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# **Estuaries of the World**

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Fishing boats resting on Pemba Island, Tanzania (photo by Peter Scheren, February 2010)

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Salif Diop • Peter Scheren  
John Machiwa  
Editors

# Estuaries: A Lifeline of Ecosystem Services in the Western Indian Ocean



*Editors*

Salif Diop  
National Academy of Sciences  
and Techniques – Section of  
Agricultural Sciences and  
Université Cheikh Anta Diop  
de Dakar  
Dakar-Fann, Senegal

Peter Scheren  
Worldwide Fund for Nature (WWF)  
Coastal East Africa Initiative  
Dar es Salaam, Tanzania

John Machiwa  
College of Agricultural Sciences  
and Fisheries Technology  
University of Dar es Salaam  
Dar es Salaam, Tanzania

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*“...Doubling the share of African University graduates in science and technology fields within a decade, by 2025 is the key to transform Africa into a knowledge-driven continent within a generation. . . .”*

*From **Makhtar Diop**, World Bank’s Vice President for Africa. Extracted from an article written 24th May, 2014 for an Ethiopian Journal “The Reporter” by Moctar Diop on “Powering Science, technology for Africa’s economic transformation. . .*

*“**Put your thoughts** in order by reflection, pen in hand. Appropriate you the power of the pen. Read, read, **read** every day, pen in hand.”*

*From Nelson **Rolihlahla** Mandela “Madiba” (1918–2013).*



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## Foreword

It is in estuaries and deltas where the richness of the land meets the abundance of the sea, creating an environment of high diversity, dynamism and productivity. Nevertheless, the important contributions estuaries make to local livelihoods and national economies, as well as to their complex role in the functioning of the land-ocean interface, are often overlooked.

The Western Indian Ocean is dotted with important estuaries and deltas, including the Tana and Sabaki in Kenya, Pangani, Rufiji and Ruvuma in Tanzania, Zambezi, Incomati, Maputo, Pungwe and Limpopo in Mozambique, Thukela in South Africa and Betsiboka in Madagascar. With numerous plans and investments in place for a massive acceleration in infrastructure development and energy and food production, human activities will increasingly impact these important estuarine and coastal ecosystems and the life-supporting services they provide. In this regard, the unique, diverse and productive estuaries and deltas of the Western Indian Ocean stand at a crucial crossroad.

The Western Indian Ocean is internationally recognized as a hot spot of biodiversity, hosting one-third of the 38 globally, recognized marine and coastal habitats, an abundance of fish species and marine mammals, all five marine turtle species, over 40 species of seabirds and the longest fringing reef in the world. The region is also home to the charismatic coelacanth, nicknamed the living fossil, and the critically, endangered sawfish and seahorse. Furthermore, the region's coastal and marine waters are important fishing grounds, supporting the livelihoods of the local population. Its marine parks and other protected areas are also the basis for an active tourism industry.

The unfortunate reality, however, is that human activities in these river catchments are having increasingly serious impacts on these sensitive downstream estuarine and coastal ecosystems. The damming of rivers over the past 50 years, combined with reduced rainfall, expansion of irrigated agriculture and other increasing water abstraction and land uses within various catchments, are among the underlying causes of those changes. Furthermore, pollution from municipal and industrial effluents is exacerbating the serious degradation of waters and sediment quality that is being observed in these rivers, estuaries and coastal waters, resulting in a loss of biodiversity, increasing eutrophication and reduced fish catches in many locations in the Western Indian Ocean.

To set the stage for addressing the continuing degradation of these important land-sea interfacing water systems, this publication was made possible due to the leadership of four scientists: Prof. Salif Diop from the University of Dakar; Dr. Peter Scheren from WWF; Prof. John Machiwa from the University of Dar es Salaam and Prof. Jean-Paul Ducrottoy from the Institute of Estuarine and Coastal Studies, The University of Hull, UK.

The focus of this book is on estuaries, but its scope and implications extend well beyond this particular coastal feature. Indeed, estuaries can only be considered as part of the life cycle of the entire river basins draining into them and the downstream marine areas that receive these riverine inputs. These interlinked systems and the life-supporting ecosystem services they provide are particularly sensitive to human and natural pressures; hence the title of this book **“Estuaries: a Lifeline of Ecosystem Services in the Western Indian Ocean”**. It is our

belief that this book will be a valuable source of information and guidance for the numerous scientists, researchers, managers and decision makers concerned with the integrated management of estuaries, deltas, lagoons, and the coastal and marine areas of the Western Indian Ocean and will help facilitating their sustainable use.

UNEP, Nairobi, Kenya

IOC-UNESCO, Paris, France

WWF International, Gland, Switzerland

Ibrahim Thiaw

Vladimir Ryabinin

Marco Lambertini



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## Preface

This volume “Estuaries: a lifeline of ecosystem services in the Western Indian Ocean” published in the book series “Estuaries of the World” (EOTW) by Springer is the second of its nature focusing on Africa. The case studies presented in this book provide clear evidence of the fact that the estuarine ecosystems of this region are extremely valuable in providing cultural (recreational, spiritual, etc.), provisioning (food, timber, etc.) and regulatory (flood protection, climate regulation, etc.) services that are not only at the core of the coastal ecosystem functioning, but also an important basis of livelihoods of over 60 million inhabitants living in the region; the coastal ecosystems of the region, and in particular estuaries, represent important socio-economic values based on irreplaceable ecosystem functions. However, these valuable ecosystems are subject to a range of human pressures that may compromise the health of living human residents. These disturbances are multiple and include pollutants, excess nutrients (causing eutrophication), loss and transformation of habitats and disturbance of hydrological regimes causing flooding and unpredictable flow patterns. The effects of these impacts, often acting in cumulative and synergistic manners, affect the overall stability of the system and threaten its strength and resilience.

Unfortunately, due to inadequacies in the management and governance of these ecosystems, local management is often unable to control the basic causes of these attacks on ecosystem integrity, instead passively responding to their consequences without treating the cause. In addition, the exogenous pressures imposed by global climate change amplify the scale of stress on ecosystems. Its consequences (e.g. the increase in temperature, sea level rise, increased risks of flooding, etc.) may intensify the risk of seeing abrupt and nonlinear changes in natural systems. This will have an impact on flora and fauna, their structure (species richness and biological diversity), their functioning and their biological productivity.

At risk of compromising future development, policy makers are confronted with economic and legal constraints which often are antagonistic. The complexity of understanding human-marine coastal environment interactions as evidenced in this book, explain why the ecosystem-based approach constitutes one of the most valuable frameworks for promoting the sustainable development of marine and coastal ecosystems in the Western Indian Ocean as elsewhere in the world. Indeed, the book shows that adequate knowledge, scientific information and capacity, awareness and governance on ecological processes and the important role and value of ecosystems goods and services they provide are the key to allowing coastal communities and policy makers to define adequate responses to the threats at hand.

The potential of coastal or estuarine systems to provide crucial ecosystem functions and services depends on the stability of prevailing abiotic conditions, organised along gradual gradients and ecotones; a good understanding of the diversity of ecological processes in estuaries is therefore critical to apprehend the complexity of the system. More so, it is important to understand the linkages between these ecosystems and the economic realm, including aspects of market, land and other property rights regimes, as well as their related government structures and social networks. Unfortunately, more often than not, economic forces have considered ecosystems and the resources they provide as “free”, not taking account of their economic externalities in terms of the adverse effects of their use.

Based on the above underlying philosophy, the present book chapters describe the various ecosystem functions and values of the region's estuarine ecosystems and their respective habitats, including the land/ocean interactions that define and impact ecosystem services. The Western Indian Ocean region covered by this volume consists of the continental coastal states of Kenya, Mozambique, South Africa and Tanzania and the island states of Madagascar, Seychelles, Comoros and Mauritius, all being signatories to the Nairobi Convention for the protection, management and development of the marine environment of the region. One of the main goals of the Nairobi Convention is "to promote a mechanism for regional cooperation, coordination and collaborative actions in the Eastern and Southern African region that enable the contracting parties to harness resources and expertise from a wide range of stakeholders and interest groups towards solving interlinked problems of coastal and marine environment, including critical and transboundary issues".<sup>1</sup>

The authors of the book do hope that their scientific contribution will help support decision making and promote robust capacity building and management programmes tailored to the region's needs. In this regard, this book aims to provide a good scientific assessment of ecological conditions prevailing in the region which undoubtedly will benefit any future commitment to sustainable development of coastal areas of the Western Indian Ocean.

Dakar-Fann, Senegal  
Dar es Salaam, Tanzania  
Dar es Salaam, Tanzania  
Hull, UK

Salif Diop  
Peter Scheren  
John Machiwa  
Jean-Paul Ducrottoy

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<sup>1</sup> extract from the "Nairobi Convention".

The original version of the Copyright Page was revised. Salif Diop's affiliation was corrected. An erratum can be found at [http://dx.doi.org/10.1007/978-3-319-25370-1\\_21](http://dx.doi.org/10.1007/978-3-319-25370-1_21)

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A special note of thanks should be dedicated to Ibrahim Thiaw, Deputy-Executive Director of the United Nations Environment Programme, to Marco Lambertini, Director General of the Worldwide Fund for Nature and to Vladimir Ryabinin, Executive Secretary of the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organisation, for their acceptance to co-sign the foreword; special thanks also to Walter Rast, Professor Emeritus and Director, Texas State University, USA, for his extensive peer review of important sections of the book, as well as to Amadou Abdoul Sow, Dean of Faculty of Arts and Humanities, Saly Sambou and Birane Cisse, Doctoral students at University Cheikh Anta Diop/CAD of Dakar and Awa Niang, senior lecturer at the same University, for their support all along the preparation of this book. Finally the authors would also like to thank the Nairobi Convention Secretariat, UNEP, WWF, Future Earth Coasts, formerly LOICZ, IOC of UNESCO and especially Julian Barbieri, Albert Fisher and Mika Odido for their contribution during the preparation process of this volume dedicated to the Western Indian Ocean (WIO) region.



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## Contributors

- Akunga Momanyi** School of Law, University of Nairobi, Nairobi, Kenya
- Alfred N. N. Muzuka** Nelson Mandela African Institute of Science and Technology, Arusha, Tanzania
- Ameer Abdulla** International Union for Conservation of Nature (IUCN), Gland, Switzerland
- Ander M. De Lecea** Department for Biodiversity & Conservation Biology, University of the Western Cape, Belville, Cape Town, South Africa
- Ann Vanreusel** Marine Biology Research Group, Ghent University, Ghent, Belgium
- Antonio Mubango Hogueane** School of Marine and Coastal Sciences, Eduardo Mondlane University, Quelimane, Mozambique
- Aude Carro** Blue Ventures Conservation, Toliara, Madagascar
- Bienvenue Zafindrasilivonona** Blue Ventures Conservation, Toliara, Madagascar
- Chandra Giri** United States Geological Survey, Earth Resources Observation and Science Center, Duke University, Durham, NC, USA
- Cosmas N. Munga** Department of Environment and Health Sciences, Marine Sciences Section, Technical University of Mombasa, Mombasa, Kenya
- David Obura** Coastal Oceans Research and Development-Indian Ocean (CORDIO E.A), Mombasa, Kenya
- Denis Macharia** Regional Centre for Mapping of Resources for Development (RCMRD), Nairobi, Kenya
- Diana Mutiso** Kenya Marine and Fisheries Research Institute, Mombasa, Kenya
- Edward Kimani** Kenya Marine and Fisheries Research Institute, Mombasa, Kenya
- Farid Dahdouh-Guebas** Laboratory of General Botany and Nature Management, Mangrove Management Group, Vrije Universiteit Brussel, Brussels, Belgium  
Département de Biologie des Organismes, Université Libre de Bruxelles, Bruxelles, Belgium
- Gabriel Grimsditch** International Union for the Conservation of Nature, Male, Maldives
- Garth Cripps** Blue Ventures Conservation, Toliara, Madagascar
- Greg M. Wagner** MacEwan University, Edmonton, Alberta, Canada
- Harifidy Rakoto Ratsimba** Department of Forestry, University of Antananarivo, Antananarivo, Madagascar
- Henriques Balidy** Centre for Sustainable Development of the Coastal Zone (CDS-ZC), Ministry for Land, Environment and Rural Development, Xai-Xai Beach, Mozambique

- M.M. Igulu** Tanzania Fisheries Research Institute (TAFIRI), Dar es Salaam, Tanzania
- Jacob Odhiambo-Ochiewo** Kenya Marine and Fisheries Research Institute, Mombasa, Kenya
- James Gitundu Kairo** Kenyan Marine and Fisheries Research Institute, Mombasa, Kenya
- Jean-Paul Ducrottoy** Institute of Estuarine and Coastal Studies, The University of Hull, Hull, UK
- Jelvas Mwaura** Kenya Marine and Fisheries Research Institute, Mombasa, Kenya
- Jerker Tamelander** United Nations Environment Programme, Bangkok, Thailand
- John Machiwa** College of Agricultural Sciences and Fisheries Technology, University of Dar es Salaam, Dar es Salaam, Tanzania
- Johnson U. Kitheka** Department of Hydrology and Water Resources Management, School of Water Resources Science and Technology, South Eastern Kenya University, Kitui, Kenya
- Kenneth M. Mavuti** School of Biological Sciences, University of Nairobi, Nairobi, Kenya
- I.A. Kimirei** Tanzania Fisheries Research Institute (TAFIRI), Kigoma, Tanzania
- Lalao Ravaoarinosihoarana** Blue Ventures Conservation, Toliara, Madagascar
- Leah Glass** Blue Ventures Conservation, Toliara, Madagascar
- Leonard Jones Chauka** Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania
- Lisa Benson** Blue Ventures Conservation, Toliara, Madagascar
- B.R. Lugendo** College of Natural and Applied Sciences (CoNAS), University of Dar es Salaam, Dar es salaam, Tanzania
- Maria Helena Paulo Antonio** School of Marine and Coastal Sciences, Eduardo Mondlane University, Quelimane, Mozambique
- Marianne Teoh** Blue Ventures Conservation, Toliara, Madagascar
- Melckzedec Osore** Kenya Marine and Fisheries Research Institute, Mombasa, Kenya
- Mialy Andriamahefazafy** Blue Ventures Conservation, Toliara, Madagascar
- Mohamed Omar Said Mohamed** Wetlands and Marine Conservation, Parks and Reserves, Kenya Wildlife Service, Nairobi, Kenya
- Monica Zavagli** Ramsar, Gland, Switzerland
- Nico Koedam** Laboratory of General Botany and Nature Management, Mangrove Management Group, Vrije Universiteit Brussel, Brussels, Belgium
- Perrine Mangion** Department of Analytical and Environmental Chemistry (ANCH), Vrije Universiteit Brussel, Brussels, Belgium
- Peter Scheren** Worldwide Fund for Nature (WWF) Coastal East Africa Initiative, Dar es Salaam, Tanzania
- Pierre de Villiers** CapeNature, Stellenbosch, South Africa
- Rachel Cooper** Marine Research Institute and Department of Biological Sciences, University of Cape Town, Rondebosch, Cape Town, South Africa
- Raymond Raheerindray** Blue Ventures Conservation, Toliara, Madagascar



- Renison K. Ruwa** Kenya Marine and Fisheries Research Institute, Mombasa, Kenya
- Rose Sallema-Mtui** National Environmental Management Council, Dar es Salaam, Tanzania
- Saeed Mwaguni** Department of Environment and Health Sciences, Technical University of Mombasa, Mombasa, Kenya
- Salif Diop** National Academy of Sciences and Techniques – Section of Agricultural Sciences and Université Cheikh Anta Diop de Dakar, Dakar-Fann, Senegal
- Salomão Bandeira** Department of Biological Sciences, Universidade Eduardo Mondlane, Maputo, Mozambique
- M. Semba** Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha, Tanzania
- Siajali Pamba** Department of Aquatic Sciences and Fisheries Technology, College of Agricultural Sciences and Fisheries Technology, University of Dar es Salaam, Dar es Salaam, Tanzania
- Steve Mwangi** Kenyan Marine and Fisheries Research Institute, Mombasa, Kenya
- Tanausu Gomez** The Manta Resort, Pemba, Zanzibar, Tanzania
- Trevor Gareth Jones** Blue Ventures Conservation, Toliara, Madagascar  
Dynamic Ecosystems and Landscapes Lab, Department of Environmental Science and Management, Portland State University, Portland, OR, USA
- Yohana W. Shaghude** Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania
- Yukari Takata** College of Journalism and Communications, University of Florida, Gainesville, FL, USA
- Zo Andriamahenina** Blue Ventures Conservation, Toliara, Madagascar



---

## About the Editors



**Prof. S. Diop** is a water expert with number of referred related publications and broad experience in various aspects of scientific assessment of freshwater, coastal and marine resources as well as in areas related to the management and sustainable development of the environment. So far, he pursued the coordination of important international programmes on freshwater, marine and coastal processes, including scientific assessment of marine and coastal waters, assessment of groundwater resources in Africa and in other regions of the world, on evaluation processes and scientific assessment of the world oceans and coasts; on geosphere-biosphere interactions; on integrated management of marine areas and coastal interfaces land/sea/water and atmosphere; on assessment of water resources as a key factor for sustainable development; on the

development of modules for the evaluation of freshwater resources, wetlands, marine waters and coastal areas, including the relations and impacts of climate change. Prof. S. Diop has worked at the United Nations, in particular at UNEP's Division of Early Warning and Assessment (DEWA) as a Senior Officer for nearly 16 years. He holds from University Louis Pasteur/Strasbourg/France, a 3rd cycle doctorate he defended in 1978 and a state doctorate he defended in 1986. As Senior Fulbright Scholar, he spent one year sabbatical in Rosenstiel School of Marine and Atmospheric Sciences of the University of Miami/USA, Division of Biological and Living Resources in 1986/87. For more details, including his most recent publications, consult the website of Professor Salif DIOP at <http://www.esalifdiop.org>

**Prof. Salif Diop**, Professor of University at CAD – Dakar – Senegal.

*Member, National Academy of Sciences and Techniques of Senegal (ANSTS),*

*African Academy of Sciences (AAS), The World Academy of Sciences for the Advancement of Sciences in the Developing World (TWAS).* P.O.Box 5346 – Dakar-Fann – Dakar – Senegal.

E-mail: [sal-fatd@orange.sn](mailto:sal-fatd@orange.sn); [esalifdiop@gmail.com](mailto:esalifdiop@gmail.com)



**Dr. Peter Scheren** is currently attached to the Worldwide Fund for Nature (WWF) as the Leader of the Coastal East Africa Initiative. His engagement in research, assessment and management of both freshwater and marine ecosystems stretches across the African continent, banking upon over two decades of work in both Western and Eastern Africa. Among others, he played an important role in the coordination of a number of large-scale transboundary diagnostic analyses for both the Guinea current and Western Indian Ocean marine system. His real passion lies, however, in bringing the science, knowledge and understanding of such systems together for defining policies, strategies and governance systems that will lead to the better management of such systems, in order to

safeguard the ecosystem functions and values that they provide to both nature and the people that depend on them.

Peter Scheren holds a PhD from the University of Eindhoven and University of Wageningen in the Netherlands, with a focus on integrated environmental assessment of large water bodies. He has worked for various research institutions, consultancy offices and managed several large-scale coastal and marine programmes in Africa for the United Nations Environment Programme and the United Nations Industrial Development Organisation.

**Dr. Peter Scheren, Leader** | WWF Coastal East Africa Initiative,  
P.O.Box 63117 Dar Es Salaam, Tanzania - E-mail: [pscheren@wwf.panda.org](mailto:pscheren@wwf.panda.org)



**Professor John Machiwa** is a lecturer and researcher in aquatic biogeochemistry at the University of Dar es Salaam, College of Agricultural Sciences and Fisheries Technology, Department of Fisheries Sciences and Technology. He is an expert in heavy metal geochemistry and nutrient cycling in tropical aquatic systems. Having worked both in marine and freshwater systems for a long time, Professor Machiwa has gained considerable experience in studying and analysing ecological processes in aquatic environments, especially coastal marine areas. The fate of organic carbon in tropical mangrove ecosystems is one of his key interests. He has conducted considerable environmental studies on the influence of land use patterns on the health of aquatic systems, with a special interest in inland water bodies. He has conducted research and supervised a number of postgraduate students researching on

chemical pollutants in East African freshwater bodies and the Western Indian Ocean coastal zone.

**Prof. John Machiwa**

Department of Fisheries Sciences and Technology, College of Agricultural Sciences and Fisheries Technology, University of Dar es Salaam – Tanzania – E-mail: [machiwa@ucc.udsm.ac.tz](mailto:machiwa@ucc.udsm.ac.tz) and [machiwajohn252@gmail.com](mailto:machiwajohn252@gmail.com)