Engineering for Sustainable Human Development

Other Titles of Interest

***Climate Change Modeling, Mitigation, and Adaptation,* edited by Rao Y. Surampalli, Tian C. Zhang, C.S.P. Ojha, B.R. Gurjar, R.D. Tyagi, and C.M. Kao** (ASCE Technical Report, 2013). Presents the most current thinking on the environmental mechanisms contributing to global climate change and explores scientifically grounded steps to reduce the buildup of greenhouse gases in the atmosphere.

***Field Guide to Environmental Engineering for Development Workers: Water, Wastewater, and Indoor Air,* by James R. Mihelcic, Lauren M. Frye, Elizabeth A. Myre, Linda D. Phillips, and Brian D. Barkdoll** (ASCE Press, 2009). Explains sustainable engineering techniques for application in preparing for and executing international engineering service projects.

***Sustainability Guidelines for the Structural Engineer,* edited by Dirk M. Kestner, P.E.; Jennifer Goupil, P.E.; and Emily Lorenz, P.E.** (ASCE Technical Report, 2010). Offers guidelines to advance the understanding of sustainability in the structural community and to incorporate concepts of sustainability into structural engineering standards and practices.

***Sustainable Wastewater Management in Developing Countries: New Paradigms and Case Studies from the Field,* by Carsten Laugesen, Ole Fryd, Hans Brix, and Thammarat Koottatep** (ASCE Press, 2010). Draws upon the authors' experiences in Malaysia, Thailand, and other countries to examine the failures of traditional planning, design, and implementation, and to offer localized solutions that will yield effective sustainable management systems.

***Sustainable Engineering Practice: An Introduction,* by the Committee on Sustainability.** (ASCE Technical Report, 2004). Provides a broad, fundamental understanding of sustainability principles and their application to engineering work.

***Toward a Sustainable Water Future: Vision for 2050*, edited by Walter M. Grayman, Ph.D., P.E., D.WRE; Daniel P. Loucks, Ph.D.; and Laurel Saito, Ph.D., P.E** (ASCE Technical Report, 2012). Contains essays by more than 50 experts in environmental and water resource issues who describe their visions of the field in 2050 and the steps necessary to make those visions a reality.

Engineering for Sustainable Human Development

A Guide to Successful Small-Scale Community Projects

Bernard Amadei, Ph.D., NAE

ASCE PRESS

Library of Congress Cataloging-in-Publication Data

Amadei, Bernard, 1954-
Engineering for sustainable human development : a guide to successful small-scale community projects / Bernard Amadei, Ph.D., NAE.
pages cm
Includes bibliographical references and index.
ISBN 978-0-7844-1353-1 (paper : alk. paper)—ISBN 978-0-7844-7840-0 (pdf)—ISBN 978-0-7844-7841-7 (epub) 1. Sustainable construction. I. Title.
TH880.A44 2014
624.068'4—dc23
2014011726

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4382
www.asce.org/bookstore | ascelibrary.org

Errata: Errata, if any, can be found at http://dx.doi.org/10.1061/9780784413531.

ISBN 978-0-7844-1353-1 (paper)
ISBN 978-0-7844-7840-0 (PDF)
ISBN 978-0-7844-7841-7 (EPUB)
Manufactured in the United States of America.

21 20 19 18 17 16 15 14 1 2 3 4 5

Cover photo credit: Joe Thiel, from the Engineers Without Borders USA Montana State University Chapter, working with residents of the Khwisero District in Kenya. Photo courtesy of Dolan Personke; reproduced with permission.

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Preface

In spring 2000, I had the opportunity to visit several Mayan villages in Belize. One of them, by the name of San Pablo, caught my attention. Little did I know at the time that the people in San Pablo would change my life and professional career forever. During my visit, I was introduced to some young girls who, I was told, spent a lot of time doing basic house chores, including fetching water from the river located 30 m below the village. As a result, they could not go to school. Because the villagers heard that I was a civil engineer, I was asked if I could do something about bringing water to the village using an alternative method. The problem was simple from a technical point of view but not from a social aspect. The community was poor and could not afford the fuel to drive a pump. The government of Belize had not provided electricity to the village at that time. Furthermore, the village was somewhat illegal, in the sense that it was created by migrant workers from Central America who decided to set up camp on someone else's land. San Pablo was my first introduction to engineering for sustainable human development, or development engineering.

The trip to San Pablo changed my life and led to the creation of Engineers Without Borders in the United States (EWB–USA) and the development of a program on engineering for developing communities (EDC) at the University of Colorado at Boulder (CU–Boulder). It turns out that I was not the only one interested in helping the people of San Pablo; many of the engineering students at CU–Boulder wanted to be of help to the community as well. My office became a gathering point for the project, which quickly took shape. We decided, with the technical assistance of a local engineer, Dennis Walsh, to build a ram pump that would convert the potential head from a waterfall located upstream of San Pablo into enough pressure head to reach the village. The students raised the funding necessary to go to Belize in May 2001 to install the pump and build a small water distribution system. Upon our return from Belize, the students were even more excited about doing real voluntary projects as part of their education. They conveyed to me their frustration at doing the same virtual engineering work in the classroom; they wanted more of what they called at the time "meaningful engineering." Interestingly enough, I was also trying to integrate more experiential learning in my teaching. The students and I had similar interests.

The trip to Belize made me realize that I would better serve humanity by working on projects that improve people's lives rather than writing a steady stream of academic publications that few people read. I quickly realized that projects like the one in San Pablo could be integrated into the engineering

classroom and could be a powerful way of training our students to address real problems and come up with solutions that build on the fundamentals they learn in the classroom.

The San Pablo project and other projects over the past decade have made me aware that delivering engineering solutions to problems in developing communities in less than predictable conditions and in different cultural contexts is not easy and requires special skills that are not taught in engineering schools. The problems are often not well defined, and they involve technical and nontechnical issues. After all, the issue of water in San Pablo was never presented to me in a technical form; it all came about from wanting to help and do something so the girls in the village could stop fetching water and go to school. After the trip to Belize, I quickly realized that a need existed to train engineering students to address not only the needs of the richest segments of the world but also those living in poverty; this notion is addressed extensively in this book.

New ideas are challenging, and the first years of growing EWB–USA were difficult. The concept of providing experiential learning opportunities to students in an international setting was not always supported by my academic colleagues. I was told by my direct supervisors that doing work in the developing world was not part of the mission of the university and that I should focus on publishing in well established fields of engineering. Thanks to my students and friends, I was able to overcome many of the barriers deliberately created by some colleagues in my home institution. Since then, EWB–USA has grown into a fully operational 501(c)(3) not-for-profit organization with more than 14,000 student and professional members involved in 350 projects in 45 countries. Its success over the past 10 years is a true reflection of the vision and hard work of the staff, led by Executive Director Cathy Leslie; its various board members, sponsors, and donors; and all of its dedicated members and volunteers.

While moving EWB–USA forward, I came to the realization that a need existed to train young engineers to work on projects in developing countries. Even though the fundamentals of engineering are the same in projects in the developed and the developing world, the implementation of solutions to local problems can be quite different. Furthermore, in the context of development projects, engineers are required to possess hard technical skills, and other skills, such as dealing with people, culture, governance, and policy. Projects and their solutions need to be contextual, integrated, and multidisciplinary and need to account for uncertainty and complexity. These critical nontechnical skills are rarely provided or required in traditional engineering curricula, which I fear occurs for the simple reason that the teaching faculty members do not have the resources and/or experience to do so or are just not interested in them. The Engineering for Developing Communities (EDC) program at CU–Boulder was born out of the necessity to train engineers to address the needs of all, not just the richest part of the world's population. In 2010, EDC became the Mortenson

Center in Engineering for Developing Communities (MCEDC) at CU–Boulder, thanks to a generous endowment by the Mortenson family.

As a faculty member in the MCEDC, my responsibility over the past five years has been the teaching of core graduate courses, such as Sustainable Community Development I and II, and the coordination of a practicum where our students work as interns in various nongovernmental organizations around the world. This book has been a way for me to assemble the material taught in those courses. It introduces a framework and guidelines for conducting small-scale development projects in communities that are vulnerable to a wide range of adverse events and have low capacity to handle the stress associated with those events. The projects take place in medium- to high-risk and low-resilience environments. The framework presented in this book is called ADIME-E and represents an extension of the framework used by CARE International, combined with components from other frameworks used by different development agencies.

The framework presented in this book is unique, in the sense that it combines concepts and tools that have been traditionally used by development agencies and other tools more specifically used in engineering project management. It also emphasizes the importance of integrating systems thinking, risk analysis, capacity analysis, and resilience analysis in decision making. When combined, these tools and concepts from seemingly independent fields have the potential to better handle and model the complexity and uncertainty inherent in community development projects and the issues faced by households in these communities.

This book emphasizes the idea that human development calls for a new generation of global engineers who can operate in unpredictable and complex environments that are different from those encountered in the developed world. Engineering for sustainable human development is about the delivery of projects that are *done right* from a performance (technical) point of view and are also the *right projects* from a social, environmental, and economic (nontechnical) point of view. The book emphasizes that engineering for sustainable human development is not just about technology; it is also about people, values, ethics, culture, commitment, engagement, passion, and other issues that are not traditionally associated with engineering education and practice.

This book presents a framework and guidelines for small-scale engineering projects in developing communities. The methodology presented in the framework is meant to be robust, rigorous, and at the same time flexible, allowing for change and updates to be made based on experience and input. The reader should see the guidelines as a dynamic living document or a work in progress, but not as standards. Furthermore, the guidelines are presented as practical and comprehensive. Several illustrative case studies conducted by my graduate students or by me have been incorporated in the text.

This book is intended *primarily* for engineers, students, and professionals interested in small-scale human development projects, whether they reside in developed or developing countries. Development workers and practitioners may also find parts of this book useful, especially if they are interested in the technical aspect of small-scale development projects.

I want to thank Jenny Starkey, Tamara Stone, and Lauren Szenina for editing this book and Shawna Epps for drafting the various figures and tables. Special thanks go to the reviewers, who probably spent countless hours reviewing the first manuscript. Their feedback and suggestions are greatly appreciated.

I want to especially thank friends and colleagues who have supported the writing of this book, have encouraged me in pursuing my vision, and have taught me valuable tools in the various aspects of sustainability and international development. They include Bud Ahearn, Barry Bialek, George Bugliarello, Paul Chinowski, Robert Davis, Steve Forbes, Anne Heinz, Keyvan Izadi, Matt Jelacic, Rita Klees, Cathy Leslie, Hunter Lovins, Andrew Reynolds, Don Roberts, Robyn Sandekian, Mark Schueneman, David Silver, Mark Talesnick, Bill Wallace, Andy Yager, and Alex Zahnd. Special thanks go to Mort and Alice Mortenson and their family members for supporting the vision of the EDC program at CU–Boulder and believing in the future of engineering education and the betterment of humanity.

To all of the people who continue to work day in and day out to keep the mission and vision of EWB–USA alive, thank you for your commitment, vision, hard work, and more importantly, for your compassion and friendship. I also want to recognize the current and past staff of EWB–USA and its many board members over the past 13 years. I am glad to report that the future of the engineering profession is indeed in good hands.

I am also grateful to the graduate students with whom I have interacted through EWB–USA and the EDC program at CU–Boulder over the past 15 years. Their enthusiasm, energy, and dedication to the great work of making the world a better place are admirable. They have a bright future and will most likely become instruments of change in institutions that need creative disruption.

Finally, I especially thank my wife Robin and our children, Elizabeth Ann and Alex, for their support, patience, and love.