Climate Change and Agriculture

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A Historical Analysis

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Foreword

Climate change is no more a question of doubt. It is not a recent phenomenon either. The natural process of abiotic adjustment and correction got overpowered by the unsustainably fast rate of development coupled with greed of industrialization.

There are several models predicting the consequential impacts of this phenomenon now called "climate change." However, every model predicts abrupt change in weather conditions, extreme droughts at some places, and heavy rains at the other. More than anything, it is the crop productivity, both in terms of quantity and quality, which is getting affected. Added to it is the emergence of new diseases. Undoubtedly, little decline in food production is bound to cause socioeconomic unrest and chaos. This is more so for countries like India which depend largely on agricultural productivity.

Unfortunately, India is already experiencing more period of dry days than normal. Un- or under-irrigated areas bear greater loss. It is frightening to hear that climate change may reduce the agricultural income at some unirrigated areas by 15–18%. It will be a catastrophic event, unless we take timely corrective measure – including evolving new varieties through genetic engineering, extending irrigation facilities to unirrigated areas or introducing efficient irrigation technologies with minimal loss, or even re-patterning the cropping system.

It is heartening to find that a very dedicated team of agricultural plant physiologists, Dr. V.R. Reddy and Dr. J.D. Mura from the US Department of Agriculture, led by Dr. Dinesh Uprety, Professor Emeritus, Indian Agricultural Research Institute, New Delhi, who devoted all his 40 years of professional life to stress physiology in crops, have co-authored this book on *Climate Change and Agriculture: A Historical Analysis.*

The book focuses on the consequences of the past natural and anthropogenic activities on climate and its impact on crop production, adaptation, and modification. Authors have reviewed the historical background of the technologies used for these studies and the description of up-to-date scientific activities during that time.

I am sure that the readers in India and abroad will find this book interesting, informative, and thought-provoking. It is imperative that it will give various useful strategies to the farmers, scientists, and policy planners to face the challenges of climate change stresses on the basis of past historical experiences. I wish a great success to the book and the authors.

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Preface

This book provides the historical perspective on changes in the climate and its effect on agriculture. Since ancient time, human habitats have been influenced and governed by climate. Humans established themselves in the areas where climatic conditions are favorable to their activities and needs. With the inventions, they were able to modify the nature. Climate change and climate variability were the major challenges to the agriculture on this planet since the ancient time. Agriculture evolved independently where hunter-gatherers started exploring plant use. The development of agriculture was limited mainly by climate variability. We are now familiar with the current environment and have a good record of the weather. There are no records of past climate; however, the reconstruction of past climates of the Earth with historical analysis shows a link between environmental stress and its impact on the agriculture and economic stability of the region.

Climate change currently affects many people worldwide. From a historical perspective, it is also crucial to understand the role that climate has played in the past. Climate change threatens us affecting agriculture with undesirable and inevitable changes. Anthropogenic activities accelerated the process of climate change including global warming, in recent past, and the average temperature of the Earth has increased by 0.6 $^{\circ}$C over the past century. This book addresses the history of the warming of the globe since the Ice Age to the present time.

Scientists involved in the climate change research indicated that climate change or variability might lead to more frequent weather-related disasters in the form of floods, droughts, landslides, and sea level rise. There is substantial evidence over the past few decades that significant changes in climate are taking place worldwide as a result of indiscriminate use of fossil fuels. Efforts are on by many nations to mitigate the challenges posed by the global warming. The food security, especially of developing countries, is at stake due to these climatic stresses. World agriculture faces many future challenges including how potential changes in climate may alter the productivity of crop plants across the world. The potential for emissions of greenhouse gases to alter Earth's climate has been subject of joint research by many scientists. The history of environmental science and climate change deals with initiation and development of different parameters determining the climatic changes.

The description of the history of such changes and turmoil's in different regions of the world is initiated from the prehistoric period much before the first written work by man and in the Greek and Roman history as described by Aristotle and Theophrastus. However, the research on environmental science and atmosphere got impetus due to the establishment of Nalanda and Takshila universities before Greek and Roman people started taking interest in it. The factors driving the climate change in the paleoenvironments were very different from the ones causing today. However, an understanding of human interaction with the environment in the times of climate change during paleo, as implicated by historians, is useful to us and gives some valuable information about the responsiveness of societies to rapid climate changes regarding agriculture and resource availability. The information is available relating to the development of agriculture, environmental protection and adaptive mechanisms in the form of art, glacial ice, scriptures, coins, etc. which are the historical indicators of climate change. From this distant past, we can use a window of historical agriculture through which future adaptation might be understood. The past environments and their transformation following climate change and disasters, future climates, and their challenges can be known. In this monograph, we attempted to highlight different studies and observation relating to climate change. This book is useful for teaching and research work carried out at various institutes, university colleges, and scientific societies beginning from the period of initiation to the present time. This gives a comprehensive approach that may trace an outline of the history of the environmental changes in different regions of the world for general readers interested in climate change. It was desired to be written in a very simple understandable language without any ambiguity. The objective of this monograph is to make our younger generation know that our ancestors were aware of the changes in climate, which is currently a significant problem faced by the humankind and how these people had faced the challenges when they passed through a tumultuous phase.

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About the Authors

Dinesh Chandra Uprety (Dr. D. C. Uprety) is an Emeritus Scientist at the Indian Agricultural Research Institute, New Delhi, and has 43 years research and teaching experience. He has led the South Asian and Indian program on CO_2 enrichment research and technology. He has designed and developed Open Top Chamber (OTC), FACE and FATE climate change research technologies for the South Asian region, bringing India into GCTE research network. He was a member of the IPCC working group II in 2003. He has published about 150 research papers, 4 books and 5 chapters in edited books relating to climate change and agriculture. He is Fellow of the National Academy of Sciences (FNASc); Fellow, START International, USA; Indian Soc. Plant Physiology (FISPP); and received the Gold medal of Acad. Advanc. Agric. Sci. India (AAAS); Sukumar Basu Award in 2004; Eminent Citizen MNERGA 2010; B. N. Singh Memorial Award BHU Centenary Award 2016. He was honored at the 8th International Photosynthesis Conference, Univ. Hyderabad, 2017. The South Asian CO_2 research network of Nepal, Bangladesh, Sri Lanka, Pakistan and India was coordinated by Dr. Uprety at IARI. Dr. Uprety's research and technologies have helped farmers, scientists, students and policy makers to address the challenges of rising atmospheric CO_2 and temperature.

V. R. Reddy is currently the Research Leader and Supervisory Plant Physiologist for the USDA-ARS, Adaptive Cropping System Laboratory, Beltsville, MD, USA. Dr. Reddy has served on various professional and administrative positions, most recently as Acting Associate Director for ANRI (2011–2012) and as Beltsville Area representative on the RL Advisory Council (2010–2012). Presently, he is member of Scientific Advisory Board of the Organization for Economic Co-operation and Development (OECD), Paris, France. He is a Fellow of the American Society of Agronomy and Crop Science Society of America and serves on several Editorial Boards of international scientific journals.

Dr. Reddy's research focuses on crop responses to climate change, especially processes like photosynthesis, respiration, transpiration, carbon and nitrogen metabolism and growth analysis of cotton, soybean, corn and various other crops. In addition to his research, Dr. Reddy provides both technical and administrative leadership for the Crop Systems and Global Change Laboratory.

Jyostna Devi Mura completed her Ph.D. in Genetics in 2008 and has been a Visiting Scientist at USDA-ARS, MD, USA, since 2016.

Acronyms

AD	Anno Domini
BC	Before Christ
BCE	Before the Common Era
BP	Before Present time
C	Carbon
Ca.	Circa
Cal	Calibrated
CE	Common Era or Current Era
CFC	Chlorofluorocarbons
Cl	Chloride
ClO	HypoChlorite
CO_2	Carbon dioxide
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
GHG	Greenhouse gases
Gj	GigaJoule
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
IMO	International Meteorological Organization
IPCC	Intergovernmental Panel on Climate Change
Kg	Kilogram
Kyrs	Kilo years (1000 years)
N_2O	Nitrous oxide
NASA	National Aeronautics and Space Administration
O_2	Oxygen
O_3	Ozone
PFC	Perfluorocarbons
Ppb	Parts per billion
Ppm	Parts per million

Tg	Teragram
UNEP	United Nations Environment Programme
UV	Ultraviolet
WMO	World Meteorological Organization
Yr	Year

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