Shah Fahad · Mirza Hasanuzzaman
Mukhtar Alam · Hidayat Ullah
Muhammad Saeed · Imtiaz Ali Khan
Muhammad Adnan *Editors*

Environment, Climate, Plant and Vegetation Growth

Springer

Environment, Climate, Plant and Vegetation Growth

Shah Fahad • Mirza Hasanuzzaman
Mukhtar Alam • Hidayat Ullah
Muhammad Saeed • Imtiaz Ali Khan
Muhammad Adnan
Editors

Environment, Climate, Plant and Vegetation Growth

Springer

Editors

Shah Fahad
Hainan Key Laboratory For Sustaianable Utilization of Tropical Bioresource, College of Tropical Crops
Hainan University
Haikou, Hainan, China

Department of Agronomy
The University of Haripur
Haripur, Pakistan

Department of Agriculture
The University of Swabi
Swabi, Pakistan

Mukhtar Alam
Department of Agriculture
The University of Swabi
Ambar, Pakistan

Muhammad Saeed
Department of Agriculture
The University of Swabi
Ambar, Pakistan

Muhammad Adnan
Department of Agriculture
The University of Swabi
Khyber Pakhtunkhwa, Pakistan

Mirza Hasanuzzaman
Department of Agronomy
Sher-e-Bangla Agricultural University
Dhaka, Bangladesh

Hidayat Ullah
Department of Agriculture
The University of Swabi
Ambar, Pakistan

Imtiaz Ali Khan
The University of Swabi
Ambar, Pakistan

ISBN 978-3-030-49731-6 ISBN 978-3-030-49732-3 (eBook)
https://doi.org/10.1007/978-3-030-49732-3

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents

1 Carbon Cycle in Response to Global Warming 1
Iqra Mehmood, Amna Bari, Shakeel Irshad, Fatima Khalid, Sehrish Liaqat, Hamza Anjum, and Shah Fahad

2 Agricultural Land Degradation: Processes and Problems Undermining Future Food Security 17
Akbar Hossain, Timothy J. Krupnik, Jagadish Timsina, M. Golam Mahboob, Apurbo Kumar Chaki, Muhammad Farooq, Rajan Bhatt, Shah Fahad, and Mirza Hasanuzzaman

3 Promising Technologies for Cd-Contaminated Soils: Drawbacks and Possibilities 63
Amanullah Mahar, Amjad Ali, Altaf Husain Lahori, Fazli Wahid, Ronghua Li, Muhammad Azeem, Shah Fahad, Muhammad Adnan, Rafiullah, Imtiaz Ali Khan, and Zengqiang Zhang

4 Climate Change and Costal Plant Lives 93
Muhammad Noor, Naveed ur Rehman, Ajmal Jalil, Shah Fahad, Muhammad Adnan, Fazli Wahid, Shah Saud, and Shah Hassan

5 Climate Change Forecasting and Modeling for the Year of 2050 109
Bayram Ali Yerlikaya, Seher Ömezli, and Nazlıcan Aydoğan

6 Effects of Climate Change on Irrigation Water Quality 123
Amanullah, Shah Khalid, Imran, Hamdan Ali Khan, Muhammad Arif, Abdel Rahman Altawaha, Muhammad Adnan, Shah Fahad, Azizullah Shah, and Brajendra Parmar

7 Prospects of Biochar in Alkaline Soils to Mitigate Climate Change 133
Muhammad Rashid, Qaiser Hussain, Khalid Saifullah Khan, Mohammad I. Al-Wabel, Zhang Afeng, Muhammad Akmal, Shahzada Sohail Ijaz, Rukhsanda Aziz, Ghulam Abbas Shah, Shahzada Munawar Mehdi, Sarosh Alvi, and Muhammad Farooq Qayyum

8 Biochar; a Remedy for Climate Change 151
Muhammad Arif, Talha Jan, Muhammad Riaz, Shah Fahad, Muhammad Adnan, Amanullah, Kawsar Ali, Ishaq Ahmad Mian, Bushra Khan, and Fahd Rasul

9 Biofortification Under Climate Change: The Fight Between Quality and Quantity 173
Amir Maqbool, Muhammad Abrar, Allah Bakhsh, Sevgi Çalışkan, Haroon Zaman Khan, Muhammad Aslam, and Emre Aksoy

10 QTL Mapping for Abiotic Stresses in Cereals 229
Saman Saleem, Amna Bari, Bani Abid, Muhammad Tahir ul Qamar, Rana Muhammad Atif, and Muhammad Sarwar Khan

11 Effectiveness of Conventional Crop Improvement Strategies vs. Omics 253
Muhammad Tahir ul Qamar, Amna Faryad, Amna Bari, Barira Zahid, Xitong Zhu, and Ling-Ling Chen

12 Development and Applications of Transplastomic Plants; A Way Towards Eco-Friendly Agriculture 285
Md Jakir Hossain and Allah Bakhsh

13 Alternative and Non-conventional Soil and Crop Management Strategies for Increasing Water Use Efficiency 323
Farah Riaz, Muhammad Riaz, Muhammad Saleem Arif, Tahira Yasmeen, Muhammad Arslan Ashraf, Maryam Adil, Shafaqat Ali, Rashid Mahmood, Muhammad Rizwan, Qaiser Hussain, Afia Zia, Muhammad Arif Ali, Muhammad Arif, and Shah Fahad

14 Role of Biotechnology in Climate Resilient Agriculture 339
Sadam Munawar, Muhammad Tahir ul Qamar, Ghulam Mustafa, Muhammad Sarwar Khan, and Faiz Ahmad Joyia

15 Insect Pests of Cotton Crop and Management Under Climate Change Scenarios 367
Unsar Naeem-Ullah, Muhammad Ramzan, Syed Haroon Masood Bokhari, Asad Saleem, Mirza Abdul Qayyum, Naeem Iqbal, Muhammad Habib ur Rahman, Shah Fahad, and Shafqat Saeed

16 Plant-Microbes Interactions and Functions in Changing Climate 397
Fazli Wahid, Muhmmad Sharif, Amjad Ali, Shah Fahad, Muhammad Adnan, Muhammad Noor, Ishaq Ahmad Mian, Imtiaz Ali Khan, Mukhtar Alam, Muhammad Saeed, Muhammad Ilyas, Rafi Ullah, Haroon Ilahi, and Muhammad Azeem

17 Measuring Vulnerability to Environmental Hazards: Qualitative to Quantitative 421
Md. Enamul Huq, A. Z. M. Shoeb, Mallik Akram Hossain, Shah Fahad, M. M. Kamruzzaman, Akib Javed, Nayyer Saleem, K. M. Mehedi Adnan, Swati Anindita Sarker, Md Yeamin Ali, and Most. Sinthia Sarven

18 Soil Microarthropods and Nutrient Cycling 453
Gopakumar Lakshmi, Bernard N. Okafor, and Donato Visconti

19 Environment, Climate Change and Biodiversity 473
Zia-ur-Rehman Mashwani

20 Consequences of Salinity Stress on the Quality of Crops and Its Mitigation Strategies for Sustainable Crop Production: An Outlook of Arid and Semi-arid Regions 503
Ayman EL Sabagh, Akbar Hossain, Celaleddin Barutçular, Muhammad Aamir Iqbal, M Sohidul Islam, Shah Fahad, Oksana Sytar, Fatih Çiğ, Ram Swaroop Meena, and Murat Erman

21 Advances in Pyrolytic Technologies with Improved Carbon Capture and Storage to Combat Climate Change 535
Mohammad I. Al-Wabel, Munir Ahmad, Adel R. A. Usman, Mutair Akanji, and Muhammad Imran Rafique

22 The Effects of Climate Change on Human Behaviors 577
Senol Celik

23 Role of Plant Bioactives in Sustainable Agriculture 591
Amjad Iqbal, Muhammad Hamayun, Farooq Shah, and Anwar Hussain

24 Microbes and Environment: Global Warming Reverting the Frozen Zombies 607
Ibrar Khan, Aneela Rehman, Khola Zia, Urooba Naveed, Sana Bibi, Rabia Sherazi, Ishtiaq Hussain, Mujaddad Ur Rehman, and Salvatore Massa

25 Extent of Climate Change in Saudi Arabia and Its Impacts on Agriculture: A Case Study from Qassim Region 635
Mohammad I. Al-Wabel, Abdelazeem Sallam, Munir Ahmad, Khalid Elanazi, and Adel R. A. Usman

26 Rice Production Under Climate Change: Adaptations and Mitigating Strategies 659
Sajid Hussain, Jie Huang, Jing Huang, Shakeel Ahmad, Satyabrata Nanda, Sumera Anwar, Awais Shakoor, Chunquan Zhu, Lianfeng Zhu, Xiaochuang Cao, Qianyu Jin, and Junhua Zhang

Editors and Contributors

About the Editors

Shah Fahad completed his Ph.D. in 2015 in the field of Agronomy and Crop Physiology (Climate Change) from Huazhong Agriculture University, Wuhan, China. Later, he completed his postdoctoral research in the field of Crop Physiology and Climate Change from Huazhong Agriculture University, Wuhan, China. Presently he is serving in the Department of Agronomy, The University of Haripur, Pakistan. His research work encompasses plant stress physiology and antioxidant metabolism, coping with weather adversity and adaptation to climatic variability. Dr. Shah Fahad has published over 220 articles in peer-reviewed journals having an impact factor of 610.34. He has edited 10 books and handwritten 35 book chapters on important aspects of plant physiology, plant stress tolerance, and crop production. According to Google Scholar Citation, Dr. Shah Fahad's publications have received about 5847 citations with an h-index of 40 and i10- index of 128. He is an editor and reviewer for more than 10 peer-reviewed international journals and was a recipient of the Publons Peer Review Award 2019. He has been honored by different authorities for his outstanding performance in different fields like research and education and received the Young Rice Scientist Award in 2014 and Distinguish Ph.D. Scholar of Huazhong Agricultural University in 2015. Dr. Shah Fahad has won 9 international and 3 national projects.

Imtiaz Ali Khan is Professor in the Department of Entomology at the University of Agricultural University, Peshawar, Pakistan. Currently he is working as Vice Chancellor of Swabi University, Khyber Pakhtunkhwa, Pakistan. He received his Ph.D. in 2003 from the University of Bonn, Germany. Dr. Imtiaz Ali Khan has been involved in research with IPM of insects and mite pests of fruits, vegetables, and field crops since 2003. He has completed several national and international research projects. Dr. Imtiaz Ali Khan has published 110 articles and chapters related to IPM, plant physiology, and environmental stresses with Springer, Elsevier, Wiley, etc. He has supervised 30 M.S. students and 9 Ph.D. students as the main supervisor. He is involved in editorial activities and is a reviewer for a number of international journals.

Mukhtar Alam is Dean of the Faculty of Sciences and Pro-Vice Chancellor of The University of Swabi, Khyber Pakhtunkhwa born in 1965. He earned his Ph.D. in the year 1995 from the University of Wales, Aberystwyth, UK, on the Ministry of Education, Pakistan, Merit Scholarship. He served for more than 10 years in Civil Services of Pakistan. He has been associated with teaching, research, and administration in the field of biological sciences. He is the member of national and international organizations. Prof. Alam wrote multiple books on agriculture and is the author of more than 100 articles. As a key speaker, he attended international conferences, congresses, symposia, and workshops. Prof. Alam organized international level conferences in his home country. He secured funding of million dollars from national and international organizations. Throughout his professional career, he held the following positions: Vice Chancellor, Dean, Chairman, Coordinator, Director R&D, Additional Registrar, Deputy Director of Oil Board, and Section Officer.

Mirza Hasanuzzaman is Professor of Agronomy at Sher-e-Bangla Agricultural University in Dhaka, Bangladesh. He received his Ph.D. in "Plant Stress Physiology and Antioxidant Metabolism" from the United Graduate School of Agricultural Sciences, Ehime University, Japan, as a recipient of a scholarship from the Japanese government (MONBUKAGAKUSHO). Later, he completed his postdoctoral research at the Center of Molecular Biosciences, University of the Ryukyus, Okinawa, Japan, as a recipient of the Japan Society for the Promotion of Science (JSPS) postdoctoral fellowship. Subsequently, he received the Australian Government's Endeavour Research Fellowship for postdoctoral research as an Adjunct Senior Researcher at the Tasmanian Institute of Agriculture, University of Tasmania, Australia. Mirza Hasanuzzaman has supervised 20 M.S. students. His current work is focused on the physiological and molecular mechanisms of environmental stress tolerance. Prof. Hasanuzzaman has published over 120 research publications in peer-reviewed journals. He has edited 12 books and written 45 book chapters on important aspects of plant physiology, plant stress responses, and environmental problems in relation to agricultural plants. According to Scopus®, Prof. Hasanuzzaman's publications have received roughly 4400 citations with an h-index of 33. He is an editor and reviewer for more than 50 peer-reviewed international journals and was a recipient of the "Publons Peer Review Award 2017, 2018, and 2019." He has been honored by different authorities for his outstanding performance in different fields like research and education, and has received the World Academy of Science Young Scientist Award (2014). He has attended and presented 25 papers at international conferences in many different countries (USA, UK, Germany, Australia, Japan, Austria, Sweden, Russia, Indonesia, etc.). Prof. Hasanuzzaman is an active member of 40 professional societies and is currently the Acting Research and Publication Secretary of the Bangladesh JSPS Alumni Association. He is also a fellow of The Linnean Society of London.

Muhammad Saeed is an Associate Professor in the Department of Agriculture at Swabi University, Pakistan. He received his Ph.D. in Agriculture Entomology from Gomal University D. I. Khan, Pakistan. His research interests include population dynamics, molecular characterization, and management of different insects in different plants. Dr. Saeed is a member of several societies like Royal Entomological Society of London, Entomological Society of America (ESA), Entomological Society of Canada, and The Pan-Pacific Entomological Society of California. He has supervised three M.S. students and one Ph.D. student as the main supervisor. Dr. Saeed has written for about 50 publications (journals and books) and has edited 11 books.

Hidayat Ullah (Associate Professor) is associated with teaching and research at The University of Swabi, Khyber Pakhtunkhwa. He was born in 1979 and earned his Ph.D. in the year 2011 from the University of Agriculture, Peshawar, as Indigenous Fellow of the Higher Education Commission of Pakistan. As a visiting scholar, he contributed towards the legume genome at Southern Illinois University, Carbondale, USA. In the year 2014 he was awarded the prestigious Executive Endeavour Fellowship by the Ministry of Tourism and International Education, Government of Australia. He has been the Author of more than 50 peer-reviewed articles. Recently, he has been nominated by the Government of China for postdoctoral studies under the Talented Young Scientist Program. Previously, he served in the Department of Agriculture Extension, Nuclear Institute for Food & Agriculture, Philip Morris International Pakistan, the University of Sydney Plant Breeding Institute, and Legume Genomic Lab., Southern Illinois University, Carbondale, USA.

Muhammad Adnan is Lecturer in the Department of Agriculture at The University of Swabi (UOS), Pakistan. He has completed his Ph.D. (soil fertility and microbiology) from the Department of Soil and Environmental Sciences (SES), the University of Agriculture, Peshawar, Pakistan, and Department of Soil, Plant and Microbial Sciences, Michigan State University, USA. He has received his M.Sc. and B.Sc. (Hons) in Soil and Environmental Sciences from the Department of SES at the University of Agriculture, Peshawar, Pakistan. Dr. Adnan's main research interests are soil microbiology and plant nutrition, including fertilizer use efficiency, N losses, management of legume N_2 fixation for increasing cereal production, and management of organic wastes for sustainable agriculture production. He has published over 84 peer-reviewed articles, 3 book chapters, edited 1 book, and has received over 2.4 million PKR in research funding as a Co -PI. He has presented his research work in 7 international and 6 national conferences. He has also organized two national and three international conferences in Pakistan. He is the member of the Canadian Society of Soil Sciences, Soil Science Society of Pakistan, and Weed Science Society of Pakistan and was a member (2014–16) of BOS in the Department of Geology at UOS and currently a BOS member in the Department of Environmental Sciences at UOS.Dr. Adnan is the recipient of three Gold medals [one in B.Sc. and two in M.Sc. (Hons)], President of Pakistan Award [B.Sc. Hons)], Indigenous Ph.D. scholarship, and IRSIP grant for Michigan State University, USA, in his educational career. He was also awarded Best University Researcher Award for the year 2015 by UOS.

Contributors

Bani Abid Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Faisalabad, Pakistan

Muhammad Abrar Department of Agronomy, Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan

Maryam Adil Department of Environmental Sciences and Engineering, Government College University Faisalabad, Faisalabad, Pakistan

K. M. Mehedi Adnan College of Economics and Management, Huazhong Agricultural University, Wuhan, Hubei, China
Department of Agricultural Finance & Banking, Sylhet Agricultural University, Sylhet, Bangladesh

Muhammad Adnan Department of Agriculture, The University of Swabi, Swabi, Pakistan

Zhang Afeng College of Natural Resources and Environment, Northwest Agriculture and Forestry University, Yangling, Shaanxi, China

Munir Ahmad Soil Sciences Department, College of Food & Agricultural Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia

Shakeel Ahmad State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Mutair Akanji Soil Sciences Department, College of Food & Agricultural Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia

Muhammad Akmal Institute of Soil Science, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Punjab, Pakistan

Emre Aksoy Department of Agricultural Genetic Engineering, Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, Niğde, Turkey

Mukhtar Alam Department of Agriculture, The University of Swabi, Swabi, Khyber Pakhtunkhwa, Pakistan

Amjad Ali College of Natural Resources & Environment, Northwest A&F University, Yangling, Shaanxi, China

Kawsar Ali Department of Agriculture, Abdul Wali Khan University, Mardan, Pakistan

Md Yeamin Ali DanChurchAid(DCA), Country Office, Cox's Bazar, Bangladesh

Muhammad Arif Ali Department of Soil Science, Bahauddin Zakariya University, Multan, Pakistan

Shafaqat Ali Department of Environmental Sciences and Engineering, Government College University Faisalabad, Faisalabad, Pakistan

Abdel Rahman Altawaha Department of Biological Sciences, Al-Hussein bin Talal University, Maan, Jordan

Sarosh Alvi Soil and Water Testing Laboratory, Rawalpindi, Pakistan

Mohammad I. Al-Wabel Soil Sciences Department, College of Food & Agricultural Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia

Amanullah Department of Agronomy, The University of Agriculture Peshawar, Peshawar, Pakistan

Hamza Anjum Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Faisalabad, Pakistan

Sumera Anwar Shandong International Biotechnology Park, Shandong, China

Muhammad Arif Department of Agronomy, The University of Agriculture Peshawar, Peshawar, Pakistan

Muhammad Saleem Arif Department of Environmental Sciences and Engineering, Government College University Faisalabad, Faisalabad, Pakistan

Muhammad Arslan Ashraf Department of Botany, Government College University Faisalabad, Faisalabad, Pakistan

Muhammad Aslam Department of Plant Breeding and Genetics, Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan

Rana Muhammad Atif Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan

Nazlıcan Aydoğan Department of Agricultural Genetic Engineering, Ayhan Şahenk Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, Niğde, Turkey

Muhammad Azeem Department of Agriculture, The University of Swabi, Swabi, Pakistan

Rukhsanda Aziz Department of Environmental Science, International Islamic University, Islamabad, Pakistan

Allah Bakhsh Department of Agricultural Genetic Engineering, Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, Niğde, Turkey

Amna Bari Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Faisalabad, Pakistan
National Key Laboratory of Crop Genetic Improvement, College of Informatics, Huazhong Agricultural University, Wuhan, People's Republic of China

Celaleddin Barutçular Department of Field Crops, Faculty of Agriculture, University of Cukurova, Adana, Turkey

Rajan Bhatt Regional Research Station, Kapurthala, Punjab Agricultural University, Ludhiana, Punjab, India

Sana Bibi Department of Microbiology, Abbottabad University of Science and Technology, Havelian, Pakistan

Syed Haroon Masood Bokhari Institute of Plant Protection, MNS-University of Agriculture, Multan, Punjab, Pakistan

Sevgi Çalışkan Department of Plant Production and Technologies, Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, Niğde, Turkey

Xiaochuang Cao State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Senol Celik Department of Animal Science, Biometry Genetics Unit, Agricultural Faculty, Bingol University, Bingol, Turkey

Apurbo Kumar Chaki On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh
School of Agriculture and Food Sciences, The University of Queensland, Brisbane, QLD, Australia

Ling-Ling Chen State Key Laboratory of Conservation and Utilization of Subtropical Agro-bioresources, College of Life Science and Technology, Guangxi University, Nanning, People's Republic of China
National Key Laboratory of Crop Genetic Improvement, College of Informatics, Huazhong Agricultural University, Wuhan, People's Republic of China

Fatih Çiğ Department of Field Crops, Faculty of Agriculture, Siirt University, Siirt, Turkey

Ayman EL Sabagh Department of Agronomy, Faculty of Agriculture, Kafrelsheikh University, Kafr el-Sheikh, Egypt

Khalid Elanazi Soil Sciences Department, College of Food & Agricultural Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia

Murat Erman Department of Field Crops, Faculty of Agriculture, Siirt University, Siirt, Turkey

Shah Fahad Hainan Key Laboratory For Sustaianable Utilization of Tropical Bioresource, College of Tropical Crops, Hainan University, Haikou, Hainan, China
Department of Agronomy, The University of Haripur, Haripur, Pakistan
Department of Agriculture, The University of Swabi, Swabi, Pakistan

Muhammad Farooq Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
The UWA Institute of Agriculture and School of Agriculture & Environment, The University of Western Australia, Perth, WA, Australia
Department of Crop Sciences, College of Agricultural and Marine Sciences, Sultan Qaboos University, Muscat, Al-Khoud, Oman

Amna Faryad Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Faisalabad, Pakistan

Muhammad Hamayun Abdul Wali Khan University Mardan, Mardan, Pakistan

Mirza Hasanuzzaman Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

Shah Hassan Department of Agricultural Extension Education and Communication, The University of Agriculture, Peshawar, Pakistan

Akbar Hossain Bangladesh Wheat and Maize Research Institute (BWMRI), Dinajpur, Bangladesh

Mallik Akram Hossain Department of Geography and Environment, Jagannath University, Dhaka, Bangladesh

Md Jakir Hossain Department of Agricultural Genetic Engineering, Faculty of Agricultural Sciences and Technologies, Nigde Omer Halisdemir University, Nigde, Turkey

Jie Huang State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Jing Huang State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Anwar Hussain Abdul Wali Khan University Mardan, Mardan, Pakistan

Ishtiaq Hussain Department of Microbiology, Abbottabad University of Science and Technology, Havelian, Pakistan

Qaiser Hussain Institute of Soil Science, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Punjab, Pakistan

Sajid Hussain State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Md. Enamul Huq State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan, China

Shahzada Sohail Ijaz Institute of Soil Science, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Punjab, Pakistan

Haroon Ilahi Department of Agriculture, The University of Swabi, Swabi, Khyber Pakhtunkhwa, Pakistan

Muhammad Ilyas Department of Botany, The University of Swabi, Swabi, Khyber Pakhtunkhwa, Pakistan

Imran Department of Agronomy, The University of Agriculture Peshawar, Peshawar, Pakistan

Amjad Iqbal Abdul Wali Khan University Mardan, Mardan, Pakistan

Muhammad Aamir Iqbal Department of Agronomy, University of The Poonch, Rwalakot, AJK, Pakistan

Naeem Iqbal Department of Entomology, MNS-University of Agriculture Multan-Pakistan, Multan, Punjab, Pakistan

Shakeel Irshad Center of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad, Pakistan

M. S. Islam Department of Agronomy, Hajee Mohammad Danesh Science &Technology University, Rangpur, Bangladesh

Ajmal Jalil Department of Agriculture, Hazara University, Mansehra, Pakistan

Talha Jan Department of Agronomy, University of Agriculture, Peshawar, Pakistan

Akib Javed State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan, China

Qianyu Jin State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Faiz Ahmad Joyia Center of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad, Pakistan

M. M. Kamruzzaman Department of Computer and Information Science, Jouf University, Sakaka, Al-Jouf, Kingdom of Saudi Arabia

Fatima Khalid Key Laboratory of Horticultural Plant Biology (Ministry of Education), Huazhong Agricultural University, Wuhan, People's Republic of China

Shah Khalid Department of Agronomy, The University of Agriculture Peshawar, Peshawar, Pakistan

Bushra Khan Department of Environmental Sciences, University of Peshawar, Peshawar, Pakistan

Hamdan Ali Khan Department of Agronomy, The University of Agriculture Peshawar, Peshawar, Pakistan

Haroon Zaman Khan Department of Agronomy, Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan

Ibrar Khan Department of Microbiology, Abbottabad University of Science and Technology, Havelian, Pakistan

Imtiaz Ali Khan Department of Agriculture, The University of Swabi, Swabi, Khyber Pakhtunkhwa, Pakistan
University of Agriculture, Peshawar, Pakistan

Khalid Saifullah Khan Institute of Soil Science, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Punjab, Pakistan

Muhammad Sarwar Khan Center of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad, Pakistan

Timothy J. Krupnik International Maize and Wheat Improvement Center (CIMMYT), Sustainable Intensification Program, Dhaka, Bangladesh

Altaf Husain Lahori College of Natural Resources and Environment, Northwest Agriculture and Forestry University, Yangling, Shaanxi, China

Gopakumar Lakshmi School of Environmental Studies, Cochin University of Science and Technology, Kerala, Kochi, India

Sehrish Liaqat Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Faisalabad, Pakistan

Ronghua Li College of Natural Resources and Environment, Northwest Agriculture and Forestry University, Yangling, Shaanxi, China

Amanullah Mahar College of Natural Resources & Environment, Northwest A&F University, Yangling, Shaanxi, China
Centre for Environmental Sciences, University of Sindh, Jamshoro, Pakistan

M. Golam Mahboob ASICT Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh

Rashid Mahmood Institute of Agricultural Sciences, The University of Punjab, Lahore, Pakistan

Amir Maqbool Department of Agricultural Genetic Engineering, Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, Niğde, Turkey

Zia-ur-Rehman Mashwani Department of Botany, PMAS Arid Agriculture University, Rawalpindi, Pakistan

Salvatore Massa Faculty of Medicine, University of Foggia – Università di Foggia, Foggia, Italy

Ram Swaroop Meena Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Shahzada Munawar Mehdi Soil Fertility Research Institute, Lahore, Pakistan

Iqra Mehmood Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Faisalabad, Pakistan

Ishaq Ahmad Mian Department of Soil Environmental Science, University of Agriculture, Peshawar, Pakistan

Sadam Munawar Center of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad, Pakistan

Ghulam Mustafa Center of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad, Pakistan

Unsar Naeem-Ullah Department of Entomology, MNS-University of Agriculture Multan-Pakistan, Multan, Punjab, Pakistan

Satyabrata Nanda State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Urooba Naveed Department of Microbiology, Abbottabad University of Science and Technology, Havelian, Pakistan

Muhammad Noor Department of Agriculture, Hazara University Mansehra, Mansehra, Khyber Pakhtunkhwa, Pakistan

Bernard N. Okafor National Horticultural Research Institute (NIHORT), Ibadan, Nigeria

Seher Ömezli Department of Agricultural Genetic Engineering, Ayhan Şahenk Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, Niğde, Turkey

Brajendra Parmar ICAR-Indian Institute of Rice Research, Soil Science, Hyderabad, India

Mirza Abdul Qayyum Department of Entomology, MNS-University of Agriculture Multan-Pakistan, Multan, Punjab, Pakistan

Muhammad Farooq Qayyum Faculty of Agriculture Science and Technology, Bahauddin Zakariya University, Multan, Pakistan

Muhammad Imran Rafique Soil Sciences Department, College of Food & Agricultural Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia

Rafiullah Department of Agriculture, The University of Swabi, Swabi, Pakistan

Muhammad Habib ur Rahman Department of Agronomy, MNS-University of Agriculture Multan-Pakistan, Multan, Punjab, Pakistan
Institute of Crop Science and Resource Conservation (INRES), Crop Science Group, University of Bonn, Bonn, Germany

Naveed ur Rehman Department of Agriculture, Hazara University, Mansehra, Pakistan

Muhammad Ramzan Institute of Plant Protection, MNS-University of Agriculture, Multan, Punjab, Pakistan

Muhammad Rashid Institute of Soil Science, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Punjab, Pakistan

Fahd Rasul Department of Agronomy, University of Agriculture, Peshawar, Pakistan

Aneela Rehman Department of Microbiology, Abbottabad University of Science and Technology, Havelian, Pakistan

Mujaddad Ur Rehman Department of Microbiology, Abbottabad University of Science and Technology, Havelian, Pakistan

Farah Riaz Department of Environmental Sciences and Engineering, Government College University Faisalabad, Faisalabad, Pakistan

Muhammad Riaz Department of Environmental Sciences and Engineering, Government College University Faisalabad, Faisalabad, Pakistan

Muhammad Rizwan Department of Environmental Sciences and Engineering, Government College University Faisalabad, Faisalabad, Pakistan

Muhammad Saeed Department of Agriculture, The University of Swabi, Swabi, Khyber Pakhtunkhwa, Pakistan

Shafqat Saeed Department of Entomology, MNS-University of Agriculture Multan-Pakistan, Multan, Punjab, Pakistan

Asad Saleem Department of Entomology, MNS-University of Agriculture Multan-Pakistan, Multan, Punjab, Pakistan

Nayyer Saleem State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan, China

Saman Saleem Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Faisalabad, Pakistan

Abdelazeem Sallam Soil Sciences Department, College of Food & Agricultural Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia

Swati Anindita Sarker School of Economics & Management, University of Chinese Academy of Sciences, Beijing, People's Republic of China
Department of Agricultural Economics, EXIM Bank Agricultural University Bangladesh, Chapainawabganj, Bangladesh

Most. Sinthia Sarven College of Plant Science and Technology, Huazhong Agricultural University, Wuhan, Hubei, China

Shah Saud College of Horticulture, Northeast Agricultural University, Harbin, China

Azizullah Shah Pakistan Agriculture Research Council, Islamabad, Pakistan

Ghulam Abbas Shah Department of Agronomy, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Punjab, Pakistan

Farooq Shah Abdul Wali Khan University Mardan, Mardan, Pakistan

Awais Shakoor Department of Environment and Soil Sciences, University of Lleida, Lleida, Spain

Muhmmad Sharif Department of Soil Environmental Science, University of Agriculture, Peshawar, Pakistan

Rabia Sherazi Department of Microbiology, Abbottabad University of Science and Technology, Havelian, Pakistan

A. Z. M. Shoeb Department of Geography and Environmental Studies, University of Rajshahi, Rajshahi, Bangladesh

Oksana Sytar Department of Plant Physiology, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture, Nitra, Slovakia

Muhammad Tahir ul Qamar State Key Laboratory of Conservation and Utilization of Subtropical Agro-bioresources, College of Life Science and Technology, Guangxi University, Nanning, People's Republic of China
National Key Laboratory of Crop Genetic Improvement, College of Informatics, Huazhong Agricultural University, Wuhan, People's Republic of China

Jagadish Timsina Institute for Studies and Development Worldwide, Sydney, Australia

Adel R. A. Usman Soil Sciences Department, College of Food & Agricultural Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia

Donato Visconti Department of Agricultural Sciences, University of Naples Federico II, via Università, Portici, Italy

Fazli Wahid Department of Agriculture, The University of Swabi, Swabi, Pakistan

Tahira Yasmeen Department of Environmental Sciences and Engineering, Government College University Faisalabad, Faisalabad, Pakistan

Bayram Ali Yerlikaya Department of Agricultural Genetic Engineering, Ayhan Şahenk Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, Niğde, Turkey

Barira Zahid Key Laboratory of Horticultural Plant Biology (Ministry of Education), Huazhong Agricultural University, Wuhan, People's Republic of China

Junhua Zhang State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Zengqiang Zhang College of Natural Resources and Environment, Northwest Agriculture and Forestry University, Yangling, Shaanxi, China

Chunquan Zhu State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Lianfeng Zhu State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou, Zhejiang, China

Xitong Zhu National Key Laboratory of Crop Genetic Improvement, College of Informatics, Huazhong Agricultural University, Wuhan, People's Republic of China

Afia Zia Department of Agricultural Chemistry, The University of Agriculture Peshawar, Peshawar, Pakistan

Khola Zia Department of Microbiology, Abbottabad University of Science and Technology, Havelian, Pakistan

Abbreviations

Cd	Cadmium
EGTA	Ethylene glycol tetraacetic acid
CDTA	Cyclohexanediaminetetraacetic acid
OC	Organic carbon
ABA	Abscisic acid
AQPs	Aquaporins
SAR	Systemic acquired resistance
ISR	Induced systemic resistance
P	Phosphorus
Pi	Inorganic phosphate
AR5	Assessment Report
CO_2	Carbon dioxide
IPPC	Intergovernmental Panel on Climate Change
GHG	Greenhouse gases
N	Nitrogen
CEC	Cation-exchange capacity
SOM	Soil organic matter
FAO	Food and Agriculture Organization
USSL	United States Salinity Laboratory
FC	Field capacity
Ca	Calcium
Mg	Magnesium
PO_4^{3-}	Phosphate ions
Al	Aluminum
Fe	Iron
Mo	Molybdenum
K	Potassium
S	Sulphur
PGPR	Plant growth-promoting rhizobacteria
ACC	Aminocyclopropane-1-carboxylic acid
ECe	Electrical conductivity of the saturated soil extracts

ST	Salt tolerance
APX	Ascorbate peroxidase
DHAR	Dehydroascorbate reductase
MDHAR	Monodehydroascorbate reductase
AsA	Ascorbate
ROS	Reactive oxygen species
MAS	Marker assisted selection
N_2O	Nitrous oxide
CH_4	Methane
PFCs	Perfliorocarbons
HFCs	Hydrofluorocarbons
SF6	Sulfur hexafluoride
SOC	Soil organic carbon
N_2O	Nitrous oxide
DCFC	Direct carbon fuel cells
MFC	Microbial fuel cell
Cu	Copper
US-EPA	United States Environmental Protection Agency
WWF	World Wildlife Fund
UNNC	United News Centre report
UNISDR AF	United Nations Office for Disaster Risk Reduction – Regional Office for Africa
UNEP	United Nation Environmental Programme
UN	United Nations
SOD	Superoxide dismutase
POX	Peroxidase
MNR	Ministry of Natural Resources
Pb	Lead
IBSRAM	International Board for Soil Research and Management;
GR	Glutathione reductase
GSH	Glutathione
GLASOD	The Global Assessment of Soil Degradation;
VLP	Virus-like particles
NSIDC	National Snow and Ice Data Centre
GCC	Global climate change
ITS	Internal Transcribed Spacer
KP	Khyber Pakhtunkhwa
NCBI	National Center for Biotechnology Information
BGI	Beijing Genomics Institute
MEGA	Molecular evolutionary genetic analysis
BNF	Biological nitrogen fixation
PGPR	Common plant growth promoting rhizobacteria
NSF	National Science Foundation
ENSA	Engineering Nitrogen Symbiosis for Africa
BBSRC	Biotechnology and Biological Sciences Research Council

NUE	Nitrogen use efficiency
ICAR	Indian Council of Agriculture Research
FACE	Free Air Carbon dioxide Enrichment
AM	Arbuscular mycorrhizas
KSA	Kingdom of Saudi Arabia
ECiw	Electrical conductivity
SAR	Sodium Adsorption Ratio
SARadj.	Adj. Sodium Adsorption Ratio
SSP	Exchangeable Sodium Percentage
RSC	Residual Sodium Carbonate
CSLF	Carbon Sequestration and Leadership Forum
CCS	C capture and storage
CDM	Clean Development Mechanism
GIS	Geographic information system
PS	Salinity Potential
TMA	Tripartite moving average
IHRA	Identical halves rainfall average
TDI	Total dissolved ions
NDVI	Normalized difference vegetation index
SSP	Soluble Sodium Percentage
VG	Vector generation
CSLF	Carbon Sequestration and Leadership Forum

Chapter 1
Carbon Cycle in Response to Global Warming

Iqra Mehmood, Amna Bari, Shakeel Irshad, Fatima Khalid, Sehrish Liaqat, Hamza Anjum, and Shah Fahad

Abstract Global warming is a crucial problem in the whole world since the nineteenth century. There are several reasons responsible for global warming. Most considerable from them are anthropogenic activities. Through a variety of human activities, greenhouse gases are continuously released into the atmosphere which resulted in raised Earth temperature. Various greenhouse gases are emitted into the atmosphere. Most common of them are CO_2, methane, nitrous oxide, SO_2, and ozone. CO_2 emission usually occurred naturally by plants in dark, through human respiration and the natural carbon cycle. But, due to anthropogenic activities, the significant amounts of CO_2 are released into the atmosphere which is above the normal threshold limit. High concentrations of CO_2 caused Global Warming. Global warming, in turn, disrupts natural carbon cycle which releases more CO_2 into the environment. Thus, this cycle is continuously running with disastrous effect on the natural earth's environment. Natural carbon cycle normally occurred by the degradation of SOC (soil organic carbon) by a variety of microbes and other chemical reactions which then released CO_2 in the atmosphere. But, due to the decline of organic carbon in the soil, a huge amount of CO_2 is being released into the environment. This process has disastrous effects on not only humans but also on plants and

I. Mehmood · A. Bari · S. Liaqat · H. Anjum
Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Faisalabad, Pakistan

S. Irshad
Center of Agricultural Biochemistry and Biotechnology, University of Agriculture, Faisalabad, Pakistan

F. Khalid
Key Laboratory of Horticultural Plant Biology (Ministry of Education), Huazhong Agricultural University, Wuhan, People's Republic of China

S. Fahad (✉)
Hainan Key Laboratory For Sustaianable Utilization of Tropical Bioresource, College of Tropical Crops, Hainan University, Haikou, Hainan, China

Department of Agronomy, The University of Haripur, Haripur, Pakistan

Department of Agriculture, The University of Swabi, Swabi, Pakistan
e-mail: shahfahad@uoswabi.edu.pk

S. Fahad et al. (eds.), *Environment, Climate, Plant and Vegetation Growth*,
https://doi.org/10.1007/978-3-030-49732-3_1

other wildlife. This chapter reveals the effects of global warming on the natural carbon cycle which is the prime concern of today's studies.

Keywords Climate change · Greenhouse emission gases · Methane, nitrous oxide · Temperature

1.1 Introduction

Carbon is one of the most important elements of the periodic table. In nature, the major Carbon reservoirs are atmosphere, ocean, plant, soil and fossil fuels. Carbon keeps flowing among these reservoirs. If Carbon concentration is disturbed in one reservoir it automatically affects the carbon concentration of other reservoirs. Higher carbon concentration in the atmosphere results in an increase in the global temperature. However, Carbon is not the enemy as it is very essential for life on earth. It is necessary for soil health. Photosynthesis is driven by CO_2. The microorganisms play an important part in converting the carbon compounds into stable, life-giving organic compounds (McDonough 2016). The processes of decomposition and fossil fuel combustion releases the CO_2 into the atmosphere again. The increased CO_2 concentration in the atmosphere has increased as a result of deforestation, industrialization, transportation and current human lifestyle which resulted in a global climate shift (Adnan et al. 2018; Akram et al. 2018a, b; Aziz et al. 2017; Habib ur et al. 2017; Hafiz et al. 2016, 2019; Kamran et al. 2017; Muhammad et al. 2019; Sajjad et al. 2019; Saud et al. 2013, 2014, 2016, 2017; Shah et al. 2013; Qamar-ur et al. 2017; Wajid et al. 2017; Yang et al. 2017; Zahida et al. 2017; Fahad and Bano 2012; Fahad et al. 2013, 2014a, b, 2015a, b, 2016a, b, c, d, 2017, 2018, 2019a, b).

In 2013, IPPC (Intergovernmental Panel on Climate Change) reported an increase in the global mean surface temperature of 0.8 °C from 1880 to 2012 with an increase of about 0.72 °C from 1951 to 2012. Global warming is a major problem which is leading to climate change in most of the countries throughout the world. The crucial factors responsible for global warming include disastrous human activities. Changes in the environment now exceeded the limits of natural divergence. Human activities lead to the release of greenhouse gases in the environment through a variety of sources which ultimately increase the environment's temperature, commonly known as global warming (Wheeler and Watts 2018). Species are now forced to pass through more rigorous selection pressures and will require more adaptation to persist in the environment which will ultimately affect the evolution of the organisms (Monroe et al. 2018a). It has been estimated that at the end of the current century there will an increase of 3 °C in temperature if the current trends continue. Efforts are now being made to somehow limit the global warming around 1.5 °C above preindustrialization but serious efforts are required to do so (Monroe 2018b). Scientists have now accumulated experimental evidence to prove human involvement in global climate change like ozone depletion, pollution, etc. (Santer et al. 2018). The

ozone layer has an important role in maintaining the normal temperature of the ecosystem. The continuous release of greenhouse gases above certain limits depleted the ozone layer which ultimately leads to the global warming (Santer et al. 2018). This chapter aims to provide insights about natural Carbon cycle and its response to global warming.

1.2 The Carbon Cycle

The biogeochemical cycle through which carbon is exchanged among carbon reservoirs like biosphere, pedosphere, hydrosphere, and atmosphere of the Earth is called the Carbon Cycle (Fig. 1.1). In nature, carbon is the main component of the biological compounds as well as the minerals e.g. limestone. The carbon is among the important cycles on the earth which make it sustainable for life. It provides a description of the carbon recycling, re-usage, sequestration and release from the sinks.

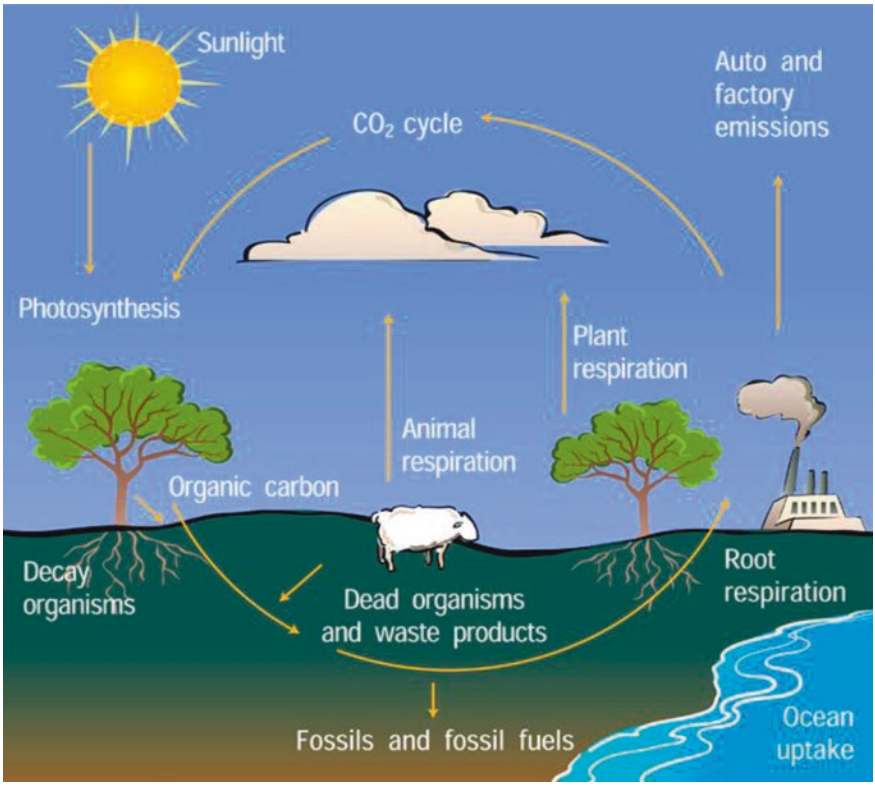

Fig. 1.1 Global Carbon Cycle

Overall, there are five carbon pools: the aquatic pool is the huge one among pedologic, geologic, atmospheric and biotic pools (Fig. 1.2). All these pools are connected with each other and carbon flow between them.

Carbon dioxide concentration was low in atmosphere before industrial development. One study revealed that CO_2 concentration was approximately 280 ppm before industrial development. After industrial development, in 2008 concentration raised up to 384 ppm (Tans et al. 1990). Human activities and isolation of CO_2 from sea water and land have 50% contribution in increased level of CO_2 (Menon et al. 2007; Raupach et al. 2007). Inland waters have major role in CO_2 emissions. Inland water includes natural ponds, rivers, streams, wetlands and reservoirs. No doubt they cover only 1% of earth but they have significant contribution in CO_2 emissions as compared to terrestrial and marine ecosystem (Richey et al. 2002; Cole et al. 2007; Tranvik et al. 2009; Battin et al. 2008; Harris et al. 2012). 0.6 pg carbon buried inside water inlands per year (Richey et al. 2002). It is equal to 20% of carbon which is thought to be buried inside soil and terrestrial ecosystem. Carbon buried inside sediments over thousands of years (Richey et al. 2002; Einsele et al. 2001). Some stable carbon buried inside sediments may reach lithosphere. Due to deficiency of oxygen in inland water as compared to oceans inhibits decomposition of sedimentary carbon and further its emission into atmosphere. This whole process is well presented in (Fig. 1.3). Organic carbon mobility from terrestrial ecosystems to inland water resources is an attention grabbing situation which is responsible for climate change (Battin et al. 2009). To understand carbon seclusion primary step is to find out where this process occurs. After this it is necessary to understand processes that maintain and enhance it. For instance, when soil erosion occur it create a path by which carbon move from land to inland water resources. However, reservoirs, sea water maintain their sediments and bounded carbon (Richey et al. 2002; Battin et al. 2008). They also block carbon movement from water to other inland

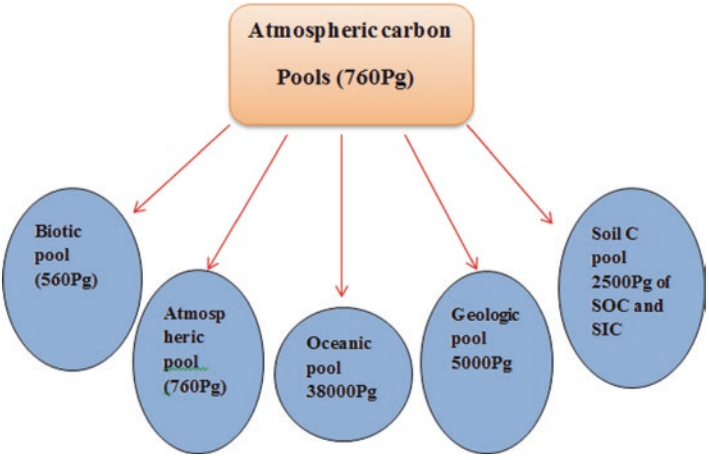

Fig. 1.2 Five worldwide carbon pools. Biotic, Atmospheric, Aquatic, Geologic and Pedologic