December 2009 marks the fifth anniversary of the Boxing Day tsunami in Southeast Asia. Easily the largest natural disaster in recent history, the 9.1-magnitude earthquake and resulting tsunami on December 26, 2004, brought incredible devastation to many coastal countries, particularly Indonesia. A wave 30 meters high hit the province of Aceh, on the northern tip of Sumatra. From the beginning, geographic information system (GIS) technology played an important role in relief efforts. GIS maps acted as guides to affected areas and were used to coordinate emergency services and rebuilding.

Asset management is a large focus for Aceh. Rebuilding continues via the Infrastructure Reconstruction Enabling Program (iREP) established through the Multi Donor Fund. Many international aid agencies are continuing to update the GIS data, reflecting new infrastructure being built. Germany’s Gesellschaft für Technische Zusammenarbeit GmbH (GTZ) created an asset management application called SIMDA that can be used by all agencies for efficient mapping and maintenance of infrastructure in the province.

The wealth of data continues to be useful today for spatial planning and environmental sensitivity mapping such as forest management through the Aceh Green initiative. The economy of the area is supported through GIS use by mapping and analyzing sand and gravel mining exploration and supporting tourism to the area.

This is the epicenter of the 9.1-magnitude Indian Ocean earthquake of December 26, 2004, which left 150,000 houses damaged or destroyed and 3,000 kilometers of road impassable. The initial damage and loss assessment of Aceh was US$4.5 billion, and for Nias, a nearby island also affected, US$400 million. This devastation paled in comparison to the direct toll on human lives: 175,000 people killed or missing and 600,000 left homeless. (WorldSat International, Inc., and ESRI Data & Maps CD-ROM)

AusAID funded the Asset Mapping Assistant Project (AMAP), which is managed by GTZ. AMAP facilitates the allocation of scarce resources and manages public assets.

A Sustainable System from the Ground Up
This carefully coordinated GIS effort is a testament to the strong spirit of the Acehnese people who literally built a system from nothing. In the hours after the tsunami, every infrastructure and service was impacted. Water, sewer, and electrical systems were destroyed and had to be

Assets and the Economy Gain from Spatial Planning
“As a result of the GIS data collection and compilation during the past five years of reconstruction, this area may be considered one of the richest provinces in terms of spatial data and information in Indonesia,” says Erik van der Zee, GIS adviser for spatial planning and environmental management component of the Earthquake and Tsunami Emergency Support Project (ETESP) supported by the Asian Development Bank (ADB).

ADB and more than 60 other organizations have been involved with the rebuilding effort from the start, coordinating activities with the Indonesian government. GIS has made collecting, managing, and sharing information in a timely manner between these many different stakeholders possible.
reestablished. Even the transportation of supplies and labor force to affected areas was hampered since the single road along the west coast had been severely damaged or completely washed away in large sections.

To begin coordination of the relief effort, emergency responders needed to be guided to affected areas. Maps were required to visualize where supplies should go and which organizations would be able to assist. Since the tsunami tore up the shoreline of the area, it was a challenge to find current and accurate geographic data for the region. The national mapping agency Badan Koordinasi Survei dan Pemetaan Nasional (Bakosurtanala) provided 1:50,000-scale maps, but what remained of the mapped infrastructure for the province was not always up-to-date.

Within days of the devastation, the United Nations (UN) set up a Humanitarian Information Centre (HIC). Based in tents at the heart of the catastrophe, HIC collected data from the Indonesian government, nongovernmental organizations (NGOs), and international agencies. UN HIC delivered GIS data and maps to the responding humanitarian community, allowing workers to deliver assistance more effectively immediately after the emergency.

“Unfortunately, disasters happen when we least expect them,” says van der Zee. “This emergency really exemplified the importance of countries investing in national mapping agencies to provide the information necessary to respond to catastrophes such as this.”

Where maps were rendered useless by either changed infrastructure or the impact of the tsunami, UN HIC turned to high-resolution satellite imagery to supplement the vector base data. Since a complete image of the area was unobtainable due to heavy cloud cover, older topographic maps were also scanned.

**GIS Transitions from Recovery to Development**

As the relief efforts transitioned into recovery and development, the focus of the UN HIC shifted as well. In September 2005, the HIC was renamed the United Nations Information Management System (UNIMS), and its mission changed to reflect the need for better coordination with the Indonesian government as well as continuing to meet the high demand for GIS during the next rehabilitation and reconstruction phase.

Six months later, the GIS software, data, and expertise were successfully transitioned from UNIMS to the Indonesian government through the Spatial Information & Mapping Centre (SIM-Centre). Partially funded by a grant from the Norwegian government and the United Nations, SIM-Centre was part of a temporary building and reconstruction arm of the Indonesian government in the province. This arm, the Badan Rehabilitasi dan Rekonstruksi (BRR) NAD-Nias, oversaw the work of the humanitarian agencies and ensured that the needs of the local population were met.

SIM-Centre created and supported a GIS user group and GIS consortium that continue to meet. The consortium is a voluntary group of GIS users from more than 20 agencies who deal with issues related to the use of GIS in the province. For example, to make training of local staff easier, the consortium created a customized training manual for ArcGIS written in Bahasa Indonesian and based on Aceh Province datasets.

To date, the BRR SIM-Centre has been transferred to the Aceh Geospatial Data Center (AGDC) of the provincial development and planning board in Aceh (BAPPEDA) and the governor’s office. The AGDC is managed by Yakob Ishadamy, who also managed the SIM-Centre at BRR. GIS centers have been established in six districts in Aceh province and are able to do basic GIS processing. GIS data is maintained with ESRI GIS software, and data is available in shapefile format.

States Ishadamy, “GIS continues to have a role to play by providing information to government officials and others to support their efforts. The reconstruction, economic, and social factors involved all have a time-and-space component. GIS provides an invaluable framework for building an information base and providing the best decision support, communication, and collaboration possible.”
GIS Use during Tsunami Disaster Response

Apart from providing informative topographic maps to coordinate relief efforts, GIS was used in specific sectors during the initial response to the disaster.

Health
The most immediate concerns were the containment of any outbreak of disease and prevention of further deaths as a result of starvation. Information on the location and number of survivors, as well as the extent of their injuries, was urgently needed to provide food, water, and medical supplies.

The UN HIC team, working with the UN World Health Organization (WHO), set about collating and evaluating data using GIS to create an accurate picture of the damage and prioritize need. Activities were coordinated and prioritized; field hospitals and mobile health clinics were set up where needed. No major outbreak of disease occurred, and there were few deaths, contrary to expectations after a disaster of this magnitude.

Mobile Resource Planning
Since the main west road and all seaports were not usable, transporting food, water, and medical supplies seemed nearly impossible. GIS was used to plan movement of trucks and prioritize shipments.

Infrastructure
Many groundwater reservoirs were polluted, sanitation at temporary shelters was an issue, and drinking water had to be trucked in to the city. GIS was used to identify risk areas and develop management plans.

Education
Since 50 percent of the schools in the area were damaged or destroyed, GIS was used to discover where best to build, or not build, new schools based on population density and proximity to health facilities. An assessment of damaged facilities was also taken to identify which ones could be restored more quickly.

Mobile Health Clinics
GIS was used to plan movement of vehicles and ship goods efficiently throughout the region. (Credit: Joerg Meier, Aceh Besar)

GIS was an invaluable tool in planning work to fix infrastructure.

GIS maps helped agencies rebuild and repair more than 100 education facilities in the region, allowing children to return to school.

UN HIC worked with WHO to collect and evaluate data, using GIS to create an accurate picture of the damage and prioritize need.
Housing
The simple act of providing shelter presented many challenges. More than half a million people were left homeless when land washed away and traditional land markers vanished. Land that remained had to be cleared of millions of tons of debris and silt before it could be used again, and many areas were no longer suitable housing locations because of the impact of the earthquake.

The international aid community responded to the problem by going to the field to map where houses once stood and determine who owned the properties. Pseudo land titles were issued with the signatures of all neighbors and the village leader.

Initially, there was no mandate to coordinate rebuilding among the various agencies. The government, through its reconstruction and rehabilitation agency BRR NAD-Nias, performed this coordination role, focusing its resources on coordinating activities including spatial planning, village mapping, community planning, engineering design, and house building. GIS was seen as a crucial tool to assist this coordination among many agencies as they scrambled to rebuild.

While it may take decades for affected communities to fully recover from the devastation, GIS will continue to play an important role in the sustainable development, repatriation, and restoration of the area.