T. D. Lama · Dhiman Burman ·
Uttam Kumar Mandal ·
Sukanta Kumar Sarangi ·
H. S. Sen *Editors*

Transforming Coastal Zone for Sustainable Food and Income Security

Proceedings of the International Symposium of ISCAR on Coastal Agriculture, March 16–19, 2021

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Editors
T. D. Lama
Regional Research Station
ICAR-Central Soil Salinity Research Institute
Canning Town, West Bengal, India

Dhiman Burman
Regional Research Station
ICAR-Central Soil Salinity Research Institute
Canning Town, West Bengal, India

Uttam Kumar Mandal
Regional Research Station
ICAR-Central Soil Salinity Research Institute
Canning Town, West Bengal, India

Sukanta Kumar Sarangi
Regional Research Station
ICAR-Central Soil Salinity Research Institute
Canning Town, West Bengal, India

H. S. Sen
ICAR-Central Research Institute for Jute and Allied Fibres (Formerly)
Barrackpore, West Bengal, India

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Preface

The global coastline is about 440,000 km long and varies greatly around the world from frozen polar shorelines to tropical mangroves and beaches. Coastal regions include coastal seas on the continental shelf to a depth of 50 m, the coastline and the adjacent land that is routinely inundated with sea water and extends over approximately 2.3–7.0 million km^2. In general, the coastal and marine environment can extend up to 100 km inland and up to 50 m water depth in the ocean. Tropical and subtropical coastlines are dominated by mangroves, sandy beaches, coral reefs and seagrass beds, whereas tidal marshes, macroalgal forests and seagrass beds abound on higher latitude coastlines. While coastal areas cover only 4% of the earth's total land area and are equivalent to only 11% of the world's ocean area, they host one-third of the world's population and are twice as densely populated as inland areas.

In India, around 250 million population reside within 50 km of the 7500 km coastline that is shared by 9 states and 2 union territories comprising 77 towns and cities including 3 megacities, viz., Mumbai, Kolkata and Chennai. The coastline supports several economic activities that are vital for the nation's economy like oil and gas, ports and harbours, power plants, fishing, tourism and mining that keep affecting the coastal ecology and environment. At the same time, it is important to note that the coastal stretches are well endowed with highly productive ecosystems that support the coastal human population in numerous ways, ranging from alleviating their poverty by offering a variety of coastal resources, to protecting them from natural and manmade hazards like erosion, cyclones, storm surges, tsunamis, pollution, etc.

Despite the multitude of services that coastal ecosystems provide us, their degradation and the subsequent loss of biodiversity continue at an unprecedented rate. This undermines coastal ecosystem functioning and resilience and thus threatens the ability of coastal ecosystems to continuously supply the flow of services for present and future generations.

Agriculture is the major occupation of the people in the rural areas of coastal regions of the country, but it is highly complex, risk-prone and entirely dependent on the vagaries of nature.

Thus, farmers primarily grow low-yielding long-season traditional varieties of rice during the wet season and much of the land lies fallow during the dry season.

Changing rainfall patterns and increased frequency of extreme events attributed to climate change proceeding unabated are inflicting added vulnerabilities to livelihoods and resources in the region. A range of ecosystem services critical to the ecological and economic security of the region needs attention for its sustainable uses. There are opportunities for intensification through efficient use and optimal management of fresh surface and groundwater resources, careful planning of the crop calendar and efficient agronomic practices that maximize water use efficiency.

The Indian Society of Coastal Agricultural Research (ISCAR), established in 1983, is a pioneer scientific body in India engaged with international associations in establishing linkage among the scientists, academicians, research institutes, universities and NGOs, for coordination of overall research activities related to agriculture in coastal areas of India and abroad. It publishes regularly a research journal *Journal of the Indian Society of Coastal Agricultural Research* and holds meetings, workshops, seminars, etc., to keep close exchange of views among the farmers and research workers working on different problems of agriculture and allied sectors in coastal areas. The society has already organized twelve national seminars/symposiums and one international symposium in various parts of the country. In the Annual General Body (AGM) held on March 31, 2019 under the chairmanship of Dr. H. S. Sen, President of ISCAR, it was decided that the forthcoming symposium would be held during November 5–8, 2020 at Kolkata as the Second International Symposium of ISCAR. Due to the COVID pandemic, the symposium was postponed, and finally, it was decided that the Second International Symposium would be held on March 16–19, 2021 in virtual mode. Along with COVID, two devastating recent cyclones *Bulbul* during November 2019 and *Amphan* during May 2020 as well as frequent storm surges in coastal India raised concern about the very existence of the coastal region. Suitable policies are to be evolved to protect the vested interest of different stakeholders of the coastal region with particular focus on multiple uses of coastal resources. Exceptions are India, Bangladesh, Philippines, Thailand, Sri Lanka, Vietnam, Cambodia, Egypt, Australia, Latin America and possibly a few other countries paying concerted attention to the coastal ecosystem for improvement in the agricultural front in particular. The problems of livelihood in these areas are compounded manifolds owing to a series of technological, administrative and socio-economic constraints, which need to be addressed on a common platform. It was important in the same context to draw instances and research progress from other countries, sharing significant coastal areas, like USA, Italy, Canada, New Zealand, Kenya, Poland, etc., for global upkeep of the research recommendations that we strive for in this symposium. Keeping in view of the above issues, the Indian Society of Coastal Agricultural Research (ISCAR), Canning Town, West Bengal, India, in collaboration with ICAR-Central Soil Salinity Research Institute, Karnal, India, organized this International Symposium on Coastal Agriculture (ISCA Webinar): Transforming Coastal Zone for Sustainable Food and Income Security during March 16–19, 2021 in a virtual mode.

One National Advisory Board and one International Advisory Board under the chairmanship of Prof. M. S. Swaminathan always guided the society to chalk out the entire programme of the symposium. The symposium was attended by more than

250 delegates comprising researchers, academicians and students from Australia, UK, USA, Bangladesh, Canada, Kenya, Ghana, Thailand, Malaysia, Poland, Italy, Philippines, New Zealand and various parts of the coastal states of India. A total of 274 abstracts were received out of which 182 abstracts were voluntary contributions. There were 11 plenum lectures and 86 invited talks during the symposium. Those 78 full-length articles were evaluated and are presented in this book under five major theme areas on coastal region development like (a) system approach to address abiotic and biotic stresses, (b) resource management and technological innovations in fisheries and animal husbandry, (c) assessment and management of natural resources, (d) climate change trend and its impact and (e) socio-economic issue and value chain. We hope this book has collected all the know-how available with researchers, academicians and various other stakeholders for addressing the complex problems of coastal regions and to draw out strategies for resilient agricultural technologies and improving livelihood security in coastal agro-ecosystem and preparing a road map taking into consideration the value addition and market intelligence under changing global environment.

Canning Town, India — T. D. Lama
Canning Town, India — Dhiman Burman
Canning Town, India — Uttam Kumar Mandal
Canning Town, India — Sukanta Kumar Sarangi
Barrackpore, India — H. S. Sen

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The editors are thankful to all the authors for having given their valuable time in the preparation of contributed chapters. Sincere thanks are also due to the reviewers and editors for their valuable comments and feedback.

T. D. Lama
Dhiman Burman
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Sukanta Kumar Sarangi
H. S. Sen

Inaugural Address by DG ICAR

My special thanks to Dr. H. S. Sen, President of the Indian Society of Coastal Agricultural Research; our Special Guest, Dr. Shaikh Mohammad Bokhtiar, Executive Chairman, Bangladesh Agricultural Research Council; our Special Guest, Dr. Luke York, Counsellor Agriculture, Australian High Commission, New Delhi; my valued colleague Dr. S. K. Chaudhari, Deputy Director General (Natural Resource Management), Indian Council of Agricultural Research; Dr. P. C. Sharma, Director of Central Soil Salinity Research Institute, Karnal; Dr. Burman, Organizing Secretary of the International Symposium on Coastal Agriculture; other colleagues from various countries who are participating in this particular webinar; my own colleagues from the Indian Council of Agricultural Research and the State Agricultural Universities and State Governments; and all delegates, ladies and gentlemen. It is a great pleasure on my part to be associated with this International Symposium. Thanks to Dr. H. S. Sen for being very persistent and very particular about me participating in this international symposium, though I was reluctant and explained that probably I do not know much about the coastal agriculture in terms of research conducted by me and therefore may not be befitting on my part to speak about it. But anyway in such webinars and conferences, they are supposed to be addressed by some person and he has chosen me. I know him for pretty long time when he was Director of Central Research Institute for Jute and Allied Fibres, Barrackpore. I have regards and very deep regards for him, so I agreed and I am here. Thanks Dr. Sen once again profusely for continuing and insisting that I should be here.

I am extremely happy to see online Dr. Bokhtiar. He has been a good friend for a quite long time and that we know each other. Not only that he visited here, he also invited me to Dhaka and we had very good interaction, when he was with the SAARC Agriculture Centre and moreover our friendly relationship between the two countries gets further cemented through these relationships. Opportunities are further provided through such international conferences and symposia where we sit together in a common platform to deliberate on issues and problems of relevance to our countries. So, Dr. Bokhtiar, a very happy welcome on my own personal behalf to you and to your other colleagues who are there. Also, I welcome Dr. Luke York Counsellor Agriculture, Australian High Commission, New Delhi. I am sure the kind of situation

Australia faces due to the fact that the whole country is surrounded by the ocean causes coastal agriculture and its relevance for Australia as huge. And rightly Dr. Luke has highlighted, and very importantly again India and Australia have been interacting on various facets of agriculture including coastal agriculture. I am happy to see Dr. Luke York and to listen to him. To my own colleague Dr. Chaudhari and to all of you from my own behalf and on behalf of the Indian Council of Agricultural Research and Department of Agriculture Research and Education, a very hearty welcome. Congratulations to Dr. Sen and his colleagues, the Indian Council of Agricultural Research and my colleagues there for having this international symposium organized which has been planned over a pretty long time. Dr. S. K. Chaudhari did inform me that we have here Dr. A. K. Singh, former DDG Natural Resource Management and former Vice Chancellor of one of our agricultural universities. We have also heard Dr. A. R. Khan, CGM from NABARD Kolkata and many others whom I cordially welcome on my own behalf. For this symposium, since time available with me is very limited, I will not be able to deal deeper into it.

The symposium has chosen the topic *Transforming Coastal Zone for Sustainable Food and Income Security*. This is something which is a very challenging one. Transforming coastal zone and coastal agriculture for food and income security is a huge challenge. Indian agriculture was focusing on enhancing production. Core production brings in more return to the farmers and that is how it was emphasized in view of the deficit situation that was quite relevant. Over the years, global agriculture and Indian agriculture have moved quite far, and today, we have here in India and other countries in the neighbourhood food self-sufficiency. In many fronts, we have quite a bit satisfactory development. Indian agriculture has done pretty well, and for this year prediction and assessment is that we will be crossing 300 million tonnes mark for the food grains, 20 million tonnes mark for horticultural crops, so on and so forth. So, agriculture is moving at a faster rate. Our growth rate has been close to 4%, and it has been quite a significant growth despite COVID-19. In fact, in case of milk production, our growth is close to 6% fisheries sector even more than 10%. So that is a kind of remarkable growth rate that you see in Indian agricultural sectors.

But coming to the challenges that we face, we have small marginal land holdings, 85% of our farmers being small and marginal. When we talk of the coastal agriculture, IPCC says in its Fourth Report that more than 2.4 billion people are staying in coastal region, within about 100 km from the sea shore, and it is a huge number close to little more than 40% of the total population at the global level. It is quite a dense region at the same time with regard to population density. Obviously, the anthropogenic activities in the coastal zone are quite huge and that put pressure on the ecology. That is a very serious challenge to sustainable production systems and increased income for the farmers. Today in India, Hon'ble Prime Minister of India has given a call for doubling farmers' income. When we look on the challenges, they are so formidable, and it is not just population density in the coastal regional but the climate change as well. The climate change is a serious threat, and when it is temperature rise, we are already 1 °C more than what we had in the pre-industrial era, and it is going to reach 1.5 °C by the turn of the century. Some prediction says that even earlier by 2050 we might reach there because we are increasing temperature @ 0.2 °C per

decade, quite a fast increase in temperature. So, this is a very serious threat and is associated with reduced productivity in wheat. It said that 10% yield reduction will be there for every 1 °C rise in temperature. In case of rice, rise in carbon dioxide is supposed to increase rice yield particularly the biomass, while the temperature rises, which are concomitant with yield increase, but tends to increase sterility in grains. This will finally counterbalance, and in the process, you will not have much gain particularly in *kharif* season.

This is an important area in the coastal zone where the population density being high has positive anthropogenic activities with negative impacts, and the temperature rise poses a big challenge. Temperature rise is again associated with sea-level rise leading to inundation and intrusion of the sea water with all kinds of problems associated with them. In fact, during 1900–2010 sea level has risen by 19 cm and that is what I am told that it is going to rise further. By the end of this century, we might be crossing 50 cm increase in the sea level and some say it might go up to 98 cm. Salinity is concomitantly increasing. The coastal areas are getting submerged which is one kind of problem, and getting frequent flooding is another problem, but yet the other one being the kind of salinity increasing. It is predicted and assessed that by 2050 about 50% of the fallow land in the world would be rendered saline.

That is something which is very frightening. When you describe all these, you see that where are those rays of hope for us? Where can we pin our hope? What is that should we be doing? Certainly, the symposium of this kind I mentioned is very well planned and I believe you will be covering most aspects which are relevant. Anthropogenic pressure, and how do we really minimize the pressure, mangrove ecology and the mangrove forest—they are all very important. Almost 5 million hectares of mangrove forest area has been reduced over the past 30–40 years. And it is all because of the anthropogenic pressure, and of course, the tidal effects were always there. In addition, tsunami effects are there. So how do we really counterbalance these changes in case of climate and in terms of anthropogenic pressure, and move forward. I think it is a long way to go. Fortunately for us, the coastal ecosystem is positive for carbon and has plenty of carbon sequestration taking place and methane emissions are relatively low. So, these coastal wetlands and shallow lowland ecosystem are actually cropped where rice is grown in two seasons. Our own study at CRRI has revealed that the system is a carbon sink, so this is something which is positive with regard to the coastal system. How do we really enrich this further? What all should we be doing to enrich and strengthen our activities?

First of all, we should start building institution, because without that you cannot succeed. India took note of all these probably long times ago since India has a very long coastline stretching for more than 7500 km including the island ecosystems. Nine states, two islands—Andaman and Nicobar Islands, altogether it is a huge ecosystem, which is actually there for India. That is the reason why the government recognized the importance and built institution that is Central Coastal Agricultural Research Institute way back in 1976 at Goa. Before that recognizing that salinity would increase not only for inlands but also the coastal areas, the Central Soil Salinity Research Institute was established way back in 1969 and 1971 to address the issues related to inland and coastal salinity, respectively. Central Island Research Institute

at Port Blair was established in 1978. So, the institutional framework is very essential to understand what is actually happening and this is all the more significant in today's context. Across nations, this has to be our emphasis that we must build institutions of relevance and intensify our efforts in these institutions to work on coastal zones and agriculture in the regions. When I say agriculture, agriculture includes allied sector activities, so that we build information and build science-based decision support system for helping this ecosystem. Coastal areas represent very fragile ecosystems, as I highlighted earlier, and this is very essential to consider. So, I am sure that we should be able to build networks, international networks across the nation as a crucial strategy. Institutions can do their own work individually but what is more important is building network across institutions. To understand very fragile nature of the coastal ecosystem, the threats to this ecosystem opportunities which are available and steps as to how we can capitalize on the existing strength to take advantage of, our expertise scattered across nations may be utilized. Can we really build it as a part of our deliberations during this symposium? In order to be a part of the international networks across nations, I think it would be very crucial and rewarding for all of us. Whatever we are discussing we must check the gaps at the global level and ensure participatory approach in addressing the farmers, since they are mostly small and marginal in the coastal ecosystem. This participatory approach is of crucial relevance. I remember some years ago we visited Bali Island in Sundarbans of West Bengal and we could clearly see how vulnerable agriculture was in that part of the country and that required participatory approach. Probably that is a very important component of our activity while we are trying to address the risk, minimize the risk and build sustainable agriculture production system to enhance income in this zone.

I will touch upon a few points as to how do we use more and more technologies. This coastal region is quite advanced in certain segments, but in other segments particularly in island ecosystem and some of the coastal regions in the main land we do see quite a bit of weakness with regard to technology use. For the farmers belonging to low-income groups, situation in this region is a big challenge. I strongly believe that given the emphasis on that kind of infrastructure, with access to fund and the kind of government schemes, there are scope and need for accelerated technology use. I should also emphasize here that India planned for mainstreaming technology use through climate-resilient platform, and while planning for this, we did think of the coastal region and its fragile nature and almost 8–10 of our climate-resilient villages are there in this ecosystem. For instance, in 24 Parganas (S) of West Bengal we find climate-resilient villages present. From the kind of lessons, we learnt with regard to technology interventions we find that these need to be really mainstreamed for helping the farmers for addressing the challenges. Similarly, in Kendrapara in Odisha, which is highly cyclone prone, tsunami impacts were severely observed in the past, and also in Ramanathapuram in case of Tamil Nadu. I was citing a few examples only that how these climate-resilient villages in this region are providing deeper technology mainstreaming, which is so essential to address the facts of climate change. In this region and particularly in the coastal ecosystem, how do we really go further with regard to today's use of technologies. I remember during my days at CRRI, Cuttack, we were promoting 'Swarna Sub-1' resistant to flash flood. I

visited Bangladesh, and I saw 'Binadhan 8' and 'Binadhan 10' were getting popularity there as salt-tolerant varieties. We introduced them in India and then a few other lines were developed/identified in the institute and introgressed to develop salt-tolerant, drought-tolerant and flood-resistance varieties, and these traits were getting pyramided. CR Dhan 801 and 802 from CRRI, Cuttack, again got a big step in the direction of putting multiple genes of drought and submergence, and in certain instances, the salinity is also getting added. So, we have this kind of technologies developed and International Rice Research Institute is conducting works in India and Bangladesh in a big way.

Technology demonstration, handholding and participatory mode with farmers, as we are doing in climate-resilient village system, are thus very important for us. Use of technology in the form of drones or even remote sensing to map and build decision support system with regard to use of appropriate soil and land systems for various cropping patterns and integrated farming systems is another very crucial area, where, I think, we are lagging tremendously. So, this requires immediate international collaboration. Another issue is how do we use our artificial intelligence system, which will be very effective to use data from large data pool available in the respected regions and countries, and they build decision support system to use in all modern tools and technologies. Gender in this region is again a very sensitive point. How do we really mainstream gender and bring them to the front? There are plenty of opportunities as well as challenges. By handholding, we can make entrepreneurs in small and medium scale of tomorrow. Entrepreneurship is very important.

If agriculture has to be remunerative, and if agriculture has to be lucrative, this has to be built as a business model in the coastal zone. I strongly believe that women need to be trained and incubated to be entrepreneurs. India is trying in a small way, we have built centres, and we are building in fact start-ups. More than 500 start-ups we have built over the past few years, but there is plenty of opportunity to go in this direction.

Fishery is extremely important. The marine fishery catch is declining particularly in few nautical miles from the coast. Deep-sea fishing is essential, and so, we can go in fact to address the marine aquaculture system. How do you really build that platform so that we have sustainable and responsible fishery system developed? It should be a responsible fishery system built up. Nitrogen when applied through river systems is reaching the coastal zone and polluting it. That is a serious threat today in another area. How do we really purify this region, the coastal region? Reduced use of nitrogen in the inland will help this ecosystem further, and that is a big challenge.

Similarly, a kind of problem we face with regard to the mangrove ecology as I stated. Can you really strengthen the wetlands of coastal ecologies—the flora and fauna and the biodiversity getting extinct in the coastal zones—which are serious concerns? In fact, it is said that thirty per cent of the animal and plant species would be wiped out because of this global temperature rise which is happening very fast. By 2050, if we reach 1.5 degrees, and more increase in temperature probably by end of this century, you can imagine what would happen to the flora and fauna in the coastal zones. How do you really protect the biodiversity in this region? I mean that is another serious challenge to sustainability of the coastal ecosystem.

While I talked of the mainland of coastal region, the ocean system particularly the coral reefs and coral reef ecosystem, it is in fact getting negatively impacted and is very significant worldwide. It is not just in the Indian peninsula but worldwide. In fact, carbon dioxide levels in sea water particularly increase and have adverse impact on the microbes and microalgae, and that is again impacting this ecosystem particularly the coral reef ecosystem. This is again a very serious challenge and what we all can do to protect it? Can we do something? Deep sea water studies are lacking actually in this region, and what is happing in ocean unless we understand the temperature profile, the kind of tides, the volcanic eruptions taking place under sea, etc. Unless we understand all those phenomena, we will not be able to address what is happening there.

In terms of the anthropogenic activities, I referred to several times earlier, and these are to be minimized as the central key point in order to save the ecological disaster. So, who would be doing this and creating awareness is very essential in this context?

Through these symposia and conferences and beyond this, the activities of this society, I believe, are very praiseworthy and I am sure this would create more and more of awareness, for instance, on afforestation and strengthening of the kind of mangrove ecosystem in the coastal ecosystem. Sustainable and responsible fishery in the oceans is also very important, so also the marine ecosystem is also important—and all these need to be really promoted through extensive awareness programmes along with the agricultural system where clinical use is very extensive and needs to be again addressed through creating awareness and proper education to the farmers. So, we have tremendous responsibility for our future generations. I am sure the deliberations in this symposium would be quite rewarding. This common platform would provide countries in the region to deliberate on issues and concerns to address them by way of network programmes which would be very helpful in defining our future course of action. Developing new pathways, finding resources, building resources, taking care of natural resources which are available in this region, protecting biodiversity, using newer technologies which are there at this point of time for precision systems to be effectively utilized, and working with the farmers mainstreaming with gender-neutral programmes are some of the pathways suggested. I am sure you will go beyond these points which I mentioned because you are more knowledgeable than what I am because I have not worked in this particular area. So, I take this opportunity once again to thank profusely Dr. Sen, Dr. Chaudhari and all my colleagues for inviting me to be part of this symposium and also listen to many erudite speakers to learn from them many new facts and enrich myself. So, thank you Prof. Sen for giving me this opportunity and I wish this programme a grand success. Wishing you all the very best and thank you Dr. Bokhtiar for joining us from Bangladesh and also Dr. Luke York for being with us in this inaugural session. Thanks to all of you and

thanks delegates. Thanks to press and media who are here today in this particular programme. Thank you very much.

Dr. Trilochan Mohapatra
Chief Patron
Advisory Committee of International
Symposium on Coastal Agriculture

Secretary
Department of Agricultural Research
and Education, Ministry of Agriculture
and Farmers Welfare, Government of
India, New Delhi, India

Director General
Indian Council of Agricultural
Research
New Delhi, India

Contents

Editors and Contributors

About the Editors

Dr. T. D. Lama is Principal Scientist (Soil Science) at ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town, West Bengal, India. He holds a Ph.D. in Agricultural Physics from Indian Agricultural Research Institute, New Delhi, India. His current research interests are in the area of soil and water management in coastal saline ecosystem, hyperspectral remote sensing of salinity stress in rice crop and mapping of coastal saline soils using remote sensing and GIS. Earlier, he had worked as Member of an interdisciplinary team for assessment and demonstration of technologies for sustainable management of natural resources and livelihood improvement of the farmers in the north-eastern hilly region of India. He has also worked on evaluation of resource conservation technologies and water management for improving resource use efficiency in vegetable crops. He was Member of the team for demonstration and refinement of technology of low-cost rainwater harvesting structures and in-situ residue management for soil moisture conservation under Farmers Participatory Action Research Programme in North East Hilly Region, funded by DST, Government of India, for which the Ground Water Augmentation Award 2008 under the institution category was bestowed by Ministry of Water Resources, Government of India, to the implementing institute. He has authored over 40 research papers, conference papers, chapters, bulletins and technical articles.

Dr. Dhiman Burman is Head and Principal Scientist (Soil Science) at ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town. He received his Ph.D. in Agricultural Physics from IARI, New Delhi. Since 1995, he is engaged in research at various scientific positions at ICAR institutes (Indian Grassland and Fodder Research Institute and Central Soil Salinity Research Institute) on sustainable management of problem soils in semiarid and coastal region for augmenting agricultural production. He has 18 years of research experiences on soil and water management for agricultural development in the coastal salt-affected

region. He has developed many agricultural technologies especially for small and marginal farmers of the salt-affected coastal region. During his research career, he has handled many in house research projects and international projects funded by GEF, CGIAR under CPWF, BMGF, IRRI and ACIAR as Principal Investigator/Co-principal Investigator. He received Jawaharlal Nehru Award of ICAR and Young Scientist Award of Indian Science Congress Association. He was awarded Fellow of Indian Society of Coastal Agricultural Research. He has several publications in national and international journals.

Dr. Uttam Kumar Mandal is Principal Scientist in Soil Physics at ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town. He holds a doctorate in Agricultural Physics from IARI, New Delhi. He was awarded Post Doctoral Fellow at ARO Israel and was conferred Lal Bahadur Shastri Young Scientist Award in the field of natural resource management. He received the Golden Jubilee Young Scientist Award from Indian Society of Soil Science. His research interests are soil water balance, sustainable land management in watershed, soil quality assessment, climate change, soil carbon sequestration. He is associated with ICAR network project National Innovations in Climate Resilient Agriculture (NICRA) where the team is looking after the spatio-temporal dynamics due to climate variability in Sundarbans region. He has several publications in national and international journals.

Dr. Sukanta Kumar Sarangi is Principal Scientist in Agronomy at ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town. He holds a doctorate in Agronomy from Banaras Hindu University (BHU), Varanasi. He received Gold Medal in bachelor's degree in Agriculture and University Gold Medal during master's degree in Agronomy. He was awarded national scholarship during graduation studies, Junior and Senior Research Fellowships of ICAR for master's and Ph.D. studies. He worked at M. S. Swaminathan Research Foundation for conservation of rice biodiversity. He has about 20 years of experience on farming system research in hill and coastal ecologies of India. His research interests are improving productivity of rice-based farming system through efficient management of natural resources in salt-affected coastal areas. He has more than 80 research papers published in peer-reviewed national and international journals and more than 25 chapters/conference proceedings published by renowned publishers. Presently, he is Editor-in-Chief of the *Journal of the Indian Society of Coastal Agricultural Research* (https://www.iscar.org.in/publications) and Editor of the *Indian Journal of Agronomy*.

Dr. H. S. Sen Former Director, Central Research Institute for Jute and Allied Fibres (CRIJAF, a unit under Indian Council of Agricultural Research or ICAR under the Ministry of Agriculture, Government of India), located at Barrackpore, West Bengal, has retired from regular service on superannuation from the institute, which was his last official posting, on 31 January 2008. He did his M.Sc. and Ph.D., both from the Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi.

After completing his Ph.D., he joined the ICAR service in various capacities, which he continued with until joining the last posting as Director, CRIJAF, Barrackpore, in July 2002. Broadly, his nature of experience can be divided into two parts, viz. (i) research and (ii) research management and administration. He was devoted to research in various capacities especially in the fields of 'water management and soil salinity and ecology related to coastal ecosystem' during 1971–1976 and 1982–2002 at Central Soil Salinity Research Institute, Regional Station, Canning Town, West Bengal, which was in the heart of Sundarbans, and in the field of 'water management and ecology under rice-oriented cropping system' at Central Rice Research Institute, Cuttack, Odisha, during 1976 to 1982. He was devoted to Research Management and Administration at CRIJAF, during his last posting, having its mandate on 'Productivity and Quality Improvement of Jute and Allied Fibres' with emphasis on ecology of the environment. He has devoted considerable attention for planning for future research strategies and livelihood securities in tidal dominated lower Ganges delta covering India and Bangladesh and authored a book on this topic published by Lap Lambert Publishing Academy in Germany, besides writing a few chapters on similar topics published by others. He has been Guest Lecturer at postgraduate level in the University of Calcutta for 25 years. He guided 5 students so far for Ph.D. degree. He has so far published more than 160 research papers in various forms. He has earned the national 'Vasantrao Naik Award' conferred by ICAR on his contribution to rainfed agriculture in coastal ecosystems in 1998. He is Fellow of two professional societies and Honorary Member of a number of other national and international societies and organizations. He is also President of two societies of national and international repute. He has authored a book on Sundarbans which has been published by Springer International in 2019.

Contributors

Sankar Kumar Acharya Department of Agricultural Extension, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

S. K. Adhikary Agrotechnology Discipline, Khulna University, Khulna, Bangladesh

Wasim Akram Vidyasagar University, Midnapore, West Bengal, India

Rubayet Ara Department of Agricultural Extension, Govt. of the People's Republic of Bangladesh, Dhaka, Bangladesh

Marco Arcieri ICID National Italian Committee, Ministero delle Politiche Agricole, Alimentari e Forestali, Rome, Italy

L. Aruna PJN College of Agriculture and Research Institute, Karaikal, Puducherry, India

V. Arunachalam ICAR-Central Coastal Agricultural Research Institute, Ela, Old Goa, Goa, India

K. V. Arya Rice Research Station, Kerala Agricultural University, Vyttila, Kochi, Kerala, India

Shashwat Avi United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), Bangkok, Thailand

V. V. Aware Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Kokan Krishi Vidyapeeth, Dapoli, Maharashtra, India

U. Bagavathi Ammal Department of Soil Science and Agricultural Chemistry, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry U.T., India

C. P. Balasubramanian ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu, India

Husne Banu ICAR-Central Institute of Fisheries Education, Salt Lake City, Kolkata, West Bengal, India

Edward G. Barrett-Lennard Department of Primary Industries and Regional Development, South Perth, WA, Australia

Nirmalendu Basak ICAR-Central Soil Salinity Research Institute, Karnal, Haryana, India

M. E. A. Begum Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh

P. Behera Kakdwip Research Centre of ICAR-Central Institute of Brackishwater Aquaculture, Kakdwip, West Bengal, India

R. W. Bell Centre for Sustainable Farming Systems, Future Food Institute, Murdoch University, Perth, Australia

S. B. Bhagat AICRP on IFS, Regional Agricultural Research Station, Dr. B. S. Konkan Krishi Vidyapeeth, Karjat, Maharashtra, India

C. Bhakat ICAR-National Dairy Research Institute, Kalyani, West Bengal, India

Pratap Bhattacharyya ICAR-National Rice Research Institute, Cuttack, Odisha, India

Malay K. Bhowmick International Rice Research Institute-South Asia Regional Centre, Varanasi, Uttar Pradesh, India

G. Biswas ICAR-Central Institute of Fisheries Education, Kolkata Centre, Salt Lake City, Kolkata, West Bengal, India

P. S. Bodake Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

D. K. Borse Khar Land Research Station, Dr. B. S. Konkan Krishi Vidyapeeth, Raigad, Maharashtra, India

Tapas Chandra Bose Bangladesh Betar, Agargoan, Dhaka, Bangladesh

Brajendra ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana, India

Dhiman Burman ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town, West Bengal, India

E. B. Chakurkar ICAR-Central Coastal Agricultural Research Institute, Goa, India

V. Chandrasekar ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu, India

Riti Chatterjee Department of Agricultural Extension, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

K. J. Chaudhari College of Fisheries, Dr. B. S. Konkan Krishi Vidyapeeth, Shirgaon, Ratnagiri, Maharashtra, India

N. D. Chogale Marine Biological Research Station, Dr. B. S. Konkan Krishi Vidyapeeth, Zadgaon, Ratnagiri, Maharashtra, India

Abir Choudhury Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

P. K. Choudhury Ministry of Textiles, National Jute Board, Govt. of India, Kolkata, West Bengal, India

Soni Chowrasia LBS Centre, ICAR-National Institute for Plant Biotechnology, New Delhi, India

K. Coumaravel Department of Soil Science and Agricultural Chemistry, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry U.T., India

A. V. Dahiphale AICRP on IFS, Regional Agricultural Research Station, Dr. B. S. Konkan Krishi Vidyapeeth, Karjat, Maharashtra, India

Anupam Das Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Koushik Das The Jute Corporation of India Ltd, Kolkata, West Bengal, India

P. Das Fish Genetics and Biotechnology Division, ICAR-CIFA, Kausalyaganga, Bhubaneswar, Odisha, India

P. C. Das ICAR-Central Institute of Freshwater Aquaculture (CIFA), Kausalya-ganga, Bhubaneswar, Odisha, India

S. K. Das ICAR-National Dairy Research Institute, Kalyani, West Bengal, India

Sanjoy Das Kakdwip Research Centre, ICAR-Central Institute of Brackishwater Aquaculture, Kakdwip, West Bengal, India

Upama Das Kakdwip Research Centre, ICAR-Central Institute of Brackishwater Aquaculture, Kakdwip, West Bengal, India

Purnabha Dasgupta Prasari, Kolkata, India

Bishnuprasad Dash Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

P. K. Dash ICAR-National Rice Research Institute, Cuttack, Odisha, India

Debasis De Kakdwip Research Centre, ICAR-Central Institute of Brackishwater Aquaculture, Kakdwip, West Bengal, India

Paramita Deb Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Shovik Deb Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengsl, India

A. Debbarma ICAR-National Dairy Research Institute, Kalyani, West Bengal, India

J. Deepa Rice Research Station, Kerala Agricultural University, Vyttila, Kochi, Kerala, India

K. H. M. A. Deepananda Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara, Sri Lanka

A. A. Deogirikar Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Kokan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Sujeet Desai ICAR-Central Coastal Agricultural Research Institute, Goa, India

Thiyam Tamphasana Devi National Institute of Technology-Manipur, Imphal, Manipur, India

Rupesh Devidas ICAR-Central Coastal Agricultural Research Institute, Goa, India

Maria Bernadet Karina Dewi United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), Bangkok, Thailand

Ahana Dey Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Pradip Dey ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh, India

P. V. Diya Rice Research Station, Kerala Agricultural University, Vyttila, Kochi, Kerala, India