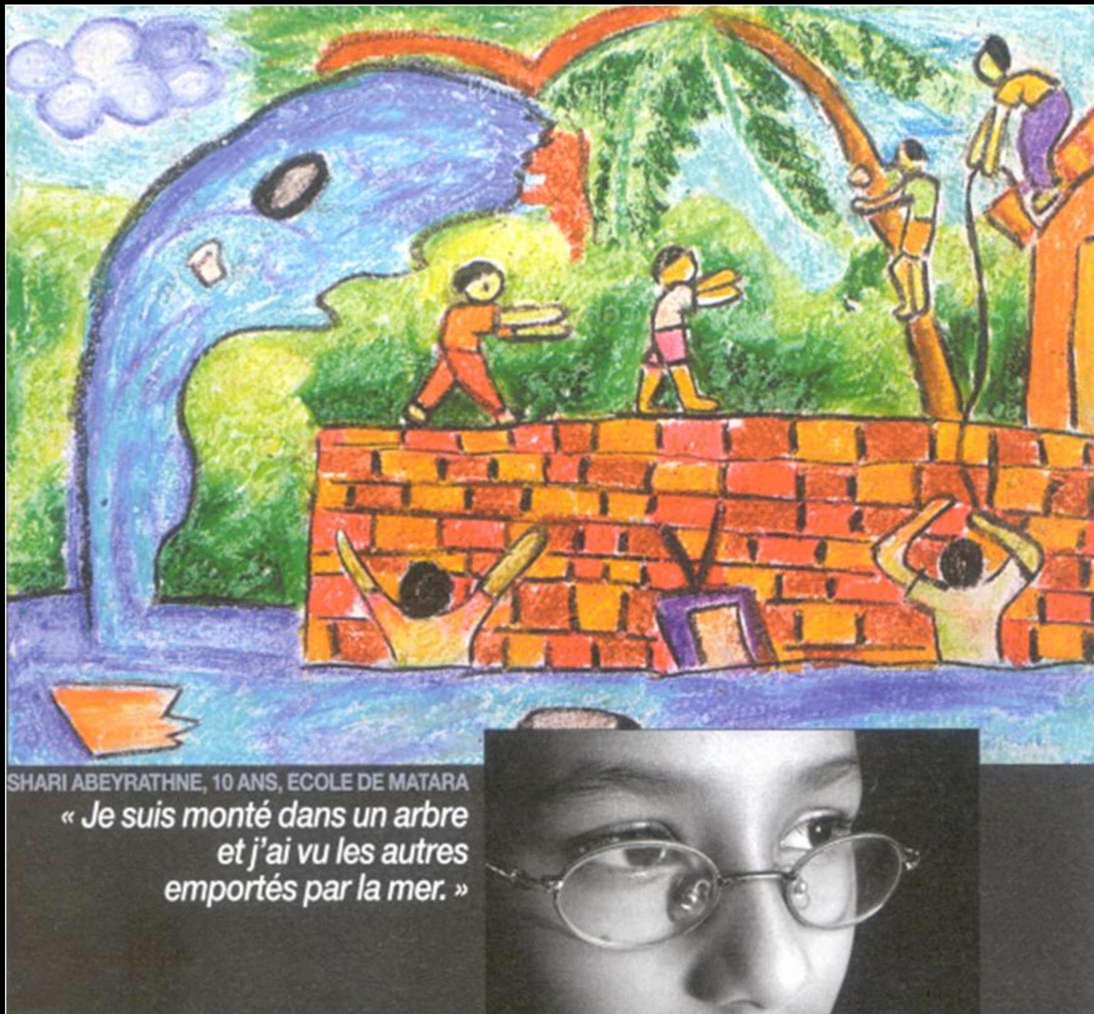
Shelter from the storm?

Use and misuse of bioshields for managing natural disasters on the coast

Feagin Rusty A., Nibedita Mukherjee, Kartik Shanker, Andrew H. Baird, Joshua Cinner, Alexander M. Kerr, Nico Koedam, Aarthi Sridhar, Rohan Arthur, L.P. Jayatissa, Danny Lo Seen, Manju Menon, Sudarshan Rodriguez, Md. Shamsuddoha and Farid Dahdouh-Guebas



Statements in the international media :

Why save the forest ?

Fear of big waves is no reason to plant mangroves.

Statements in the international media :

Let’s plant bioshields along the entire coast.
Let’s plant mangroves all around Indonesia.

Recent research background (2004-2005)

Current Biology, Vol. 15, 579–586, March 29, 2005, ©2005 Elsevier Ltd All rights reserved. DOI 10.1016/j.cub.2005.01.053

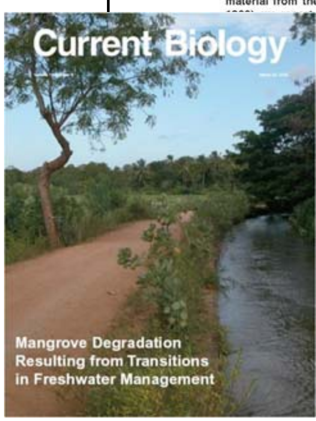
Transitions in Ancient Inland Freshwater Resource Management in Sri Lanka Affect Biota and Human Populations in and around Coastal Lagoons

F. Dahdouh-Guebas,[1,6,*] S. Hettiarachchi,[3,6] D. Lo Seen,[4] O. Batelaan,[5] S. Sooriyarachchi,[3] L.P. Jayatissa,[3] and N. Koedam[2]
[1]Biocomplexity Research Team and
[2]Laboratory of General Botany and Nature Management
Mangrove Management Group
Faculty of Sciences
Vrije Universiteit Brussels
Pleinlaan 2
B-1050 Brussels
Belgium
[3]Department of Botany
University of Ruhuna
Matara
Sri Lanka
[4]French Institute of Pondicherry
Post Office Box 33
11 St. Louis Street
605001 Pondicherry
India
[5]Department of Hydrology and Hydraulic Engineering
Faculty of Applied Sciences
Vrije Universiteit Brussel
Pleinlaan 2
B-1050 Brussels
Belgium

Summary

The increasing anthropogenic pressure on natural environments results in impacts that affect tropical forest areas and their biodiversity [1, 2]. Adverse impacts on terrestrial and oceanic environments often compound in the intertidal area, where mangrove forest ecosystems thrive. In tropical coastal areas of many developing countries where people depend on wood and other mangrove forest products and services, forest degradation leads to socioeconomic problems. At the same time, increasing freshwater needs in these areas are expected to cause additional problems [3–5]. On the basis of remote sensing and ground truthing complemented by colonial archival material from the Dutch East India Company (1602– … that changes to the historic system … ter management have increased dra… t times. Hydrological changes, such … nsfers, have resulted in a qualitative … ocioeconomic degradation in three … in southern Sri Lanka. Variations in … have caused changes in the areas … rove habitat and, thus, have resulted … ribution. However, increases in mangrove area can mask the degradation of the site in terms of floristic composition, significance of the species, and biodiversity (this effect is termed "cryptic ecological degradation"). It is important that such changes be carefully monitored to ensure biological and socioeconomic sustainability.

…n van de Universitaire Stichting van België, …000 Brussels, Belgium.
…hdouh@vub.ac.be
…ibuted equally to this work.



Results and Discussion

Sri Lanka has a long-standing tradition of water resource management. For several millennia, lake-sized water reservoirs sustained highly developed cultures, even in the dry environments of Anuradhapura, the Sinhalese capital from 437 B.C.E. to 1017 C.E., which developed into a metropolis of great importance [6]. This former capital is now a UNESCO World Heritage Site [7]. Out of an estimated 30,000 man-made reservoirs built in ancient times, over 10,000, with a total area exceeding 170,000 ha, are still scattered across the country, and many are restored and functional today [8].

In the 20th century, the freshwater needs of people have led several Sri Lankan governments to initiate major water management projects for socioeconomic development. Irrigation has been prioritized, but the technology and magnitude of contemporary hydrological projects are different from historical water-management policies. Storage reservoirs and diversion weirs have been used for irrigation since ancient times [9], but increasingly the diversion of river systems is used in freshwater management.

The Walawe Ganga river basin (Figure 1) has historically been used by man for irrigation purposes, as shown by an ancient water course near the Samanalawewa Dam. Archaeological remains of a first millennium C.E. iron-smelting industry [10] and an ancient Hambegamuwa Reservoir [11] have been found upstream, whereas downstream the legacy of ancient Sinhalese irrigation systems is represented by the Thenketiya diversion channel and the Magama or Urusitta Reservoir [9, 11]. With the foundation of the Irrigation Department at the beginning of the 20th century and the adoption of a Water Resources Development Plan in 1959, modern irrigation and hydropower development began. The Udawalawe Scheme was constructed between 1964 and 1981 and formed the 3,400 ha Udawalawe Reservoir, containing $268.76 \times 10^6\ m^3$ water at full supply [4, 12], and associated canals. The purpose of the Udawalawe Scheme was to provide irrigation water for 32,000 ha of newly developed land, particularly paddy fields, and to generate hydroelectricity [13]. Consequently, additional freshwater was diverted into the river basins of the nearby Kuchchigal Ara, Urubokka Oya, and Kirama Oya rivers (Figure 1). The aim of this study is to quantitatively and qualitatively assess the biological impact of these transitions from ancient small-scale to modern large-scale freshwater resource management on the biota and human population in a set of three coastal lagoons. To investigate this, we used a unique interdisciplinary approach that tran-

Current Biology 15(6)
29 March 2005

substrates depend on binding at this site, there are probably additional substrate recognition sites. Another contribution to substrate selection is made by scaffold proteins, e.g. AKAP79, which target the phosphatase to neuronal synapses or other cellular sites. Calcineurin also delegates work to protein phosphatase 1 (PP1) through a phosphatase cascade, in which dephosphorylation of the PP1 antagonists DARPP-32 or inhibitor-1 by calcineurin relieves their inhibitory effect on PP1, and allows PP1 to act on its own preferred substrates.

What are its inhibitors? Cyclosporin A (CsA) and FK506 bind tightly to the abundant intracellular proteins cyclophilin A and FKBP12, respectively, and the resulting ligand–protein complex binds to calcineurin and impedes access of protein substrates to the active site. Blockade of a biological process by CsA and independently by FK506 is diagnostic for calcineurin involvement. Other inhibitors that find frequent experimental use are the autoinhibitory peptide from calcineurin and fragments of the regulatory proteins DSCR1/MCIP/calcipressin/Rcn1p, Cabin1/cain, and AKAP79.

Does it have any medical relevance? Calcineurin signalling is prominent in transplant rejection and autoimmune disease, where the inhibitors CsA and FK506 are used clinically, and is being studied for its contribution to myocardial hypertrophy and to virulence in fungal pathogens.

Where can I find out more?

Aramburu, J., Rao, A., and Klee, C.B. (2000). Calcineurin: from structure to function. Curr. Top. Cell. Regul. *36*, 237–295.
Rusnak, F., and Mertz, P. (2000). Calcineurin: form and function. Physiol. Rev. *80*, 1483–1521.

The CBR Institute for Biomedical Research and Department of Pathology, Harvard Medical School, Boston, Massachusetts 02115, USA.
E-mail: hogan@cbr.med.harvard.edu

Essay

How effective were mangroves as a defence against the recent tsunami?

Whether or not mangroves function as buffers against tsunamis is the subject of in-depth research, the importance of which has been neglected or underestimated before the recent killer tsunami struck. Our preliminary post-tsunami surveys of Sri Lankan mangrove sites with different degrees of degradation indicate that human activity exacerbated the damage inflicted on the coastal zone by the tsunami.

F. Dahdouh-Guebas[1*], L.P. Jayatissa[3*], D. Di Nitto[1], J.O. Bosire[4], D. Lo Seen[5] and N. Koedam[2] (* = equal contribution)

Mangrove forests have iconic status as natural ecosystems that provide services to humans. They function as breeding, spawning, hatching and nursing grounds for marine and pelagic species, and are important in the daily livelihood of local human subsistence communities. Mangrove representatives such as *Rhizophora* spp. also function as a physical barrier against tidal and ocean influences by means of their large above-ground aerial root systems and standing crop. Like many habitats, mangrove forests have been degraded and destroyed by humans, and their loss is a source of global concern. In the second half of the 20th century, 50% of the world's mangrove forests have been destroyed, and current annual loss rates vary from 1 to 20% [1]. Ironically, the great human tragedy of the recent December 26th tsunami may provide the stimulus for a better understanding of what mangrove forests can and cannot do for human well-being.

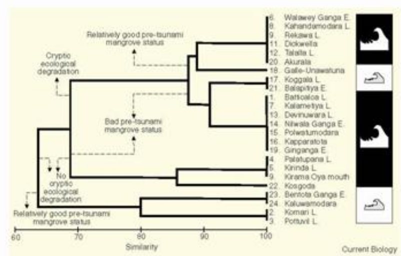


Figure 1. Dendrogram generated by a cluster analysis of the 24 mangrove sites investigated, indicating their characteristics and the impact of the tsunami (big wave, severely impacted; small wave, little impacted).

The 'mangrove status' is a combination of pre-tsunami aerial extent of the front mangrove and pre-tsunami mangrove destruction (see text). The tsunami had only a small impact on lagoons that show no cryptic ecological degradation (sites 2, 3, 23 and 24) or that are protected by the distance from the shore and by frontal *Rhizophora* spp. fringes (sites 17, 18 and 21). The lagoons are numbered clockwise from East to West, to emphasize that damage was not linked to geographic position in view of tsunami wave energy. A map overview of all lagoons can be found in Jayatissa *et al.* [18], with the exception of Batticaloa, Komari and Potuvil, which are located at the easternmost extremity of the island. L, Lagoon; E, Estuary.

Current Biology 15(12)
21 June 2005

Recent natural disasters (2004-2008)

- 26 December 2004 : Indian Ocean tsunami
  ca. 230000 human casualties
  ??? billion € damage
- August 2005 : Hurricane Katrina (US)
  2541 human casualties
  60.8 billion € damage
- November 2007 : Cyclone Sidr (IN-BD)
  ca. 3400 human casualties
  1.2 billion € damage
- May 2008 : Cyclone Nargis (MM)
  ca. 200000 human casualties
  6.8 billion € damage

New research questions (2009)

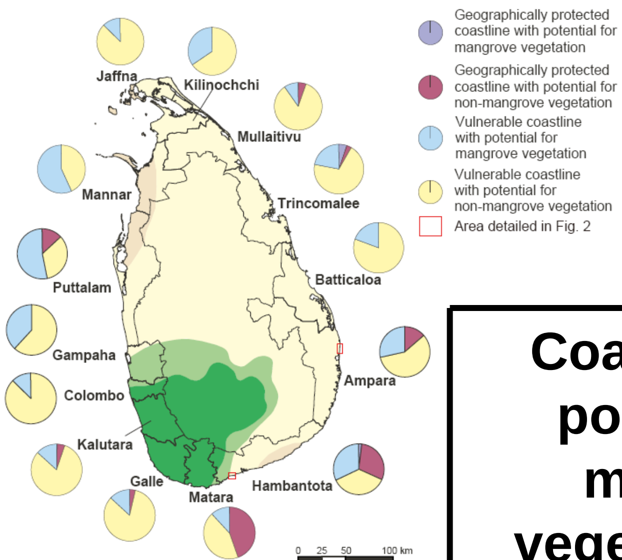
- Can bioshields protect the coast ?
- Can bioshield provide shelter for the "storm" ?

A **bioshield = coastal vegetation structures** (both natural and planted) expected **to protect** the coast from natural disasters (e.g. mangroves, *Casuarina* plantations,…)

A **"storm" = real storm, cyclone wave surges, tsunamis, excessive rain,…**

→ Interdisciplinary case-study on the potential for mangroves to protect Sri Lanka.

New research answers (2009)



	Coastline with potential for mangrove vegetation (km)	Coastline with potential for non-mangrove vegetation (km)	Total (km)
Vulnerable coastline (km)	523 **<33%**	1057	1580 **>90%**
Geographically protected coastline (km)	15	143	158
Total (km)	538	1200	**1738**

New conclusions
(in press for *Conservation Letters*)

- We should use bioshields, not misuse them
  - *Casuarina* plantations may negatively affect turtle nesting areas
  - mangroves can protect but they do not grow everywhere
  - there is nothing wrong in restoring mangroves where they have been previously destroyed

- We should investigate where to use which type of bioshield :