Uplift and Damage from the M_W8.7 Nias Earthquake of 28 March 2005

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Abstract

The M_w 8.7 Nias Earthquake was caused by rupture along a ~350km length of the plate boundary subduction zone interface between the Indian/Australian and EurAsian plates ~25km beneath Nias Island. Nias is a fore-arc island 110 km to the west of North Sumatra. The Nias earthquake occurred three months after the great M_W9.2 Aceh Earthquake and was located immediately to the south of the earlier event. In this region the two tectonic plates converge at ~60mm/year and great earthquakes occur regularly.

The great earthquake of 2005 uplifted the entire 110 km western coastline of Nias by ~2m, while the coastline 40 to 50 km to the east is not significantly changed. Uplift is clearly marked by raised beaches and exposed coral reefs. Fossil coral limestones, up to ~200m elevation around the perimeter of the island, indicate a cumulative trend of tectonic uplift in the recent geological past.

The earthquake caused approximately 3 minutes of very strong (MM Intensity 9 to 10) shaking on the island and a tsunami from the west. There was extensive and major damage to buildings and infrastructure throughout the island. However, well built, earthquake resistant masonry structures survived without significant damage. The unique Nias traditional timber houses were also undamaged.

Examples are given of uplift and damage on Nias, the reconstruction underway and the difficulties faced. The observations were made while the authors were working as technical advisors for the BRR and UNDP on Nias in 2006 and 2007. The assistance of these organisations and GNS Science, is gratefully acknowledged.

Keywords: (Nias earthquake; disaster; damage; relief; reconstruction, risk reduction).

1 Introduction

Earthquakes have shaped both Nias Island and the traditional culture of its inhabitants. Great earthquakes are a frequent occurrence on this tropical island, which sits on top of what tectonic geologists call a fore-arc island/accretionary wedge of a subduction zone. The subduction zone is formed by the collision of two tectonic plates, which are moving towards each other at a rate of approximately 60mm per year. It is the locking then release of the accumulated strain on the subduction zone ~25km beneath Nias which causes the earthquakes. The coastline of Nias has been regularly uplifted by the great subduction zone earthquakes, exposing coral reefs and causing new ones to grow. The mountains of Nias were also formerly folded and faulted by these same tectonic processes (EERI August 2005).

A feature of great subduction earthquakes is that they generate tsunami which sweep ashore, inundating the coastline with powerful waves. In response to these events the people of Nias lived in the hills where they built beautiful villages with wide, stone paved streets and steps, bordered by stone carvings and rows of remarkable traditional houses which incorporate sophisticated bracing structures to protect the houses against earthquakes. The braced pile systems are not fixed to the ground. They allow the structure to displace in response to seismic waves making an effective frictional base isolation system (Pudjisuryadi et al 2007). Some of the bracing systems are weighted with rocks in order to increase their friction and effective earthquake base isolation.

		
The Chiefs house in Bawomataluo		Bracing and piles below the Chiefs house
		
A traditional house in Gunung Sitoli with bracing and piles on stone blocks		Detail of bracing and weighting used for increased friction & earthquake resistance

The well organised villages are an early version of what is now called “Community Based Disaster Risk Management”. The Nias communities used their knowledge and wisdom to live safely with the frightening and destructive shaking of earthquakes and the subsequent tsunami which frequently impacted their tropical paradise Island. Their disaster risk management allowed them to flourish and develop a vibrant and colourful society with a rich culture of costume, dance, music, stone and wood carving, athletic armour protected warriors, stone jumping and other village traditions.

Nias experiences great earthquakes (>M8) every 150 to 200 years and many smaller magnitude earthquakes in between the main events (Zachariasen 1998). In this unusual situation, the frequently occurring “Maximum Credible Earthquake” also becomes the “Design Earthquake”. At the beginning of the 1900’s western culture and construction methods, which have their origins in parts of Europe where earthquakes do not occur, arrived in Nias. Over the last century construction has often been poorly reinforced brick masonry, similar to many other parts of seismically and volcanically active Indonesia.

Settlers from Britain to New Zealand in the mid 1800’s brought similar non-earthquake resistant masonry construction methods. However, damage from powerful earthquakes in 1848 (Marlborough), 1855 (Wairarapa) and 1931 (Hawkes Bay), together with a plentiful supply of domestic timber into the later 1900’s, were influential in altering construction methods and design towards using and developing advanced earthquake resistant methods. It appears that the great Aceh and Nias earthquakes and tsunami, with the Yogyakarta earthquake and Pangandaran tsunami of 2004, 05 and 06, will have a similar influence in Indonesia, resulting in improving design and construction methods.

2 Damage caused by the recent earthquakes and tsunami

The tsunami which triggered the greatest widespread destruction in modern history radiated round the Indian Ocean following a M_W 9.3 (Moment magnitude) earthquake on 26 December 2004. The earthquake ruptured ~1,200 km of the subduction zone from the island of Simeulue in the Province of Aceh, north towards India. The tsunami devastated Banda Aceh City and the coast of Aceh, as well as causing significant damage on Nias Island in North Sumatra. The tsunami also wreaked havoc in countries surrounding the rim of the Indian Ocean including Thailand, Malaysia, Andaman and Nicobar, Sri Lanka and the East Coast of Africa. A death toll of 165,862, including the 37,066 classed as missing, was reported in Aceh and Nias. The total economic loss for Indonesia has been estimated at 41 trillion rupiah, exclusive of indirect losses caused by the interruption of economic activities. The effects of the 26 December 2004 tsunami were light on Nias compared with Aceh and other countries such as Thailand and Sri Lanka, with a recorded total in Nias of 122 deaths, 18 missing, and 2,300 people directly affected.

On 28 March 2005, only three months later, a massive earthquake recorded as M_W 8.7 struck Nias Island. This earthquake was devastating for the mainly rural areas in Nias, which has a population of 710,000. It caused the death of 839 people, about 6,300 were injured, 70,000 people made homeless; 13,000 houses destroyed and 60,000 houses damaged; 12 ports and piers damaged or destroyed; 400 bridges and 1,000 km of road impassable; 760 government buildings damaged, 720 schools destroyed, two hospitals and 350 health clinics damaged, 1,940 religious buildings (churches and mosques) damaged, and 90% of people had their livelihoods disrupted.

Figure 2. The geographic location of Nias (arrowed) and other fore-arc islands along the west coast of Sumatra above the subduction trench is illustrated on this Google Earth image.

3 Coastal uplft and subsidence

Geological evidence shows that Nias has been regularly uplifted by past great earthquakes, the previous time in the 1861 earthquake. The great 28 March 2005 earthquake caused Nias Island to tilt to the NE. The entire length of the west coast of the island is uplifted approximately 2m while the furthest SE of the island has down-warped a little due to tectonic subsidence, reportedly about 0.3m at the village of Tagaeuli. There was also consolidation settlement in this area of up to a metre (Richard Stone, Science Vol. 314, 20 October 2006). The maximum uplift observed was about 4m to 6m to the NW of Lahewa on the northern tip of Nias, with uplift of approximately 2m on the west coast and about 0.5 to 1m on the south-west coast, with no uplift apparent at Teluk Dalam to the SE. At the Gunung Sitoli museum and zoo on the mid-east coast, uplift is reported to be about 0.5m, measured from high tide levels in the turtle ponds.

In uplifted areas coral reefs are now (well) above high tide level and beaches are up to 200m wider. The uplifted former beaches and coral reef are rapidly becoming vegetated and within tens of years it will be difficult to recognize that they were formerly tidal areas. It is likely that people will wish to occupy such areas. New beach ridges are forming along the new shore line and a succession of such ridges away from the shore indicates uplifts from previous great earthquakes (Figure 3).

Uplifted coral reefs found around the perimeter of Nias, indicate that in the last 100's of thousands to a few millions of years, the great subduction zone earthquakes have gradually been raising Nias out of the sea. Uplift from the sea is generally benign or even benevolent, creating more land and much easier to live with than subsidence, which causes the sea to flood former land areas and is destructive.

However, the great Nias earthquake has initially caused a severe adverse impact to the population of Nias by causing damage to infrastructure and buildings, and disrupting livelihoods and transport. Now with assistance pouring into Nias and rebuilding in full swing, the people of Nias have been given a chance to turn disaster into opportunity. A relatively isolated, poor and forgotten island has been thrust into view of the world and could become a show-case for constructive and sustainable post-disaster development.

We recommended that the most recently uplifted beaches and reefs of Nias are zoned as (plantation) reserve and remain unoccupied, as they are a high tsunami hazard area. These areas can be used productively for plantations, but people should not live there. People will be tempted to move in and live in these areas and there could be commercial pressure in the future for some attractive beachs to become tourist resorts.

Figure 3. An aerial view of beach ridges uplifted by past great subduction zone earthquakes at Sirombu on the mid west coast of Nias. At least 6 beach ridges and possibly as many as 10 can be seen. The peninsula at the bottom of the photo is an atoll which has become joined to the main island of Nias, probably after the earthquake and uplift which occurred before the 1861 earthquake. Six of the ridges are arrowed

Figure 4. Uplifted coral reef, a short wharf now high and dry and a new beach ridge forming 1 year after the great earthquake - at Sirombu on the mid-eastern coast.

4 Disaster Risk Reduction (DRR)

In Nias the disasters to be mitigated are from Natural Hazards, which include earthquakes, tsunami, flood, landslide, possibly strong wind and drought, and pandemic – such as bird flu. The risk of a disaster is a combination of the size or strength of the natural hazard and the vulnerability of the community:

Risk = Hazard x Vulnerability

Communities in Nias are vulnerable to natural hazards for a variety of reasons: because of limited access to resources, an age and gender balance with many women, children and elderly, poverty, education, training and skills, population expansion, urbanisation, uncontrolled development, environmental degradation, living in dangerous locations, dangerous buildings and low income levels. Some natural hazards, such as exposure to tsunamis, floods, drought, landslides and pandemic, can be mitigated by good planning but others, such as the magnitude of an earthquake, can not. The main thrust of DRR is to reduce vulnerability. Many of the vulnerability issues are being tackled directly and indirectly in Nias by programs within the Four Strategic Pillars developed by the Nias Bureau of Reconstruction and Rehabilitation (BRR), the special agency established by the Indonesian Government with a four year mandate to oversee disaster recovery in Aceh and Nias.

The UN Economic and Social Council's Resolution Number 63/1999 calls for world governments to formulate and implement a National Action Plan for Disaster Risk Reduction to support and ensure the attainment of the objectives and targets of sustainable development.

The Hyogo Framework for Action 2005-2015 urges all countries of the world to prepare an integrated disaster risk reduction mechanism that is supported by a proper institutional basis and adequate resources.

BAPPENAS, the Indonesian Government Planning Agency, with support from UNDP, has prepared a *National Action Plan for Disaster Risk Reduction* (2007). This is being supported by Indonesian Government legislation. On 29 March 2007 the Parliament (DPR) approved new legislation that will bring Indonesia into line with the Hyogo Framework for Action 2005-2015 and have wide reaching changes in the way Indonesia approaches disaster management. An extract from the Introduction to National Action Plan for Disaster Risk Reduction is as follows:
"The formulation of the National Action Plan for Disaster Risk Reduction, which later on will be referred to as RAN-PRB, involves a nation-wide process that engages national and sub-national stakeholders from government, civil society and the private sector. The participatory approach was employed because RAN-PRB comprises an integrated plan that includes social, economic and environmental aspects. The Action Plan has also been adapted to fit in with regional and international disaster risk reduction plans. The community occupies a crucial position in the Action Plan, given that it is a subject, object and main target of disaster risk reduction efforts. ***The Action Plan must adopt and respect local wisdom and traditional knowledge prevailing in Indonesian communities.*** *Both aspects are key in making disaster risk reduction a success considering the depth and variety of tradition growing in Indonesia. As subject, the community is expected to enhance access to all formal and informal information sources, hence allowing for direct involvement of the community in disaster risk reduction. The government is expected to make available accessibility facilities and infrastructure as well as adequate resources to implement the action plan.*

RAN-PRB also reflects a shift of paradigm in disaster management Indonesia. There are three important aspects to this paradigm shift:
1. *Instead of focusing merely on emergency response, disaster management now represents all aspects of risk management*
2. *Protection against disaster threats must be provided for by the government not out of obligation but for the fulfilment of the basic human rights of the people*
3. *Responsibility for disaster management lies no longer with the government alone, but a shared responsibility of all elements of the society."*

As stated in item 3 above, the 2006 National Plan recognises that the responsibility for disaster management lies no longer with the government alone, but is a shared responsibility with all elements of society. Community Based Disaster Risk Management (CBDRM), which is being adopted widely in South East Asia, takes this process to the community building blocks at the heart of society. It is a process of disaster risk management in which at risk communities are actively engaged in the identification, analysis, treatment, monitoring and evaluation of disaster risks in order to reduce their vulnerabilities and enhance their capacities. This means that the people are at the core of decision making and implementation of disaster risk management activities. The involvement of the most vulnerable is paramount and the support of the least vulnerable is necessary. In CBDRM, local and national governments are involved and supportive.

5 The recovery process

After a disaster of such magnitude as the Aceh and Nias tsunami and earthquakes, the main requirement over the first two years is for short term emergency response on an unprecedentedly large scale, providing medical care, food, drink and shelter. For Nias this was very difficult when the basic infrastructure of roads, bridges, ports and airstrips were badly damaged and destroyed. Emergency response was provided by the Indonesian Government (BRR) and on a generous scale by the international community (ie. NGO's and Multi-donor Trust Fund). The next step is rehabilitation, with the restoration of basic community services and functions, such as health-care, education, transport and basic infrastructure (ie. water supply, sanitation, roads, ports, etc.), followed by a longer duration reconstruction phase taking years, with resumption of services plus preventive measures. Mitigation in the form of risk assessment, prevention and preparedness, can not be practically carried out during emergency response because of immediate and pressing needs, but can be implemented later when reconstruction is underway. Mitigation includes hazard mapping, hazard and community vulnerability assessment, building improvements, structural and non-structural measures. Preparedness includes contingency planning, warning and evacuation procedures and preparations for possible future natural hazards.

Experience shows that even in the wealthiest and most technologically advanced nations, relief and recovery after major disasters takes time which far exceeds the expectations of the affected community. For example in the USA, the relief efforts, recovery planning and reconstruction of New Orleans after the August 2005 hurricane Katrina disaster are controversial and have for many reasons taken considerable time and are not meeting the expectations of many in the local community. As well there are many difficult and delicate associated issues to deal with. The cost of obtaining and transporting large volumes of relief supplies and reconstruction materials, the use of non-local contractors and workers, establishing land ownership and the purchase of land no longer suitable for habitation, and the relocation of affected communities, are some examples from New Orleans, Aceh and Nias.

6 Building standards

It is often said "it's not earthquakes that kill people, it's buildings". By far the most deaths that have occurred in Indonesia following earthquakes have been as a result of the collapse of buildings and houses. Therefore, the most important aspect regarding the reduction in probable deaths due to future earthquakes is to improve the design and construction of houses and other buildings. This is of particular importance on Nias which is located in the highest seismic risk zone in Indonesia (Zone 6).

It has been observed on Nias that, due to urgent needs, many well meaning donor agencies have and are constructing houses, schools and clinics to their own standards, rather than standards that are legally required in Indonesia. The BRR is now moving toward encouraging these agencies to construct buildings in accordance with Indonesian regulations.

Local government agencies are responsible for overseeing and enforcing Indonesian government regulations related to buildings and it is clearly an important component of CBDRR (Community Based Disaster Risk Reduction). Over the past two years much reconstruction work has been undertaken with minimal involvement from local government (PEMDA). BRR recognizes this and is in the process of forming joint secretariats with Local Government and is providing assistance with capacity building to enable Local Government to meet its obligations under the Indonesian Building Code.

Indonesia has a well developed seismic loadings code, which if always used and the quality of construction enforced, will strongly mitigate against the risk of building collapse during earthquakes.

7 Microzoning for Nias

Seismic Microzoning examines the response of different types of ground to strong and weak earthquakes. The response of soils with regard to liquefaction, amplified ground shaking and landslides can be assessed and shown on maps. Seismic microzoning maps can include fault rupture, tsunami and other hazard zones, such as flooding.

Amplified ground shaking is a complex and difficult subject which has several relatively technical and expensive field methods used for its assessment. Weak soils can strongly amplify weak to moderate ground shaking, but can reduce (de-amplify) strong ground motions when these are great enough to cause inelastic ground deformation. There can also be amplified ground motions due to topography and other effects. However, it is very clear that the tragic and catastrophic losses on Nias from the recent great earthquake were due mainly to buildings and other structures (bridges, wharves, etc.) not being designed and constructed to adequate earthquake resistant standards. Seismic microzoning cannot remedy this issue for Nias, where great earthquakes are a regular occurrence and become the “Design Earthquake”.

Seismic microzoning is useful in large cities, such as Tokyo or Jakarta, where there are a huge variety of buildings of different heights and designs with different response frequencies. It is also used for places where the response of a range of weak and strong ground motions have to be considered. In Nias the design earthquake is also the maximum probable earthquake, a very unusual situation in which **all** buildings have to be designed and constructed to the highest possible earthquake standards to be able to resist the very strong ground motions expected. In this situation seismic microzoning can have limited benefit. As well in Nias the range in building height is restricted to a maximum of three levels. For these reasons, seismic microzoning can affect only relatively minor refinements and the urgent first priority must be given to achieving the very high earthquake resistant building design and construction standards which are required for the island.

From descriptions of people who experienced the great 2005 Nias earthquake, from observations of the damage it caused and from seismic calculations, it is known that the earthquakes produced ~3 minutes of Modified Mercalli (MM) 9 to 10 intensity shaking for the whole of Nias Island, during which people were unable to stand. When shaking intensity is so high, in practical terms it can not get stronger, and amplification and other such effects are minor. Clearly and most importantly, to be safe from such earthquakes, buildings have to achieve the highest possible seismic resistant standards.

For these reasons we proposed a simple, practical and easy to apply seismic microzoning system which subdivides Nias into two ground types:

1. Firm or compact ground and rock;
2. Weak or soft ground which may liquefy and/or suffer gross ground movements, such as consolidation settlements and lateral spreading, during earthquakes.

The two classes of ground are recommended because:

- Firm, stiff and hard ground require lighter foundations to adequately support buildings up to three levels in height under the highest earthquake shaking loads. These foundations are easier to design.
- Soft and weak ground can deform with large, inelastic movements due to differential settlement, liquefaction and lateral spreading during strong shaking. Such ground movements can cause distortions to the building structure which in turn can cause it to be damaged and/or collapse. In this case damage or collapse of a structure can be attributed to ground deformation rather than the earthquake shaking alone. Thus the foundations for buildings in soft and weak ground need to be particularly good to support the building and prevent damage. They should be specifically designed for a particular site based on a subsurface site investigation.

Figure 5. A bridge pier and abutment damaged by liquefaction and lateral spreading causing settlement and rotation. The bridge superstructure is well designed and undamaged but unfortunately can no longer be used because of the abutment and pier deformation.

Figure 6. Structural failure due to light reinforcing and wide spaced (lack of) stirrups - a common problem

8 Post 28 March 2005 building quality in Nias

Between December 2005 and 2007, Gunung Sitoli transformed from a disaster area with many displaced people in tents, to a “boom town” with a huge amount of new construction taking place. In general a hard lesson has been learnt from the great earthquake of

March 2005 and the new buildings are being built well, following sound construction techniques for earthquake areas. A common problem seen in earthquake damaged and collapsed buildings in Nias and other countries, is a lack of stirrups or ties in reinforced concrete columns (Figure 6).

The features required to ensure the survival of reinforced concrete and brick houses and buildings in great earthquakes are:

- A good foundation with well reinforced ring beams and cross beams in the ground. In soft and weak ground areas (Microzone 2 areas) the ring beams and cross beams should not be more than about 4m apart. Reinforced concrete floor slabs are very rarely used but provide valuable additional strength in soft and weak ground areas
- Well reinforced, closely spaced columns with sound concrete. In general the 100mm thick brick panel infill walls should not be more than about 3m square without using intermediate columns and beams. Stirrups (also known as ties) should be of adequate size and closely spaced (typically not more than 100mm apart). Within beam and column joints, tie spacings may be less if the building design requires ductility
- Well reinforced ring beams are required at the top of all masonry walls (Figure 7).
- All door frames and wall joints should be trimmed with reinforced concrete columns
- Reinforced concrete beams should be placed above and below all windows
- Roof trusses and beams must be well fastened to the tops of walls. Trusses should be used at the top of each column and the truss must be well connected into the structure using bolts, or the column reinforcing rods. This is important for houses and all buildings where the ubiquitous corrugated iron roof is a strong diaphragm which adds strength at the top of the walls (heavy clay tiles are not used in Nias).

The use of unreinforced masonry in Nias, as well as other parts of Indonesia, is widespread. Unreinforced masonry has been shown repeatedly, both in Indonesia and elsewhere, to perform poorly in earthquakes. In developed countries earthquake design codes have severely restricted the use of unreinforced masonry construction. For example, in New Zealand all concrete block construction is required to have a minimum width of 150mm with vertical steel bars D12 at 800mm centres. The imposition of such standards in Nias would increase significantly the cost of house construction and is unrealistic. A more realistic approach in locations such as Nias, is to continue to utilize unreinforced masonry but to take steps to mitigate against the risk of collapse in earthquakes. The following give additional emphasis to the good construction techniques listed above and are of proven to be effective in Nias:

- Limit the size of unreinforced panels
- Provide mid-height bond beams and or mid-span columns in masonry walls
- Provide shear connections between all bond beams and columns, and unreinforced masonry

In addition for Batako construction (100mm hollow unreinforced concrete blocks) starter bars from foundation beams and from bond beams constructed on top of walls, can be used to provide some shear resistivity at the interfaces between panels with columns and beams. Horizontal connecting bars can be used in the same way from columns into Batako and brick walls.

Figure 7. The above 2 level building in Nias has a deep ring-beam at the top of the wall, numerous stirrups and reinforcing rods, beams and columns with wide dimensions, and two intermediate beams in the brick panel walls. It is located on soft ground and also has excellent foundation ground beams. Observations of similar undamaged buildings indicate it should survive very strong MM9 to 10 intensity shaking without collapse.

9 Conclusions

- Earthquake and tsunami recovery in Nias has provided invaluable experience and examples which highlight the challenges confronting relief organisations working on major disasters in isolated and poor regions.
- Initial emergency response and recovery provided by a wide range of differing private, government and international relief organisations, has encountered difficulties, but overall response and recovery have been effective and well co-ordinated by the BRR.
- In broad consultation with the relief organisations, the BRR have developed a strategic plan for Nias which aims to steer all elements and sectors of Nias society through the sort-term reconstruction “boom” generated by aid funding, into a long-term, self funded phase of sustainable social and economic development.
- In recognition of their unusual earthquake prone environment, traditional Nias society developed advanced, braced, base-isolated, earthquake resistant, timber structures which allowed their society to flourish. In Nias, where in modern terminology the “design earthquake” is also effectively the “maximum credible earthquake”, similar advanced earthquake resistant methods are required for all components of building and infrastructure (re)-construction today. Innovative earthquake resistant design, and construction to highest standards, remains a key and vital component of Community Based Disaster Risk Reduction.

10 Acknowledgements

The observations for this paper were made while the authors were working as technical advisors for the BRR and UNDP on Nias in 2006 and 2007. The assistance of these organisations, and GNS Science, is gratefully acknowledged.

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The cheerful optimism and friendliness of the Nias people in difficult and apparently bleak circumstances is extraordinary and inspiring.

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Author's Biography

Dick Beetham is an Engineering Geologist and Geotechnical Engineer with extensive earthquake engineering, natural hazards assessment, large project, and international experience. He is a NZ Chartered Professional Engineer (CPEng) and on the International Professional Engineers (IPE) register. Dick is a Fellow of IPENZ and a member of NZ geological, geotechnical and earthquake engineering societies and their international associations

He has qualifications and training in civil engineering including structures, geology, geophysics, soil mechanics and engineering seismology, followed by broad experience using these skills, Dick is well placed to assess and review the geological, geophysical, geotechnical and earthquake engineering environments relating to natural disasters. His early background was with volcanic debris control projects for 3 years at Merapi and Agung in Java and Bali (1971 -74), geothermal investigations in Java, and earthquake reconnaissance in Bengkulu, Sumatra in 2000 and West Sumatra 2007. He has 12 years experience with site investigations for large hydro development in New Zealand, landslide reconnaissance at Thredbo, Australia, earthquake disaster reconnaissance at Edgecumbe (NZ), Japan, Indonesia and USA (Seattle) and involvement in numerous natural hazard and risk assessment projects. He regularly works as a project team member who interacts with a variety of people in field and office situations, and uses his technical expertise to rapidly and accurately evaluate important data.

While on his three year VSA assignment with the Public Works Department in Indonesia (1971–74), Dick became fluent in Bahasa Indonesia. This assignment prepared him well for work in other countries with a different language and culture. He has experience as a Section Manager at GNS Science for 7 of the last 10 years, where he was responsible for the management of approximately 25 staff.

His latest work in Nias as technical adviser to BRR and UNDP, with co-author Bill Sinclair and Djauhari Noor, has given Dick the opportunity use his accumulated knowledge and expertise to contribute to a vital humanitarian project, and to learn much from the experience.