



Sustainable, post-tsunami restoration of Aceh - Indonesia

Odelinde Nieuwenhuis (*DHV, Amersfoort, the Netherlands*)

Ibrahim Salva (*Nanggroe, Aceh, Indonesia*),

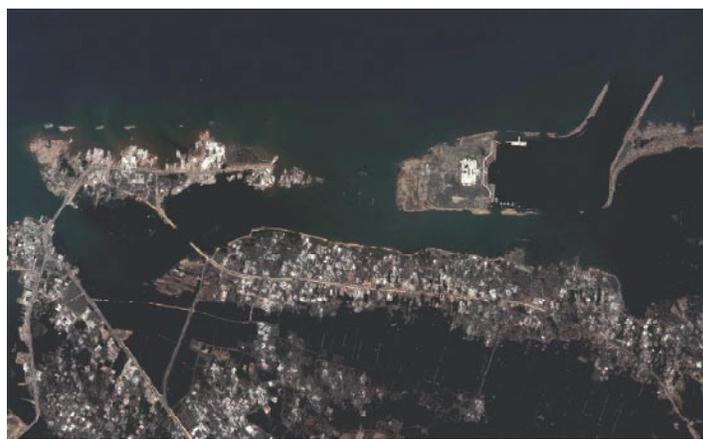
Jeroen Alberts (*DHV, Amersfoort, the Netherlands*),

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Summary

The Indian Ocean Tsunami of 26th of December 2004 hit the Province of Aceh in Indonesia hard, causing massive casualties and destruction of houses and infrastructure. An Indonesian - Netherlands consortium developed a strategy for coastal restoration focusing on sea defence, flood protection, multifunction refuge construction and a regional early warning system. A comprehensive strategy was developed based on integration of results of vulnerability assessments, public participation, base-line surveys, modelling and flood mapping, disaster management and public awareness and leading to adaptive and preventive measures. The consortium worked intensively with local government, NGOs and local research centres. The strategy forms the basis of investment packages for restoration of the coastal area of about US\$ 120 million. The Detailed Engineering Design and Tender Documents are prepared and the works are being constructed. These works support the people of Aceh and Nias in the establishment of a safe habitable environment enabling economic recovery and sustainable development.



Tsunami destruction Banda Aceh, satellite pictures: before (left) and after the 2004 Tsunami (right) struck the coast.
(photos: © United Nations Environment Programme © Digital Globe)

1. Introduction

In the morning of the 26th of December 2004, a very strong earthquake of 9.1 on the Richter scale (USGS website) occurred below the Indian Ocean, just northwest of Sumatra Island. The earthquake caused a tsunami wave, which hit the west coast of Aceh within 30 minutes. The tsunami caused major loss of life, loss of goods, houses and infrastructure, and a major disruption to social and economic activities. In Aceh and North Sumatra it is estimated that about 130.000 people lost their life and about 37.000 are missing (BRR, 2005).

The impact of the tsunami was well documented:

- Damage to life (160,000 victims) and goods (approx. US\$ 5.6 billion)
- About 500,000 Internally Displaced Persons
- Major damage on the West Coast of Aceh over a length of 1,200 km
- Infrastructure destroyed, Banda Aceh to Meulaboh road plus 120 bridges
- Houses (120,000 units), schools (2,000 units), health facilities (127 units) destroyed
- Nias struck by Earthquake in March 2006, damaging houses & roads.



Figure 1: Google Earth map of Aceh and Nias island with submarine continental plates. (photo: Google Earth Image ©2012 TerraMetrics ©2012 Cnes/Spot Image Data SIO, NOAA, U.S. Navy, NGA, GEBCO)

The Indonesian Agency for Reconstruction and Rehabilitation (BRR) and the provincial government (supported by NGOs and international donor community) guide and supervise the reconstruction of the Province of Aceh. Because of the impact of the tsunami, this is an enormous challenge. Since 2005, there has been a massive operation in which houses, schools are being built, damaged roads, drainage, and water supply systems repaired, electricity networks re-established, businesses re-opened, health clinics operating and people resettled.

In order to speed up and structure the reconstruction the BRR has formulated the Aceh Nias Tsunami and Earthquake Response Programme (ANTERP). This programme consists of a number of initiatives, each designed to address the needs of discrete infrastructure packages. One of the initiatives in this programme is the Sea Defence, Flood Protection, Refuge and Early Warnings System (EWS) initiative, an integrated plan by the Sea Defence Consultancy. The challenge faced by the project is to create a safe habitable environment that enables economic recovery and sustainable development in Aceh and the island Nias.

Early in 2006, SDC - Sea Defence Consultancy Project, financed by the Royal Netherlands Embassy, was awarded to a Netherlands - Indonesia consortium. SDC consortium, lead by DHV together with Witteveen + Bos, Deltares and several Indonesian consultants, is to support the Aceh Provincial Government and BRR - Agency for Reconstruction and Rehabilitation of Aceh – Nias.

2. Coastal restoration strategy

Sea Defence Consultancy Project (SDC) started with the formulation of a strategy for coastal restoration and the definition of “wet” infrastructure reconstruction projects. The strategy was formulated based on the following main steps:

1. Execution of a vulnerability assessment;
A vulnerability assessment was carried out based on existing data about physical coastal properties, population data and economic values in the coastal zone (including tsunami damage reports).
2. Identification of six representative pilot areas;
Vulnerabilities were studied in depth in selected pilot areas each representing different types of vulnerability conditions such as:
 - *Urban areas in high risk situation*, large flood hazard (low-lying areas in high impact zone) and large impact of such an event (large population rates and economic values);
 - *Rural areas in high risk situation*, large flood hazard (low-lying areas in high impact zone) with smaller impact (low population rate and economic values);
 - *Urban area in low risk situation*, adopted because of reconstruction in post-conflict situation.
3. Damage inventory of the pilot areas
4. Public consultation
The main driver for a successful formulation and execution of a sustainable restoration strategy is the organisation of several on-site public consultation meetings in selected pilot areas. Meetings include representatives of local communities, local government (municipality and districts) and representatives of NGOs working in the field of housing and infrastructure reconstruction. By doing so, SDC formulated a demand-based project strategy whereby project ideas and concepts are embedded in the local environment and community. The approach is shown in Figure 3.

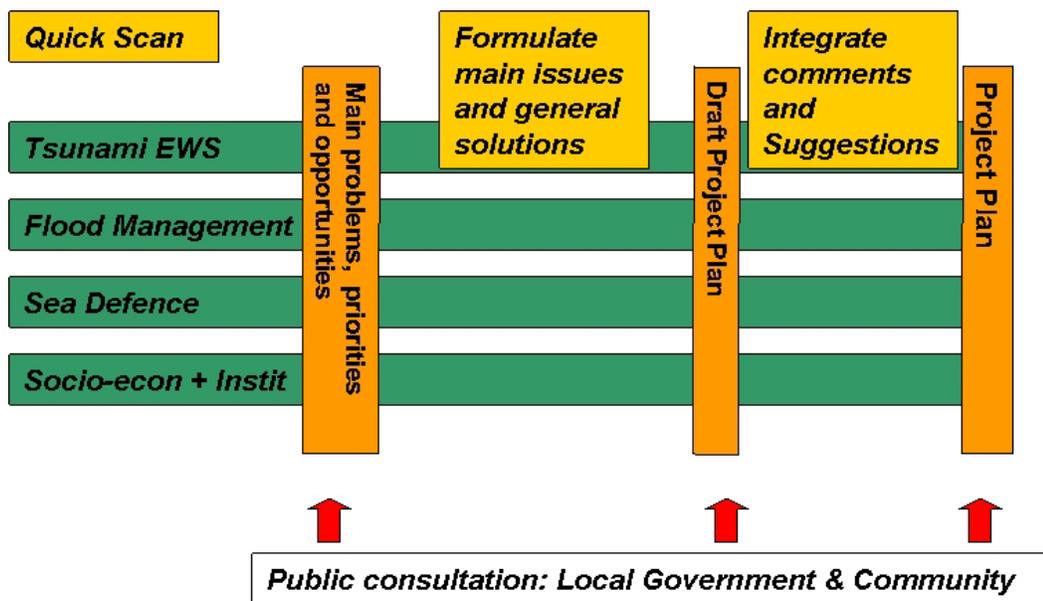


Figure 3: **Public consultation: Local Government & Community**, leading to demand – based, integrated strategy for restoration of Aceh and Nias. (source: SDC- Sea Defence Consultancy Project)

Several rounds of consultation were necessary to formulate the integrated coastal restoration strategy:

- Public consultation 1 of the pilot areas: problem definition and priority setting (engineers view and public opinion);
- Public consultation 2 of the pilot areas: project ideas and first concepts for solutions.

After drafting the strategy, the following consultations were organised for the pilot studies:

- Public consultation 3: preliminary designs and start feasibility studies (EIA, finances, land acquisition, resettlements etc);
- Public consultation 4: draft designs and presentation of results feasibility study;
- Public consultation 5: finalisation and handing over to BRR for implementation (tendering and construction).

3. Results

3.1 Integrated coastal strategy

An integrated strategy was drafted for the coastal restoration of Aceh and Nias in the aftermath of the tsunami based on the approach and lessons learned of the pilot studies.

The coastal strategy results in a combination of adaptive measures (warning system, evacuation and refuge facilities, -zoning risk zones and implementation of setback zones) and preventive measures (coastal protection measures- with a preference for soft flexible measures). The combination of adaptive and preventive measures formed the basis for an integrated approach, delivering far more in reducing the risk of future hazards than just the sum of the elements proposed. Furthermore, the coastal restoration strategy was also implemented for other problem areas identified.

Preliminary designs, detailed designs and tender documents were drafted. These include structures such as flood dikes, drainage channels, outfall structures, seawalls, breakwaters etc. as well as designs for soft measures such as nourishments and re-greening of coastal areas.

3.2 Early Warning System (EWS) and Risk Zoning

SDC has focused on building a complete chain of early warning centres, including generation of a warning signal and warning communication as well as identification of areas at risk and providing escape and refuge infrastructure. This task was supported by zoning of areas at risk.

Zoning helps identify areas that need to be evacuated and areas that are suitable for providing a refuge. Four zones are distinguished: the safe zone, the wet feet zone, the evacuation zone and the direct impact zone. Based on the tsunami inundation map (produced through extensive and state-of-art tsunami inundation modelling) it is possible to produce a zoning map (see Figure 4). A basic principle applied is that for water heights above 1 m evacuation is required.

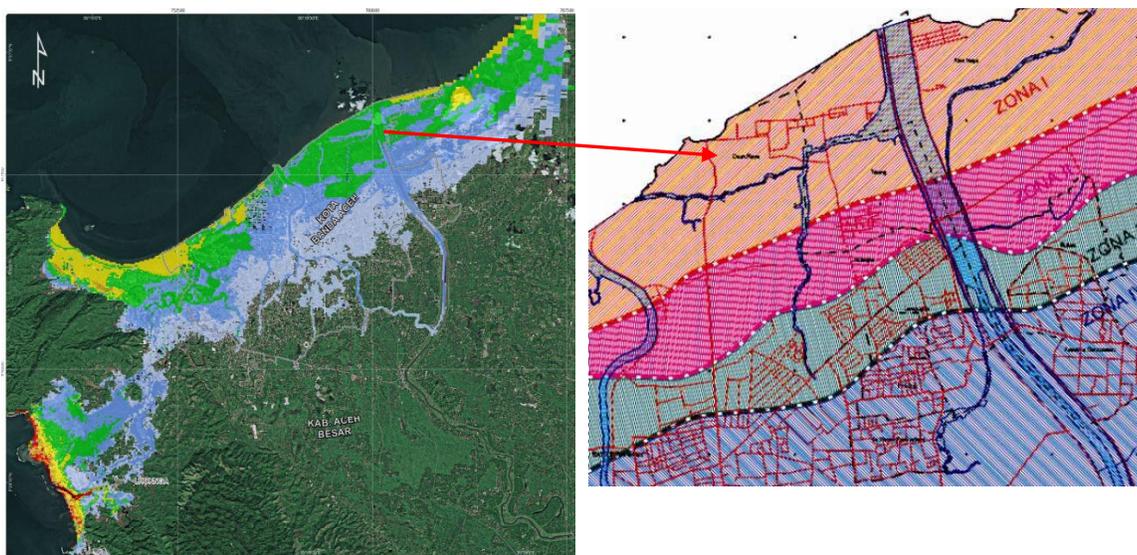


Figure 4: *Computed inundation map Banda Aceh (left), and zoning map Banda Aceh (right).*

(source: SDC- Sea Defence Consultancy Project)

For evacuation planning, horizontal and vertical evacuation is considered. Tsunami inundation maps provide critical information about the required height of escape buildings. Areas are identified in which (existing or new) 1, 2 or 3 storey

buildings can serve as escape buildings (see Figure 5). Furthermore, supported by tsunami inundation maps, the location of critical infrastructure can be evaluated such as hospitals, warehouses for emergency goods, police head quarters, communication centres and local government offices. These critical facilities should preferably be located in the safe zone. Facilities in the wet feet zone can be used, but adjustments should be made for flooding and access. For example, critical hospital facilities (emergency rooms and operation theatres) should be located at the first floor, while the ground floor should be easily evacuated.



Figure 5: *Sea Defence Consultancy design for escape building (left), and constructed escape building in Banda Aceh (right). (source: SDC- Sea Defence Consultancy Project)*

3.3 State-of-the art baseline studies

A problem encountered in Aceh (and encountered in many disaster areas) was the lack of reliable data and information as well as consistent approach and guidelines.

SDC prepared several state-of-the art baseline studies to provide a solid base of knowledge and information, necessary for SDC project design but also for any future coastal developments. Results of the studies are available to use for all interested parties, and have been shared through training, workshops etc. (see SDC - PDF Reports)

The baseline studies drafted are:

1. Coastal morphology during and after the tsunami (impact and expected future development)
2. Hydraulic conditions (tides, waves, currents, water levels)
3. Tsunami inundation modelling + damage modelling (tsunami risk assessment, see a modelling output Fig. 4)
4. Guidelines and Manual for Design of Coastal Protection Aceh & Nias (later translated to national guidelines).

A wide range of numerical models was used as basis for the studies, including drainage models, wave models, tidal models, tsunami propagation models, tsunami inundation models, damage models, morphological models etc. Furthermore, SDC tendered out and managed bathymetric and topographic surveys. The surveys were required for design purposes but also forming the basis for a solid monitoring programme.

3.4 Awareness building and capacity building

Public awareness and community preparedness are key-elements for Aceh society to be prepared for a potential tsunami. SDC focused on development and implementation of public awareness campaigns, community preparedness and the planning and implementation of regular evacuation drills. In a first pilot phase, a number of small community-awareness events were executed in cooperation with the local University Syiah Kuala, Provincial Red Cross and local disaster management authorities. Events focused on a joint inventory of refuge areas / buildings, escape routes, evening meetings with desa (village) community and finally evacuation drills. SDC's public awareness methodology was further developed based on these exercises. Public awareness programmes were extended and handed over to the consortium of Provincial Disaster Management Agency, University, PMI - Red Cross Indonesia.

Based on the pilot experiences, SDC and partners concluded to focus on the future generation as the special target group. With local experts, help of teachers and trials at schools, course material was developed for primary schools and incorporated through the Department of Education in the curriculum of all primary schools in Aceh.



Figure 6: From left to right - **Tsunami drill, public consultation and courses at primary school.**
(photos: SDC- Sea Defence Consultancy Project)

SDC from its start in 2006 until the end of 2009 has cooperated extensively with local government departments, local institutions, universities and NGOs. By various ways and means (workshops, training, joint exercises, joint policy formulation, joint research programmes) different organisations were supported. Some highlights are:

- Preparation of regional guidelines Aceh & Nias for coastal protection and restoration post-tsunami;
- Preparation of national guidelines for coastal protection (see Box below);
- Joint development of RiskMap (a tsunami warning tool) with local universities;
- Training, hand-over of RiskMap to Provincial Disaster Management Agency and national authorities
- Guidelines on escape routes, designs of refuge buildings and escape areas (including sets of designs of escape infrastructure for the towns of Banda Aceh en Meulaboh)
- Quick scan for escape infrastructure, which was jointly implemented with local government departments along the west coast of Aceh.
- Joint public awareness campaigns with various institutions.
- Institutional strengthening of the provincial disaster management agency.

The Guidelines for Coastal Protection for Indonesia consist of the following subjects:

- Coastal characterisation (based on coastal type, physical properties, coastal land use and functions) and integrated coastal zone management
- Strategy for coastal protection Indonesia (for flooding and erosion)
- Site-specific selection of solutions
- Functional design of solutions

The Guidelines book was accompanied by the Design Manual for Coastal Protection Works, in which a more detailed elaboration of design rules and calculations is given for different types of coastal protection measures, based on site specific data.

For more information on the results of the SCD - Sea Defence Consultancy project, see the extensive list of downloadable SCD – PDF reports.

4. Conclusions

Formulation of a restoration strategy in a post – disaster area faces many challenges. By using an integrated approach, using the knowledge and experience of different disciplines, a coastal restoration strategy can be developed in which prevention and adaptation measures are combined. The strategy is worked out in different Guidelines and tools, which are adopted by

the national government departments. Sustainability is achieved by working intensively with local governments and community in the formulation of the restoration strategy. The strategy formed the sound basis for the formulation and design of infrastructure investment packages with a value of about US\$ 120 million. The infrastructure packages are currently being implemented and are supporting the people of Aceh and Nias in the establishment of a safe habitable environment that enables economic recovery and sustainable development.

5. PDF reports and Websites

PDF reports:

- **BRR - Badan Rehabilitasi dan Rekonstruksi /Rehabilitation and Reconstruction Agency NAD-Nias, 2005: *Aceh and Nias One Year After the Tsunami - The Recovery Effort and Way Forward*; December 2005: http://siteresources.worldbank.org/INTEASTASIAPACIFIC/Resources/1YR_tsunami_advance_release.pdf**
- **SDC – Sea Defence Consultancy’s PDF reports :**
 - *Main report: coastal strategy and design guidelines Aceh and Nias*
 - *Volume I: Morphology and Coastal System*
 - *Volume II: Hydraulic Conditions*
 - *Volume III: Tsunami Modelling and Risk Assessment*
 - *Volume IV: Guidelines Coastal Defence Measures*
 - *Guidelines for Coastal Protection Aceh and Nias*
 - *Manual for the Design of Coastal Protection Works Aceh and Nias*
 - *Guidelines for Coastal Protection Indonesia*
 - *Manual for the Design of Coastal Protection Works Indonesia.***can be downloaded through: <http://seadefenceconsultants.com/en-download/>**

Websites:

- **DHV BV – Consultancy and Engineering, the Netherlands: www.dhv.com**
- **SDC -Sea Defence Consultancy project, Aceh, Indonesia: www.seadefenceconsultants.com**
- **USGS – US Geological Survey, USA : <http://earthquake.usgs.gov>**