thus require changing crops other cultivars species moving them. Even to benefit from potential positive effects, such as longer growing seasons in some cold regions would most of the time ,require significant changes in agricultural systems and practices to effective translate into production growth. Also these changes of climate conditions will go with changes of other biotic parameters (like pests and disease) which can counteract the benefit of climate changes.

Climate change has far-reaching implications for food security, health and safety. The impacts of climate change are in fact already becoming evident, and there is no indication that these trends will reverse in the foreseeable future. Action must therefore be taken now to adopt crops and cropping systems in a timely manner to prevent unpredictable and undesirable outcomes crop varieties, cropping system, and agricultural management strategies changes are needed that provide farmers with options for counter weighing climate.

In particular, research investments and efforts are needed to further:

- Understanding the physiology, genetic and molecular basis of adaptation to drought, heat and biotic stress likely resulting from climate change
- Translate new knowledge into new agricultural system that integrate genetic and management technologies. Inother wards both

breeding and agronomy will contribute adaptation.

➢ Transfer knowledge effectively and make technologies and inJanations widely available to increase food production and stability.

➢ Collaboration and communication between research and development.

- Genetic engineering approaches have been significantly applied to develop transgenic plants with enhanced resistance against different biotic and a biotic stress responses.
- Eco-friendly genome edited crops through a CRISPR /cas9 mediated genome editing to battle against climate change.

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