

# Tropical Cyclone ZOE

Tikopia and Anuta  
Solomon Islands

December 26 – 29, 2002



## Introduction

Severe Category 5 Tropical Cyclone Zoe, was the most intense cyclone ever to be forecast and monitored by the Fiji Meteorological Service in the southwest Pacific region. Weather services around the world watched Zoe's development and movement with interest as the system intensified and concern was raised that landfall may eventually be made in Fiji.

International interest in the progress and impact in this system was intensified when it was evident that Tikopia and Anuta in the Solomon Islands, two of the worlds smallest and most remote islands, had suffered the full fury of the storm over several days. Communities living on these islands were known to have been without two-way communication with national and international weather services and there was a very real possibility that they had been unwarned and unprepared.

Following the IWTC in Cairns earlier in December there was a raised awareness of the need for scientists from all disciplines, specialising in tropical cyclones, to cooperatively and collectively evaluate the detection, forecasting, monitoring and impact of landfalling severe tropical cyclones. Ideally this should be achieved through the conduct of internationally cooperative, multi-disciplinary case studies. Cyclone Zoe has presented the opportunity for such a case study.

Prepared by Linda Anderson-Berry (Bureau of Meteorology Australia / JCU Centre for Disaster Studies); Chanel Iroi and Alan Rangi (Solomon Island Weather Services) The discussion includes an evaluation and description of the physical and societal impacts of Cyclone Zoe on the islands Tikopia and Anuta and their resident communities. It further evaluates the effectiveness of warnings for this event and recommends strategies to support warning services for future events.

### Partners and Stakeholders

- Bureau of Meteorology -Australia (Jim Davidson, Jeff Callaghan, Ray Canterford. Alan Sharp, ?Linda Anderson-Berry)
- Solomon Island Weather Service – Solomon Islands (Channel Iroi, Alan Rangi)
- Bureau of Meteorology – New Zealand (Steve Ready)
- Fiji Meteorological Service RSMC – Fiji (?, Alipate)
- Tropical Cyclone Commission – South Pacific (Steve Ready)
- James Cook University Centre for Disaster Studies (Linda Anderson-Berry, David King)

# The Environmental and Societal Impacts of Cyclone Zoe and the Effectiveness of the Tropical Cyclone Warning Systems in Tikopia and Anuta

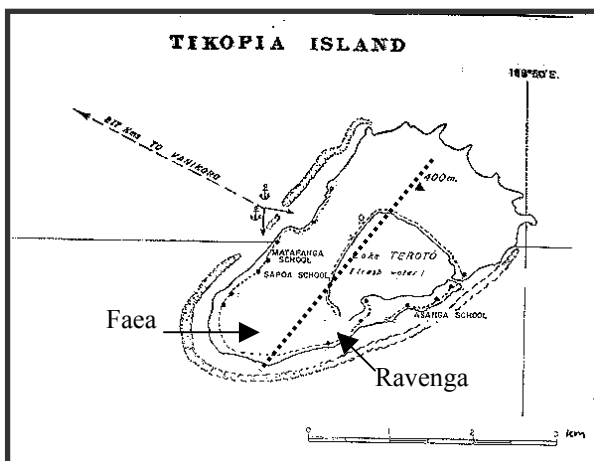
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This chapter is prepared in four sections. The first contains the field assessment report of the impact of Tropical Cyclone Zoe based on field observations in both Tikopia and Anuta and the experience of working with the UNDAC / OCHA assessment team. This is followed by discussions of the implications of the environmental impacts on the islands and the societal impacts for their resident communities. The final section deals with the issues surrounding the effectiveness of warnings and warning systems in the Solomon Island context.

## Tikopia

Tikopia and Anuta are the furthestmost islands in the Solomon Islands eastern province of Temotu. They are so distant and remote from the other islands in the province that they are usually included in maps only as insets.

Tikopia is located in the southwest Pacific Ocean at Latitude 12°15'30'' South and Longitude 168°50'00'' East. It is 1025 kilometres south east of the national capital of Honiara and 375 kilometres from the provincial capital of Lata on the island of Santa Cruz. The almost circular volcanic island is 4.5 square kilometres of land area with Lake TeRoto, a fresh water crater lake, located near the centre. The terrain around the lake is steep and hilly. Mt Riam, the highest point, is approximately 400 metres above sea level. A small flat coastal plain on the western side of the island supports almost half of the islands population (currently 1446 – 48% male, 52% female ). The Tikopians are Polynesian and are racially more closely related to the people of Vanuatu than the predominantly Melanesian Solomon Islanders. The predominant languages spoken are Tikopian and Solomon Island Pijin.



Tikopia is divided into two socio-geographic districts. The eastern side is known as Faea and the western side is Ravenga. The people live in villages in eight main communities, based on the church attended. All parishes belong to the Church of Melanesia. Village and district

distinctions are cross-cut by a system of four principal kinship groups, each headed by a chief. While the people are all Christian, they continue to acknowledge the authority of their four chiefs and adhere strongly to many customary practices and beliefs. Tikopians demonstrate a strong sense of cultural identity and even those who have lived away from the island for many years continue to feel attachment to the land and ‘belonging’ to the society.

**Table 1 Community settlement structure on Tikopia**

<b>Area</b>	<b>Community</b>	<b>Village/s</b>
Ravenga	St. Pauls	Namu
Ravenga	St. Marks	Asanga, Nuku, Fangarere
Ravenga	All Saints	Ravengalasi
Ravenga	St Johns	Tai
Faea	St Marys –	Faea
Faea	St Lukes	Faea
Faea	St Barnabas	Rofaea
Faea	St Michael	Rofaea

There is virtually no cash economy. Tikopian villagers follow a traditional substance life style, typically harvesting food from gardens, rearing chickens and catching and collecting seafood. The traditional currency is a rope made of feathers collected from the near-by island of Fatutaka, this is used primarily for payment of bride price and compensation. Some cash income is generated with the sale of marine products such as trochus shells, beche-de-mer and shark fin which are sold to buyers either locally or exporters in Honiara. A small but significant amount of money, sent from wontoks (relatives) working in other parts of the Solomon Islands or overseas is also injected in to the local economy. This most often passes through the economy as it is spent on educating a small number of students who have been fortunate enough to win places in secondary schools in Honiara.

Cyclone Zoe devastated Tikopia. High winds began battering the island late in the evening of Friday December 27, 2002, and for the next three days the island and the village communities were relentlessly pounded with cyclonic winds, storm surge and wind-driven waves. When the storm finally subsided the full extent of Zoe’s destructive forces began to be realised. Initial delays to an early emergency response resulted in the medical assessment team not arriving on Tikopia until Sunday January 5, 2003. The remainder of the combined NDO<sup>1</sup> / OCHA<sup>2</sup> assessment team arrived the next day. Details of the findings of the combined teams field assessment on Tikopia are as follows.

### Communications

<sup>1</sup> Solomon Islands National Disaster Office

<sup>2</sup> United Nations Office for the Coordination of Humanitarian Affairs

Prior to, during and immediately following Cyclone Zoe the people of Tikopia were totally without interactive communications with the rest of the world. The only 2-way radio on Tikopia belongs to the clinic, although it was generally available to the villagers. It had not been functional for several weeks prior to Cyclone Zoë. Two-way communications was only restored when the medical assessment team replaced the radio and batteries immediately upon their arrival. Access to broadcast media is limited to radio. SIBC<sup>3</sup> (Solomon Islands Broadcasting Commission) radio, transmitted via Lata, is received with relative clarity in the early morning and early evening. Reception at other times is poor. Radio Australia and Vanuatu radio stations are also received but are not widely accessed as residents prefer broadcasts in their familiar language of Solomon Island Pijin. Each village has access to at least one battery operated short-wave radio. Cyclone Zoë warnings were received via SIBC late from late Thursday December 26 until early Saturday 28 December - then transmission was lost. Warnings were missed in some villages as preparations for celebrations in churches were underway. Other residents warned some villagers. There are no telephones on the island. Intra-island communication is by word of mouth.

### Access



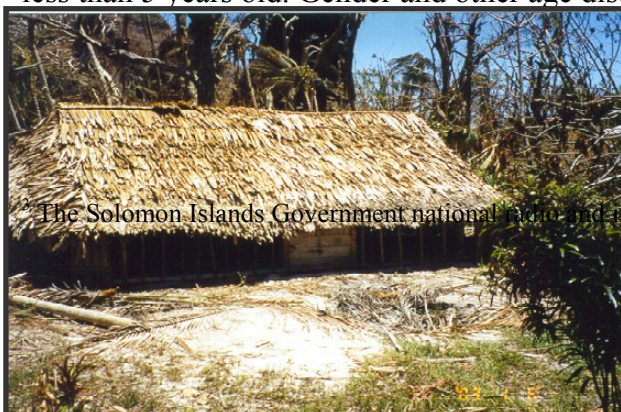
**Figure 1 Boats anchored off-shore – supplies brought to shore by dingy**

for helicopter landing. Access difficulties are responsible for hampering early and continuing emergency response activities.

As there are no vehicles or bicycles on the island there are no roads - only well defined walking tracks. Following Cyclone Zoë most of these tracks were blocked with debris and fallen trees. There is no airstrip and no jetty. Canoes and outriggers launch from the beach and the inter-island ships anchor offshore with cargo and passengers being transferred to shore in canoes or dinghy's. Ships to the island are irregular, averaging one every five months. The longest period between ships in 2002 was seven months. Some wide flat beach areas may be suitable

### Health and Human Population Details

The total population on Tikopia at the time of Zoë's impact was 1446, 191 (13.2%) being less than 5 years old. Gender and other age distribution details were not collected during



the assessment however 1999 Census data for Tikopia and Anuta indicates that 65% of the population is less than 18 years old and 14.8% is older than sixty

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<sup>3</sup> The Solomon Islands Government national radio and information network

years. This leaves just 20.2% of the population in the typically most productive 18-60 years age group. Population growth, averaged over the past 5 years, is 1.9%. This is lower than the national average of 3.2% - primarily because of internal migration. Between 15 and 20 live births are recorded annually. Amazingly no deaths and few injuries – one broken arm and relatively minor infections – were reported as a direct result of Cyclone Zoë. The village residents whose homes were washed into the lake or out to sea by the three large waves that came from the south east survived by sheltering in large groups (of 50 or more) under over-hanging rocks on higher ground. These were not caves and they became increasingly exposed as the wind stripped the surrounding ground cover. Diarrhoea, sepsis and boils, particularly in children, have increased significantly post-cyclone. Chronic health problems include TB and Diabetes. High levels of smoking and beetle nut chewing may also contribute to underlying debilitating health problems. Population considered to be vulnerable included 15 lactating mothers, five pregnant



women and four physically disabled. Limited medical services are available with only two resident health workers operating out of a clinic that has been in poor condition for several years. Drugs and medicines are in limited supply due to ongoing shipping difficulties. Flies, and to a lesser degree mosquitoes, have increased post-cyclone. Currently there is no malaria present. Health workers advise that there are no Anopheles mosquitoes (malaria vectors) on either Tikopia or Anuta, this seems unlikely and should be confirmed.

The island supports 329 households in 8 communities. A household is typically a nuclear family unit, the average size being 5 persons, living in a traditional style hut. Most also have a kitchen in a separate hut, although approximately 30% of households share kitchens.

During the cyclone several graves were washed open, only one body that was buried a few weeks ago was found exposed, others have presumably washed away. The body was quickly retrieved and re-buried and, while this was distressing, it was not considered to pose a health risk.

### Structural Damage

Structural damage was most severe in Ravenga - the eastern side of the island that suffered the effects of rain, destructive winds and storm surge. Faea on the western side was exposed to rain and severe winds. Overall it was estimated that approximately 70%





of the total village housing was severely damaged or destroyed.

**Figure 4a. Damaged hut – Faea**



**Figure 4b. Damaged hut Ravenga**

Most of the remaining 30% of dwellings were somewhat damaged. A total of 176 huts in Ravenga, almost all the dwellings in the district, were totally destroyed, many were

completely washed away. Numerous residents lost all their belongings and escaped with only the clothes they were wearing. These families are now living in very rudimentary shelters built from debris and black plastic sheeting. A majority of the 153 houses in Faea were also damaged or destroyed. Some with limited damage have been repaired with broken sago palm leaves. These repairs are a good temporary measure but are unlikely to last in the



**Figure 6. Remains of Asanga Primary School**

longer term. Approximately 330 dwellings across the island are in need of replacement or substantial repair. In addition to household dwellings most community buildings, constructed with both traditional materials and sawn timber with corrugated iron roofs were also damaged or destroyed. Three of the islands seven churches were washed away, one was destroyed and three sustained moderate damage. Both of the primary schools were destroyed with all educational materials lost. The clinic building was damaged but was still able to be used by the medical assessment

team - substantial repairs are urgently required. One of the two trade stores in Ravenga village was totally destroyed the other building was badly damaged but the stock was saved. The vast majority of buildings on Tikopia are traditional structures constructed with local materials. The normal life span of sago palm roof thatch is just two years; therefore all surviving structures on the island will need new roofs within the next 12-18 months. All traditional housing material on the island has been lost. It will take 6-12 years for sago palms to regenerate and even longer for structural timber. Tikopia will therefore not be able to approach self-sufficiency in building materials for at least 12 years.



**Figure 7a. &7b. Temporary shelter - Ravenga**

### Production Damage

Agricultural productivity on the island has been totally wiped out. All gardens on the hill slopes were destroyed by high winds, sand and salt spray. Those on lower ground were affected by wind and/or storm surge. Coconut palms were stripped, twisted or snapped.

Areas in Ravenga that previously supported swamp taro are now devoid of mud and covered with sand. Large fruit trees such as local avocado and breadfruit have been stripped and broken; any that survive will not produce fruit for 2-3 years. There is no productive capacity remaining in any of the gardens. Tikopians have typically practiced rotation cropping which includes a fallow period. In ideal conditions some arable land



would be available for planting however the cyclone has left the ground stripped of vegetation, humus and topsoil. It is now dry, hard, exposed and unsuitable for planting - even if any seedling stock were locally

available.

**Figure 8. Remains of Swamp Taro gardens**

**Figure 9. Any surviving Taro has begun to**





Agricultural officers advise that it is likely to take 2-3 years for taro to become available, and in excess of 5 years for coconuts. A more detailed agricultural assessment is currently being completed, early recommendations include the import of seedling stock



**Figure 11. Women fishing in the lake for the last of the fresh water Tilapia**

for green vegetables for the short term; root crops for the medium term; and fruit trees and coconuts for the long term re-establishing of gardens. Tools for gardening are also needed. An issue of concern is the possibility of introducing pests and disease with imported seedlings and planting materials. Prior to the cyclone the islands food crops were disease and pest free. A small number of domestic pigs and chicken provide a source of



**Figure 10a. Remains of gardens on Tikopia**



**Figure 10b. Gardens in Lata – for comparison to demonstrate what gardens on Tikopia would have looked like prior to Cyclone Zoe**

protein. Some survived the cyclone but stocks will need to be rebuilt. Ocean fish and seafood are likely to remain plentiful however the ability to catch fish has been seriously affected by the loss of equipment. In Ravenga 95% of the households lost their dugout canoes, fortunately most in Faea saved theirs by pulling them inland. New canoes can be built in 2 – 4 weeks depending on the availability of manpower and tools such as axes and adzes. Some large logs are locally available from uprooted trees however, given the large number required many will have to be imported from other parts of the Solomon Islands. At the time of the assessment, villagers had not re-commenced fishing as the seas were still considered to be too rough. Saltwater inundation of the fresh water lake together with in filling with debris, swamp mud and sand means that the four species of fish that have provided a reliable food source will not survive. Even if the lake becomes relatively fresh again over the next 12 – 18 months re-stocking from other islands will be necessary.

### Environmental Damage

The fury of Cyclone Zoë wreaked havoc on the physical environment and landscape in Tikopia. High winds stripped vegetation and salt and sand spray dried and 'burned' all vegetation not directly affected by storm surge and waves. With the exception of one small patch of relatively intact vegetation on a west facing hill slope there is no 'greenery' left on the island. Damage to flora is almost total. Many of the larger trees, including coconut palms were snapped or uprooted. In some places the ground was scoured down to bare rock by the rain and storm surge and several medium sized landslips are clearly visible. With the humus layer, topsoil and shade cover removed it is unlikely that vegetation will fully recover, except in the very long term.

In Ravenga, the storm surge and a series of three waves removed a 2.5 - 4 metre high sand ridge that had extended along the coast between the shoreline and the lake. The swamp area behind the ridge was also swept away and the area covered with sand and coral debris. The village houses situated along the ridge were also swept away. The new shoreline is now where the seaward base of the ridge used to be. Previously the beach in front of the ridge was estimated to have been approximately 80 metres wide. The central lake formerly contained very slightly brackish water. Sand, mud, debris and seawater have now washed into the lake thus raising the salinity and substantially filling it in (up to 30 metres into the lake on the seaward side). Water in the lake is now shallow enough to wade through in many previously deep sections. Additionally, erosion of the sand spit that separates the lake from the sea has created an open channel that allows fresh water to flow out of the lake and tidal seawater to flow in. Water in this channel is now running green.





**Figure 12. Hillslopes are stripped of vegetation and topsoil; landslides are evident; sand ridge in front of the lake has been completely removed**



**Figure 13 Lake TeRoto – 40% filled in and shallow**



**Figure 14 Open channel between lake and sea**



A detailed survey will be necessary to determine the effect of Cyclone Zoë on the islands fauna. Without the benefit of recent ecological studies it is assumed that the most significant fauna are birds, flying foxes and insects. While some species of insects have increased since the destruction (flies and mosquitoes) the flying foxes and birds will suffer greatly, reducing the populations and ultimately their ability to contribute to the recovery through the dispersal of seeds.

### Water Supply and Sanitation



**Figure 15. Damaged Water tank Ravenga**

Tikopia has two gravity-fed water supply systems. The system that supplies the Ravenga district has been severely damaged. The intake was blocked, the reservoir tank smashed and the reticulation piping broken and displaced.

The system that supplies Faea suffered damage to the reticulation network and requires some new pipes and fittings. Repairs are currently being carried out. In the meantime families are using good quality fresh water sourced from a

spring on the beach, but this is accessible only at low tide. The main issue is water distribution as this has implications for hygiene and disease control. Diarrhoea and various skin diseases are noted to have increased since the cyclone, particularly among children.

There is no sanitation on the island; the only toilet is the inter-tidal zone. Given current conditions and the increase in flies, and possibly other vectors, this practice may pose a threat to health, especially for children.

**Figure 16. Water distribution difficulties**





## Anuta



**Figure 17. Aerial photograph – taken post Cyclone Zoe**

Anuta is located at Latitude 11°36'06'' South and Longitude 169°50'09'' East. It is 1110 kilometres south east of the national capital of Honiara and 75 kilometres northeast of Tikopia. The circular volcanic island is smaller than Tikopia; it is hilly with the highest point being approximately 75 metres above sea level. The total land area of just 1.2 square kilometres supports 232 villagers living in 75 households. Households usually live in individual dwellings and cook meals in their own kitchen huts. Shared kitchens are usually between members of the same family eg

parents and a married son's household may share food and cooking facilities. In the wake of Cyclone Zoe residents on Anuta have been communally cooking and sharing any remaining food on the island. Like the Tikopians, the people of Anuta are Polynesian and speak their own local language and Solomon Island Pijin. Residence in the two communities is based attendance at one of two local parishes of the Church of Melanesia. St. John's on the western side of the island with 14 households is the smaller village of Rotoapi and St. James on the eastern side with 61 households is the larger village of Fangarotoro. The people continue to adhere strongly to customary beliefs and practices and respect the ultimate authority of the two Chiefs. This is demonstrated by the fact that there has been no clinic on the Island since 1995. The chiefs refused to support its existence and demanded its removal, arguing that modern medicine brought illness and that customary healing practices promoted health. Villagers follow a traditional, largely subsistence lifestyle. There is virtually no cash economy and the island has no trade store.

The impact of Cyclone Zoe was less devastating than it had been on Tikopia; the island was nevertheless battered for almost 3 days resulting in significant wind and storm surge damage. Details of the findings of the field assessment on Anuta are as follows.

### Communications

Anuta's two-way radio facility (like Tikopia's) had not been functioning for some weeks prior to the cyclone. This made outside communication with the island residents impossible and exacerbated their isolation. Post cyclone Zoë the medical assessment team repaired the radio and replaced the battery and solar panel. The facility is now working

and is located in the Tematai School building. Access to broadcast media is limited to radio and most residents have some access to a battery operated short-wave radio. SIBC broadcasts transmitted via Lata are received in the mornings and early evenings only. Other radio stations that can be received include Radio Australia and Radio Vanuatu. During the Cyclone Zoë warning period most residents heard the initial warnings on SIBC. Some tuned in to Radio Australia on an irregular basis for further information although islanders generally found the English language broadcasts difficult to understand. All radio reception was lost by early morning on Saturday December 28 Any residents that had missed the early warning messages were advised of the Cyclone Zoë threat by the local school teacher who was listening for and passing on any available information. There are no telephones on Anuta and intra-island communication is by word of mouth.

### Access

There are no roads on Anuta, only well defined walking tracks. Most of these were blocked with uprooted trees and covered with vegetation debris after the cyclone. As part of the emergency response larger trees were removed after being cut into pieces with a chainsaw. There is no airstrip, no jetty and no obvious expanse of flat beach suitable for helicopter landing. Outriggers are launched directly from the beach. Ships to the island anchor offshore and passengers and cargo are transported to shore by canoe. Surf around the entire island increases the difficulty of bringing dinghy's to the shore. During the transfer of essential supplies post Cyclone Zoë one of the dinghy's capsized and 20 bags of rice were lost.

### Health and Human and Operational Details

The resident population of Anuta at the time of Zoë's impact was 232 villagers living in 74 households. Gender and age distribution as detailed in the 1999 census are discussed in the previous section. The only groups considered to be particularly vulnerable were babies and infants and five lactating mothers. No pregnant women or disabled residents were identified. Approximately ten live births are recorded annually. No casualties were



**Figure 18. Women bringing children to the clinic – temporarily set up at Tematai Primary School**

sustained as a consequence of the cyclone although an increase in the incidence of diarrhoea, boils and skin disease, especially among children has been noted since the cyclone.

Existing significant health problems within the population includes scabies, ring worm (bakua), diarrhoea, TB and acute respiratory infection. A high proportion of the population smokes wild tobacco, usually in pipes. There is currently an epidemic of Chicken Pox, probably

introduced in late November via a passenger on the ship that came to the island for the provincial elections. There is no clinic or health facility on Anuta. Village chiefs have refused the establishment of a clinic and there is strong adherence to customary healing practices. Flies and mosquitoes have increased since the cyclone, particularly mosquitoes. There is no malaria present and although the medical assessment team did not identify any other mosquito borne disease this is certainly a potential problem.



**Figure 19. Village Chief in front of communal hut Rotopai**

The villagers live in nuclear family units in traditional style huts constructed with local materials with kitchens usually in a separate hut. Each village has a large communal traditional style building and a church. Many keep domestic cats and dogs as pets.

### Structural Damage

Cyclone damage to built structures in Anuta was less than that experienced in Tikopia.

The majority of buildings are constructed with bush materials: sago palm thatched roofs and walls covering bamboo and timber frames. The main fastenings are twine made of natural vines or nylon and nails. Five dwellings were destroyed during the cyclone, a further 24 were badly damaged, and several more were somewhat damaged. Much of the minor damage has been repaired using broken sago leaves but this is not expected to last long.



**Figure 20 Many dwellings were protected to some degree by the sea wall**



Most residents were able to secure their possessions and few were lost. Roofs were often protected with palm fronds and banana trunks that were cut down and laid against the roof and walls. Severe damage from storm surge was mitigated with the three metre high sea wall that protects the main village along the east coast. The wall is constructed of unmortared coral blocks and is well maintained by the people whose homes are behind it. The wall withstood the waves well and was damaged only where trees fell on it. One of the two churches lost its roof but this had already been rethatched when the assessment team arrived. The Tematai primary school,



**Figure 21. Most dwellings suffered only moderate damage and have been temporarily repaired**



**Figure 22. Tematai Primary School**

constructed of sawn timber and corrugated iron was not damaged however it is in extremely bad repair and it is very poorly resourced. With students about to return to school, school-packs sent by world vision will help the problem however more resources are urgently needed.

The severe damage to the natural environment means that no sago palm for repairs or rebuilding is available locally. This will remain the case for many years.

### Production Damage

On initial viewing it appeared that Anuta had not suffered as badly as Tikopia in terms of damage to gardens and foliage. These first impressions were deceptive, gardens on the hill slopes that were still green were actually spoiled, taro was uprooted in the earth mounds and cassava had begun to deteriorate. Most of the swamp taro had been damage by salt water inundation; bananas, papaw and breadfruit trees had been stripped of fruit and damage by high winds; 80% of coconut palms were severely damaged and after the current crop of nuts is consumed the trees may not recover. It is estimated that 70% of the gardens have been lost. A week after the cyclone some plants had begun to sprout again,





**Figure 23. Swamp taro that appeared to have survived has actually been spoiled by salt water spray**

however because of current soil conditions this crop is likely to be spoiled, subsequent crops are many months away. Large older fruit trees still standing may recover but are unlikely to bear fruit for 3-4 years.

Mixed plot cropping with extensive mulching is commonly practiced; this has served to protect the soil somewhat and will reduce the time before the land becomes available for planting again. The

extensive damage has depleted the island of seedling stock. This will need to be sourced from elsewhere in the Solomons. The risk of importing plant disease and pests is an issue and quarantine processes may limit the bringing in of some plant materials.



**Figure 24. Hillslope gardens – All garden produce in hillslope gardens is destroyed – despite the healthy green appearance**

Fish and seafood are the primary protein sources, supplemented with chicken and eggs (no pigs). Only a few dugout canoes were lost and it is likely the reef survived the cyclone. Villagers had not resumed fishing post Cyclone Zoë as the seas were still considered to be too rough. Stocks are expected to continue to be plentiful. The practice of preserving breadfruit by burying fruits meant that some limited stored food supplies were available however these were expected to last two weeks at most.

Recommendations for re-planting from the agricultural officers are the same as those for Tikopia although the process is likely to be faster. Emergency food supplies that are nutritionally balanced will be required for at least the next eight months, some support will continue to be required for the next few years.

### Environmental Damage

Superficially the physical environment in Anuta ‘looked’ better than Tikopia; it has nevertheless been severely damaged. Large trees were uprooted and vegetation had been



**Figure 25. Damage to vegetation and hillslopes**

stripped, twisted and snapped. Vegetation along the coast has been covered with sand, some obviously suffering the effects salt-water inundation. Erosion is already evident in many areas and small to medium size landslips on the steeper slopes were observed. Much of the hill slope vegetation has been ‘burned’ by salt and sand spray. The ecological health of the flora and fauna is

unknown but the same assumptions made for Tikopia probably also apply in Anuta.

### Water supply and Sanitation

Water supply to the main village is a gravity-fed system sourced from a spring on a nearby hill. Water is collected in a reinforced 2000-gallon tank and is then reticulated via a network of pipes to ten shared standpipes. During the cyclone there was some damage to the reticulation system. Villagers temporarily repaired some of the pipes immediately. Materials and equipment to carry out permanent repairs has been sent from Honiara. Currently the supply of fresh water is considered to be adequate for both drinking and basic hygiene purposes, although the quality needs to be tested as there are concerns about children and an increased incidence of diarrhoea.

## Discussion

### **Environmental impact**

*Considered in terms of the impact on landscape and coastal structures; flora; and fauna.*

The high winds, storm surge, wind driven waves and heavy rain that characterised Cyclone Zoe had a devastating effect on the landscape and physical environment of both Tikopia and Anuta. While Tikopia was more severely impacted both islands have been stripped of viable vegetation and food crops and much of the land surface, particularly on the steeper hill slopes has lost the valuable layers of humus and top soil that are necessary



for supporting plant growth. The delicate ecological balance of the islands' flora and fauna has been disrupted and it is unlikely that the previously rich tropical vegetation will regenerate except perhaps in the very long term. In Tikopia the total removal of the sand ridge on the eastern side of the island has permanently altered the dynamics of the coastal processes. The coastline has effectively receded and the lake has been in-filled with sand and swamp mud. The open channel between the ocean and the once clear, and essentially freshwater, lake has left the water too saline to continue to support fresh water fish and plants.



**Figure 26. Sea wall Anuta – Protected coastal dwellings - Damaged only where a tree fell on it.**

In Anuta the three-metre coral-block sea wall proved to be an effective barrier that protected some of the coastal village dwellings from the storm surge. This has provoked discussion amongst disaster managers and provincial authorities about the value of constructing a similar wall, or a groyne to protect the remaining beach, in Tikopia. However, given the crippled state of the

Solomon Island economy it is unlikely that resources will be available for major coastal engineering works in such a remote location that supports less than 1500 people.

## Societal Impact

*Considered in terms of loss of life; impact on lifestyle practices; loss of livelihood; and impact on societal infrastructure.*

The ferocity and duration of Cyclone Zoe were such that it is a 'miracle' that there were no casualties and only very few injuries. Tikopian villagers on the eastern / south-eastern side of the island give detailed accounts of sheltering in craggy rocky overhangs (not caves), as the surrounding vegetation was being torn away by the storm and staying there, exposed to the elements, for up to three days. Others described being carried in the waves that were crashing through their dwellings, and then being 'deposited' in the vegetation at the far side of the lake.



**Figure 27a & 27b ‘Caves’ on Tikopia where up to 50 villagers sheltered for 2-3 days during Cyclone Zoe**

Many young men were in the surge-swollen water for up to eight hours during the total darkness of the storm during the night. Some parents described rescuing their children and holding the heads of their babies above the water, often for hours. Hundreds of people were without shelter and exposed to the effects of wind and rain for days, with only the clothes they were wearing and if they were lucky, some plastic to wrap their small children in. When the winds died down and the surge waters receded there was nothing left of their homes or their gardens. An appreciation of these accounts makes their 100% survival rate all the more remarkable. Cyclone Zoe has changed life on Tikopia and Anuta. The destruction of the physical environment has left the islands with no capacity to adequately support human life and the village communities will be unable to resume their previous livelihood activities for very many years.

Tikopians and Anutans are often described locally in the Solomon’s as “having strong culture”. They typically enjoy strong cohesive family and societal networks that are based on a long history of adherence to customary practices and belief systems, and acceptance of a common worldview that has incorporated Christian values and practices. This has probably been maintained in part because of the relative isolation of the communities. It has certainly supported the resilience that has been demonstrated by the affected population during, and in the wake of, Cyclone Zoe.

Life will necessarily change for these people. Long-term existence on the islands seems highly unlikely. The initial enthusiasm and support of various aid agencies in providing emergency food, shelter and communications will almost certainly wane as other humanitarian crises demand attention. Within the Solomon Islands context, it is just not within the capacity of the government to provide on-going support for the Tikopian and Anutan communities. Official efforts are currently focussed on rehabilitation of the tropical vegetation and support for the resident communities. However, the logical outcome of this ‘disaster’ is that many of the people that cannot be supported on the



islands will move away and settle with their 'wontoks' in established communities in other parts of the Solomon Islands.

It seems likely that the people will endure and recover from this crisis and move on with their lives wherever they locate in the short (or even long)-term. A week after the impact of Cyclone Zoe people displayed a quiet acceptance of the events that had changed their lives. Many appeared to be 'depressed' but their simple descriptions of their experiences and the absence of outrage and confused disbelief seems to demonstrate this acceptance and evidence their resilience. Many were already considering and making plans for the future. Like those that have moved away in the past, these people will retain their cultural identity and the cultures will endure into the distant future when the islands are again habitable.

## Warnings Effectiveness

*Considered in terms of: how and when residents became aware of the cyclone threat (official warnings and environmental signs); how and when broadcast messages were received; preparatory and defensive actions taken; long-term and medium-term preparatory behaviours; behaviours during the cyclone (shelter and evacuation); communication networks (formal and informal); broadcast media – radio stations that can be accessed, preferred radio stations.*

Infrastructure generally throughout the Solomon Islands is in a critical state of breakdown and disrepair. In terms of the capacity of the Solomon Islands Weather Service, this means that despite the skills and technology to produce and disseminate weather forecasts and tropical cyclone warnings being locally available, the service is not able to provide these essential services. Rent for the government offices where the Weather Service is located has not been paid for some time and eviction is imminent, the supply of electricity is unreliable and the telephone account is seriously in arrears and telephones and fax can be used for in-coming calls only. The resident meteorologist must go to the Internet café to receive and send e-mail.

During the period Cyclone Zoe threatened Solomon Island communities the Weather Service was temporarily located in the Civil Aviation offices at the airport and warning messages for Cyclone Zoe were produced by the Bureau of Meteorology in Australia and transmitted directly to SIBC for broadcast to the Solomon Island community. This provided an effective 'band-aid' solution to a chronic infrastructure problem. Ideally warning messages are delivered together with defensive action statements. This is typically the product of a partnership arrangement between the weather services and emergency management authorities. In the Solomons the weather service is responsible for providing the meteorological details and the National Disaster Council (NDC) is responsible for giving the message local meaning and providing the defensive action advice. As the NDC has a large outstanding account with SIBC it is denied broadcast time. On this occasion the General Manager of SIBC allowed the broadcast of emergency advice messages with the warnings, against SIBC policy. To avoid this problem in future

events the production of both the weather warning information and the action statements should perhaps be the responsibility of the weather office alone.

Residents of both Anuta and Tikopia did, in fact, receive the warning messages that were transmitted by SIBC in Honiara, and relayed via Lata, on short-wave radio. Those who did not hear the messages directly were generally advised by friends and family members who had. It appears therefore that both the formal and informal warning communication networks were effective. Initial concern that warning message had not got through arose because there was no two-way radio communication with people on either Tikopia or Anuta and authorities had no way of knowing what information people had received and no other way of informing them. People were generally satisfied with the warnings they received although they were somewhat limited because they could only be received in the early morning and early evening, and only then when the weather conditions were conducive. An Australian aid supported development project that will facilitate medium wave radio transmissions in Temotu Province, and effectively extend radio reception time has been 'fast-tracked' and should be completed by mid-year. This will partially resolve the problem. Some residents attempted to seek additional information during the warning period through Radio Australia and Radio Vanuatu, while reception was sometimes possible the value of the information was limited because of language difficulties. People prefer to receive warnings in Solomon Island Pijin, only then are they confident that they have fully understood the messages.

Despite the very long-term residency on the islands and the sensitivity of the people to the environment and natural processes there was no indication that people refer to or rely on any environmental signs to indicate the threat of a cyclone. Occasional references were made to the timing of the 'dropping' of breadfruit being a sign that an active cyclone season was likely. No one however indicated that the 'signs' had been noticed this season. People therefore rely on official warnings to indicate that they must make cyclone preparations and take appropriate defensive actions.



**Figure 28. Villagers in both Tikopia and Anuta attempted to strengthen roofs with banana trunks during the warning period**

People that received timely warning messages generally began preparations immediately. This was limited to cutting palm fronds and banana trunks and laying them on roofs to support and strengthen roofs and walls and confining chickens to their coups. There was no evidence of fruit being taken from trees or the storage of food in huts. In one instance a planned outdoor feast was moved into a communal hut. People generally sheltered in their own dwellings. There was no attempt to evacuate people to

higher ground or areas of safety until the storm had become so intense that properties were threatened with imminent inundation or had begun to break up.

The design of the village huts with low walls and sloping thatched roofs may be considered to be a long-term cyclone mitigation strategy as this design typically withstands cyclones although many that were located on the near-shore beach areas were exposed and unprotected from both wind and surge effects. In Anuta the 3 metre sea-wall along the eastern edge of the beach just behind the high tide line that has been constructed from coral block and is well maintained and provided an effective protective barrier. During Cyclone Zoe waves over-topped this wall and sand and salt water spread through the village wetting property and spoiling crops. Dwellings however were saved as they were protected from the force of the powerful storm surge.

Tikopian and Anutan communities were not well warned for Cyclone Zoe and neither was particularly well prepared. They have some experience of living with cyclones, although it is more than 50 years since a cyclone of Zoe's intensity has been experienced. Even then, as one elderly villager pointed out, *"that cyclone lasted only three hours – this one lasted three days!"* Response to warnings was appropriate albeit a bit late. Damage to both island communities was severe and losses are catastrophic. The fact that no lives were lost may possibly be attributed to a combination of many factors including, the peoples understanding and knowledge of their landscape; well developed intuitive self-protective behaviours; the supportive societal networks that foster a sense of mutual community responsibility; a resilience arising from the communities relative isolation and perhaps also a lot of 'good luck'. It must be clearly stated and always remembered that, in terms of loss of life, the actual outcome of this event was absolutely the **most unlikely** outcome.

The inability of the Solomon Island Government to support its national Weather Service so that tropical cyclone warnings can be produced and disseminated locally together with the inability of the NDO to immediately conduct an assessment of the post disaster situation on Tikopia and Anuta exposes chronic deficiencies in the capabilities and capacity of the nations infrastructure. This is a problem of development that is common throughout the developing world. It continues to worsen and in the event of natural hazards, such as Cyclone Zoe, threatens the safety and security of the population.

## Recommendations

Recommendations relating to the humanitarian response to the assessment of the impact of Cyclone Zoe in Tikopia and Anuta are contained in the NDO/OCHA report. The purpose of this evaluation is to provide recommendations that relate to the weather services and the effective delivery of warnings

### (a) Support to the Solomon Islands Weather Service

The Solomon Islands Weather Services office needs infrastructure support and an assured operating budget. The remote meteorological station in Lata requires proper office facilities, including a HF radio transceiver in order to communicate with the Weather Services central office in Honiara.

The Solomon Islands Weather Service should take on the responsibility of producing and disseminating the defensive action statements that are such an essential part of the warning message

### (b) Support to the Solomon Islands Broadcasting Corporation

The AusAID funded project to improve SIBC coverage needs to be accelerated. Specifically, the relay station on Nendo Island should be completed as soon as possible to enhance the reception of SIBC broadcasts across Temotu Province.

### (c) Support from international radio stations

International stations such as Radio Australia, Radio New Zealand, and local stations in Vanuatu, that are commonly and reliably accessed throughout the Pacific region can provide back up to SIBC when it is off-air. These stations should be encouraged to broadcast their warnings in Pijin as well as English, ideally this should be achieved via live, timely interviews with the senior Solomon Island meteorologist who can give local meaning to the messages and deliver them in the appropriate language.



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