EU EDF 8/9 – SOPAC Project Report 53

Reducing Vulnerability of Pacific ACP States

TECHNICAL REPORT
ANALYSIS OF COASTAL CHANGE AND EROSION – TEBUNGINAKO VILLAGE, ABAIANG, KIRIBATI

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Summary / Introduction

This work was undertaken as part of the SOPAC EU Reducing Vulnerability in Pacific Island States Project and was designed to address the issue of coastal erosion at Tebunginako Village, Abaiang Island.

Areas of the lagoon coast of Tebunginako have receded up to 80 m since 1964 and erosion is reported by the village elders to have been an ongoing problem for as long as they can remember.

The village community, island council and PWD (Public Works Department) have all undertaken coastal protection works of various types and at various times but all have essentially failed. More recently, the lagoon waters have broken through to a formerly freshwater pond bordering the village, killing vegetation, causing seawater flooding in some households and changing local groundwater quality.

The village community intends to pursue further protective work but wishes to understand why erosion continues to attack parts of this coastline so as to better design such works. Previous studies find no evidence that erosion is being caused by coastal engineering and it is surmised that Tebunginako is simply a large northward moving sand bulge.

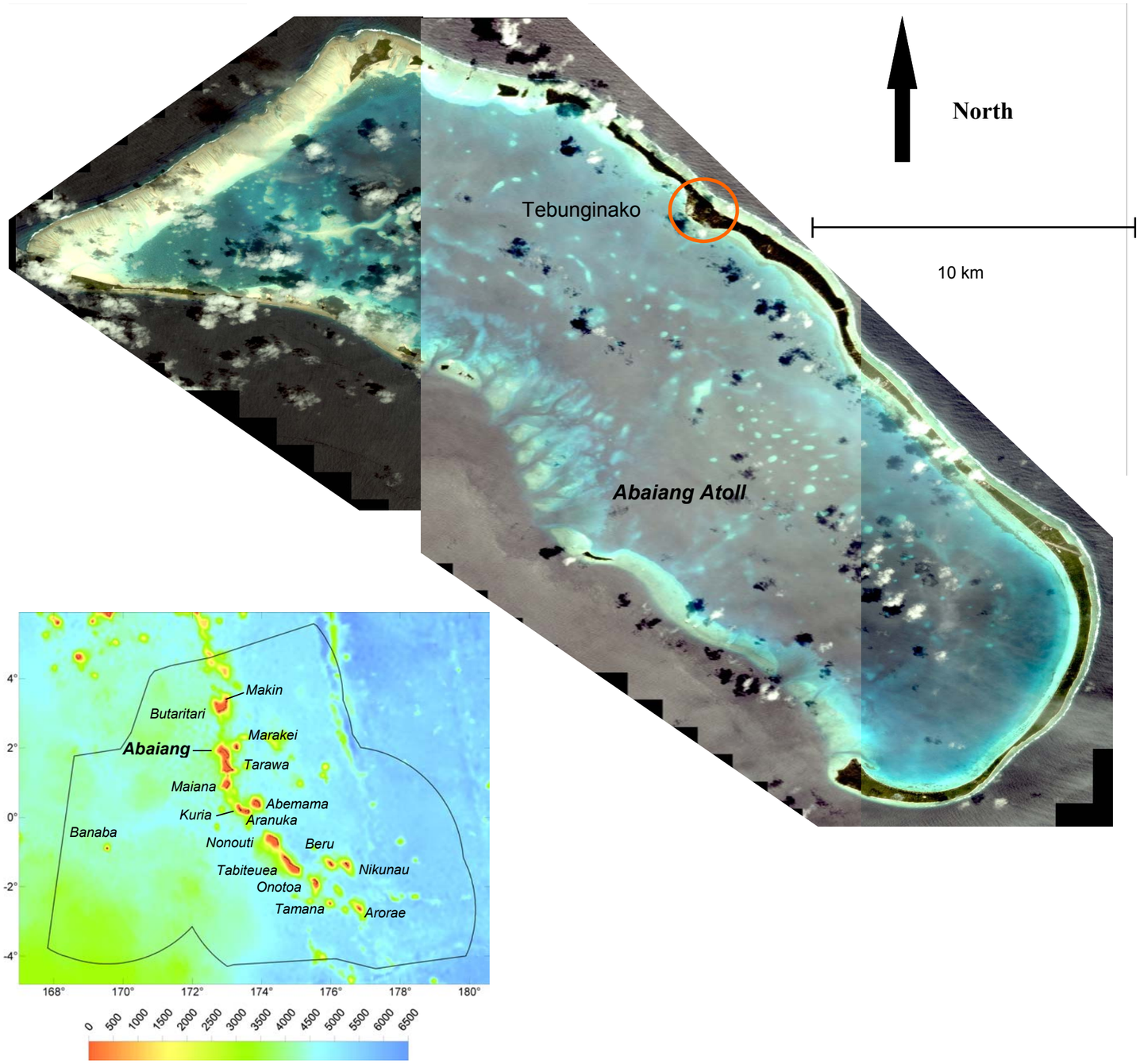
This study used multi-temporal aerial photographs and satellite image comparisons, combined with detailed interpretation of digitally enhanced historical images to develop a more comprehensive understanding of coastal processes in this area.

It was found that immediately south of Tebunginako Village was previously (*ca*. 100 — 150 years ago) the site of an ocean / lagoon passage. The extensive shallows immediately off the lagoon shore from the village, are the result of sand transport through this former passage (depositional fan). Likewise, the widening of the island at Tebunginako is the result of shoreline processes consistent with an ocean / lagoon passage.

Ground truthing confirmed this hypothesis and later graphic presentation of the study to the Tebunginako community found general agreement that there was an oral history that such a channel existed (possibly about 100 years ago). Indeed the name of the land in the area immediately south of Tebunginako is *Terawabono* – “the blocked channel”.

The coastal instability experienced at Tebunginako is therefore an ongoing adjustment of this shore to the blocking of the channel and consequential halt of sand supply from the ocean to the lagoon beaches. Predominant northerly transport on the lagoon coast continues to redistribute material accumulated by the former channel northwards, causing erosion in the southern areas of the bulge and accretion in the northern areas of the village.

With a clear understanding of why shoreline instability has been a dominant feature of their coast, the village elders and community agreed to consider an alternative approach to this issue. Rather than try to rebuild seawalls, they accepted their resources may be better used moving important village buildings to more stable ground. It was also understood that a removal of vulnerable households to better sites and eventual movement of the village to areas east of the road represented the best long-term solution to this issue.



Abaiang location map within the Kiribati Group and the 2004 IKONOS satellite image of Abaiang Atoll. The satellite image shows the location of Tebunginako Village (red circle) and its unusual form. Note that “Tebunginako” literally means “jutting out” in reference to the bulging shape of the area in relation to the rest of the coastline (location map source; Smith, W. H. F., and D. T. Sandwell, 1997).

Background

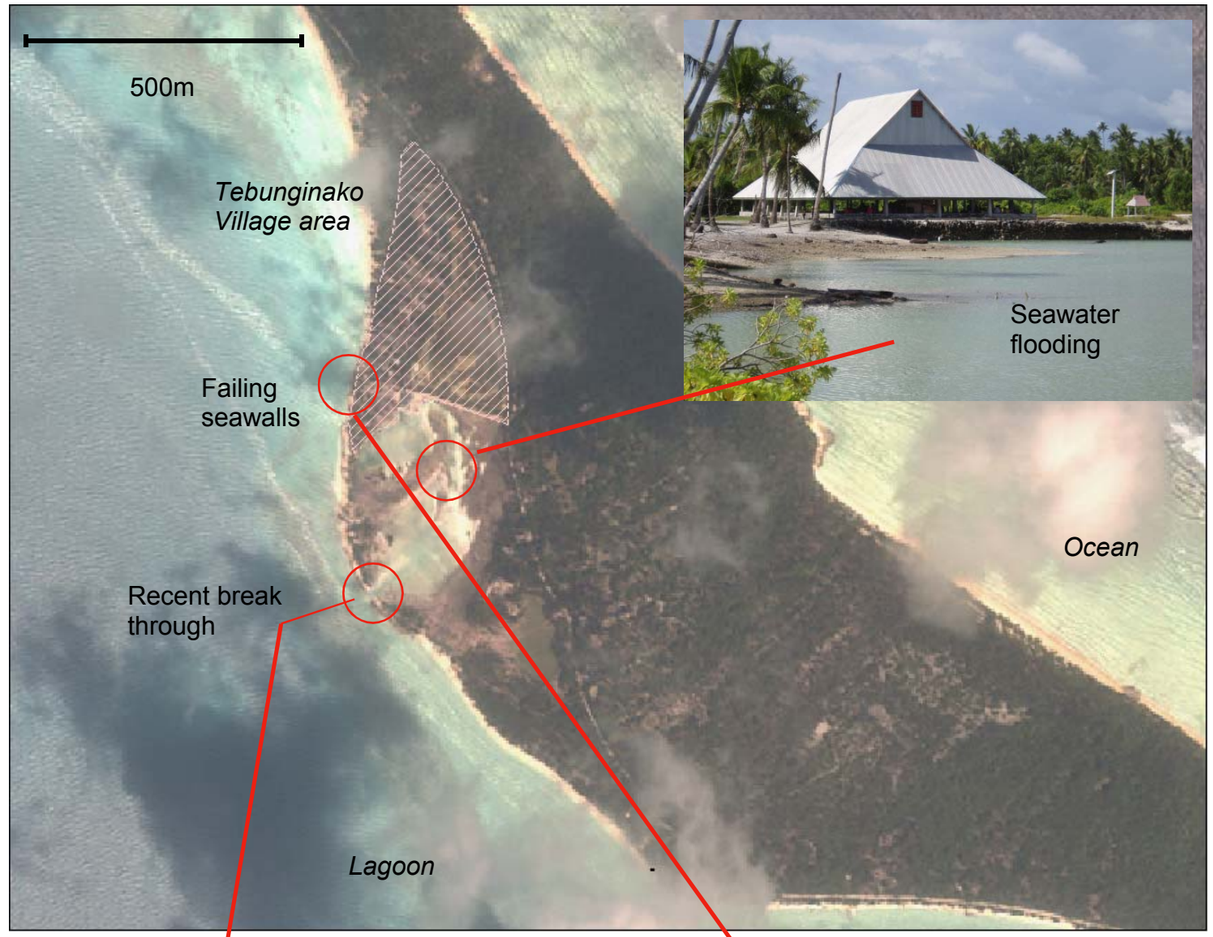
The lagoon side coast of Tebunginako Village, Abaiang (see adjoining images) has experienced ongoing erosion for many years. The issue was first documented by Harper in 1989 and later by Holden in 1992 (both SOPAC reports). This additional analysis was made in response to further requests by the village via the Ministry of Fisheries and Marine Resource Development (MFMRD), Kiribati and was addressed as a component of the SOPAC-EU Kiribati Work Plan (Tasks KI 3.4.1 and KI 3.5.1). This study sought to assess the actual reason for the continued instability on the coastline and thereby provide the villagers with the best possible advice regarding mitigation recommendations.

In response, two site visits were made by a joint SOPAC/EU Project and MFMRD team in July and November 2005. The first trip consisted of a brief site visit and discussions with village elders. Following this, a desk-top study was undertaken at the SOPAC Secretariat using image rectification methods and multi-temporal image comparisons (ERDAS Image® and MapInfo®). Digital image enhancement of historical aerial photographs was also undertaken allowing better interpretation of salient features, which in turn led to a revised assessment of processes at work on Tebunginako's coast. During the second trip ground truthing was undertaken which confirmed the alternative hypothesis and the results of the study and recommendations were presented to the Tebunginako Village community.

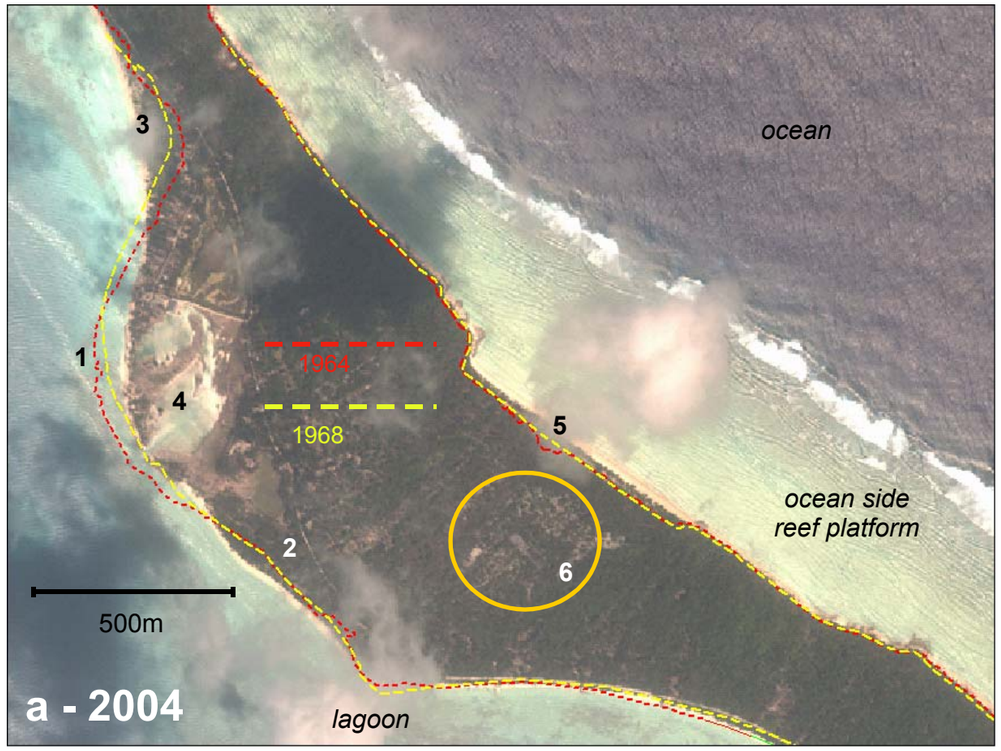
The results were formulated into a graphical presentation which was projected onto a large screen within the village "*maneaba*" (meeting house) by the use of a laptop, projector and small generator. The presentation was an extremely effective tool to guide the villagers through the findings and allowed the team to clearly impart an understanding of the processes which caused coastal instability at this location. Following the presentation, there was a general consensus that the village was better able to accept the recommendations as they now understood why the shoreline was eroding in some areas. Lastly, the village elders requested the author to leave behind images which explained how Tebunginako had changed over time so that they might review these findings during subsequent meetings to discuss the future of the village.

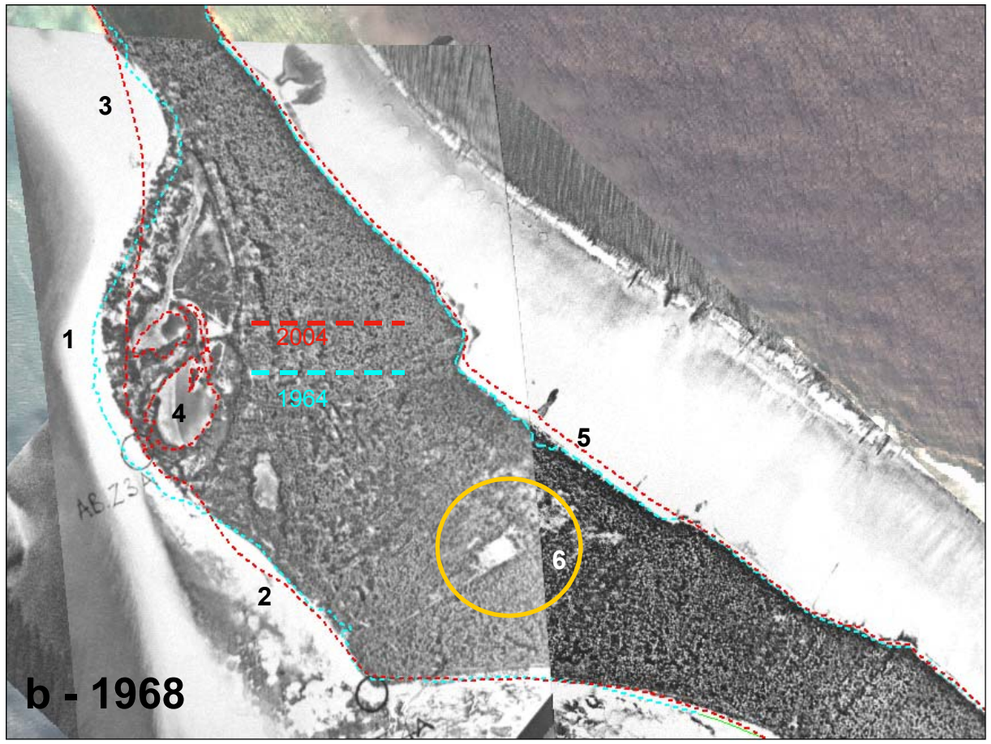
This graphical guide to the coastal processes study of Tebunginako Village is a response to that request. Whilst many of the graphics are self explanatory, additional text allows for more in-depth understanding and it is hoped that this report format will remain informative and useful as a reference at multiple audience levels.

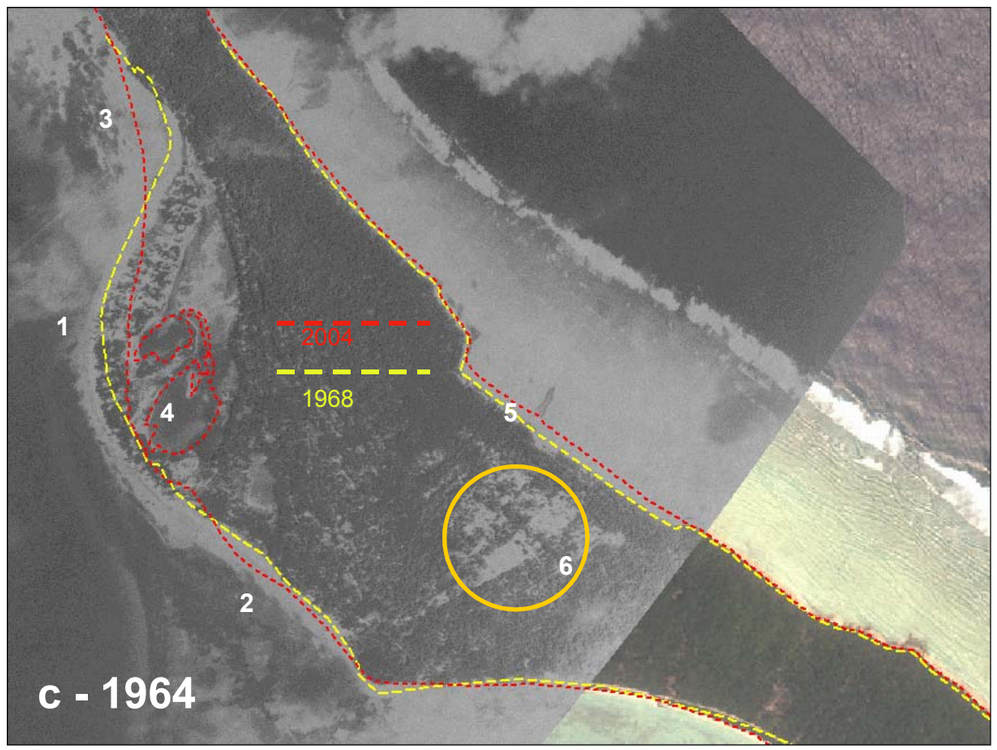
All of the historical aerial photographs and the IKONOS satellite images are orientated identically to grid north (UTM / WGS 84) and the GIS layers and historical rectified images produced during this study are available as MapInfo® files via the SOPAC Secretariat (an indication of individual scale on different images throughout the report is given where appropriate). The purchase of the 2004 IKONOS imagery and geo-referencing was also undertaken as part of the SOPAC-EU Reducing Vulnerability Project. Historical aerial photographs were sourced from the SOPAC Secretariat Archives.



The 2004 satellite image close up of the Tebunginako Village area and a summary of the issues presently faced by the village. Seawall failure, erosion of the sand bank and subsequent break through of lagoon waters into a formerly freshwater pond. Also, nuisance seawater flooding on the village boundary.





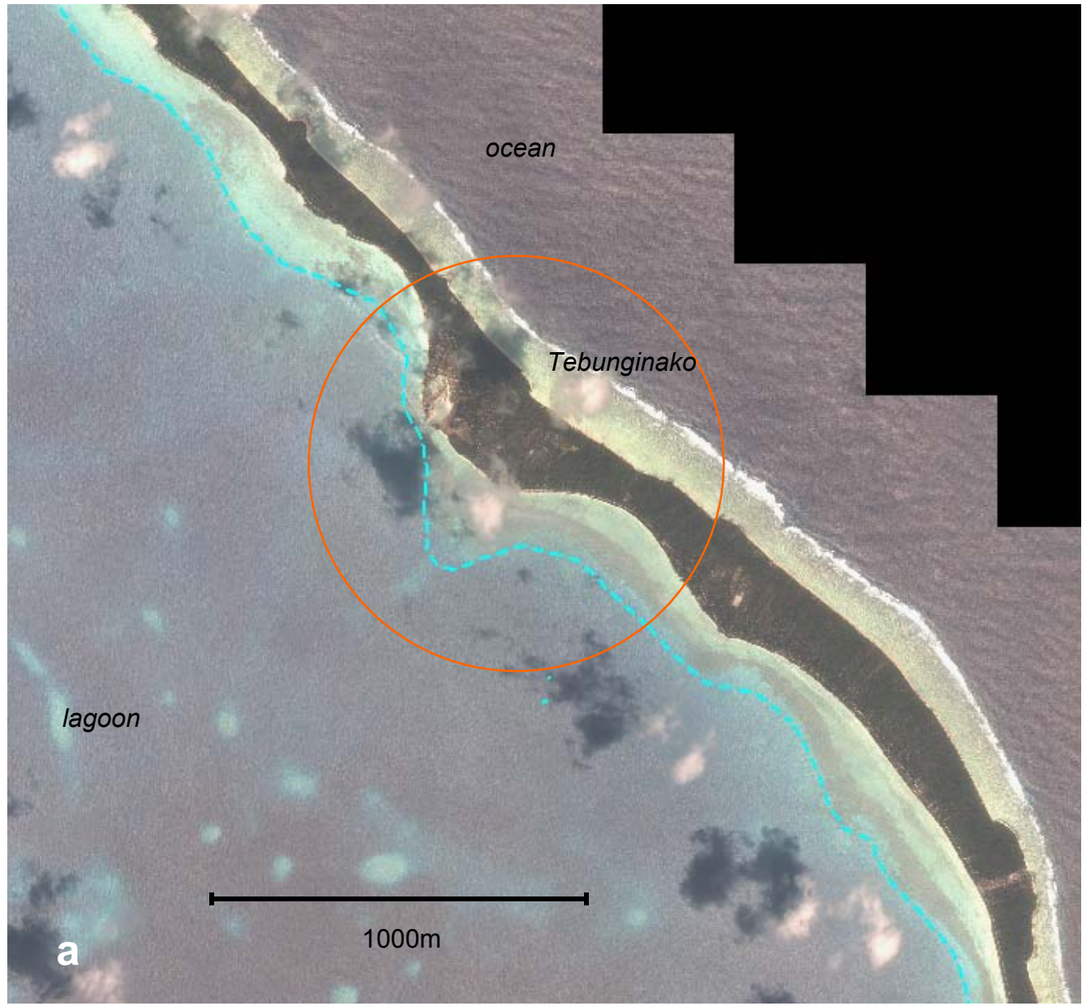


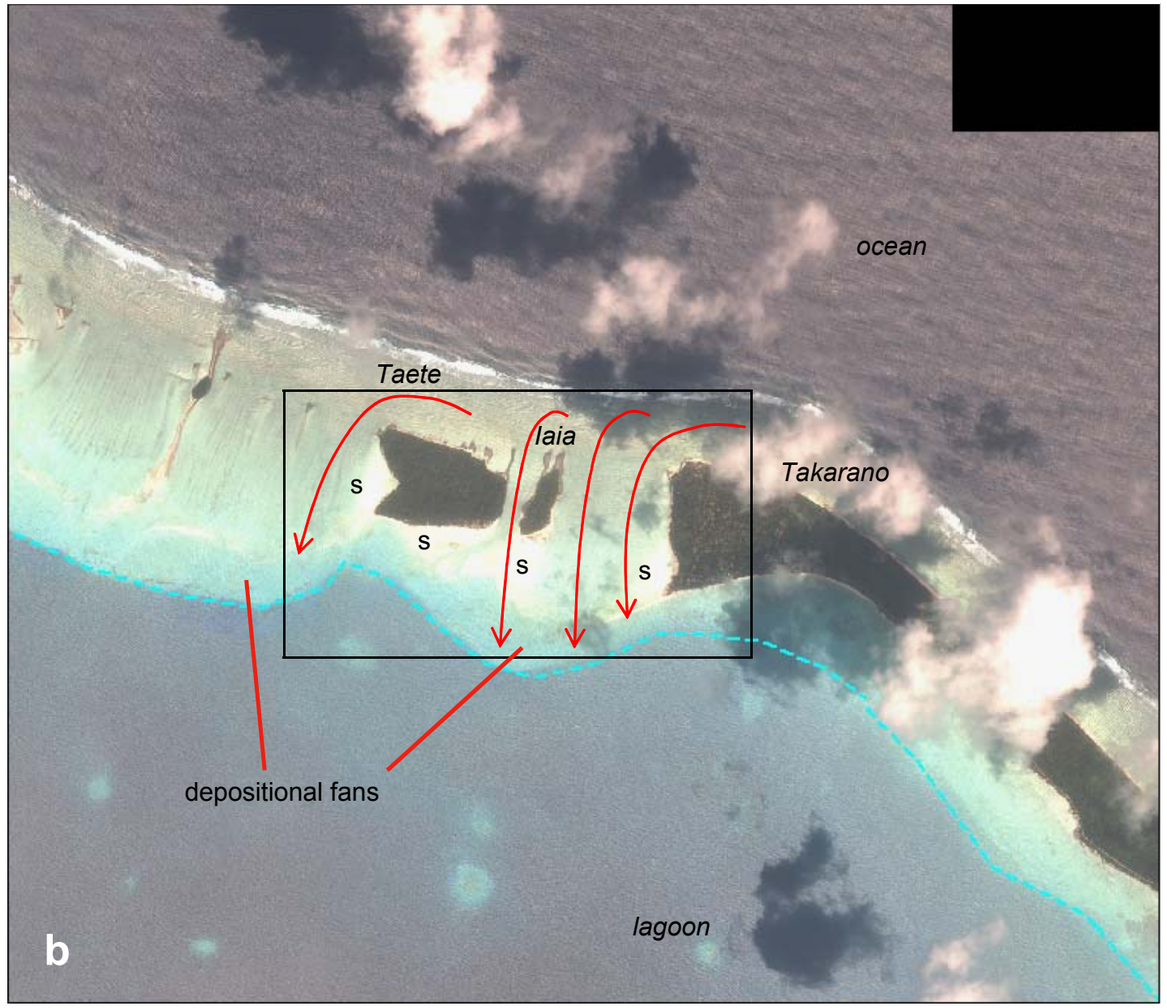
Historical coastline changes (multi-temporal comparisons)
These figures show a comparison of the Tebunginako Village area in 2004 (**a**), 1968 (**b**) and 1964 (**c**). The superimposed shorelines shows the large degree of shoreline change particularly on the lagoon coast (note all images are of identical scale and orientation and the black and white historical aerial photo boundaries can be seen where they over lay the base satellite colour image).

In 2004 (**a**) the position of the 1964 (red) and 1968 (yellow) coastlines show that approximately 2.73 Ha (6.7 acres) of land has been lost in area (1). However about 2.56 Ha (6.3 acres) of land has also accreted (built up) in areas 2 and 3. This shows that whilst there has been erosion at some locations (e.g. 1) the sediments are being redeposited in other locations. At location 3 the shoreline has accreted by nearly 100 m since 1964, overall there has only been a net loss of 0.165 Ha (0.41 acres) of land over the last 40 years.

Of particular concern to the village community however, has been the recent break through of lagoon waters into the freshwater ponds south of the village (4). In this area the shoreline has eroded about 50 m since 1964.

The historical aerial photographs (**b** and **c**) show some additional important information which gave clues as to what processes have been at work in this area during the last 100 years or so. Location 5 shows that a section (about 650 m long) of the ocean-side coast has also prograded (moved out) by some 20 m since the 1960's. The area in 6 (orange circle) shows a persistent feature in the vegetation of this area. Note the poor / sparse vegetation (whitish area) and the persistent curving boundary to the south of this feature. This is thought to be a prograding shoreline of the now in-filled channel and similar line features (running approximately parallel) can be detected over much of Tebunginako.





How did Tebunginako's unusual shape form?

Figure (**a**) shows the Tebunginako area (red circle) in relation to the rest of the island. As mentioned the name "Tebunginako" refers to the way in which this area bulges into the lagoon and as can also be seen, a large corresponding shallow area also projects some 800 m into the lagoon from the shore. Elsewhere the lagoon coastal shallows are only half this width. Earlier studies (Harper, 1989 and Holden, 1992) simply refer to Tebunginako's unusual land form as a moving sand bulge, this implies a randomness of origin which maybe misleading. In these environments, such bulges and shallow protrusions are consistently associated with ocean to lagoon channels and openings where sand transport through from the windward ocean reef to the lagoon environment builds a depositional fan (see Figure **b** – note both figures are of identical scale and orientation).

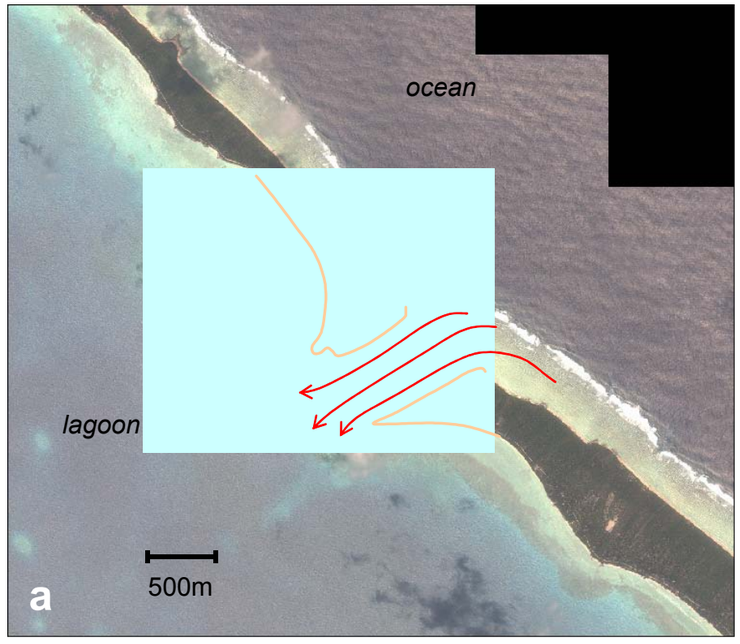
The northern point of Abaiang (*Takarano* Figure – **b**) is a clear example of island widening and depositional fan formation. Sand transport from the ocean to the lagoon has produced large depositional fans into the lagoon (see figure **b**) and sand shoals (**s**) on the leeward points of the islets. Some sand from these shoals is moved onto the shoreline slowly widening the island and some will move over the reef flats contributing to the depositional fans. Note the close relationship between the depositional fan's shape (blue line) and the position of the channels and islets. This pattern can be found throughout the lagoon atolls of Kiribati and it is strong evidence that the bulge and extensive shallow area of Tebunginako was also formed by such a channel in the past.

The large white sand deposits or shoals (**s**) in Figure **b**, also help explain how channels may slowly become in-filled and can eventually close. In turn, such areas are often quickly planted and occupied since they represent new land. Unfortunately, such areas often remain unstable for many years and new settlers may find their new land disappears as quickly as it arrived.

This natural ongoing process is often associated with prevailing easterly (Trade) winds in these environments (Webb, 2005). Easterly winds produce consistent near-shore currents which move sand (northwards in this case) along the beach (= long-shore transport). Sand continues to move in this fashion until it is either lost off the end of an islet (into deeper ocean or lagoon areas) or enters an ocean / lagoon channel (as in Figure **b**) where it contributes to the formation of shoals, island widening and depositional fans.

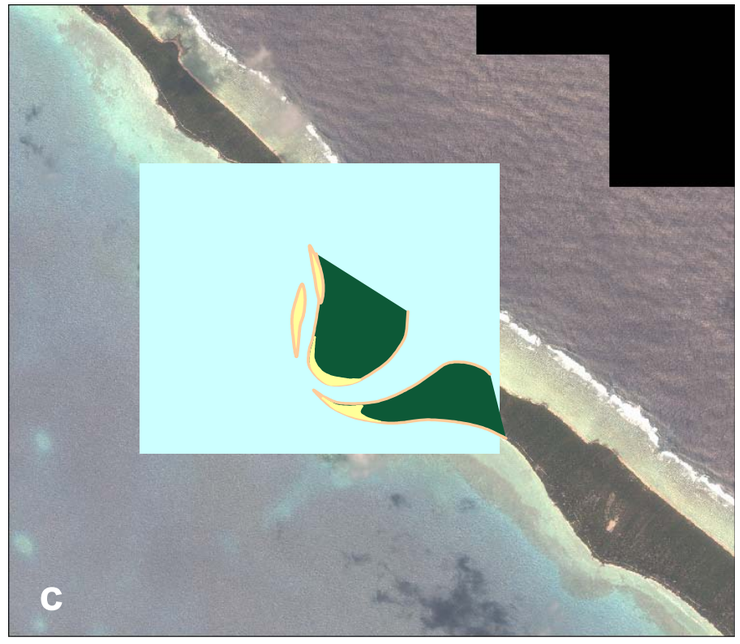
On neighbouring Tarawa Atoll, nearly 100% of the seawater flow through North Tarawa's ocean channels was towards the lagoon, at rates up to 1 m / second during normal easterly wind conditions (Damlamian and Webb, 2006). Since the northern arm of Abaiang and North Tarawa are very similar in orientation and form, it is expected that a similar flow pattern occurs in the northern part of Abaiang. This explains why such large amounts of sand accumulate at the end of these island features (figure **b**) and produce such extensive shallow depositional fans in the lagoon.

Reconstruction of coastal changes in Tebunginako

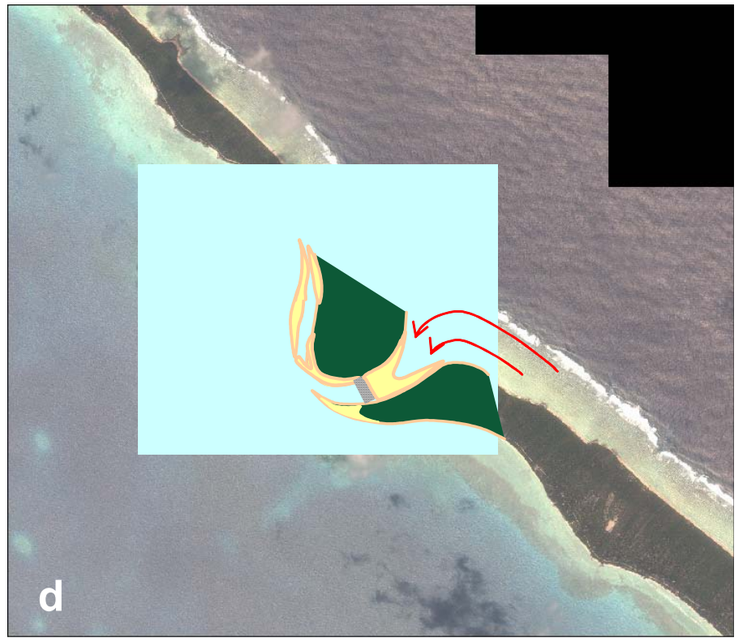


(a) This series of images re-constructs the likely shape and events which formed the bulge and shallows of Tebunginako. **a**) This image shows the likely extent of Tebunginako channel before it was settled as a village site. (All images are of identical orientation [true north] and scale).

(b) Over time the channel fills with sand and eventually becomes narrower and shallower. The persistent northern sand transport pattern not only supplies this sand from the ocean reef through the passage but on the lagoon side it pushes a sand spit extending to the north.



(c) The channel continues to narrow and the sand spit extends further north. The shape and migration of the lagoon-side sand shoal formations can only be guessed and may not have occurred exactly as is shown here.



(d) At some time, about 70 to 100 years ago, villagers built a causeway across this channel (this area is still known as "*Terawabono*" – "the blocked channel". This stopped the supply of sand moving to the lagoon side.

(e) With sand supply blocked the channel on the ocean side quickly infilled (red arrows). On the lagoon side the unstable sandy spit moves and changes shape since the supply of sand from the ocean has stopped. Low areas which were once part of the lagoon / channel are isolated from the sea and over time become freshwater ponds (p).

(f) Today, many people now live on this new land; however, the Tebuginako coastline is still moving and is unstable. The sand bank between the freshwater ponds and the lagoon has eroded to a thin strip and lagoon waves have now broken through, flooding settled areas with seawater.

Ground truthing Tebunginako coastal processes study

The underlaying historical 1964 aerial photograph opposite, clearly shows some important additional features and gives a clear impression of the extent of shoreline change over the last 40 years (yellow line – 2004 coastline).

(1) Note that in 1964 the ocean side of the Tebunginako channel area was still in the process of infilling. The distance between the 2004 coast and 1964 coast is 20 to 25 m.

(2) There is an obvious boundary between the coconut woodland (dark) and the pond (whitish area) in this photo. This is thought to be close to the original position of the lagoon shoreline. Inset photo is taken from high ground and shows houses built lower than the former shoreline.

(3) These bare sandy areas are persistent in the 1964, 1968 and also the 2004 images. Ground truthing revealed that these are agriculturally poor soils and coconut palms in this area remain stunted and sparse. Such poor soils in these environments are commonly associated with recently accreted land as they have very low levels of organic matter and no top-soil layer.

(4) Beachrock consistent with a channel shoreline is present at this point. This fossil beach face is formed perpendicular to the shoreline and dips towards the north indicating this was the southern shoreline of the former channel. This is also adjacent to the area known as "*Terawabono"* ("blocked channel"). It is also important to note that this beachrock now acts to "pin" the present beach, particularly that in the south (groyne effect), and should not be disturbed under any circumstances.

(5) During consultations with the village of Tebunginako, an elderly gentleman indicated that his grandfather had told him stories of a time during his youth when an open channel separated Tebunginako from the rest of Abaiang. Assuming his age to be some 60 years and his grandfather likewise, it is guessed that the channel was blocked some 100 years ago.

Recommendations

The people of Tebunginako have settled in areas which are unstable and the shoreline will continue to change over time for many years to come. Over the last 30 years the people of this village have spent a huge amount of time, energy and money trying to stop the natural movement of the lagoon shoreline. This has failed and much of the protective structures built have been destroyed by ongoing shoreline change and westerly gales (**1**).

In past times, people lived in harmony with shifting coastlines and their local buildings could be easily moved if the shoreline changed (**2**). May of the houses in Tebunginako are still local but some large and important buildings (the village maneaba and church) are built of permanent materials and can not be easily moved (**3**).

During discussions with the people of Tebuninako Village it was agreed that the changes on their coast were caused by the blocking of the channel many years ago and that this coast would remain unstable for many years to come. It was also agreed that it would be better to use their time, effort and money to rebuild important buildings east of the road on high safe ground (**4**) and not to try and rebuild seawalls. It was understood that there was no need to move the whole village right way. In some areas accretion is occurring (the land is getting bigger) and so long as local houses are built in these areas, they could always be moved if need be. Certainly, permanent buildings should not be built anywhere west of the road and people in flooded areas should also be encouraged to move east of the roadway (**4**).


1


2


3

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