A Balancing Act: An assessment of the environmental sustainability of permanent housing constructed by international community in post-disaster Aceh.

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Abstract

Building permanent houses for entire communities that have suffered natural and human-induced disasters poses numerous challenges. Balancing environmental sustainability among a complex array of other issues is critical, however, if the communities for whom housing is intended are to remain resilient from future disasters, secure profitable livelihoods, and maintain safe and steady water supplies. The case of Aceh, Indonesia, whose coastal communities suffered severe impacts from the Indian Ocean Tsunami in 2004, is particularly relevant given the magnitude of the disaster, and the scale of the international response. After over three years of reconstruction efforts, the direct impacts of construction on the environment, particularly with respect to timber and other locally-sourced building materials needed to construct some hundred thousand houses are becoming clear.

Within the international development paradigm the concept of sustainable development, particularly with respect to construction of permanent homes, is a nebulous term, open to many different interpretations. Through research and field interviews, involving a diverse group of stakeholders, this study examines what various INGOs consider sustainable in reference to building permanent houses in post-tsunami Aceh, while trying to uncover why more ecologically sound choices have not been made. Practical recommendations are also provided for the international development community for considering the local resource carrying capacity of raw materials intended for reconstruction.

Keywords: *post-disaster reconstruction; environmental sustainability; construction materials; permanent housing; international development organisations*

1. Introduction

Over the past few decades the world has witnessed and felt an increasing abundance of man-made and natural disasters. Today, they appear to occur more frequently, affect more people, and cause greater economic damage than ever before. Many *natural* disasters are actually triggered by population growth, years of environmental degradation, rapid urbanisation, and even climate change, and tend to have a disproportionate impact on the developing world. One of the worst and most publicised disasters in recent history was the December, 2004 earthquake and resultant tsunamis off the coast of Aceh, Indonesia. The international community responded with unprecedented generosity to support the recovery, reconstruction and rehabilitation of the affected communities. Over three years have passed and despite much progress, particularly in housing reconstruction, many problems have emerged around the issues of sustainability.

To provide sustainable construction requires integrating a vast array of issues simultaneously, from the planning stages through to post-construction monitoring. There are three distinctly separate and often conflicting elements of sustainable construction: environmental impacts, social issues, and economic factors. The technical utility of the construction materials and durability of the resulting structure are often given precedence over the social and environmental aspects that have longer term sustainability implications. When reviewing the context of a post-disaster situation with displaced people living in temporary shelters, time is another crucial element to consider. The urgency of helping people to return to normality in as little timeframe as possible is a major reason environmental impacts are relegated to lower on the priority list. Disaster victims need homes to regain their lives and livelihoods. Besides the urgency of constructing permanent shelters, a complex mix of other issues related to land tenure, water and sanitation, energy, livelihoods, future disaster risk reduction, and often resettlement add to the pressures of an already challenging scenario.

Aceh is a revealing case study for reviewing sustainable construction in post-disaster contexts. The earthquake and tsunamis killed some 130,000 people, devastated much of the coast line, and left more than 500,000 people without homes. The rebuilding of over 120,000 homes by International Non-Governmental Organisations (INGOs), local NGOs, the Indonesian government, and the victims themselves has created a number of benefits; boosting the local economy, strengthening local markets, securing supply chains for infrastructure, and providing the opportunity to gain masonry and carpentry skills and better construction methods.

As positive as many of these aspects are, many negative issues have arisen from such an extensive housing demand: much of the money intended for these projects has been diverted into the coffers of the corrupt; social jealousy has grown from neighbours receiving houses of different sizes, quality, and made by different agencies at varying rates; and, illegal logging in Aceh has risen ten-fold with the high demands for timber and bricks for building materials. Poor quality construction, along with deforestation, and building upon flood plains that are now devoid of many of their natural barriers have left many houses more vulnerable to future disasters. Other possible indirect effects of housing reconstruction have left tsunami victims without livelihoods, as they have been relocated inland away from the coast and among the forests, creating a platform for illegal logging without any reasonable alternative. Despite many INGOs having adopted the slogan "*Build Back Better*", an article in the Financial Times in December of 2006 reports nearly one-quarter of the 50,000 homes built at the time were of 'questionable quality' and many will need to be rebuilt (Aglionby, 2006). Rehabilitation efforts in Aceh represent a very practical case for uncovering the range of issues and problems in the post-disaster permanent housing construction context.

The sections that follow identify various negative effects of 'acting locally' with regards to procuring raw materials for construction after a disaster, by focusing on three materials used on a massive scale in Aceh. While there may be a strong motivation to factor sustainability into the housing sector, there are a number of critical barriers that prevent adoption of more environmentally conscious decisions in the field, particularly after disasters. Through research and a series of interviews conducted in the months of June and July 2007 in Aceh and Jakarta, Indonesia, this study examines the sustainability of the permanent housing projects built by various INGOs, highlighting the undervalued role of environmental issues in the balance of sustainability. The high demand for local natural building materials, which are being mined, cut, and dredged in such a short amount of time, are having impacts on ecosystems which might never recover. Lessons need to be drawn from this and future planning from INGOs needs to take account of the diversity of materials and the impacts each has on the environment. Finally, the paper will propose some potential preparations for future post-disaster reconstruction efforts by the international community.

1.1 Background

Indonesia is an archipelago of around 17,000 islands, about 6,000 of which are inhabited. Indonesia has been identified by world-renowned scientists and various environmental and ecological organisations as a leading hotspot for biodiversity and potentially holds 10 percent of the world's terrestrial biodiversity in the tropical rainforests of Borneo and Sumatra (Greenpeace, 2004:1).

On December 26, 2004, an earthquake measuring 9.2 on the Richter scale occurred in the Indian Ocean; the epicentre was approximately 150 km off the west coast of Sumatra. The resulting tsunamis killed, displaced and left missing over half a million people while causing massive amounts of destruction to housing and infrastructure, redrew the coastline, and significantly impacted the social fabric throughout the province. The destruction to infrastructure was immense: communication was cut, homes and buildings were destroyed, drinking water supplies were contaminated, hospitals and clinics as well as bridges and ports were washed away or damaged beyond repair.

There were three phases to the disaster response within the housing sector in Aceh: immediate or emergency relief with tents and makeshift structures; transitional semi-permanent housing made mostly of timber; and finally the building of permanent homes, a phase which is ongoing. According to the database of the Rehabilitation and Reconstruction Agency (BRR), the government agency established to coordinate all tsunami reconstruction projects in Aceh and Nias, there are 107 different 'partners' who are building permanent houses in Aceh. Partners are local, national and international NGOs, development agencies, and even the BRR's own housing sector. Some started building permanent structures only a few months after the reconstruction began and others continue to build. According to a report published in June 2007, 40-60 percent of the 120,000 permanent homes needed have been built (New, 2007: 4).

The rush to build permanent homes as quickly as possible has led to enormous problems. Many of the INGOs have already had to destroy and rebuild, or try to retrofit homes, which have either never been lived in or have been lived in for less than a year. Oxfam and Save the Children have conducted serious overhauls in their programmes, but other organisations are still uncovering massive problems with many of their homes. A report written in July of 2006, by Save the Children states, “Of 708 houses contracted, 571 were completed. Of these, 371 houses need to be replaced and 200 need repairs” (Save the Children, 2006). Many of the houses with serious problems were built before July 2006, and some reports suggest construction quality has improved since then (Aglionby, 2006), but Teddy Boen (2007), a seismic structural engineer from Indonesia, reported that as much as 95 percent of the homes he monitored in May 2007 throughout Aceh, built by the INGOs, were not earthquake resistant. This raises serious questions about the sustainability of these and the thousands of other permanent homes still needing to be built.

1.2 Environmental Impact of the Construction Industry

The construction industry is directly and indirectly responsible for a great deal of environmental damage, though it is difficult to fully account for environmental impacts of building materials in a post-disaster timeframe. Every activity, from extraction to production, delivery, construction and disposal, consumes energy, produces wastes and pollution and has an ecological impact.

Some of the most severe ecological impacts are experienced during the raw material extraction stage (Newton and Venables, 1995). The construction industry is second, only to agriculture, as the largest consumer of raw materials in the world today (Berge, 2000: 5). It is also one of the most serious contributors to global CO_2 emissions, and has caused many other negative impacts throughout the world, such as land degradation, air and water pollution, intensive energy consumption, waste, and deforestation. For example, in the UK, housing accounts for nearly 30 percent of the country’s CO_2 emissions (Larazus, 2006: 2). In the developing world, studies are not frequently conducted on the environmental impacts of building materials, and when there is such a high and urgent demand on primary materials in such a focussed area, it is rarely a priority to allay environmental impacts that are not immediately apparent.

In a normal market situation the supply and demand chains are relatively balanced, and using local materials and local labour is encouraged. In a post-disaster situation, where numerous INGOs are involved, the demand for materials far outweighs the supply, potentially putting strain on local environmental systems, or forcing supply to be sourced further a field. The materials needed for construction (timber, clay, sand, gravel, mountain stone, and limestone) may be harvested or extracted well beyond the recharge rate of the local ecosystem, possibly tipping the balance beyond its capacity to recover in a suitable timeframe. In Aceh the region went from a new build market of 200 homes a year to the urgent demand of 120,000 in a day (Douglass, 2007). The flooding that has beset many coastal communities including the provincial capital every year since the tsunami is arguably a result of over-extraction of river bed materials, downstream siltation at the river’s mouth, and over-harvesting of timber from forests that historically mediated seasonal water discharge. Many longer term environmental impacts have yet to manifest themselves as a result of rampant materials sourcing. Certainly the Provincial Government’s announcement of a complete moratorium in June 2007 on timber harvesting in Aceh, at a time when many housing contractors were in dire need of timber products is testimony that the forests throughout Aceh are a prized and rapidly deteriorating ecosystem.

There is no magic bullet or fix-all solution for sustainable construction in post-disaster contexts. In fact, the opposite may be true, where a diversity of different solutions can diffuse any single impact throughout the environment and within its natural buffering capacity. Ironically, while the overall strategy for housing reconstruction should be reducing the risk of future disasters, the environmental degradation created from the excessive demands of local materials, can increase a community's exposure to natural hazards.

2. Research methods

The methodology for assessing the environmental sustainability of the permanent housing projects in post-tsunami Aceh involved a two-tiered approach, both of which specifically focussed on the material choices for the homes. The first is a secondary data review of environmental impacts of three materials which were predominately used in the structural aspect of the houses in Aceh: timber (both hard and softwoods), clay bricks and cement 'batako' blocks.

Since environmental impacts are not typically a predominant consideration when selecting building materials in post-disaster contexts, the social, technical and economic factors involved with the sustainability of the housing sector were investigated. The second step involved a set of interviews with questions geared toward INGO staff members in Aceh. The interviews inquired about what sustainability meant in the home building context, priorities for selecting housing materials, what materials were used other than the three primary ones, and what barriers prevented the use of more ecologically-friendly materials. Various other stakeholders involved with the housing sector were also interviewed to gain a broader sense of the concerns of household beneficiaries, environmental NGOs, academics, technical experts, construction contractors, and material suppliers.

Three main sources (Hammond G. and C Jones, 2006; Cole, R. J. and D. Rousseau, 1992; and Berge, B. 2000) were used for numeric data on embodied energy and embodied CO_2 of materials and anecdotal evidence was used to develop the landscape impact data and procurement availability.

Variations in the data exist for the quantities of embodied energy and CO_2 reported, their corresponding environmental impacts, and the countries from which data was available. It is beyond the scope of this study to reconcile the variations between sources. Despite these discrepancies, the figures provide a relative measure of impact, but actual impacts cannot be easily extrapolated to other countries, and unfortunately no academic studies were conducted on embodied energy, carbon footprint or landscape impact of building materials in Aceh.

In order to explore the other priorities and criteria that the international community focused on when building these homes, interviews with 19 representatives from 13 INGOs and 15 other people from various ENGOs, technical specialities, and academia were undertaken primarily during a 5 week period in the months of June and July 2007. The INGOs were of various sizes and have housing programmes ranging from building 15 homes to several thousand. The interviewed organisations were: Australian Red Cross, British Red Cross, Build Change, Canadian Red Cross, Cooperative Housing Fund, Emergency Architects, Fauna-Flora International, French Red Cross, German Red Cross, International Federation for Red Cross and Red Crescent Societies, Oxfam, Save the Children, and World Vision.

3. Research results

3.1 Secondary Data Review of Environmental Impacts on Building Materials

The first stage of research on sustainable housing consisted of gathering technical information and environmental impact data on the specified materials used by INGOs building houses in Aceh. Though there are many ways to measure environmental impact, for the purpose of this paper, the author has gathered data on embodied energy, carbon footprint and landscape impact for the three predominant materials. Along with the environmental impact data, the author has also included rough estimates of the materials needed per home and the procurement availability of the materials in the table below.

Table 1. Matrix of Environmental Impacts of Primary Materials Used In Aceh

Material	Estimated materials needed per home [a]	Embodied Energy (MJ/kg) [b]	Embodied CO_2 (Kg CO_2/ Kg) [c]	Landscape Impact	Procurement A) Village B) Province C) Country D) Global
Batako (Cement) hollow blocks	1,000-1,500 blocks	2-9.4	0.82	Gravel extraction (quarried) + sand (dredged from rivers, shoreline) + lime extracted + water + mortar / per brick + space required for factory + infra - structure to transport to building site	A, B, C, D
Clay Bricks (wood kilned)	3,000-5,000 bricks + 9 m^2 of timber	2-5.8	0.2	Ground where clay was extracted + water + local forest ground and cover loss for amount of wood needed to kiln brick + space required for factory + infrastructure required to transport to building site + mortar / per brick (cement mix)	A, B
Imported Softwood	3-6 m^2	3-7.4	0.44	Forest ground and cover loss + space required for factory to process + infrastructure to transport to building site	D
Local Hardwood	3-6 m^2	No data has been recorded, but local sources from Aceh Province would be illegal		Localised forest ground and cover loss + biodiversity loss + space required for factory to process + infrastructure to transport to building site	A (illegal as of June 2007), B, C

[a] Estimates are anecdotal figures from a wide range of interviews. Size and designs of homes differ immensely with each builder.
[b] There were three studies: Cole and Rousseau, 1992; Berge, 2000; and Hammond and Jones, 2006 in which EE data was gathered for the materials. The table shows the varying data figures from these three studies.
[c] The only study used for Embodied CO_2 was Hammond and Jones, 2006.

3.1.1 The Materials

Batako Blocks are made from mixing cement, water and aggregates (sand and sometimes gravel). The blocks are made in local factories from a press, continuously watered and sun-baked for at least 2 weeks. The cement is imported from Padang, Indonesia or from Malaysia and packaged in a factory in Aceh. The sand and gravel used in the mixtures are dredged from the rivers and mined from quarries throughout Aceh. According to two interviewed construction contractor staff, they procure the aggregates from companies with government certification, but there is no follow up to guarantee the documents are legitimate and up-to-date. The contractors themselves do not conduct any environmental impact assessments.

Clay Bricks in Aceh are made from clay, water and many times coated with sawdust. Clay is readily available throughout Aceh and many clay brick makers take the clay right from their own land. They are laid with mortar to hold them together and are usually confined within a thin layer of cement. The performance of a masonry structure depends on the quality of the mortar, the skill of the mason, and the exposure to the environment.

Timber is the most controversial of the building materials for reconstruction in Aceh. Illegal logging runs rampant in Indonesia with an estimated 70% of timber exports being illegal, costing more than US$3.7 billion a year in lost revenue (World Resource Institute, 2005: 141). Immediately after the disaster the demand for timber rose considerably and procuring certified legal timber posed arduous. Many of the NGOs chose to trust their contractors and did not check from where the supply of timber was originating. After a few of the major INGOs were found procuring timber from illegal sources, estimated timber use has been reduced by 70-90 percent from the original designs (New, 2007: 10). As of June 2007 a moratorium was placed on timber and all logging in Aceh is officially illegal.

World Wildlife Fund for Nature (WWF) has initiated the Timber for Aceh campaign to try and give alternate avenues for procuring not only legal timber but Forest Stewardship Council (FSC) certified sustainable timber from abroad. With the help of this campaign British Red Cross, Canadian Red Cross, Oxfam, and Premiere Urgence, have purchased substantial amounts of sustainable timber from international sources (WWF, 2005). After the many problems with the first round of homes built and alerted to the plight of the Aceh forests, Save the Children has procured pre-fabricated timber homes from a sustainable source in Canada.

3.1.2 Environmental Impacts

Clay bricks were thought to be an environmentally friendly alternative to timber. Depending on the fuel for baking the clay bricks (wood-fired or gas-fired), however, the environmental impacts can be significant. In much of the western world clay brick factories use gas to kiln bricks. In small scale factories, particularly in Aceh, most use wood to fuel the kilns. Estimates from various sources (Ardie, 2007; field visits) calculated that these types of kiln use approximately 3 m^3 of timber to produce 1,000 bricks. This results in 0.276 m^3 of timber burned per m^2 of wall space, when only 0.086 m^3 of timber would be used per m^2 of wall space, thus clay bricks can use over 3 times more wood than the timber used as a building material equivalent (Ardie, 2007).

The embodied energy (EE) of a material is the energy required to extract, produce and deliver it. Each of the data points shown in Table 1, above, demonstrate the relatively low EE of each of these three materials. Metals, such as aluminium, have radically higher amounts of EE due to the amount of intensive energy needed to form it.

Data collected shows aluminium has a wide range of values between 60 and 217 MJ/kg of EE as compared to timber which has a significantly lower value and has a range of only 3 to 7 MJ/kg (Cole and Rousseau, 1992; Berge, 2000; and Hammond and Jones, 2006). No EE data has been collected on small-scale wood-kilned clay brick factories to demonstrate the massive use of timber to yield high quality clay bricks. This is why other factors play significant roles in weighing environmental impacts.

The embodied CO_2 in a material is not directly proportional to its EE. Much depends on the specific energy source required in the material's production. The global CO_2 footprint is high on the agenda of environmental priorities, due to its role in climate change. Clay bricks and timber traditionally have lower values for embodied CO_2 and energy but when sourced locally, the landscape impacts have serious consequences, which cannot be seen from numeric values. Forests are sinks for carbon storage and forest loss increases atmospheric CO_2.

Evaluating building materials based on the amount of energy needed to produce them and the amount of CO_2 lost are important steps in assessing the "life-cycle" of their overall environmental impacts. Choosing materials with lower values is a step towards incorporating environmental efficiency into construction, though these should not be the only deciding factors. Knowing the amounts of EE and CO_2 of the materials does not alert one about other serious factors such as pollutants, wastes, threats to biodiversity and habitat loss, or landscape impacts, particularly in a post-disaster area, in which ecosystems are already compromised.

Many of these elements can be measured, but no quantitative studies on these topics have been published about Aceh. It is difficult to estimate the loss of biodiversity occurring due to the logging in Aceh, but it is still an important element to consider when choosing materials for reconstruction. There is not one specific building material that would be the best choice in all scenarios, but rather the combination of procuring timber from more renewable sources, switching to more efficient technologies, and realising the landscape impacts of local raw materials are a step in the right direction towards sustainability.

3.2 Interview Findings

From the 13 INGOs interviewed more than half of those made significant changes in the original design of their homes based on a number of issues. Some of the most significant challenges discussed with these INGOs related to the scale at which their efforts needed to be realised, in addition to site specific issues; corruption at all levels, lack of government capacity in the province; poor transportation infrastructure; land tenure issues; community expectations; lack of local construction skills; procurement of certified legal timber; high turnover with staff; quality of materials; and the battle with donors and headquarter offices over 'doing it right' versus reaching targets as quickly as possible. Each of these challenges is a barrier to the homes being built quickly and correctly. For example if a truck load of sand is delivered to a site, but it is of poor quality, the manager at the site has to send the load back for one of better quality. This is essential for the homes to be built soundly, but the time it takes to receive another load delays the process that much longer.

Cost viability is a major priority for housing design and the materials that are chosen. The original prices of houses ranged from around US$3,000 to US$5,000, but the cost of labour has risen, INGO management and administration costs have grown, quality material demand continues to remain higher than supply, transportation systems have not been fully rehabilitated, and increases in fuel prices throughout Indonesia have driven the prices of houses from between $US5,000 to around US$9,000.

Though cost is a significant contributor to many of the decisions within a programme, many INGOs in Aceh still have ample amounts of money, so other priorities such as social acceptability, quality of materials, and technical soundness dominate the priorities for material selection. Additional criteria for sustainability included community ownership, fit-for-purpose, earthquake resistance, durability, capacity of local labourers, and transparent (legal) procurement.

The BRR made a mandatory minimum size of 36 m^2 per house. Many organisations have provided just that, but some homes are 45 m^2; and still others are two storeys. In the city of Banda Aceh a homeowner only needs to walk in his or her own community to find a variety of shapes, sizes and colours of homes all built by different NGOs. The majority of homes are built with clay bricks, batako blocks and timber. Fauna Flora International (FFI), for example, tried to integrate bamboo into their housing projects, but after much community consultation on the designs of the homes, they decided in favour of clay bricks instead, which were more acceptable to the community. They then chose to establish livelihood programmes designed to manufacture more environmentally friendly construction materials, while providing jobs and income for the community members (Barnes, 2007).

The majority of the organisations interviewed have international and local policies on the legal sourcing of materials. The process to guarantee legally sourced timber from Indonesia can be a long, arduous process, but it is possible. Some INGOs, such as the British Red Cross (BRC) and the Canadian Red Cross (CRC), have ethical procurement policies about not only the legality of sourced materials, but a policy specifically on using sustainable timber. The BRC have purchased 10,000 m^2 of sustainable timber from New Zealand, and the CRC is currently looking into diversifying sources from outside of Aceh.

4. Discussion

Building someone else's home for them is a serious challenge. For the INGOs building thousands of homes in Aceh the challenge is enormously greater – from obtaining approval from the BRR; confirming that beneficiaries are actual victims of the tsunami and that the land they claim is in fact their own, to undertaking extensive and complex participatory interviews to adequately inform the design process and ensure a feeling of true ownership from victims, all within a reasonable budget. Proper planning and getting things right the first time are crucial for ensuring a housing project's success and for reducing vulnerability to future disasters.

For the majority of the INGOs interviewed, this was the first time they had been involved with permanent housing reconstruction, so many issues with technical designs, procurement, and contracting policies had to be developed and learned progressively. Many INGOs operate very separate programmes within the same organisation (housing, water and sanitation, livelihoods, health), and in many cases housing is distinct, sometimes having very little communication with the other projects. For example, housing reconstruction and livelihoods projects may work in the same communities with the same beneficiaries, but the staff are different, having separate means of transportation, budgets and chains of command.

From the earliest planning stages through to completion of a home, providing sustainable construction requires balancing a complex array of factors. With environmental issues there is no simple set of criteria to measure the impacts of construction. Looking at the entire life cycle and the landscape impacts of the raw resources needed to manufacture materials are important elements for consideration.

No one material can act as a universal solution to solving environmental degradation in large scale post-disaster situations, but selecting materials with less local impact can be a significant step in aiding the local ecosystems to recover.

The demand has never been so high for raw materials in Aceh. There are estimates that the timber requirement for the reconstruction runs as high as 446,000 m^3 of sawn wood (Eye on Aceh, 2006). The other locally procured natural resources (sand, gravel, mountain stone, clay, and limestone), are being extracted at an unprecedented rate. Coastal ecosystems are under pressure due in part to the high demand of the construction industry for sand. Already damaged mangroves, coral reefs and other changes in the coastline can add to the risk of future disasters (van Aalst and Burton, 2002: 8). Pollutants and waste are created from material extraction and production which include CO_2 emissions, air, water and solid waste.

In some instances environmental costs of using certain materials outweigh the benefits and it is necessary to seek alternatives that minimise risk and vulnerability to the disaster victims and to others involved in the construction process. Developing a list of suppliers, in-country and regionally, for procuring more ecologically-friendly construction material can help jump start recovery projects for future disasters. An organisation can do this as part of a country assessment before a disaster.

Some organisations are trying to be as ecologically conscious as possible. Canadian Red Cross (CRC) has hired an environmental consulting firm to verify that all of their locally procured materials are from legitimate businesses, at the same time documenting the environmental impacts of the local quarries, mines and factories involved in the process. CRC is procuring the materials for housing themselves, but for those INGOs which do not (and leave the procurement to the contractor) they should still be held accountable for guaranteeing that all sub-contractors are conforming to the same guidelines that they themselves claim to uphold. Contracts should be documents outlining not only quality control measures, but legality of materials and environmental impacts, and contractor activities should form part of donor auditing and monitoring. Though this is not necessarily an environmental impact reduction recommendation, working with legitimate businesses provides the outlet for the government and other agencies to collect proper data on how much raw materials are being sourced.

INGOs using significant quantities of materials can look for ways to support livelihoods, and involve local industries by funding more energy-efficient and environmentally sustainable factories. Although this requires more advance planning, it could create jobs closer to home, enable stronger ties among communities, facilitate on-site quality control supervision, and allow a collaborative effort between micro-enterprise and housing components within programmes. An example of this is FFI, which is investing in a small brick factory close to their community. The initial kiln was destroyed in the tsunami and a newly designed kiln reduces the amount of fuel required by one third. They have also found a local source of agricultural waste or ‘bioblocks’ to use as fuel for the kiln, instead of timber, supporting another local livelihood in Aceh. Another example is the German Red Cross (GRC), which is trying to integrate different aspects of their entire programme into their housing projects. They are using batako blocks made by local women through an enterprise development project set up by partner organisations; they have banned timber in their housing projects; and have switched to batako bricks to avoid using clay and the wood fuel needed in manufacturing clay bricks.

Environmental NGOs have raised considerable awareness around the issues of illegal logging in Aceh and throughout Indonesia, creating a catalyst for INGOs to reduce the timber in their housing designs and/or switch to legal and sometimes sustainable timber from abroad. They have also provided a lot of legwork to give alternative choices and ideas to the housing sector through providing information and avenues for procuring more ecologically sound materials. Future disaster recovery would benefit from the considerable knowledge they have acquired, which should form an integral part of the planning at the very beginning stages of rebuilding.

Collaborating through buying in bulk could save significant costs to a group of NGOs by lowering unit costs, and the issues of quality and legality could be managed by a consortium with greater capacity than each individual organisation might have. A mix of procuring some materials internally and outsourcing the rest of the materials might be a viable option. A diversified strategy for the procurement of construction materials is important to avoid situations where numerous organisations are using the same materials and unintentionally over-exploiting them, particularly local ones. Organisations need to have rigorous standards that are adhered to, at the same time as remaining open and flexible to changes in their housing designs and construction processes. Coordinating with other organisations and actively considering the full range of alternative materials can assist with avoiding over-exploitation.

5. Conclusions

In recent years, natural and man-made disasters have increasingly been affecting more and more people around the world. Funding for emergencies, disaster preparedness, and humanitarian assistance as well as disaster risk reduction have increased substantially within the development sector. These programmes need to have a distinct transition from emergency response to recovery development in order to make clear their differing objectives and time-scales in a post-disaster area.

Environmentally sustainable construction is not only a goal in itself, from mitigating carbon loss and landscape changes to maintaining biodiversity, but sound ecosystems support other development objectives including: disaster risk reduction (mitigating flooding and landslides, or buffering tsunamis and storms), preserving resource based livelihoods and sustaining safe and dependable water supplies. Attention needs to be drawn to the environmental degradation caused by the excessive use of materials for building, particularly using local materials in an area suffering from frequent disasters.

As assessed in this paper, the sustainability of building permanent houses, within development programmes in Aceh, has a multitude of elements which all need to be carefully weighed and balanced at the very earliest stages of planning. In order to assess these elements, with a focus on environmental sustainability, quantitative data was reviewed from sources in North America and Europe on environmental impact metrics of various building materials. Other sources revealed the undeniable environmental impacts of the illegal logging being undertaken at an unprecedented rate to support reconstruction, as well as the enormous increase in sourcing other local raw materials for the rebuilding of Aceh.

There are many factors involved in making a home environmentally sustainable. The Aceh situation exemplifies post-disaster development in which INGOs are building homes for disaster victims with a variety of solutions. This can be a step in the right direction with diversifying the effects of various materials, locally sourced and imported. A one-fix solution to housing is not reasonable with such a diverse group of people, and it is not realistic to expect all houses to be built exactly the same. When using locally sourced materials, using more energy-efficient technologies in production and identifying the negative landscape impacts of raw resources are valuable solutions. The process of building many homes for disaster victims is a challenge, which takes much time, planning, critical thinking, community participation and quality construction. Finding a balance between all of these vital aspects is the key to making it sustainable.

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Rachel Roseberry's Biography

Rachel Roseberry has just received a master's degree in Environment, Development and Policy at the University of Sussex in England. She witnessed the multitude of issues surrounding the international community building homes in Aceh while working there in 2006. She is currently consulting with World Wildlife Fund for Nature on guidelines for green building materials in disaster reconstruction. She plans to spend the beginning of 2008 learning about permaculture and natural building in Costa Rica.