

People, Nature and Research  
in Chwaka Bay, Zanzibar, Tanzania

**Book title:**

People, Nature and Research in Chwaka Bay, Zanzibar, Tanzania.

**Book Citation:**

de la Torre-Castro M. and Lyimo T.J. (eds.). 2012. People, Nature and Research in Chwaka Bay, Zanzibar, Tanzania. Pp. 346. ISBN: 978-9987-9559-1-6. Zanzibar Town: WIOMSA.

**Chapter citation example:**

Lyimo, T.J. 2012. "The Microalgae and Cyanobacteria of Chwaka Bay" In People, Nature and Research in Chwaka Bay, Zanzibar, Tanzania, de la Torre-Castro, M. and T.J. Lyimo (eds.). Pages 125-141. ISBN: 978-9987-9559-1-6. Zanzibar Town: WIOMSA.

© 2012 by Western Indian Ocean Marine Science Association (WIOMSA)

Mizingani Street, House No. 13644/10

P.O. Box 3298, Zanzibar, Tanzania.

E-mail: [secretary@wiomsa.org](mailto:secretary@wiomsa.org)

All rights of this publication are reserved to WIOMSA, editors and authors of the respective chapters. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the editors and WIOMSA. The material can be used for scientific, educational and informational purposes with the previous permission of the editors and WIOMSA.

This publication is made possible by the generous support of Sida (Swedish International Development Cooperation Agency) through the Western Indian Ocean Marine Science Association (WIOMSA). The contents do not necessarily reflect the views of Sida.

Graphic design and layout: AZOTE AB, Sweden. [www.azote.se](http://www.azote.se)

Photographers: Maricela de la Torre-Castro (front cover), Mats Björk and Maria Asplund

Printed by: Jamana Printers, Dar es Salaam, Tanzania.

*To the Chwaka people hoping that science can  
contribute to your well-being*

*- and -*

*to the memory of my parents Rev. Jacob I Lyimo  
and Luise J. Lyimo, and my father Jorge de la Torre  
Álvarez, who passed away while we were working  
on this book and who always encouraged us to  
follow the path of science*



– TABLE OF CONTENTS –

Foreword	11
Preface	13
Acknowledgements	15
Synthesis: Towards an Integrative Research Approach on Coastal Ecosystems – The example of Chwaka Bay <i>Thomas J. Lyimo, Maricela de la Torre-Castro, Yohanna W. Shaghude, Narriman S. Jiddawi, Mats Björk and Lars Lindström</i>	17
1. Physical Characteristics, Socio-economic Setting and Coastal Livelihoods in Chwaka Bay <i>Narriman S. Jiddawi and Lars Lindström</i>	23
2. Physical and Geological Processes in Chwaka Bay <i>Yohanna W. Shaghude, Shigalla Mahongo, Alfred N.N. Muzuka and Ntahondi Nyandwi</i>	41
3. The Coastal Vegetation of Chwaka Bay <i>I. Sware Semesi</i>	57
4. The Mangrove Ecosystem of Chwaka Bay <i>Charles Lugomela</i>	69
5. Seagrass Meadows in Chwaka Bay: Socio-ecological and Management Aspects <i>Martin Gullström, Thomas J. Lyimo, Johan S. Eklöf, Mats Björk, I. Sware Semesi and Maricela de la Torre-Castro</i>	89
6. Coral Reefs in Chwaka Bay and Adjacent Areas <i>Christopher A. Muhando and Mohammed S. Mohammed</i>	111
7. The Microalgae and Cyanobacteria of Chwaka Bay <i>Thomas J. Lyimo</i>	125
8. Carbonate Production by Calcareous Algae in a Seagrass-Dominated System: The Example of Chwaka Bay <i>Juma Kangwe, I. Sware Semesi, Sven Beer, Matern Mtolera and Mats Björk</i>	143
9. Nutrients and Pesticide Pollution in Chwaka Bay <i>Salim M. Mohammed, Nadja Stadlinger, Aviti Mmochi and Linda Kumblad</i>	157
10. Biological Connectivity and Nursery Function of Shallow-Water Habitats in Chwaka Bay <i>Martin Gullström, Martijn Dorenbosch, Blandina R. Lugendo, Augustine W. Mwandya, Yunus D. Mgaya and Charlotte Berkström</i>	175
11. Artisanal Fisheries and other Marine Resources in Chwaka Bay <i>Narriman S. Jiddawi</i>	193

12. Seaweed Farming in Chwaka Bay: A Sustainable Alternative in Aquaculture? <i>Johan S. Eklöf, Flower E. Msuya, Thomas J. Lyimo and Amelia S. Buriyo</i>	213
13. Invertebrate Collection in Chwaka Village: Importance, Gender and Resilience Aspects <i>Elin Håkansson, Sara Fröcklin and Maricela de la Torre-Castro</i>	235
14. Governing Sustainability: Chwaka Bay in Zanzibar's National Integrated Coastal Management Strategies <i>Lars Lindström</i>	265
15. Management Challenges in Chwaka Bay, Zanzibar, Tanzania: Historical Development and Future Prospects <i>Maricela de la Torre-Castro</i>	279
Annotated Bibliography for Chwaka Bay <i>Sieglind Wallner and I. Sware Semesi</i>	303
Contributors	341

– LIST OF ILLUSTRATIONS –

CHAPTER 1

Figure 1. Study site. Chwaka Bay, Zanzibar, Tanzania.	26
Figure 2a. Distribution of main income generating activities in the Chwaka Bay area.	30
Figure 2b. Main income generating activities by gender in the Chwaka Bay area.	31
Figure 3. Money saving alternatives in Chwaka.	34
Figure 4. Ownership details among a small sample of the people of Chwaka.	35

CHAPTER 2

Figure 1. Map showing the approximate location of Zanzibar along the coast of Tanzania and the major physical features of Chwaka Bay.	42
Figure 2. A schematic representation of the marine terraces at Chwaka village.	47
Figure 3. Photographs illustrating the three phases of the former shorelines at Chwaka Bay Hotel (a) the lowest terrace unit (b) the vertical cliff of the lowest terrace (c) the sloping hills, and (d) the highest terrace.	48
Figure 4. Map of Chwaka Bay showing the mean grain size distribution (in phi) of the sediments.	50
Figure 5. Map of Chwaka Bay showing the sediment thickness (in metres) on the sea bottom.	50
Figure 6. An eroding sandy beach at Uroa exemplified by the presence of stranded coconut stumps (a) and beach scarp/step (b).	51

CHAPTER 3

Figure 1. A conceptual landscape showing distribution pattern of coastal vegetation of Chwaka Bay.	58
--	----

CHAPTER 4

Figure 1. Map of Chwaka Bay highlighting the area covered by mangrove forest and the villages surrounding the Bay.	70
--	----

## CHAPTER 6

Figure 1. Coral Reefs - Coral reefs are mounds of living coral, coral skeletons and calcium deposits from other sea organisms that reside in the ocean.	112
Figure 2. Some of the coral reef invertebrates found on Chwaka Bay and adjacent coral reefs.	113
Figure 3a. Map showing the distribution of coral reefs around Unguja Island, Zanzibar.	114
Figure 3b. Map showing the distribution of coral reef in Chwaka Bay (proper) and adjacent areas, Zanzibar.	115
Figure 4. The mean percent cover (%) of reef benthos in the Chwaka Bay proper.	116
Figure 5. Fish density (numbers per 100 m <sup>2</sup> ) in surveyed reefs in 1999.	119
Figure 6. Density of macro-invertebrates in the Bay proper, Inner and Exposed outer reefs.	120
Figure 7. Coral cover dynamics of inner and outer Pongwe reefs for 1997, 1999, 2006 and 2010.	121

## CHAPTER 7

Figure 1. A typical example of microbial mats in mangrove forest of Chwaka Bay.	133
---	-----

## CHAPTER 8

Figure 1. a) <i>Halimeda macroloba</i> b) <i>H. Opuntia</i> ; c) <i>H. opuntia</i> partly decomposing into sand.	146
Figure 2. Map of Chwaka Bay showing the positions of the five sampling sites.	147

## CHAPTER 9

Figure 1. Map of Chwaka Bay showing the Cheju rice fields, Mapopwe Creek, mangrove forest and the surrounding settlements.	158
Figure 2. Rice farmer in the irrigated part of Cheju practicing manual weeding.	161

## CHAPTER 10

Figure 1. The nursery hypothesis illustrated by ontogenetic migrations of coral reef fish species between mangroves, seagrass beds and the coral reefs.	178
Figure 2. Connectivity of fish assemblages over a 60 m coral reef–seagrass gradient at the entrance zone of Chwaka Bay, based on visual census surveys.	186
Figure 3. Connectivity of fish assemblages in the coral reef – seagrass – mangrove gradient in Chwaka Bay based on visual census surveys and beach seine hauls.	187

## CHAPTER 11

Figure 1. Fish catch trend from 2004 to 2007 at Chwaka Bay.	195
Figure 2. Dema traps, basket traps traditional gear made with local materials.	200
Figure 3. Average composition of coral reef and seagrass fish found in Chwaka Bay, 2001-2003.	201
Figure 4. Catch rate of number of crabs per day per fisher and per group at Chwaka Bay.	203

## CHAPTER 12

Figure 1. Photograph of “off-bottom” seaweed farm during a low tide in Chwaka Bay, Zanzibar East coast.	214
Figure 2. Annual seaweed production (dry weight) in Zanzibar, 1990-2008.	216
Figure 3. Conceptual figure of interactions between environmental and economic factors which appear to keep earnings from seaweed farming to farmers – and indirectly, farming intensity – at low levels.	218
Figure 4. <i>Eucheuma denticulatum</i> seaweeds farmed in a shallow <i>Enhalus acoroides</i> seagrass bed in Chwaka Bay.	220

Figure 5. Conceptual diagram of environmental effects of seaweed farming on various levels of seagrass food webs.	221
Figure 6. Possible value addition products from seaweed farming; soap produced partly from seaweed extracts on Zanzibar.	227
CHAPTER 13	
Figure 1. Women gleaning in the intertidal area.	237
Figure 2. Women needing boat transport to collection grounds.	238
Figure 3. <i>C. ramosus</i> stored in large bags.	240
Figure 4. Invertebrates targeted by women in Chwaka Village based on interview data.	242
Figure 5. A day's catch of <i>C. tigris</i> .	245
Figure 6. Importance of invertebrate collection for cash income and subsistence in Chwaka village, rated by women respondents during semi-structured interviews.	246
Figure 7. Women's perception of which substrates/habitats provide good collection grounds, based on interview data.	248
Figure 8. Women respondents' opinion about whether the number of target animals in Chwaka Bay has changed.	250
Figure 9. Women respondents' opinion about whether the sizes of the target animals in Chwaka Bay have changed.	250
Figure 10. Women respondents' opinion about whether the number of people collecting invertebrates in Chwaka Bay has changed.	250
CHAPTER 14	
Figure 1. ICM organizational structure suggested by the Zanzibar Revolutionary Government.	273

– LIST OF TABLES –

CHAPTER 2	
Table 1. Amplitudes (m) of the dominating tidal components in Chwaka Bay and nearby stations.	44
CHAPTER 3	
Table 1. List of terrestrial coastal vegetation of Chwaka Bay.	60
Table 2. List of typical shoreline coastal vegetation species of the Western Indian Ocean.	62
CHAPTER 4	
Table 1. List of macrophytes species associated with the mangrove habitat in Chwaka Bay.	71
Table 2. Mangrove species and their uses in Chwaka Bay.	77
CHAPTER 6	
Table 1. Coral genera found in Chwaka Bay and adjacent reefs listed according to their relative frequency of encounter (in %) during the study.	117
Table 2. Common fish species found in the Bay, Lagoon and the exposed reefs.	118
CHAPTER 7	
Table 1. Documented species of microalgae from various habitats of Chwaka Bay.	129



## CHAPTER 8

Table 1. Average standing biomass of <i>Halimeda</i> species at the five sites in Chwaka Bay for the period December 2000 to May 2001.	148
Table 2. Growth rates of <i>Halimeda</i> spp. in Chwaka Bay as percent daily growth rate (% DGR) calculated from the ratio of the new segments to all segments of a thalli.	149
Table 3. Standing biomass, growth rate and productivity of <i>Halimeda</i> sp. in Chwaka Bay.	150
Table 4. A comparison of ranges of <i>Halimeda</i> spp. biomass, growth rate and productivity in different tropical waters.	151

## CHAPTER 9

Table 1. Water column concentrations of nutrients ( $\mu\text{M}$ ) in a gradient from Cheju rice fields, Mapopwe Creek to the outer Chwaka Bay.	164
Table 2. Pesticides in use at Cheju in 1995-2007.	164
Table 3. Pesticide concentrations in water in Cheju-Mapopwe drainage basin ( $\mu\text{g/l}$ ).	164
Table 4. Pesticide concentrations in soil from the Cheju-Mapopwe drainage basin ( $\mu\text{g/kg}$ ).	166
Table 5. Concentrations of organochlorines in sediments ( $\text{ng/g dw} \pm \text{SE}$ , $n = 2$ ) and fish tissue ( $\text{ng/g lipid weight} \pm \text{SE}$ , $n = 7$ ) of various sites of Chwaka Bay.	166
Table 6. Average metal concentrations in sediments ( $\mu\text{g/g dw} \pm \text{SE}$ , $n = 2$ ) and fish tissues ( $\mu\text{g/g dw} \pm \text{SE}$ , $n = 5$ ) collected in June 2004 at various sites in Chwaka Bay.	166

## CHAPTER 11

Table 1a. Description of types of vessels found in Chwaka Bay.	196
Table 1b. Number of fishing vessels and types found in Chwaka Bay villages.	196
Table 2. Number of full-time fishers per landing site at Chwaka Bay, 2007.	196
Table 3. Types of gears used in Chwaka Bay.	198
Table 4. Summary of gear types and number in the various landing sites in Chwaka Bay, 2007.	199
Table 5. Some common fish types found at Chwaka Bay.	201
Table 6. Average catch rates by gear per day.	201
Table 7. Export (tonnes) of Zanzibar fishery products 2003-2007.	203
Table 8. Mean net daily income in TZS of actors in Uroa fishing value chain.	206

## CHAPTER 12

Table 1. Chronology of the start and spread of seaweed farming in Tanzania.	215
---	-----

## CHAPTER 13

Table 1. Invertebrate catch analysis results. Average number of individuals and average wet weight of different animals per catch and average wet weight per individual in the catches collected by the women during the study period.	241
Table 2. Details on usage, market prices and the trade related to commonly collected invertebrate species based on interviews with collectors and resellers.	242
Table 3. Invertebrate catch analysis results. Average number of individuals and average wet weight of the different animals per catch and average wet weight per individual in catches collected by spear fishers.	244

## CHAPTER 15

Table 1. Overview of the main documents dealing with marine management in Chwaka Bay, Zanzibar, Tanzania.	289
---	-----