The Role of Agriculture in Recovery Following Natural Disasters: A Focus on Post-Tsunami Recovery in Aceh, Indonesia

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ABSTRACT

Coastal communities are especially vulnerable to the impacts of a range of natural disasters. The reported frequency of natural disasters has risen dramatically in the past 100 years, with coastal zones particularly exposed to tsunamis, cyclones, and flooding. Managing the change in coastal dynamics and securing the livelihoods of those affected as responses to these disasters, are important issues for governments and international agencies worldwide.

This paper discusses the important role that agriculture can play in the transition from immediate emergency aid to long-term recovery following natural disasters. The focus of this discussion is on the recovery following the 26 December 2004 earthquake and tsunami in the province of Aceh, Indonesia. Collaborative work such as monitoring agricultural soils and establishing experimental and extension activities to restore agriculture to tsunami-affected sites and supporting the long-term recovery of farming communities undertaken in Aceh from 2005 to 2009 is discussed. Recommendations for future agricultural recovery programs are outlined. The importance of agriculture to livelihoods in Aceh is mirrored in other populous nations of the world, many of whom farm extensively along coastal areas. Agriculture should be regarded as an integral part of any post-disaster recovery program.

NATURAL DISASTER IMPACTS ON COASTAL ZONES

The threat of frequent natural disasters poses serious questions to governments and agencies about disaster preparedness and post-disaster management. The focus of this paper is on post-tsunami recovery in Aceh and the improvement of the response efforts through clear communication with affected communities, recognition of the value of agriculture to livelihoods and social recovery, and an emphasis on utilizing and supporting local services. This paper does not discuss prevention and mitigation issues for natural disasters as these issues are addressed by a number of authors (Martine 1999; Kumar and Newport 2005).

Coastal communities are impacted by a range of natural disasters. The reported annual frequency of natural disasters is rising (Scheuren et al. 2008) increasingly affecting larger numbers of the world's population. Coastal communities are most vulnerable to the effects of predicted sea level rises (Brighton et al. 2007) which will exacerbate the impacts of storm-related events. At least 40 percent of the world's population lives within 100 kilometers of the coast (Socioeconomic Data and Application Center [SECIN] n.d.). Tsunamis, cyclones, storm surges, and flooding are common causes of death and destruction of housing, crops, and livestock. Cyclone-related storm surges in Myanmar caused widespread destruction and loss of life in 2008. The effects on agriculture from seawater inundation and sediments following Cyclone Nargis were reported to be similar to those of the tsunami in Aceh (FAO 2009).

Data on the potential frequency of tsunamis is limited, with events reported in Chile, Hawaii, Papua New Guinea, Solomon Islands, Indonesia, Japan, and Samoa during the past 100 years. No data or observations are reported on the impacts of these events on agricultural land, apart from the Solomon Islands (Jansen et al. 2007). Predictions in 2010 of a large earthquake with potential to cause a tsunami immediately impacting on the island of Sumatra (Science and Development Network 2010) makes disaster preparedness and response vital. The lessons from the 2004 earthquake and tsunami need to be collected and disseminated to allow populations along vulnerable coastlines the chance to prepare and plan.

THE IMPACT OF THE 2004 ASIAN TSUNAMI

The December 2004 tsunami triggered by a 9.1 magnitude earthquake impacted severely on the countries of Indonesia, India, Sri Lanka, and Thailand, and affected numerous other countries such as Myanmar, The Maldives, and Malaysia. The damage from the earthquake compounded the destruction in Aceh. In other affected countries, the physical damage of the tsunami waves and the inundation of coastal areas caused destruction and loss of lives and livelihoods. Coastlines were significantly altered, with areas in Aceh, the Andaman and Nicobar Islands, and Sri Lanka remaining permanently inundated.

According to Indonesia's Agency for Rehabilitation and Reconstruction (BRR) (2006), an estimated 230,000 people lost their lives as a result of the tsunami. In Aceh alone, 167,000 died and some 500,000 people were displaced.

THE TSUNAMI'S IMPACT ON AGRICULTURE IN ACEH

An estimated 70,000 hectares (ha) of agricultural land and 22,000 ha of plantation crops in Aceh were affected by the tsunami and nearly two million heads of livestock were lost (Alimoeso 2006). Estimates vary: the tsunami directly affected 92,000 farms and rural enterprises (Mariyono et al. 2009); more than 60,000 farmers (World Bank 2008), 63,977 rural households (Republik Indonesia 2005); or the livelihoods of 331,360 working people mainly from fishing and agriculture were directly affected (meaning they required food and financial assistance) in 2005 (FAO 2005a). Large quantities of sediment were deposited on fields and covered canals and drainage lines. Sediments in Aceh included coral fragments, sand, sea bed mud, and peat soils stripped from coastal wetlands and deposited inland. Some sediment had a beneficial effect on agricultural fields, once salt had been leeched by rainfall, providing a flush of nutrition for the first post-tsunami crops.

It was expected that soil salinity would be the most common cause of delays in agricultural recovery. Despite some reports predicting that salinity in particular would affect soils and that it could take between two to five years for the soil to return to full productivity in Aceh (Oxfam 2005), many farmers returned to agriculture within 18 months of the tsunami, some within six months. Soil surveys of 23 sites along the east coast of Aceh (McLeod et al. 2010) showed that high levels of soil salinity persisted at some sites three years after the tsunami even after more than 3,000–7,000 mm of rainfall. The slow rate of leaching is likely to have been due to damage to drainage systems and the flat topography of the affected areas. This matches sampling results and observations in Subagyono et al. (2005).

Farmers returning to agriculture encountered direct impacts of the tsunami, including, damage to infrastructure such as canals and drainage, layers of sediment and debris, and high soil salinity. Indirect impacts include high populations of pest animals, limited availability of planting materials and other inputs, and limited extension support. On the west coast of Aceh where the level of destruction was greatest, farmers were in limbo dealing with an altered landscape and coastline. Due to subsidence, previously productive fields were inundated at high tide, or even lost permanently to inundation. In some areas, specific soil conditions affected crops (salinity in poorly drained fields, loss of organic matter from sandy soils affecting yields, impacts on soil nutrient status by some sediments). Observations during field visits from four months up to three years after the tsunami revealed that, with time, agricultural recovery was most often delayed by unrepaired infrastructure, sediment remaining in some fields and in some villages, and the farmers who were unlikely to cultivate fields until tsunami reconstruction income sources were no longer available. The tremendous loss of life also affected farming communities' ability to recover, leaving many fields uncultivated.

Damage to agricultural infrastructure in Aceh differed from other tsunami-affected countries due to the effects of the earthquake that triggered the tsunami. The alteration of the coastal landscape observed during the Australian Centre for International Agricultural Research (ACIAR) project field trips and also described in Wong (2009), Tobita et al. (2006), and Moore (2007) was marked, with obvious subsidence (and some uplift) occurring in Aceh and Nias. Although wave heights were not as great on Aceh's north and east coasts and the epicenter of the earthquake farther away, subsidence was measured near Banda Aceh (Gibbons and Gelfenbaum 2005) and along parts of the east coast (Wong 2009).

THE IMPACT OF THE 2004 TSUNAMI ON AGRICULTURE IN OTHER COUNTRIES

The physical damage to the landscape and infrastructure was also significant in the coastal farming communities of India, Sri Lanka, and Thailand. Like Aceh, fields were inundated with sea water, and irrigation and drainage systems and fields were covered in tsunami sediments too deep for laborers to easily remove or incorporate (Newport et al. 2005; Mohan 2008; Weligamage et al. 2005). Farming communities in Tamil Nadu, India rely on fresh water wells for irrigation of dry season crops. These wells were filled with salt water and rendered unfit for irrigation. In some less affected areas, agriculture recommenced fairly soon after the tsunami. In India, the physical removal of surface salt commenced, but was later abandoned because of the costs and time involved (Singh 2006). Flushing and leaching of salt was adopted instead through the construction of bunds where irrigation water was available, or simply waiting for monsoon rainfall.

Upland fields and homegardens in Sri Lanka were reliant on rainfall for removing salt from the soil. Identifying alternative methods of flushing salt in low rainfall zones was raised as an important priority for restoring productive homegardens (Weligamage et al. 2005).

POST-TSUNAMI AGRICULTURAL RECOVERY IN ACEH

Like many areas in Asia impacted by the 2004 tsunami, the population of Aceh relies heavily on agriculture for their livelihood. Around 60 percent of household income in Aceh is derived from farming (Subagyono et al. 2005), with the number higher in rural areas. The earthquake and tsunami occurred in a province that was already experiencing disaster, damage, and poverty due to civil conflict (Joshi 2008; Shea et al. 2008), with one of the highest rates of poverty in Indonesia. Rural areas in Aceh were experiencing poverty rates above 32 percent prior to the tsunami event, compared with a national average of 17 percent. The high rate is attributed to the intensification of the civil conflict in the decade preceding the tsunami (World Bank 2008). Poverty rates increased after the tsunami, impacting on many better-off urban areas. This increase was short -lived, and in 2006 there was little difference in the rate of poverty between tsunami and non-tsunami affected areas.

Many people were forced to abandon their farmland during the conflict (Shea et al. 2008; Adam-Bradford and Osman 2009) moving away from inland villages that relied on agriculture for livelihoods to coastal settlements. Significant areas of estate crops (coffee, horticulture) were abandoned (BRR 2005). Large numbers of the estimated 500,000 people displaced by the conflict (Czaika and Kis-Katos 2007) were yet again displaced by the tsunami, joining another 500,000 total displaced (BRR 2006), some moving to camps (Nazara and Resosudarmo 2007) where 70,000 people remained two years later (Oxfam 2006).

The impact of the tsunami on coastal farming lands meant that villages reliant on farming for their income were struggling to live on limited incomes. Although coastal populations relied less on agriculture due to access to fishing and aquaculture for income, more than half the population in areas affected by the December 2004 tsunami relied on agriculture for their livelihood (Budidarsono et al. 2007).

At the time of the December 2004 earthquake and tsunami, the institutional capacity of Government Agriculture Services in Aceh had been severely eroded by years of conflict (Shea et al. 2008). Buildings and infrastructure were damaged, many offices largely inactive, and technical staff shifted away from conflict areas. Networks with farmers were fractured or lost as extension workers' ability to travel into the fields was restricted. The earthquake and subsequent tsunami exacerbated damage to agricultural facilities in coastal areas and caused significant loss of life among farming communities, agricultural staff, and their families. The ability of the technical and extension services to respond to the tsunami disaster was limited, especially when many staff members were themselves affected.

Local support services were limited and non-government organizations (NGOs) from all over the world moved into Aceh as participants in one of the largest emergency aid responses witnessed to date. Some NGOs focused on livelihood programs. A few included agriculture, though mostly in the capacity of distributing aid packages of seed, seedlings, fertilizer, and tools. It is unclear what assessments of infrastructure, community capacity, and soils were conducted to determine the timing and relevance of the aid packages to affected communities.

ACIAR supported some early 2005 visits to

Aceh to investigate how Australian researchers and extension staff familiar with a salt-affected environment might be able to assist efforts to restore agriculture to tsunami-affected areas. It was clear that farmers whose basic infrastructure was not heavily damaged were keen to replant their fields. Where no assessment of salinity levels in soils or irrigation water was provided, some farmers unfortunately planted rice crops in salt-affected fields that subsequently failed.

While the scale of the disaster (and aid response) was unprecedented, information on agricultural recovery programs was limited making it hard to communicate and coordinate action with NGOs and local and provincial agencies. Infrastructure such as roads and housing took priority. Farming communities lacked information to determine how to resume farming in their village. While recovery programs represent an opportunity for reforms that could improve the incomes and resilience of communities dependent on agriculture (Olsen et al. 2005), many communities in Aceh felt excluded from the recovery program with more consultation and two-way communication required (Eye on Aceh 2006). Decentralization of control over agricultural recovery programs may have been more effective in delivering appropriate projects and communicating progress to the rural communities in each district.

DETERMINING PRIORITIES IN POST-DISASTER RECOVERY

Less developed nations have limited resources to apply to the recovery of disaster-affected populations. For these nations, the restoration of livelihoods is crucial to long-term recovery. Restoring livelihoods in a devastated area requires a long-term commitment, often beyond the scope of most relief agencies that focus on the immediate post-disaster essentials of shelter, health, and food. Post-disaster responses usually focus on physical reconstruction and less attention is paid to rebuilding livelihoods that are sustainable in the long term (Pomeroy et al. 2006).

Agriculture does not have the immediate post-disaster priority of shelter, medical, and food aid. It should, however, be a key component of livelihood recovery programs to promote trauma recovery through activity, community recovery, nutrition, and accelerate the reinstatement of farm incomes leading to independence from food aid. Agriculture has a key role to play for both people displaced in camps and those returning to their land. In Aceh, as in most of Indonesia, poverty is significantly linked to rural areas and agriculture (World Bank 2008). Assisting the recovery of farming and targeting rural areas will have the greatest impact on poverty reduction.

Agriculture should be considered by NGOs and government agencies much sooner after disasters. The approach to agricultural recovery also needs to be improved. Too much emphasis is placed on the provision of aid packages of seed, fertilizer, even machinery, before farmers can be certain their fields are ready to be farmed. The early intervention of survey teams to test soils, monitor landscape changes, and identify the critical infrastructure damage will allow NGOs and government agencies to focus their attention on the most appropriate forms of assistance. In less affected communities, timely intervention to restore agricultural activity could lessen dependency on food aid and ‘introduced’ livelihood activities that may not be sustained. Subagyono et al. (2005) outlined damage classifications and soil and landscape survey, and rehabilitation plans based on an FAO Framework (FAO 2005b).

Cash-for-work (a common component of livelihood recovery) could have a role in the rehabilitation of farmers’ fields, once medical, food, and shelter issues have been resolved. Rubber tapping is one agricultural activity that showed strong recovery in west coast villages whose rubber groves were not destroyed in the tsunami. Communities used grants or local funds to rebuild access roads to rubber groves, allowing production to resume. Several informants in rubber-producing villages told researchers they could earn more tapping rubber than they would as laborers on projects (Thorburn 2007). This underlines the contribution of traditional agricultural activities being brought back into production relatively quickly after the tsunami, and the contribution of tree crops discussed later.

Unfortunately, many farmers had limited options for income. Many villages in Aceh, particularly along the more affected west coast lacked resources to rehabilitate fields due to the thick sediment and major damage to irrigation and drainage infrastructure. There were also many sites where loss of life meant there were not enough farmers to manage all the fields of the village.

Temporary employment in other sites seemed to play a greater role in taking farmers away from their fields than cash-for-work programs. Evidence from interviews presented in Thorburn (2007) observed that people not returning to farming still had easier ways of putting food on the table. Some villagers did not anticipate taking up farming again so long as construction jobs were available. Residents of communities where access to agricultural land was an issue or their previously productive fields were badly affected, expressed concern about what would happen to them once the post-tsunami construction boom ended. Cash-for-work schemes had ceased in Aceh within 12 months of the tsunami event (Thorburn 2009). An extension of cash-for-work could have been used to support local farmers in the timely rehabilitation of village fields, where appropriate land rehabilitation strategies had been prepared. Donations of seed and equipment would then have been more relevant and likely to be used effectively. The main concern with cash-for-work programs is the creation of an expectation that collaborative activities to restore farming require payments for labor.

ACIAR PROJECTS – A PARTNERSHIP APPROACH

The early evidence that there appeared to be a lack of a coordinated approach in post-tsunami restoration of agriculture in Aceh prompted ACIAR to contract New South Wales Department of Primary Industries (NSW DPI) and commence work in Aceh in partnership with national and local agencies. This work was part of a group of projects that supported the recovery of agriculture and aquaculture in Aceh. NSW DPI was contracted because of its experience in the management of agriculture in saline and low-lying coastal soils. The ACIAR project involved regular field visits to different tsunami-affected sites, including interviews with farmers and local extension staff. The project focused on sites in the east coast districts of Aceh Besar, Pidie, Pidie Jaya, and Bireuen from 2005 and expanded to include Aceh Barat on the west coast in 2006. Soil rehabilitation and agricultural recovery work commenced in Aceh in 2005, in partnership with Indonesian national institutes, provincial and local government agricultural agencies, and local and international NGOs (Slavich et al. 2008; Tinning et al. 2008). The presence of ACIAR projects in Aceh from 2005 onwards, trained local technical staff to survey and monitor soils for salinity (McLeod et al. 2010) and fertility status at 23 sites, established field sites with farmer groups demonstrating appropriate technology to manage issues such as empty peanut pods, appropriate varieties for altered soil conditions, and flushing salt from paddy fields, and facilitated the communication of successful restoration of farming to extension staff and farmers from other districts. While early research provided valuable data on post-tsunami soil processes, it was clear during discussion with local agricultural and extension agencies that: (1) information about post-tsunami agricultural activities was limited, (2) local government agencies were not involved in many centrally-planned and NGO-led aid projects, and (3) limited resources were available for technical and extension staff to support the farming community. The ACIAR projects commenced training and communication workshops with government extension staff, NGOs, and farmers to improve understanding of post-tsunami soil and crop issues and to improve planning for agricultural recovery. Valuable information was obtained about post-tsunami soil processes (Agus et al. 2008; McLeod et al. 2006; Rachman et al. 2008; Slavich et al. 2008) and guidelines were developed for restoration of agriculture after a tsunami [Indonesian Agency for Agricultural Research and Development/Division of Primary Industries Industry and Investment New South Wales (IAARD/DPI NSW) 2008]. The experience and technical expertise gained by provincial and local extension services working in this project resulted in aid and recovery agencies consulting Balai Pengkajian Teknologi Pertanian (BPTP) and their local partners for advice on restoration of farmland and community agriculture projects.

OBSERVATIONS IN THE FIELD – WET SEASON (EARLY 2005)

Rapid assessments of field sites were conducted along affected areas of the east coast from 2005 (IARRD/DPI NSW 2008). Permanent monitoring sites were established (McLeod et al. 2010) and the program expanded to the west coast in 2006. Some high soil salinity sites were observed in Pidie and Bireuen districts in April 2005. Villagers were living in temporary housing close to their farms and had re-excavated several drains. Farmers were planning to plant rice and vegetables in beds with high levels of salinity near the surface and irrigating from shallow surface wells with high electrical conductivity (EC) levels. Social disruption from the tsunami resulted in many crops not being sown at the usual time leading to additional problems with pests and irrigation water availability. Areas of low salinity had already harvested successful crops since the tsunami. Generally these sites had been inundated for one day and a 10-15 centimeter (cm) layer of mud sediment deposited on the soil surface. Some sites had benefited from the repair of irrigation systems that suffered conflict-related damage in the early 1990s. Consequently, farmers were reporting higher yields than those before the tsunami but still below the yields prior to conflict troubles. Recently established rice crops in good condition were observed on highly saline land where fresh irrigation water was available. Fields were drained when observed and likely to need continued irrigation to avoid salinity stress. Other fields had acidic, thin orange iron oxide crusts, over highly saline clay soils, and no attempts had been made to crop these sites again. The level of soil salinity measured was closely related to the permeability of the soils and the duration of seawater inundation after the tsunami. Salinity levels reported in Subagyono et al. (2005) decreased in three east coast districts of Aceh from March to May 2005. The wet season rainfall increased the percentage of farmland with acceptable levels of electrical conductivity (<4 mS/cm) to 65 percent.

The main problems being reported by local agricultural staff along the east coast were rainfed rice crops lacking the irrigation supply to flush salts through the paddy fields and inundation of coastal fields by high tides. On some of the low-lying floodplains, extensive areas of rice bays were covered in organic sediments and still submerged. Drainage was a particular issue on the floodplains closest to the coast. Access to communities on the west coast of Aceh was a lot more difficult. The level of destruction was much greater and the recovery response less obvious than on the east coast. Farm communities visited around the village of Suak Pandan, Aceh Barat, were badly affected by the tsunami, particularly by major changes to the landscape. The coastline had moved inland between 500 and 1,000 meters, estuaries were altered by the deposition of tsunami sediment, and previously productive paddy fields within 1,000 meters of the new coastline were regularly inundated during high tides making rice farming impossible. Housing and market infrastructure had been rebuilt in the village without any obvious assessment of the long-term viability of this area for residents' livelihoods. Furthermore, farmers could not farm two years after the tsunami and since their irrigation water was highly saline, their fields were later converted to palm plantations.

OBSERVATIONS IN THE FIELD - DRY SEASON (LATE 2005)

Soil salinity was a significant constraint to crop production in wide areas during the dry season as the flushing effects of rainfall during the wet season had not reduced soil EC levels in the longer term. Constraints related to poor drainage are the most likely cause of this, with the most severe impacts resulting in total crop failure. Many farmers and extension workers reported yield declines of up to 50 percent. Our field observations supported these reports. At 17 (in August 2005) and 15 (in January 2006) of 23 east coast sites surveyed, soil EC remained at high to very high levels (>4 mS/cm).

Rice crops which had established well in August failed to yield well due to a range of factors, mainly lack of irrigation water. The impacts on the irrigation systems meant that supply could not be guaranteed. Some irrigated rice crops which appeared to have high yield potential in August had their irrigation supply diverted to other areas. These crops yielded very poorly, possibly due to water stress and/or soil salinity. Poor grain filling was commonly found in sites up to three years after the tsunami. This may have been a result of inadequate potassium uptake, but was again observed at sites with poor water circulation and drainage.

Many Acehnese farmers felt isolated from the recovery projects. It was difficult to obtain advice on how to manage agronomic issues previously unheard of in the area. Early reports of farming activities were mixed, with successful crops reported in hard-hit areas such as Aceh Barat (Bradbury et al. 2007) contrasting with the widespread distribution of poor quality seed (Eye on Aceh 2006) affecting crop yields and farmer morale. The positive news of early successful rice crops was not reflected across all of west Aceh. In 2006, agricultural recovery was barely getting underway in tsunami-affected communities surveyed in Aceh Barat, Aceh Jaya, and Aceh Besar (Thorburn 2007). Rice paddy rehabilitation featured prominently in the recovery programs in many of the villages in Thorburn's survey, yet none had yet harvested a successful rice crop. According to informants, the most common reason for the failure of these programs was their timing. Land clearance work was completed too late for the planting season, fields were subsequently covered in grass, and the community then waited for another clearance project before they could plant. Many types of agricultural assistance provided in post-tsunami areas, such as seeds, fertilizer, equipment, and credit, were premature, because basic infrastructure was not yet ready to allow these inputs to be used.

Discussion with farmers in the districts of Pidie and Aceh Barat two years after the tsunami provided some advice from those directly affected by the tsunami. They wanted information delivered through learning-by-doing, regular field meetings, farmer exchanges, and visits from local extension services. Immediately after the tsunami, farmers would have liked information on the condition of the soil in their village and how to reduce salt levels, rehabilitation techniques, salt tolerant rice varieties, weed removal, how to reduce the number of empty rice pods, and how to obtain agricultural equipment and funding. Two years after the tsunami they wanted information on correct planting schedules, cultivation of tsunami-affected land, re-use of neglected lands, water management, fertilizer application, pest control, seed sources and seed breeding, better rice varieties, use of animal manure, and marketing. Their advice to Solomon Islander farmers affected by a tsunami just prior to our meeting in 2007 was to move on, not get buried in the sadness, know that their land will recover, be independent, start cleaning up their land immediately, work together, and get extension advice.

SUCCESSFUL PROGRAMS AND MISSED OPPORTUNITIES – THE IMPORTANCE OF COMMUNICATION NETWORKS

As early as April 2005, rehabilitation strategies were being published to help guide agricultural recovery in Aceh (Subagyono et al. 2005). What was missing was communication of these strategies to the farming community. The most effective agricultural restoration programs witnessed in Aceh involved Acehnese NGOs. These groups mostly worked in partnership with larger international NGOs who provided large-scale project management experience and access to donor funds. Local NGOs were also more likely to collaborate with local agricultural agencies. Local NGOs participated in many of the activities of the ACIAR project and had good connections with provincial and district agricultural agencies.

Groups with a history of working in the local communities had particular success and were still managing activities four years on in post-tsunami and post-conflict issues. Effective responses to the tsunami in the fishing and agricultural communities of India were largely due to the presence of local networks (Kilby 2007; Mohan 2008).

Local NGOs in Aceh managed on-ground activities, establishing new farmer groups or assisting fragmented groups to recommence farming activities. While there were reports of poor outcomes in the Acehnese fisheries sector from contracts with unsuitable local NGOs (Eye on Aceh 2006), the small number of local NGOs participating in training provided by ACIAR agriculture projects had track records in their communities and were producing impressive results from relatively small budgets. Successful initiatives including commitments to purchase production in the first year of recovery and assist with marketing, underwrote the efforts of farmers to make a living as they returned to farming in uncertain circumstances. NGOs were creating a sense of trust with the farming groups and a commitment to be present in the district in the long-term. It is unfortunate that these groups were not better able to document their post-tsunami experiences in supporting farming communities.

The majority of international NGOs working in agricultural-related projects bypassed local extension services and transfer

Box 1. Farming finally flourishes after intervention

The village of Desa Baro in Aceh's Pidie District lies adjacent to the coast. Badly affected by the 2004 tsunami, the rice fields were left unproductive, saline, and covered in mud. Attempts to grow rice and soybean crops failed, and fields were left abandoned for two years. A visit from the ACIAR project in April 2007 recommended actions to remediate the soil, removing the remaining salt by flushing with irrigation water, adding organic matter to build soil fertility, and conducting trials of new soybean varieties. The trial was proposed for as many as possible of the 45 hectares of fields not affected by periodic tidal inundation. The earthquake that triggered the tsunami caused land subsidence in many coastal areas, allowing high tides to cover previously productive fields. The ACIAR team identified that a tidal gate was needed to protect the Desa Baro fields so that farming could return.

The trial was successful, introducing improved varieties from the national legume institute and demonstrating improved management for soybean crops. The expectation of a successful harvest prompted the village to invite the Pidie District Regent to the ceremonial first harvest. The previous year's crop had failed due to empty pods and partially developed seeds (common symptoms of post-tsunami legume crops in Aceh). Yields in 2007, however, reached 2.5 tons per hectare, whereas the average harvest in pre-tsunami years was less than 1.5 tons per hectare.

The Regent's visit also presented an opportunity to highlight the tsunami's impact on the coastline and the need for the tidal gate. The Regent agreed that the tsunami's impact should be addressed and laid the foundation stone for a new tidal gate structure on the day of his visit to Desa Baro. An extra 20 hectares were now available to the farmers in the village. In 2009 the first successful rice harvest in 5 years reached 8 tons per hectare providing a healthy financial return to farmers. The Desa Baro farmers' group leader commented, "It is very important to transfer the knowledge first before distributing capital aid. We could not have grown successful crops without first understanding why previous crops had failed. Our success highlighted the tidal inundation issue and now we have reclaimed 20 hectares of land and can plant our crops with confidence."

of knowledge and capacity building to local groups was not a priority when focusing on their short-term project milestones (Eye on Aceh 2006). Independent observations and findings about soils and landscape processes did not appear to be communicated to Acehnese government services and many assumptions were made about how soils and crops would respond to the saltwater intrusion.

While the coordinating relief agency BRR reported approximately 70 percent of agricultural land restored two years after the tsunami, farmers in areas more severely impacted were still unsure of the viability of planting crops in tsunami-affected fields. A lack of communication with farmers to inform them of the condition of fields and planting options was particularly evident in the more isolated west coast districts of Aceh until 2007. Research and demonstration of successful crops by local extension staff, supported by technical expertise from the Indonesian Ministry of Agriculture had the greatest impact in alleviating farmers' concerns about the prospects for agriculture in their district (Box 1). Similarly farmers in Tamil Nadu, India were unsure of the period that their fields would be affected by salinity (Newport et al. 2005).

There are few documented examples of agricultural recovery projects. The approach to agricultural recovery demonstrated by Mercy Corps' work in Aceh Barat involved site assessment, cash-for-work to provide income stimulus while repairing fields, and provision

Box 2. Successfully farming rice on peat soil sediments in Aceh Barat

In the same sub-district reported by Bradbury et al. (2007) farmers struggled to produce good rice crops in 2006 and 2007, with their fields appearing to be affected by deep peat sediments transported by the tsunami from coastal wetlands. Healthy yields above the district average were achieved by ACIAR projects in trials of rice varieties bred by the national rice center for peat soil, and using different fertilizer regimes to target deficiencies identified by soil testing (Tinning et al. 2008). The approach was simple but effective -- a partnership of national, provincial, and local agriculture staff brought together technical and local knowledge to solve a local issue for farmers. The success of the trials highlighted the plight of farmers in the area, prompting district authorities to replicate the demonstration across the sub-district affected by peat soil deposits, and improve the irrigation supply. Building the technical and professional capacity of local extension staff has had a long-term impact on agricultural recovery for local farmers.

of grants for the purchase of seed, inputs, and tools. Successful first rice crops were harvested (Bradbury et al. 2007) and demonstrated the impact of testing soils to confirm the removal of salt by flushing and supporting the local farmers in their principal livelihood activity.

Early celebrations of positive news like this were rarely published. Unfortunately, Mercy Corps' activity was not replicated across the wider district for subsequent seasons. In this instance Mercy Corps did not engage with local agricultural services, reasoning that local technical capacity was insufficient to practically assess soil salinity and restore rice and crop production (Bradbury et al. 2007). In the devastated west coast districts, the capability of local government agricultural services to respond to issues after the tsunami was clearly restricted by previous lack of activity in conflict-affected rural areas, loss of life as a direct result of the tsunami, minimal available infrastructure for extension, and a low level of technical capability in the field. Building connections with local and provincial agricultural services to enable ongoing support for these communities could have allowed successful activities to be replicated and led to a longer-term impact. A coalition of NGOs working in partnership with local and provincial agricultural services would have been an effective method of covering more affected communities and avoiding the long wait for assistance that some endured.

While local agricultural services were primarily involved in data collection activities in the immediate years after the tsunami, and rarely provided technical advice or extension to farm communities, there were many motivated local extension staff seeking training and resources in order to assist their communities. The data collection and provision role seems to have been a de facto position for local agencies, as NGOs avoided engaging them in communication and field activities (Eye on Aceh 2006). This unwillingness may have come from a perceived lack of confidence. Most NGOs aim for rapid response projects, delivering outputs in the short-term. Building relationships with local authorities is not always a simple process. ACIAR projects involved local extension staff from local government - Penyuluh Petani Lapang (PPL) and NGOs, in 5 districts of Aceh. Provided with a support network through the provincial agricultural agency, extension staff from Balai Pengkajian Teknologi Pertanian - Nanggroe Aceh Darussalam (BPTP NAD), were able to support farmer groups, run trials and demonstrations, and promote a return to farming in tsunami-affected areas. What was not evident early on was a coordinating body for agricultural activities, allowing groups to communicate their successes and failures to each other to improve future activities. BPTP NAD has subsequently taken on this role, but could have been identified earlier and provided with appropriate resources.

LESSONS FROM POST-TSUNAMI AGRICULTURE IN OTHER COUNTRIES

In the worst-affected areas of Tamil Nadu, India, the recovery of agriculture initially received low priority from NGOs working on tsunami relief projects, apart from donations of tools and seed. An NGO Coordination and Resource Centre (NCRC) was created to convince NGOs of the value of establishing agricultural recovery projects and to coordinate these activities (Mohan 2008). The value of this coordinating body was in developing a common understanding among NGOs and encouraging a uniform approach to the implementation of projects. The comprehensive package included three sets of activities; ‘immediate’ for desalination, ‘short-term’ for restoring soil fertility, and ‘long-term’ for sustaining the farm in the long-run. The NCRC engaged in a great deal of advocacy effort with NGOs and their donor agencies to ensure a common approach.

Box 3. The important role of tree crops in resilience and recovery

Rubber’s rapid post-tsunami recovery underscores the importance of agricultural diversity, and of the critical role of tree crops in household production strategies in Aceh. The primary form of outside assistance that supported resumption of some form of farm production in districts of west coast Aceh was village road construction to allow rubber tapping to recommence (Thorburn 2007) and generate employment and income for affected communities.

Rubber, cocoa and coconut are commonly grown tree crops in tsunami-affected areas of Aceh and provide significant proportions of many farmers’ income in both coastal and inland areas. Rubber alone provides a large proportion of the total income of sample households in coastal and inland areas of both West Aceh and Nias (Joshi 2008; Budidarsono et al. 2007). The incorporation of appropriate tree species that farmers want into any form of coastal shelter belt would maximise agro-ecological diversity and establishment. The protection afforded to homegardens by trees in southern Sri Lanka, reduced the impact of the tsunami and helped these gardens to recover and produce crops earlier than unprotected gardens (Harvey and Wiewardane 2008).

The incorporation of economic crops in coastal planning provides livelihood security for coastal farmers and laborers. Allowing natural systems to protect communities and provide diverse sources of income is one of the key principles proposed by Olsen et al. (2005) to guide the rebuilding process following a tsunami. A study by Hatfield (2007) in southern Aceh recommended the intensification of existing farming areas rather than the observed post-conflict increase in forest conversion and logging attributed as the cause of a series of devastating flash flood events in Aceh since 2005.

Since farmers in different locations value tree species differently, consideration of the value of tree crops and appropriate species needs to be site specific. However greater incorporation of tree species into the landscape, particularly on the coastal fringe would provide multiple benefits for the local communities. Trees have increasing importance and potential as savings and security for the poor, of whom many already plant and retain trees as part of their livelihood strategies (Chambers and Leach 1987).

Sri Lanka's recovery effort was hampered by a lack of inter-agency coordination and the centralized control of the recovery program (Mulligan and Shaw 2007).

Olsen et al. (2005) have offered principles for the implementation of disaster rehabilitation and included the need for decentralized planning and decision making that meaningfully involve local people and allow them to shape their future. Having agricultural projects managed by a local coordinating agency for farming would help to eliminate inappropriate projects that lead to failed crops. Farmers require assistance to assess the conditions of their fields and make decisions about when it is appropriate to return to farming. Microfinance to support the resumption of farming, involving women in decision-making processes, monitoring, and review processes to involve the local community are other points raised by reviews of post-tsunami recovery programs (Eye on Aceh 2006; Olsen et al. 2005; Thorburn 2007; Thorburn 2009).

Depression and lack of motivation impacted on those most affected by the tsunami. The commencement of livelihood activities, particularly those related to agriculture, helped to improve people's well-being (Harvey and Wijewardane 2008). Time was also a crucial factor for the emotional and mental recovery of people who suffered traumatic experiences. Livelihood programs need to continue beyond a year after a significant disaster to allow the whole community to participate and benefit. In Aceh, opportunities to establish household gardens in camps for the thousands of displaced persons were missed (Adam-Bradford and Osman 2009). Residents of camps were still reliant on food aid nearly two years after the tsunami. Homegardens would have provided nutritional benefits as well as improving residents' well-being. Homegardens in Sri Lanka perform many functions, generating direct income for the sale of outputs, producing raw materials for small industries, contributing to household food security, and providing environmental amenity, such as shade and habitat (Weligamage 2005). While ACIAR projects in Aceh supported the establishment of groups to farm backyards and vacant plots, it was not until 2009 that local government in some districts recognized the value of supporting a broad scale program.

Post-disaster trauma is reported to be a major source of concern for survivors of Cyclone Nargis in Myanmar. Huge loss of life and destruction on a scale reportedly similar to post-tsunami Aceh (Mizzima News 2009), the recovery program in Myanmar received much less coverage and financial support, with limited information on agricultural recovery.

Further discussion of post-tsunami recovery (livelihood programs, opportunities to disaster-proof, and the importance of environmental protection) include Mulligan and Shaw (2007); Newport et al. (2005); Olsen et al. (2005); Srinivas and Nakagawa (2008); and Thorburn (2007).

CONCLUSION

An Improved Response to Tsunami Disasters

The experience of ACIAR-supported projects working in Aceh for four years resulted in the development of guidelines in the recovery of agriculture after a tsunami (Indonesian Agency for Agricultural Research and Development/NSW DPI 2008). This paper has taken the discussion further to consider the coordination of activities and communication necessary to make a successful recovery program. Pomeroy et al. (2006) asserts that the rehabilitation process for livelihoods should be seen as an opportunity to strengthen and revitalize coastal communities. Agriculture (together with fishing) is a key component of many coastal communities, supporting and employing a large proportion of the population. Physical reconstruction will often be necessary; however, the provision of skills and resources that allow people to determine their own long-term recovery are most important. There is also the opportunity to address pre-existing poverty and social inequalities by improving the resilience of coastal farming systems.

In Aceh, there was the added challenge of dealing with the impacts of civil conflict. Agricultural knowledge was not being communicated by extension staff and from elders to the young, due to the inherent dangers of visiting fields outside of populated areas. Acehnese communities had lost skills and experience in tree management (Roshetko et al. 2009), and similar challenges were observed in working with lowland rice and vegetable farmers. Farmers in conflict-affected areas of Aceh Besar and Aceh Barat commenced farming away from the immediate village vicinity in 2009, for the first time in 20 years.

The advantage that the ACIAR projects held in agricultural rehabilitation was the establishment of a multi-disciplinary team of research, extension, and technical staff from international, national, provincial, and local levels, broadened by communication and collaboration with international and local NGOs. The projects had no short-term goals for numbers of hectares rehabilitated or workshops conducted, but rather adopted a problem-solving approach and aimed at restoring communication networks within the agricultural community. This approach has developed into longer-term activities to improve coastal farming systems, involving an even broader range of partners. The benefit of this approach has been long-term impacts in improving crop yields (Tinning 2011, unpublished) and incomes, and developing women farmer networks that improve food security, livelihoods, and nutrition (Strempel 2011).

Many of the recommendations presented here for responding to a tsunami disaster are applicable to other coastal disasters, storm surges, cyclones, and the predicted sea level rises that will affect many of the world's populated and productive coastlines. The intensity and extent of the disasters may vary, and the recovery emphasis change. However the key principles for any response to a disaster should focus on agriculture as it remains vital for poverty alleviation efforts. In Aceh, almost 30 percent of Aceh's rural population lives below the poverty line and agriculture offers employment to over 50 percent of the workforce.

The following steps are recommended for agricultural recovery after a tsunami or similar event.

Conduct field surveys

Farming communities should be surveyed early in order to direct aid to areas of most need. Communities should be asked what they need, not only in the short-term but also to restore their livelihoods (employment, farming, fishing) once essential needs are met and people are ready. Surveys of agricultural infrastructure and soils should be included and agricultural recovery considered a high priority alongside shelter, medical, and food aid. While there may not be resources available for infrastructure repair and debris clearing of fields in the immediate aftermath of a tsunami, surveys will help direct assistance to the areas of immediate need or to opportunities to re-establish farming activities. The focus should be on rehabilitating existing farmland rather than opening up new agricultural land through forest conversion. Classification of land based on factors such as physical damage, infrastructure damage, and soil salinity levels as seen in FAO (2005b) presented in Subagyono et al. (2005) with accompanying maps provides authorities and cooperating NGOs with a greater opportunity to plan and collaborate for the rapid reclamation of farming activities on less affected sites.

Monitoring of soils for salinity and nutrient status should be carried out using local expertise, in collaboration with available university and national institute expertise. Rapid assessment techniques using an EM38 provide an accurate field assessment of the soil salinity status of each site. All available local extension staff should be involved in this process, including training in survey methods and early communication to farming communities about the prospects for agricultural recovery. As many monitoring sites as possible should be established, coordinated by local and national agriculture agencies. Data should be collected on visual indicators, discussion with locals about the length of time land was inundated, salinity (soil and water EC), soil pH, and composition of sediments, to determine whether land is ready to be farmed. Acid sulfate soils may also be an issue in affected coastal lands.

Communities should be asked what they need and what expertise they have. Local knowledge of the conditions at the time fields are inundated and the length of time saline water remains on the surface, could be important to determining what fields might be first ready for rehabilitation and where to concentrate available resources.

Crops that farmers want should be identified and the sourcing of seed and planting material to match should commence wherever possible. People prefer to return to farming activities with which they are familiar. The recovery process should be an opportunity to improve farming systems but only in consultation with the community.

Any images and information generated from surveys, mapping, and interpretation need to be made available to all local agencies and NGOs as a matter of priority.

Local coordination of activities

The impacts of the 2004 Indian Ocean tsunami were not uniform. Coordinating restoration activities from an agency in each district (or appropriate region), allows for appropriate interventions to meet local needs. Local agricultural services should be involved in rehabilitation programs, and in collaborating with national and international sources of expertise and support. The coordinating agency would identify and prioritize activities based on the results of surveys and public meetings with members of affected communities, allowing NGOs without technical experience to conduct activities supported by the local and national agricultural agencies.

It should be ensured that the timing of infrastructure and field restoration work matches the local cropping pattern. Agriculture aid packages (seed, fertilizer, tools) should only be distributed to sites where farmers and soil and infrastructure conditions are ready for farming.

Local knowledge and cooperation

Local partners should be used where available and the technical knowledge of universities and national and provincial agricultural services should be accessed. Planned activities should be discussed with local communities and local people should be involved in activities wherever possible. Leading extension staff and farmers are valuable advocates for rehabilitation activities. The recovery process is long term and will need to maintain connections with governments and their agencies to assist programs and policy for the affected communities.

Restore irrigation and drainage networks

Rainfall will leach salt from the soil with good drainage. Irrigation will accelerate leeching where fresh water is available. Areas with good surface irrigation and drainage should be ready for cropping first.

Clear debris and deep sediments

Remove debris and sediments deeper than 20 cm. Shallow sediments can be incorporated or left fallow until wet season rains flush salts from the soil. Soils should be monitored on a regular basis for at least 18 months for salinity and nutrient deficiencies. Time sediment removal should work to match the local planting seasons.

Build soil fertility

Soil fertility may be built with sources of organic matter (manures, compost, green manure crops). Tsunami impacts on soils may include the physical removal of organic matter, especially from coastal sands. Green manure crops that tolerate low salinity levels will provide valuable nutrition for future crops and contribute to soil remediation. The addition of gypsum to saline soils was found to be unnecessary.

Agriculture aid packages

Agricultural aid packages should include the following:

1. Training workshops for extension staff and farmers with follow up assessments of progress. Develop a network allowing field staff to access technical support when required.
2. Appropriate breeds of livestock provided to farmers with prior experience and training in animal management, including the use of pen and forage systems to increase stock numbers. Make use of regrowth on land yet to be rehabilitated and create sources of manure for soil improvement.
3. Locally-appropriate tree crops in replanting programs, as part of a promotion of diversified livelihoods that reduce poverty and reduce impacts on natural systems.
4. Availability of appropriate seed stock for local conditions. Include seeds of homegarden crops for nutrition and to reduce dependency on food aid. Specific varieties of rice and other staples are adapted to different conditions. Demonstrations of crop varieties and methods are important to encourage interest and adoption by farmers. Growing a diversity of crops reduces the likelihood of families being affected by poverty.
5. Vegetable crops that require less land and create more income and employment than rice farming (Mariyono et al. 2009), to help rapidly restore livelihoods.
6. Appropriate tools to allow cultivation activities to recommence.
7. Inputs such as fertilizers provided on the basis of soil tests to ensure that large quantities of nitrogen and other minerals are not leeched into ground water or waterways. Field soil test kits (PUTS – a soil test kit for irrigated areas; PUTK – a soil test kit for upland areas) developed by the Indonesian Soils Research Institute are commonly used by extension services in Indonesia.

8. Support to establish gardens in relief camps. Displaced people from rural areas will often have agricultural knowledge which can be tapped to create homegardens within the camps.

Recognize the role of women in agriculture

The role of women in farming activities is often overlooked. Women should be included in community consultations and training, and provided with access to finance where appropriate. Disasters such as the 2004 tsunami and Cyclone Nargis in Myanmar left numerous households headed by women. Lack of access to land, finance, and training are some of the issues that were encountered by women in farming communities post-tsunami.

Recognize the important role of agriculture in community recovery

The value of agricultural livelihood programs in managing trauma and suffering of disaster survivors should be acknowledged. Farming activities should be prioritized in livelihood programs and these should be extended for at least two years following the disaster, longer in devastated areas where recovery programs may be delayed. Displaced people in camps will benefit from household gardens until they can return to their village fields.

Agricultural recovery should be part of a longer-term process to diversify and strengthen local farming systems and improve livelihoods.

REFERENCES

Adam-Bradford, A., and M. Osman. 2009. Tsunami Aftermath: Development of an Indigenous Homegarden in Banda Aceh. *Urban Agriculture Magazine* 21: 29-30.

Agus F., H. Subagjo, A. Rachman, and I.G.M. Subiksa. 2008. "Properties of Tsunami Affected Soils and the Management Implications". Paper presented at the 2nd International Salinity Forum, Adelaide, Australia, March 31 – April 3.

Alimoeso, S. 2006. "Progress Report on Agricultural Sector Rehabilitation One and a Half Years after the Tsunami Disaster in Aceh." In *Report of the Regional Workshop on Rehabilitation of Agriculture in Tsunami Affected Areas: One And A Half Years Later.* Bangkok: FAO.

Bradbury, H., J. Afrizal, T.P. Stewart, and E. Hasibuan. 2007. "After the Tsunami: A First Rice Harvest The Approach, Methodology and Results of a First Rice Crop on Tsunami Affected Land in Meulaboh, West Aceh." Accessed July 2011. http://www.mercycorps.org/sites/default/files/file1142973132.pdf.

Brighton, U.K., R.V. Cruz, H. Harasawa, M. Lal, S. Wu, Y. Anokhin, B. Punsalmaa, Y. Honda, M. Jafari, C. Li, and N. Huu Ninh. 2007. "Climate Change 2007: Impacts, Adaptation and Vulnerability." In *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, 469-506. Cambridge, U.K.: Cambridge University Press.

Badan Rehabilitasi dan Rekonstruksi (BRR). 2006. Aceh and Nias - Two Years after the Tsunami. Progress Report. Jakarta/Banda Aceh: BRR NAD-Nias.

Budidarsono S., Y.C. Wulan, Budi, L. Joshi, and S. Hendratno. 2007. Livelihoods and Forest Resources in Aceh and Nias for a Sustainable Forest Resource Management and Economic Progress. *ICRAF Working Paper 55*. Bogor, Indonesia: World Agroforestry Centre.

Czaika M., and K. Kis-Katos. 2007. Civil Conflict and Displacement: Village-Level Determinants of Forced Migration in Aceh. *Households in Conflict Network (HiCN) Working Paper No. 32*. Brighton, United Kingdom: Institute of Development Studies.

Doocy, S., M. Gabriel, S. Collins, C. Robinson, and P. Stevenson. 2006. Implementing Cash for Work Programmes in Post-Tsunami Aceh: Experiences and Lessons Learned. *Disasters* 30 (3): 277-296.

Eye on Aceh. 2006. "A People's Agenda? Post-tsunami Aid in Aceh". Accessed July 2011. http://reliefweb.int/node/415753

Food and Agriculture Organization (FAO). 2005a. Report of the FAO/WFP Food Supply and Demand Assessment for Aceh Province and Nias Island (Indonesia). Accessed July 2011.http://www.fao.org/world/regional/rap/home/news/detail/en/?news_uid=47115 \

______. 2005b. F*ramework for Soil Reclamation and Restart of Cultivation*. *Version 2: 1-16*. Bangkok, Thailand: FAO.

______. 2009. "Myanmar Post-Nargis Recovery and Preparedness Prioritized Action Plan." Accessed July 2011. http://www.fao.org/emergencies/tce-appfund/tce-appeals/appeals/emergency-detail0/en/item/37741/icode/?uidf=14594

Gibbons, H., and G. Gelfenbaum. 2005. "Astonishing Wave Heights among the Findings of an International Tsunami Survey Team on Sumatra." *Sound Waves Magazine*, March 2005. Accessed July 2011. http://soundwaves.usgs.gov/2005/03/.

Harvey, M., and S. Wijewardane. 2008. Cultivating Resilience: Lessons from the 2004 Tsunami in Sri Lanka. *Leisa Magazine* 24 (4): 26-27.

Indonesian Agency for Agricultural Research and Development/ Department of Primary Industries New South Wales (IARRD/DPI NSW). 2008. *A Practical Guide to Restoring Agriculture after a Tsunami*. Wollongbar, NSW, Australia: Indonesian Agency for Agricultural Research and Development, Jakarta, Indonesia and New South Wales Department of Primary Industries.

Jansen, T., I. Barry, P. Tikae, R. Kabu-Maemouri, and S. Kere. 2007. *Western and Choiseul Province Earthquake and Tsunami Disaster: Rapid Assessment of Agriculture and Food Security.* Solomon Islands: Kastom Gaden Association.

Joshi, L. 2008. Accelerating Livelihood and Environmental Recovery in Aceh and Nias through Tree Crops. In *Proceedings of the International Workshop on Post-tsunami Soil Management,* Cisarua, Bogor, Indonesia, July 1-2, 2008 edited by F. Agus and G. Tinning. Jakarta, Indonesia: IARRD/DPI NSW.

Kilby, P. 2007. The Strength of Networks: The Local NGO Response to the Tsunami in India. *Disasters* 32 (1):120-130.

Kumar, T.S.A., and J.K. Newport. 2005. The Role of Microfinance in Disaster Mitigation. *Disaster Prevention and Management* 14 (2): 176-182.

Mariyono J., M. Battharai, M. Ferizal, and Fitriana. 2009. "Impacts of Farmers' Field School on Livelihood Capitals in Tsunami-Affected Communities of Aceh, Indonesia." Kumpulan Makalah Seminar Ilmiah Perhorti Accessed July 2011. http://203.64.245.61/fulltext_pdf/EAM/2006-2010/eam0362.pdf

Martine, G. 1999. *Population, Poverty and Vulnerability: Mitigating the Effects of Natural Disasters, Part 1*. Sustainable Development Department, Food and Agriculture Organization of the United Nations. Accessed July 2011. http://www.fao.org/sd/Wpdirect/Wpan0042.htm.

Mcleod, M.K., P.G. Slavich, A. Rachman, T. Iskandar, and N. Moore. 2006. "Soil and Crop Assessment in the Tsunami Affected Agriculture Lands of Nanggroe Aceh Darussalam Province, Indonesia." Paper presented in the ASSSI National Soil Conference, Adelaide, Australia, December 3-7.

McLeod, M.K., P.G., Slavich, Y. Irhas, N. Moore, A. Rachman, N. Ali, T. Iskandar, C. Hunt, and C. Caniago. 2010. Soil Salinity in Aceh after the December 2004 Indian Ocean Tsunami. *Agricultural Water Management* 97 (5): 605-613.

Mizzima News. 2009. Burma, Second Worst-Hit by Climate Change: Report. *Mizzima News*, December 9, 2009. Accessed July 2011. http://www.mizzima.com/news/world/3137-burma-second-worst-hit-by-climate-change-report.html.

Mohan, C. 2008. Post-tsunami Agriculture Livelihood Restoration, Nagapattinam, Tamil Nadu, S. India - A District-Level Coordination Effort. In *Proceedings of the International Workshop on Post-Tsunami Soil Management*, Bogor, July 1-2.

Moore, A. 2007. Coastline changes to Aceh from the great 2004 Sumatra-Andaman earthquake. *Vignettes*. Accessed July 2011. http://serc.carleton.edu/NAGTWorkshops/geomorph/vignettes/25462.html.

Mulligan, M., and J. Shaw. 2007. What the World Can Learn from Sri Lanka's Post-Tsunami Experiences. *International Journal of Asia-Pacific Studies* 3 (2): 65-91.

Nazara S., and B.P. Resosudarmo. 2007. *Aceh-Nias Reconstruction and Rehabilitation: Progress and Challenges at the End of 2006.* Tokyo: Asian Development Bank.

Olsen, B. O., W. Matuszeski, T.V. Padma, and H.J.M. Wickremeratne. 2005. Rebuilding after the Tsunami: Getting It Right. *Ambio* 34 (8): 611-614.

Oxfam. 2006. "Oxfam Calls to Step up Response for 70,000 Tsunami Survivors Living in Barracks in Aceh." Accessed July 2011. http://www.oxfam.org.uk/applications/blogs/pressoffice/2006/11/17/oxfam-calls-to-step-up-response-for-70000-tsunami-survivors-living-in-barracks-in-aceh/.

______. 2005. "One Year after Tsunami, Livelihoods Recovering Fast". Press Release - 20 December 2005. Accessed July 2011. http://www.oxfamireland.org/news/releases/2005/12_20.htm.

Pomeroy R.S., B.D. Ratner, S.J. Hall, J. Pimolijinda, and V. Vivekanandan. 2006. Coping with Disaster: Rehabilitating Coastal Livelihoods and Communities. *Marine Policy* 30 (6): 786-793.

Rachman A. 2006. Impacts of Tsunami on Soil Properties in Aceh. In *Report of the Regional Workshop on Rehabilitation of Agriculture in Tsunami Affected Areas: One And A Half Years Later.* Bangkok, Thailand: FAO. Accessed July 2011. http://www.fao.org/docrep/009/ag104e/ag104e00.htm

Rachman, A., and D. Erfandi. 2007. "Dampak Tsunami Terhadap Kondisi Tanah Pada Lahan Pertanian. Balai Penelitian Tanah." Makalah disampaikan pada Kongres Nasional IX HITI ("The Impact of Tsunami on the Soil Conditions of Agricultural Land." Paper presented at the Indonesian Soil Science Society Congress) Yogyakarta.

Rachman, A., F. Agus, M. McLeod, and P. Slavich. 2008. "Salt Leaching Processes in the Tsunami-Affected Areas of Aceh, Indonesia." Paper presented at the 2nd International Salinity Forum, Adelaide March 31–April 3.

Republic of Indonesia. 2005. Rencana Induk Rehabilitasi Dan Reconstruksi Wilayah Dan Kehidupan Masyarakat Provinsi Nanggroe Aceh Darussalam Kepulauan Nias Provinsi Sumatera Utara (A Master Plan for Rehabilitation and Reconstruction for the Province of Aceh and Nias Island, North Sumatra). April 2005

Roshetko J., N. Idris, P. Purnomosidhi, T. Zulfadhli, and J. Tarigan. 2009. Farmer Extension Approach to Rehabilitate Smallholder Fruit Agroforestry Systems: The Nurseries of Excellence (NOEL) Program in Aceh, Indonesia. Bogor, Indonesia: The World Agroforestry Centre (ICRAF).

Scheuren J.M., O. le Polain de Waroux, R. Below, D. Guha-Sapir, and S. Ponserre. 2008. A*nnual Disaster Statistical Review: The Numbers and Trends 2007*. Center for Research on the Epidemiology of Disasters (CRED).

Science and Development Network 2010. "No Let-up for Indonesian Earthquake Risk." Accessed July 2011. http://www.scidev.net/en/news/no-let-up-for-indonesian-earthquake-risk.html

Shea, G. A., T. Mahmud, E. Indris, E. Kesumawati, and Nursyidah. 2008. Institutional Development for Post-Tsunami and Post-Conflict Recovery in Aceh. In *Proceedings of the International*

Workshop on Post-tsunami Soil Management, Cisarua, Bogor, Indonesia, July 1-2, 2008 edited by F. Agus and G. Tinning. Jakarta, Indonesia: Indonesian Agency for Agricultural Research and Development and New South Wales Department of Primary Industries.

Singh, N.B. 2006. Rehabilitation of Agriculture in Tsunami Affected Areas in India: One and a Half Years Later. In *Report of the Regional Workshop on Rehabilitation of Agriculture in Tsunami Affected Areas: One and a Half Years Later.* Bangkok, Thailand: FAO. Accessed July 2011. http://www.fao.org/docrep/009/ag104e/ag104e00.HTM

Slavich P., M. McLeod, N. Moore, G. Tinning, R. Lines-Kelly, T. Iskandar, A. Rachman, F. Agus, and P. Yufdy. 2008. "Tsunami Impacts on Farming in Aceh and Nias, Indonesia." Paper presented at the 2nd International Salinity Forum, Adelaide 31 March 31 –April 3.

Socioeconomic Data and Applications Center (SEDAC).2011. "Percentage of Total Population Living in Coastal Areas." Accessed July 2011. http://sedac.ciesin.columbia.edu/es/papers/Coastal_Zone_Pop_Method.pdf

Srinivas, H., and Y. Nakagawa. 2008. Environmental Implications for Disaster Preparedness: Lessons Learnt from the Indian Ocean Tsunami. *Journal of Environmental Management* 89 (1): 4-13.

Strempel, A. 2011. "Women and Agriculture in Aceh, Indonesia. Needs Assessment for the BPTP and ACIAR 'Women Farmer Groups' project." Accessed July 2011. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0015/380112/KWT-NeedsAssessment-English.pdf

Subagyono, K., B. Sugiharto, and B. Jaya. 2005. "Rehabilitation Strategies of the Tsunami-Affected Agricultural Areas in NAD, Indonesia." Paper presented in Salt-Affected Soils from the Seawater Intrusion: Strategies for Rehabilitation and Management Regional Workshop, Bangkok, Thailand, March 31 –April 1.

Thorburn, C. 2007. The Acehnese Gampong Three Years On: Assessing Local Capacity and Reconstruction Assistance in Post-tsunami Aceh. *Report of the Aceh Community Assistance Research Project (ACARP)*. Jakarta, Indonesia: AusAID Jakarta.

Thorburn, C. 2009. Livelihood Recovery in the Wake of the Tsunami in Aceh. *Bulletin of Indonesian Economic Studies* 45 (1): 85-105.

Tinning, G., N. Moore, and A. Gani (Eds). 2008. *A Summary of Field Trials in Nangroe Aceh Darusalaam 2005–2008*. Jakarta, Indonesia: Indonesian Agency for Agricultural Research and Development, and New South Wales Department of Primary Industries, Wollongbar, NSW, Australia. Accessed July 2011. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/254876/A-summary-of-field-trials-in-Nangroe-Aceh-Darusalaam-2005---2008.pdf.

Tinning, G. 2011. Unpublished. Acehnese Farmers Trial Conservation Farming Techniques.

Tobita, M., H. Suito, T. Imakiire, M. Kato, S. Fujiwara, and M. Murakami. 2006. Outline of Vertical Displacement of the 2004 and 2005 Sumatra Earthquakes Revealed by Satellite Radar Imagery. *Earth Planets Space* 58 (1): e1–e4.

Weligamage, P., M. Anputhas, R. Ariyaratne, N. Gamage, P. Jayakody, K. Jinapala, P.G. Somaratne, N. Weragala, and D. Wijerathna. 2005. *Bringing Hambantota Back to Normal: A Post-tsunami Needs Assessment of Hambantota District in Southern Sri Lanka*. International Water Management Institute. Accessed July 2011.http://www.iwmi.cgiar.org/tsunami/News&Updates4.asp.

Wong, P.P. 2009. Impacts and Recovery from a Large Tsunami: Coasts of Aceh. *Polish Journal of Environmental Studies* 18 (1): 5-16.

World Bank. 2008. Aceh Poverty Assessment 2008: The Impact of the Conflict, the Tsunami and Reconstruction on Poverty in Aceh. Washington, D.C.: World Bank.