5

GREEN

GUIDE TO

MATERIALS AND THE SUPPLY CHAIN

GREEN RECOVERY AND RECONSTRUCTION: TRAINING TOOLKIT FOR HUMANITARIAN AID

The Green Recovery and Reconstruction Toolkit (GRRT) is dedicated to the resilient spirit of people around the world who are recovering from disasters. We hope that the GRRT has successfully drawn upon your experiences in order to ensure a safe and sustainable future for us all.

5 GREEN GUIDE TO

MATERIALS AND THE SUPPLY CHAIN

James Good, InterWorks LLC

A NOTE TO USERS: The Green Recovery and Reconstruction Toolkit (GRRT) is a training program designed to increase awareness and knowledge of environmentally sustainable disaster recovery and reconstruction approaches. Each GRRT module package consists of (1) training materials for a workshop, (2) a trainer's guide, (3) slides, and (4) a technical content paper that provides background information for the training. This is the technical content paper that accompanies the one-day training session on environmentally sustainable approaches to material selection and the supply chain.

ACKNOWLEDGEMENTS

Project Manager Jonathan Randall, World Wildlife Fund

Training Specialist Paul Thompson, InterWorks LLC

Creative Director Melissa Carstensen, QueenBee Studio

Advisory Committee
Erika Clesceri, U.S. Agency for International Development
Veronica Foubert, Sphere
Christie Getman, American Red Cross
Ilisa Gertner, American Red Cross
Chris Herink, World Vision
Emma Jowett, Consultant
Charles Kelly, Consultant
Robert Laprade, American Red Cross
Anita van Breda, World Wildlife Fund

Expert Reviewers
Joseph Ashmore, Consultant
Rick Bauer, Oxfam-UK
Gina Castillo, Oxfam-America
Prem Chand, RedR-UK
Scott Chaplowe, International Federation of Red Cross and Red Crescent Societies
Marisol Estrella, United Nations Environment Programme
Chiranjibi Gautam, United Nations Environment Programme
Toby Gould, RedR-UK
Tek Gurung, United Nations Environment Programme
Yohannes Hagos, American Red Cross
James Kennedy, Consultant
Earl Kessler, Consultant
John Matthews, World Wildlife Fund
Andrew Morton, United Nations Environment Programme
Radhika Murti, International Union for Conservation of Nature
Marcos Neto, CARE
Jacobo Ocharan, Oxfam-America
Judy Oglethorpe, World Wildlife Fund
Robert Ondrusek, International Federation of Red Cross and Red Crescent Societies
Adrian Ouvry, Danish Refugee Council
Megan Price, RedR-UK
Catherine Russ, RedR-UK
Graham Saunders, International Federation of Red Cross and Red Crescent Societies
Ron Savage, U.S. Agency for International Development
Hari Shrestha, Save the Children
Rod Snider, American Red Cross
Margaret Stansberry, American Red Cross
Karen Sudmeier, International Union for Conservation of Nature
Nigel Timmins, Tearfund
Muralee Thummarukudy, United Nations Environment Programme
Anne-Cécile Vialle, United Nations Environment Programme

Special Thanks
The development of the GRRT has truly been a collaborative process and could not have been done without an extraordinary team of international experts from the humanitarian and environmental sectors. Over the course of a two-year development process, the GRRT was built on the diverse experiences of over 15 technical authors and training specialists, over 30 expert reviewers, and a dedicated team of graphic designers and copy editors. Special thanks go to Paul Thompson whose depth of experience in humanitarian training helped to shape this project and whose commitment made it a reality. Thanks to Anita van Breda, Robert Laprade, and Ilisa Gertner for their insight, ideas, and time spent reviewing many rounds of drafts. Special acknowledgement goes to the participants of the GRRT pilot workshops in Sri Lanka and Indonesia for all of their excellent feedback. Special thanks also goes to Gerald Anderson, Marcia Marsh, Alicia Fairfield, Achala Navaratne, Julia Choi, Bethany Shaffer, Owen Williams, Brad Dubik, Leah Kintner, Tri Agung Rooswiadji, Tom Corsellis, Eric Porterfield, Brittany Smith, Sri Eko Susilawati, Jan Hanus and Manishka de Mel. *–Jonathan Randall, WWF*

MODULE 5: GREEN GUIDE TO MATERIALS AND THE SUPPLY CHAIN

Table of Contents

1 INTRODUCTION

1.1 Module Objectives

This module is concerned with two key aspects of sustainable construction: 1) identifying the most appropriate building materials for post-disaster construction projects that will both protect people and offer environmental sustainability; and 2) identifying procurement policies and practices that help achieve environmental sustainability.

Specific learning objectives for this module are as follows:

1. Identify the typical environmental impacts of building material choices in order to minimize impacts to people and communities recovering from disaster.
2. Use environmentally aware approaches in the design of buildings and selection of materials for post-disaster housing reconstruction.
3. Identify the typical environmental impacts of material procurement options.
4. Describe strategies for procuring materials for post-disaster housing reconstruction that have the least negative impact on human welfare and the environment.
5. Explain the benefits and limits of environmentally conscious decision making in the selection and procurement of building materials after disasters.

1.2 The Green Recovery and Reconstruction Toolkit

This is Module 5 in a series of ten modules comprising the Green Recovery and Reconstruction Toolkit (GRRT). Collectively, the GRRT modules provide information and guidelines to improve project outcomes for people and communities recovering from disaster by minimizing harm to the environment and creating opportunities to improve the environment. Module 1 provides a brief introduction to the concept of green recovery and reconstruction to help to make communities stronger and more resilient to future disasters by integrating environmental issues into the recovery process. GRRT Module 2 provides guidance on how project design, monitoring, and evaluation can better incorporate and address environmental issues within the typical project cycle. GRRT Module 3 builds upon Module 2, focusing specifically on assessment tools that can be used to determine the environmental impact of humanitarian projects regardless of the type of project or sector. GRRT Modules 4, 5, and 6 pertain specifically to building construction, with Module 4 focusing on site planning and development, Module 5 on building materials and the supply chain, and Module 6 on building design and construction management. GRRT Modules 7 through 10 provide sector-specific information to complement Modules 2 and 3, including livelihoods, disaster risk reduction, water and sanitation, and greening organizational operations.

1.3 Intended Audience

The primary audience for Module 5 is the people who decide which construction materials are procured and incorporated into post-disaster construction projects. These decision makers include the building project manager, project designer, and the staff responsible for procurement and logistics. Additional audiences for this module include others in the post-disaster construction industry, such as contractors, construction supervisors, government officials, and other technicians responsible for planning and implementing post-disaster building construction and reconstruction efforts.

1.4 Module Key Concepts

This module builds on the following key concepts:

1. **Only support sustainable and legal sourcing of materials.** In large-scale, post-disaster rebuilding campaigns, the demand for raw materials can quickly outstrip the supply of sustainably produced natural resources, such as clay for bricks, sand for cement, and wood for timber. This situation produces collateral devastation that was not directly created by the disaster. For example, unsustainable excavation of clay from hillsides to rebuild hundreds or thousands of houses increases the risk of landslides and topsoil erosion, which can lead to the pollution of waterways and negatively impact livelihoods and human health. Such environmental damage can increase risk and jeopardize the success of the overall recovery effort. Project managers should be aware of the sources of their building materials and make sure that they establish contract specifications for the use of sustainably sourced materials. Using materials that have been officially certified is one strategy for ensuring that materials have been sourced sustainably.
2. **Design to use fewer materials.** In designing structures such as houses, project managers should consider ways to effectively meet humanitarian needs with fewer materials. This can be done with design strategies such as using cavity walls in place of solid masonry walls or ribbed slabs in place of solid concrete slabs where feasible. Designing structures with standard material sizes can also help to prevent waste of materials during the construction phase.
3. **Use local sources – where this can be done in a sustainable way.** Local procurement of materials can be a more environmentally sound strategy than the procurement of distant materials because of the savings in transportation costs and packaging. When using local materials, however, project managers should make sure that extraction, processing, and use do not put people's health or environment at risk. The Sphere Humanitarian Charter and Minimum Standards specify that "Natural resources are managed to meet the ongoing needs of the displaced and host populations."[1]
4. **Use disaster debris as a reconstruction material.** One of the most environmentally sustainable options for construction projects in a post-disaster setting is the reuse of building materials found in disaster debris. If using disaster debris, project managers must ensure that the debris meets applicable specifications for strength and safety.
5. **Use materials with recycled content.** Recent technological innovations have led to the availability of building materials that contain recycled content. For example, fly ash from coal-fired power plants can be incorporated into cement production. Project managers should consider using building materials with recycled content where practical to reduce demand on natural resources and lower the project's human and environmental impacts.

---

1 The Sphere Project. 2004. *Minimum Standards in Shelter, Settlement, and Non-food Items.* Sphere Handbook. Geneva: Oxfam Publishing.

1.5 Module Assumptions

This module assumes that users are familiar with the project management cycle for humanitarian assistance or development projects; have a basic understanding of building design, planning, materials procurement, and construction; and are interested in learning how to integrate environmental considerations into this process. The module recognizes a continuum of activities in support of disaster survivors, from the earliest hours of emergency lifesaving functions through the permanent re-establishment of communities. The principles of this module are intended to apply to recovery and reconstruction projects being developed after immediate lifesaving activities have been completed.

1.6 Key Module Definitions

The following are key terms used in this module. A full list of terms is contained in the Glossary.

Life Cycle of a Material: The various stages of a building material, from the extraction or harvesting of raw materials to their reuse, recycling, and disposal.

Life Cycle Materials Management: Maximizing the productive use and reuse of a material throughout its life cycle in order to minimize the amount of materials involved and the associated environmental impacts.

Embodied Energy: The total amount of energy used to create a product, including energy expended in raw materials extraction, processing, manufacturing and transportation.

Reuse: The reuse of an existing component in largely unchanged form and for a similar function (e.g., reusing ceramic roof tiles for a reconstructed house)

Recycle: Melting, crushing, or otherwise altering a component and separating it from the other materials with which it was originally produced. The component then reenters the manufacturing process as a raw material (e.g., discarded plastic bags reprocessed into plastic water bottles).

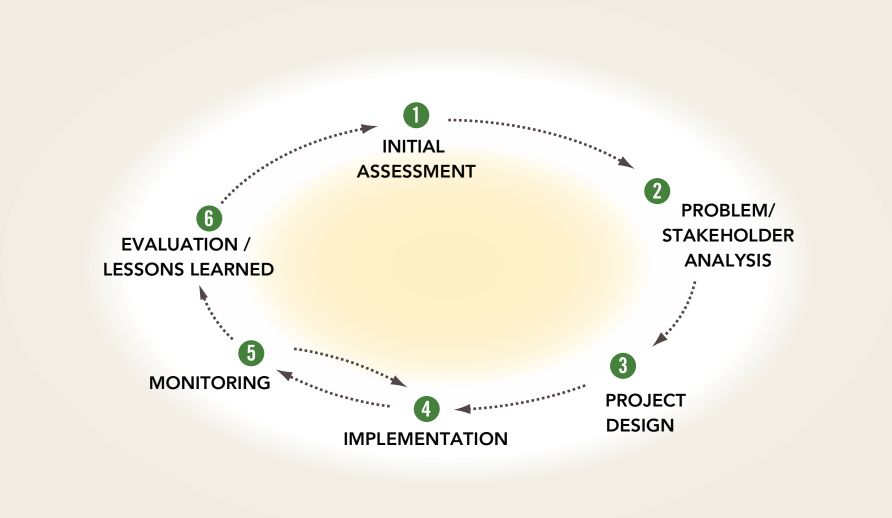
Carbon Footprint: The total set of greenhouse gas emissions caused directly and indirectly by an individual, organization, event, or product. For simplicity of reporting, the carbon footprint is often expressed in terms of the amount of carbon dioxide, or its equivalent of other greenhouse gases, emitted.

After the 2004 Indian Ocean tsunami, WWF, Conservation International, and the U.S. Agency for International Development worked with international timber suppliers to transport environmentally sustainable wood to help rebuild houses in Aceh Province, Indonesia. The wood was certified by the Forest Stewardship Council. This is one strategy for procuring materials that have a lower impact on the environment and the communities that depend on it.
© WWF-US/Jill Hatzai

2 PROJECT CYCLE, BUILDING MATERIALS, AND THE SUPPLY CHAIN

In planning and carrying out disaster-response activities, many humanitarian agencies follow a standard project management cycle (Figure 1).

FIGURE 1: STANDARD PROJECT MANAGEMENT CYCLE



As indicated by the cycle, a well-managed project is by definition a set of logically sequenced, related activities undertaken to produce a planned output. The standard project management cycle pictured here identifies a sequence of activities – assessment, analysis, design, implementation, monitoring, and evaluation. This figure stresses the importance of learning lessons at each stage of the cycle and building those lessons back into future activities to improve future outputs.

Project designers and procurement officers should consider the environmental impacts of building materials at the earliest stages of the project cycle and throughout the entire project cycle, as indicated in Figure 2.

In the initial assessment stage, project planners can consider what the demand will be for building materials for their project as well as the larger context of materials demand for the post-disaster recovery and reconstruction. If the majority of building reconstruction will involve the use of timber, for example, then the initial assessment should include a specific analysis of whether local timber supplies are able to meet the demand in an environmentally sustainable way. If they are not, then project designers should consider what alternate sources are available for sustainable timber or what alternative building materials are available in supply markets (e.g., non-timber materials).

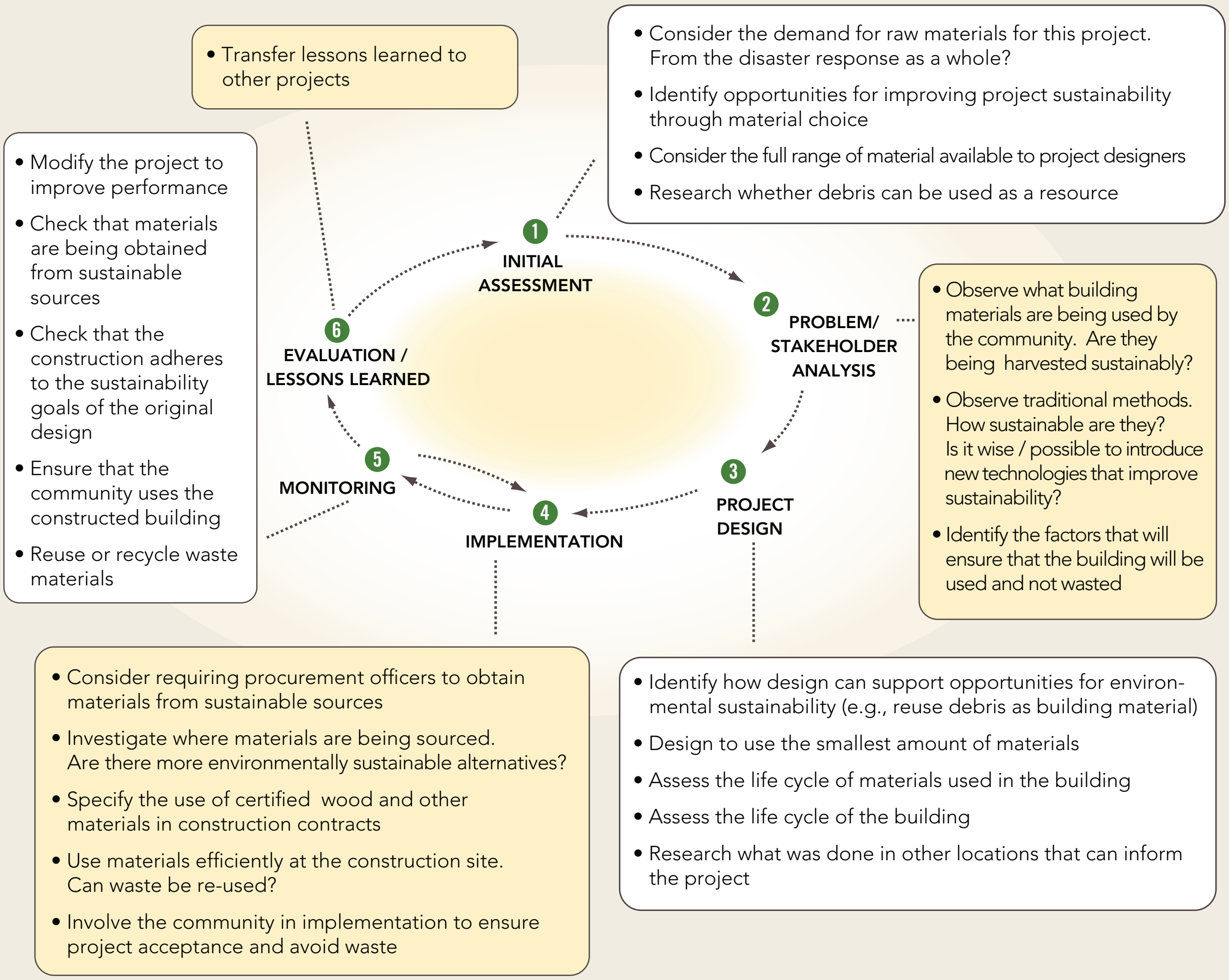
At the problem/stakeholder analysis phase, project planners will consider what building materials are being used by the community and whether it would be wise to introduce new approaches or advocate for the use of traditional methods. Part of this analysis should include specific consideration of which approaches are more environmentally sustainable. Ensuring that the community is fully committed to the project through ongoing participation will also help prevent situations in which newly constructed buildings go unused, resulting in wasted construction materials.

At the design stage, the project planners can consider how their material choices can optimize environmental sustainability, such as through the use of materials that include recycled content or the reuse of disaster debris. Consideration of the life cycle of the materials should also be a part of the design considerations (e.g., understanding how long materials will last before needing to be replaced or how households may use the materials in the future). If construction materials are not fit for the local conditions (e.g., untreated timber in a humid climate), they will require more frequent replacement. This results in the ongoing demand for raw materials, not to mention added financial burden on the household.

During the implementation stage, those responsible for procuring materials will be able to research the sources and markets that are available, and take steps to ensure that materials come from known sources that are environmentally sustainable. A more detailed description of key action points for building materials is contained in Figure 2 below and further elaborated on in the rest of this technical content paper.

These houses built after Cyclone Sidr in Bangladesh (2007) were considered both transitional and permanent because the structure was concrete but the walls were made of local thatch matting that allowed for easy repair in the event of another cyclone. The houses could be lived in as built or added to by families. This project demonstrates a number of successful strategies including: the use of local building materials, proper consideration of community needs, consideration of the life cycle of the building, and designs that reduce future disaster risk. © Kate Akhtar/CARE.

FIGURE 2: PROJECT MANAGEMENT CYCLE AND BUILDING MATERIALS CONSIDERATIONS



3 BUILDING MATERIALS, PEOPLE, AND THE ENVIRONMENT

3.1 Introduction

The appetite for raw resources in the building industry is enormous. According to the author of *The Ecology of Building Materials*, the building industry is, after food production, the largest consumer of raw materials in the world today.[2] Whether constructing a temporary shelter to house displaced people, rebuilding a health center or school, or installing sanitation systems, humanitarian aid staff involved in building construction require a wide range of building materials to complete the job.

All building materials have their origins in raw, natural resources. These raw materials consist of minerals, stone, soil materials, fossil oils, plants, animal products, and water. Minerals, for example, provide the raw materials for a suite of metal products. **Aluminum** (used in structural elements, wall cladding, gutters, doors, and windows), **iron** (processed into steel and used in structural elements, floors, walls, roofs, doors/windows, and nails/bolts), **zinc** (used in zinc galvanizing of steel), **lead** (used as an addition in concrete), **copper** (ingredient in roofing materials as well as pigments for paints and glass), **nickel** (used in steel and as a pigment in paint and tiles), and **silicone dioxide** (quartz sand used for glass) are a few examples of commonly used metals derived from the earth's minerals.

In addition to minerals, **stone rock** is used in its many different forms including blocks (used for structures and walls), crushed stone, sheets and slabs, **limestone** (ground to lime flour and used in cement), and **granite** (crushed as aggregate in concretes).

Soil materials are fine-particled materials from mineral or organic sources and include **clay** and **silt** (used in earth construction, plasters, brick production, cladding, and flooring), **sand** (used in plasters, mortars, and as insulation in flooring and aggregate in concrete), and **gravel** (used as aggregate in concrete).

Fossil oil is another source of building materials. Once it has been refined, it can be used for **tar** and **asphalt** for making roofs watertight. More refined products include **glues**, **waxes**, and **solvents** for paint. Fossil oil is also the raw material for most **plastics**.

Plants are another source of building materials and include **hardwoods** and **softwoods**, such as pine trees and mangrove wood (used in structures, doors/windows, and insulation), as well as **straws**, **grasses**, and **thatch** (used in roof covering and wall cladding).

The raw materials that go into building materials come from finite reserves. The demand for scrap for steel exceeds the maximum possible supply by a factor of around two. According to current statistical predictions, world iron reserves will last 95 years, aluminum 141 years, copper 31 years, and zinc 22 years.[3] These estimates do not take into account expected increases in consumption.

The massive rebuilding effort that occurs after a disaster requires any number of these building materials, and is therefore a part of the global demand for raw materials. The fact that communities need to rebuild the infrastructure that took decades or even centuries to build, and must do so within a much shorter recovery timeframe, means that there will be a rapid and intense demand for raw materials. The extraction of minerals, sand, or clay is likely to increase to an unsustainable rate in the years immediately following a disaster, particularly if the goal is to rebuild to the same level infrastructure that had previously existed.

---

2 Bjørn, Berge. 2009. *The Ecology of Building Materials.* 2nd Ed. Oxford: Architectural Press.

3 U.S. Geological Survey. 2007. *Mineral Commodity Summaries.*

For example, in Mozambique in 2008, it was reported that "in the two weeks following Cyclone Jokwe, the entire stock of the mangrove timber market was sold out every two days, indicating that the post-cyclone housing reconstruction effort increased the rate of mangrove consumption 14 times over nonemergency situations." [4] See the case study on page 9 for more information.

The intensive demand for raw materials in reconstruction ultimately impacts the environment and the people who depend on it. In order to ensure that the recovery effort following a disaster does not make communities more vulnerable, staff involved in building design and materials procurement should ensure that their material choices take advantage of opportunities to maximize environmental performance.

---

4 Randall, Jonathan. 2008. *Cyclone Jokwe Rapid Environmental Assessment Nampula Province, Mozambique*. Washington, DC: CARE-Mozambique and WWF.

In a post-disaster situation, the demand for raw materials is often far greater than the demand for materials before the disaster. This demand can put strain on already depleted ecosystems which can impact the long-term sustainability of communities recovering from disaster. © Bonnie Gillespie/American Red Cross

BUILDING MATERIAL DEMAND FOLLOWING THE 2008 MOZAMBIQUE CYCLONE JOKWE

On March 7, 2008, Cyclone Jokwe, a Category 3 cyclone with peak winds of 195 km/h (120 mph), made landfall in Nampula Province in northeastern Mozambique, affecting approximately 200,000 people and causing at least sixteen deaths. The cyclone destroyed or damaged over 10,000 houses, with the heaviest damage in the cities of Angoche and Moma and the Island of Mozambique in Nampula Province. The majority of the damage occurred in Nampula Province, where approximately 9,000 people were reported to have suffered damage or destruction to their homes.

From an environmental perspective, the most significant building material concern was the use of mangrove wood in the roofing beams for coastal homes. Although cutting mangroves is illegal in Mozambique, the practice is common. In Angoche, there is a well-established mangrove wood market that the operator reports has been in operation for at least the past 35 years. A second mangrove wood market acts as a satellite operation and is located further inland for easier access to homes. The price of a mangrove pole was reported to be 7.50 metical (MT), and an average home was expected to use 50 to 100 mangrove poles. Ironwood, another wood used in home construction primarily for beams, was also marketed for sale at a reported cost of 100 MT per pole.

Angoche Mangrove Market
© Jonathan Randall/WWF

According to the mangrove market operator, the entire stock of the market typically lasts about 30 days. However, in the two weeks following Cyclone Jokwe, the entire stock of the mangrove market was sold out every two days, indicating that the post-cyclone housing reconstruction effort increased the rate of mangrove consumption 14 times over nonemergency situations. Given that cyclones and severe flooding have been increasing in frequency and intensity in Mozambique over the past decade, the demand for mangrove wood is expected to increase in the future. Additionally, there has been a reported increase in the number of people collecting mangrove wood, as well as a steady rise in the number of people moving from central Mozambique to Angoche, putting added pressure on mangrove wood supplies.

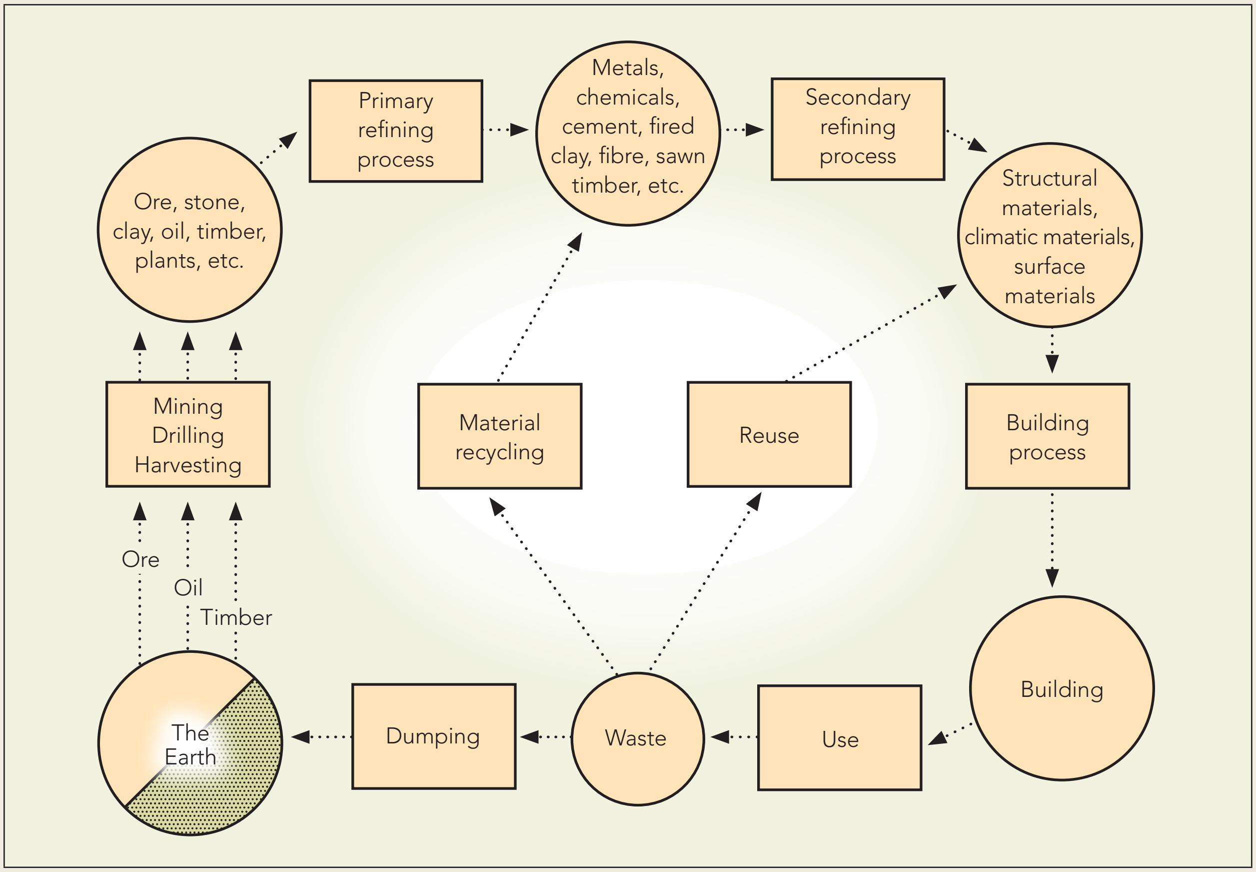
Because the harvesting of mangrove wood is illegal, local informants report that it is not harvested along the continental coast. Wood collectors sail to the islands of Eata Namacate and Larde in the Primeiras and Segundas archipelagos. These archipelagos are recognized as unique areas of high biological richness and diversity, and the mangrove habitat provides important nursery areas for juvenile fish and shrimp, which are important livelihoods resources.

Source: Randall, Jonathan. 2008. *Cyclone Jokwe Rapid Environmental Assessment Nampula Province, Mozambique*. Washington, DC: CARE-Mozambique and WWF.

3.2 Environmental Effects of the Materials Life Cycle

The life cycle of a building material refers to the various stages of a material from extraction or harvesting to reuse, recycling, or disposal. Understanding the life cycle of a building material is key to understanding the environmental implications of material choice and making decisions that will increase a building's environmental performance. Figure 3 is a schematic of a typical material life cycle.

FIGURE 3: LIFE CYCLE OF BUILDING MATERIALS



There are several different measures that can be used to determine the environmental effects of a building material. The amount of **pollution** that is generated by the various life stages of the building material is one measure. Pollution can come in the form of chemical toxins such as ammonia, arsenic, asbestos, or cyanide emitted during the material extraction and processing phases. These pollutants contaminate air, surface water, groundwater, and soil, and cause adverse human health effects. Greenhouse gases, such as carbon dioxide, are another form of pollution that is directly linked with climate change. It has been estimated that about 30 to 40 percent of the Earth's total global greenhouse gas emissions come from the construction sector. [5] Dust and particulate matter is another type of pollutant and byproduct of the manufacturing of construction materials.

5 UNEP. 2009. *UNEP Year Book: New Science and Developments in Our Changing Environment.*

A second measure of the environmental impact of building materials is **embodied energy**. Embodied energy is the sum total of the energy spent in the life cycle of a building material or component. This sum includes all of the energy required for the existence of that component, including extraction or harvest, transport, manufacture, assembly, installation, maintenance, and destruction and disposal.

A third measurement of the environmental impact of building materials is the **quantity of habitat destroyed or damaged** as a result of the material's use, where habitat is commonly defined as the natural home of an animal or plant. Raw material extraction and harvesting can destroy or alter the habitat for plants and wildlife that humans depend on for their survival and livelihoods. It can also displace people that have traditionally used a given area for their own homes, such as the displacement of people from their land for the mining of minerals used in metal production, stone, or granite.

In order to best understand the environmental effects of a given type of building material, it is useful to think about how each stage of the building material life cycle impacts the environment and the people that rely on it. A brief analysis is provided below.

3.2.1 Raw-Material Extraction and Harvesting

The life cycle of a building material starts with the extraction or harvesting of the raw material that will be used to produce the finished building material. Materials such as gravel, stone, and wood are primarily single-material building products, although other materials may be used in their manufacture. The term extraction refers to removal from the earth of a raw material that cannot be replenished (e.g., iron for steel or limestone for cement). Harvesting refers to the acquisition of raw materials such as wood, bamboo, or thatch that are typically plant-based materials and can be replenished over time.

Extraction of raw materials can lead to the pollution of water sources, increase the potential for natural hazards (e.g., landslides, erosion, and flooding), or result in air quality impacts from dust and particulates that can affect human health. When dust, soil, and other particulates enter into streams and rivers, the passage of light through the water is reduced, negatively affecting the photosynthetic microorganisms that fish and other species depend on for food. This suspension and eventual sedimentation of particulates can also increase water temperature and fill habitat in streambeds that fish use for foraging and shelter. Snails, worms, and other invertebrates that fish species depend on for food can be buried by the influxes of deposited sediment that is caused by sand mining. Figure 4 is a picture of river mining in Tambopata Province, Peru, and suspended sediment can be seen in the river. The sand is used for the production of cement for building construction. Extraction of clay from hillsides (Figure 5) can also create a landslide hazard for residents living in areas adjacent to the clay quarry.

Harvesting has its own set of impacts on people and the environment. The removal of timber from hillsides can result in the loss of habitat for food species, erosion of topsoil, and pollution of streams and rivers, as shown in Figure 6. The production of plants for building materials, such as reeds or bamboo, may also result in pesticide or chemical pollution of water and land, putting people at risk if not done sustainably. Workers involved in material extraction or harvesting may also experience health problems from working with toxic chemicals, such as mercury used in mineral extraction or pesticides or fertilizers used in plant production, especially in areas where safety standards are not well enforced.

Figure 4: River mining operation in Tambopata Province, Peru © Sylvia Jane Yorath/WWF

Figure 5: Clay Mining in Aceh, Indonesia © Shinta Sianturi/ American Red Cross

Figure 6: Logging in Aceh, Indonesia © Shinta Sianturi/ American Red Cross

3.2.2 Processing

The processing of building materials involves the conversion of a raw material into a bulk material that can be used to manufacture a building product.

The conversion from iron ore to steel also requires a series of processes, including the breaking up of the ore, cleaning, and sintering (heating). The amount of water needed in steel production at an average-sized plant is the equivalent of what a small town would use. It also takes 440 – 600 tons of coal to produce 1 ton of iron.[6] As a result of steel processing, large amounts of carbon dioxide are emitted, as well as sulfur dioxide, fluoride compounds, dust, and a wide range of heavy metals. Arsenic, a chemical that is toxic to human health, can also be released as iron ore is converted to steel. Additionally, zinc coating and galvanizing, which are common processes that protect steel from humid air, water, acids, and salt that contribute to rust, have an environmental effect. These processes lead to the emission of organic solvents, cyanides, chrome, phosphates, and fluorides, mainly in the cleaning water used in processing.

The kilning of clay bricks requires significant amounts of energy as part of the burning process. It has been estimated that in Aceh, Indonesia, after the 2004 Indian Ocean tsunami, it took twice the amount of wood to make a house out of brick (because of the wood used in the brick kilns) than it did to build the house from timber in the first place (see Figure 7). According to a report by the Food and Agriculture Organization, a typical brickworks in Sumatra, Indonesia, produces approximately 10,000 bricks per week, enough to build one home. It requires approximately 9 cubic meters of wood to fire this number of bricks. By comparison, a house constructed from wood requires about 3 cubic meters of wood. Therefore, roughly twice as much wood is needed to fire the bricks for a brick house than to build a wooden house.[7]

For additional information on the environmental effects of processing aluminum, lime, cements, glasses, stone, and other common building materials, see Berge's *The Ecology of Building Materials*.

Figure 7: Fuel wood used for burning brick in Aceh, Indonesia © Jonathan Randall/WWF

6 Berge, Bjørn. 2009. *The Ecology of Building Materials.* 2nd ed. Oxford: Architectural Press.

7 Kuru, George. 2005. *FAO Assessment of Timber Demand and Supply for Post-Tsunami Reconstruction in Indonesia*. Report prepared for the Food and Agriculture Organization.

3.2.3 Transportation and Packaging

A building material typically goes through several stages of transportation, including transport from the extraction or harvesting site to the processing site where it is manufactured. The manufacturing process itself may require transportation of product between various manufacturing locations. The manufactured building product must also be transported from the manufacturing site to the building construction site, and this may include several intermediate stops at distribution centers, retail outlets, and storage facilities. The transportation of the building material can account for over 50 percent of the energy expended to use the product, and contributes to carbon dioxide emission and demand for oil, gas, and other energy resources.[8] In post-disaster situations, where building materials are often transported long distances because demand exceeds the available local supply, carbon dioxide emissions can be an even higher percentage of the total energy used in the production of the building material.

Packaging also contributes to the environmental impact of building material choice. Much of the packaging used for building materials is not biodegradable and cannot be safely burned (e.g., plastics), and this leads to situations in which the use of the building materials creates a solid waste management issue. Some materials need protective packaging due to moisture sensitivity. However, it is more commonly the case that materials are overpackaged. According to the World Health Organization, "packaging of emergency response provisions (e.g., food, water, medicine, shelter) can produce serious waste problems."[9]

3.2.4 Building and Maintaining

After the building material has been delivered to the site, it becomes incorporated into the building project. The environmental impact at this stage is related to how the materials may affect the construction workers and building occupants. Building products that may be considered harmful include 1) many forms of paint and varnish and 2) formaldehyde in resin-bonded boards including plywood, chipboard, and some foam products (e.g., vinyl products such as flooring tiles). Solvent and paints emit particles and gases that can cause respiratory problems or increase susceptibility to asthma and allergies. For these compounds, emissions will be greatest during the first weeks or months of construction. Additionally, many organic materials as well as mineral materials with organic additives are apt to host fungal growth when exposed to continuous humidity. They can emit mycotoxins (substances produced by a mold or fungus that are toxic to humans and animals) and other serious irritants.

3.2.5 Demolition and Disposal

Building product removal can occur during or after the building's useful life. During a building's life, deconstruction can include removal and replacement of one or more building products. This may be 1) because the product's life is less than that of the overall building, or 2) because of technological obsolescence (i.e., replacing the product with a newer version will be more efficient or cost-effective)

When building materials become obsolete, they need to be properly disposed of, and this places demands on solid-waste management systems. Especially in a post-disaster setting, the capacity of solid-waste management systems can be quickly exceeded. In many developing countries, solid-waste management systems do not function well, and the disposal of building materials places an added burden on these systems.

---

8 Halliday, Sandy. 2008. *Sustainable Construction*. Oxford: Elsevier Science & Technology.

9 WHO. 2005. *Solid waste management in emergencies*. Technical Note Number 7.

4 GUIDANCE FOR PROJECT DESIGNERS

As described above, the use of building materials, whether of steel, sand, or thatch, has a range of environmental impacts that ultimately affect human well-being. Fortunately, there are steps that can be taken to reduce these impacts. In the context of post-disaster building reconstruction, there are two key intervention points: 1) **building design** and 2) **materials procurement**. The **building design stage** is important because this is where decisions about the type and size of the building are made, research on traditional building methods and community preferences is conducted, and certain building materials are selected. At the design stage, the decision to build houses out of mud-stick material, stabilized earth brick, or cement block, for example, ultimately results in different environmental impacts.

The **materials procurement stage** is equally important because the choice of supplier for a given building material (e.g., sand for cement) will have an environmental impact depending on where the suppliers are sourcing their materials. If supplier A is sourcing sand from a sustainable and legal source whereas supplier B is illegally sourcing sand in a way that is negatively impacting the community, then procurement staff should ensure that sand is obtained from supplier A. Of course it is essential for project designers and procurement staff to work together, because the availability of building materials will have an impact on the types of designs that are possible, and those designs, in turn, drive the demand for the building materials. The following section provides guidance for project designers. Section 5 contains guidance for procurement staff.

4.1 Design to Minimize Total Raw Material Consumption

Project designers should analyze ways to meet programmatic needs while at the same time minimizing total raw material consumption. At a minimum, project designers should consider at least two different building designs to see what practical options exist for reducing materials consumption. For example, project designers could compare a stabilized earth-block design with a brick-kiln design in terms of the quantity of building materials required. In many instances, it is possible to reduce the material content of buildings without compromising standards: Solid masonry walls can be replaced by cavity walls or buttressed walls, solid concrete slabs by ribbed slabs, and timber beams by lightweight trusses; lightweight insulating materials can be used to help provide climatic protection at low energy cost. Active engagement with the community is also essential so that the constructed building is used and materials do not go to waste. The size of the structure should also meet minimum standards without exceeding the building size necessary to meet the need. This minimizes stresses on resource markets and natural resources. Designers may also consider adapting the design in such a way that additions can be made to the house by the owner at a later date.

- ❑ At least two (2) different building designs are examined, with consideration given to the quantity of building materials needed for each type of design.
- ❑ Design is based on the use of standard material sizes (i.e., modular dimensions) for less waste at the construction site.
- ❑ The building is designed in such a way that its materials can be reused later in the life cycle of the building. The building can be deconstructed so that materials can be reused without being completely demolished and disposed of.
- ❑ The design includes engineering strategies that optimize material strength with lower quantities of materials while still meeting standard building codes and safety considerations (e.g., cavity walls or buttressed walls).
- ❑ The size of the structure meets minimum standards but does not exceed the building size necessary to meet the need.
- ❑ The building design reflects active engagement with the community to ensure that the structure will be used once it has been constructed.
- ❑ Materials are selected based on consideration of long-term durability so that the need for replacement is minimized.
- ❑ Local builders are trained on the construction techniques and materials being used in order to minimize waste during construction.

SWISS RED CROSS AND THE RAT TRAP CONSTRUCTION METHOD AFTER THE INDIAN OCEAN TSUNAMI

The Swiss Red Cross utilized environmentally sustainable housing models in its planning for reconstruction in Pondicherry, India, after the 2004 tsunami. Consideration of the environment informed material selection and construction technology. The "rat trap" method of masonry structure conserved 25% of production materials. All the bricks were laid on their sides instead of flat. The headers (the bricks with the smallest end showing) were laid across the wall to form a similar pattern on the other sides. As a result the stretchers (bricks with the long sides showing) effectively form two parallel walls with a gap between them. It is this gap (about 2 inches) that gives the pattern its name, rat trap. Nonstructural walls were built like this because they used fewer bricks and were therefore cheaper. The project also introduced fly ash (a coal residue) as a resource, recycling a material that would otherwise be wasted.

Source: SKAT Foundation. 2008. *Sustainable Reconstruction Initiative in Tsunami-affected Villages of Karaikal Pondicherry, India.*

STRAW BALE HOUSING IN BELARUS IN THE AFTERMATH OF CHERNOBYL

Straw bale housing was pioneered in Belarus and other countries in the Commonwealth of Independent States (CIS) as a means of providing affordable, environmentally sustainable public housing for groups displaced by the 1986 Chernobyl nuclear accident. It has been estimated that about 60 percent of the nuclear fallout from the Chernobyl incident landed in Belarus. Because of the poor regional economy and the needs of the target groups, it was imperative that the housing be inexpensive. A sustainable approach was also desirable because of the environmental problems caused by Chernobyl and by military activities in the area.

The housing program, undertaken jointly by a Belarusian nongovernmental organization and the government, is today viewed as a success, particularly in its environmentally sustainable use of straw, an annually renewable agricultural waste product, and in its use of solar power for hot water and heating in each house from April to September.

Straw as a construction material has many benefits. Using straw (which would otherwise be burned, as it is difficult to reintegrate into the soil) instead of wood helps to curb deforestation. It is a good soundproofing and insulating material. Inhabitants of straw bale houses report using one-quarter of the fuel they would have used in similar conventional brick houses. Additionally, straw bale homes constructed with simple earth plaster maintain good fire resistance properties and have been shown to meet fire safety building codes. Recognition of straw's merits as a sustainable resource is growing. Indeed, straw burning is now banned in the U.K. and other countries.

Source: Barakat, S. 2003. *Housing reconstruction after conflict and disaster.* London: Overseas Development Institute Humanitarian Practice Network.

4.2 Choose Construction Materials with Lower Embodied Energy

As mentioned in Section 3.2, embodied energy is the sum total of the energy spent in the life cycle of a building material or component. This sum includes all of the energy required for the existence of that component, including extraction or harvest, transport, manufacture, assembly, installation, maintenance, and destruction and disposal. The materials used for small buildings, such as houses and community centers, differ widely in terms of the energy content required for their manufacture, and savings can often be made by an appropriate selection of materials without reducing standards. Unfortunately, the lowest-embodied-energy solutions are generally those involving timber, which is becoming increasingly scarce. However, secondary species of timber available from managed forests, such as rubber and coconut, among other kinds, can provide a sustainable supply. Technologies for protection against biodegradation and preserving the dimensional stability (i.e., the ability of wood to retain its form when exposed to moisture) of these species are already available and are cost effective. Also, new lightweight or hollow blocks, fiber-concrete products, and other composites can save energy compared with more conventional products.

- ❑ Material selected with the goal of reducing the embodied energy of the material. In examining the building materials being used, designers have considered the amount of energy that was required in the following processes:
  - Extraction/harvesting
  - Transportation
  - Processing
  - Building and maintenance
  - Demolition and disposal
- ❑ Materials are chosen based on a preference for local sources.
- ❑ Environmentally sustainable materials, such as lightweight or hollow blocks, fiber-concrete products, other composites, and timber from well-managed forests are considered.

BUILDING WITH LOWER EMBODIED ENERGY IN CUBA FOLLOWING HURRICANE DENNIS

In order to promote the construction of more efficient homes in Cuba in the aftermath of Hurricane Dennis in 2005, CIDEM or the *Centro de Investigación y Desarrollo de Estructuras y Materiales* (Research and Development Center for Structures and Materials) created a training and capacity-building program for local builders on the production and use of "ecomaterials" that feature a low embodied energy. Materials included micro-concrete roofing tiles, pre-cast hollow concrete blocks, clay bricks fired with bio-waste fuels, bamboo, and partially replacing Portland cement with lime-pozzolana cement (CP-40). As a result of this project, over 19 ecomaterials workshops were started in Cuba and over 2,300 homes were renovated or repaired using the new technology. This case illustrates how material selection can contribute to both lower energy use and local capacity building. CIDEM is involved in hurricane-damage-mitigation efforts to implement similar methods of localized production and ecomaterial usage in housing construction.

Source: World Habitat Awards. 2007. *Ecomaterials in Social Housing Projects*.

4.3 Include Reuse Strategies as Part of Building Design and Construction

The most environmentally sustainable option for resourcing construction projects is the reuse of waste building materials in their existing state without downgrading and reprocessing into new products. Massive amounts of materials can come from disaster debris and demolition sites. The potential for using these materials is enormous; they mitigate the need to buy new materials and prevent the consumption of energy in moving debris to landfill areas. The steel, bricks, timber, and tiles that are left after a disaster can often be used to provide transitional shelter to affected families, and can serve as the starting point for reconstruction. In some cases, the salvage of building materials for reuse can be a revenue-generating activity.

Instead of dumping or destroying the damaged materials from storm-damaged housing stock, post-disaster projects can actively pursue reuse strategies where feasible. Many building materials are reusable, even after being exposed to a disaster (e.g., metal roofing blown off of a house in a cyclone). Metal roofing sheets may be reshaped and renailed into place. Lumber damaged in earthquakes and trees blown over in storms can be cut and reused, especially when shorter lengths are needed. Damaged concrete blocks can be used as fill, and stones can be cleaned and reused for masonry construction. If the reuse of materials is an option, special care should be taken to ensure that the materials are of high enough quality to be used for safe and long-lasting construction, as they can become dangerously weakened either by predisaster use or by the disaster itself. A process to assess the quantity of disaster debris that is available, as well as costs for transportation and processing, should be taken into account in project budgeting.

- ❑ The availability and quality of disaster debris for use in building designs has been actively considered (e.g., corrugated steel roofing, timbers, wood framing, doors, windows, masonry units (brick or block), concrete for aggregate as a base for roads.)
- ❑ Building designs and construction methods are selected so that additions and modifications can be made using the same fundamental designs and methods.

THREE LEVELS OF RECYCLING

Reuse: The use of a whole component, in largely unchanged form and for a similar function; for example a brick reused as a brick.

Recycling: The melting or crushing of the component and its separation into its original constituent materials, which then reenter the manufacturing process as raw materials.

Recovery: Burning of the demolished product to produce energy. The use of the raw material as a resource is lost and only its energy content is recovered.

Source: Berge, Bjørn. 2009. *The Ecology of Building Materials*. 2nd Ed. Oxford: Architectural Press.

REUSE AND RECYCLING IN TURKEY

In 1999, two devastating earthquakes in Turkey left 300,000 housing units damaged or destroyed, and emergency shelter was needed for 600,000 people. In the initial phase, a number of temporary houses were constructed. Post-disaster efforts were subsequently made to disassemble a number of unused temporary housing units and reuse or recycle many of the materials to construct longer-term "redesigned" houses. This approach can speed up the recovery process, allowing for a quicker transition to normalcy for affected populations. A study found that disassembly and reuse of materials from temporary houses for the longer-term houses resulted in significant materials and energy savings without compromising structural integrity.

Source: Arslan, Hakan. 2005. Re-design, re-use, and recycle of temporary houses. *Building and Environment* 42:400-406.

MERCY CORPS, THE GREEN PROJECT, AND THE REBUILDING CENTER AFTER HURRICANE KATRINA (2005)

Mercy Corps, The Green Project, and the ReBuilding Center worked together in New Orleans after the devastating effects of Hurricane Katrina in 2005. This group devised a deconstruction method that could help low-income residents salvage materials from disaster-ravaged homes. These materials could in turn be reused in the reconstruction and rebuilding process. The project pilot was implemented on a partially collapsed home and included a six-day salvage operation, nail and debris removal, and full-site cleaning. Working by hand, people managed to salvage roughly 40% of the damaged home, or 150 cubic yards of material.

Source: Mercy Corps. 2006. *The Story of 2118 Dumaine Street*.

4.4 Include Recycling Strategies as Part of Building Design and Construction

One of the greatest technological opportunities available to building-materials industries and reconstruction project designers is the potential to incorporate wastes from agriculture and industry as raw materials and as fuel substitutes, thus simultaneously reducing pollution and the need for the extraction of new raw materials. Waste from coal-fired power stations, such as blast-furnace slag and fly ash, can be incorporated in cement production. The utilization of industrial wastes can reduce the need to dispose of these products and reduce demand for raw materials. Timber wastes and agricultural wastes can be processed and used to form building boards. The residues from rice and palm-nut processing, and from coconut and groundnut, are materials that can be used as fuels in brick burning and lime burning. Many nonhazardous industrial wastes can be used as aggregates in concrete production. In addition, the ash from many agricultural residues has chemical and physical properties (e.g., the ability to set in water) that makes it suitable for incorporation into cements.

Even in cases where materials may be so badly damaged that they are not reusable in their current form, such materials may still be recycled and made into new products at lower cost and with less ecological damage than is incurred in the manufacture of new materials. In addition to recycling materials damaged by the disaster, managers can help the environment by specifying and buying building products that contain recycled materials. Information on reusing and recycling disaster debris is contained in the box below.

- ❑ Designer has consulted with procurement staff on the availability of recycled material that can be used in the building designed.
- ❑ Project designer should select building materials that include a high degree of recycled material when appropriate and available.

REUSING AND RECYCLING DISASTER DEBRIS

How a community manages disaster debris depends on the debris generated and the waste management options available. Many communities are finding effective ways to salvage, reuse, and recycle all kinds of disaster debris. Soil, green waste, and construction and demolition materials can be recycled or composted into useful commodities. For example:

- Green waste, such as trees and shrubs, can be "recycled" into valuable organic material, such as compost or mulch.
- Concrete and asphalt can be crushed and sold for use as a base in road building.
- Metal can be recycled and sold by scrap metal dealers.
- Brick can be sold for reuse or ground for use in landscaping applications.
- Dirt can be used as landfill cover or as a soil amendment for farmers.

Benefits of recycling disaster debris include:

- Recovering large amounts of materials for reuse
- Reducing the burden of large volumes of material on local landfills
- Saving money by avoiding disposal costs and through resale of materials

Source: U.S. Environmental Protection Agency. Disaster Debris. www.epa.gov/osw/conserve/rrr/imr/cdm/debris.htm (Accessed March, 31 2010)

5 GUIDANCE FOR PROCUREMENT MANAGERS AND LOGISTICIANS

Once the project designer has chosen the building materials, it is the responsibility of the procurement manager or logistician to procure the materials. The material procurement phase is an important opportunity to reduce the environmental impact of building materials. The following section provides guidance on ways that procurement managers and logisticians can investigate the source of building materials, integrate environmental criteria into bidding documents, and work with the producers on building materials to reduce the longer-term impacts of building material use.

5.1 Investigate the Source of Materials

The primary responsibility of a procurement officer/logistician is to deliver the appropriate supplies, in good condition and in the quantities required, to the right places and the people who need them, on time and cost effectively. To this fundamental job description, this module adds the description of "appropriate supplies," meaning that they meet the criteria of minimizing pollution, embodied energy, and negative impact on the environment. Procurement should not be based only on cost, timeliness, and availability criteria, but also on verification that the source of material is legal and sustainable, while simultaneously seeking to minimize energy used for the transportation.

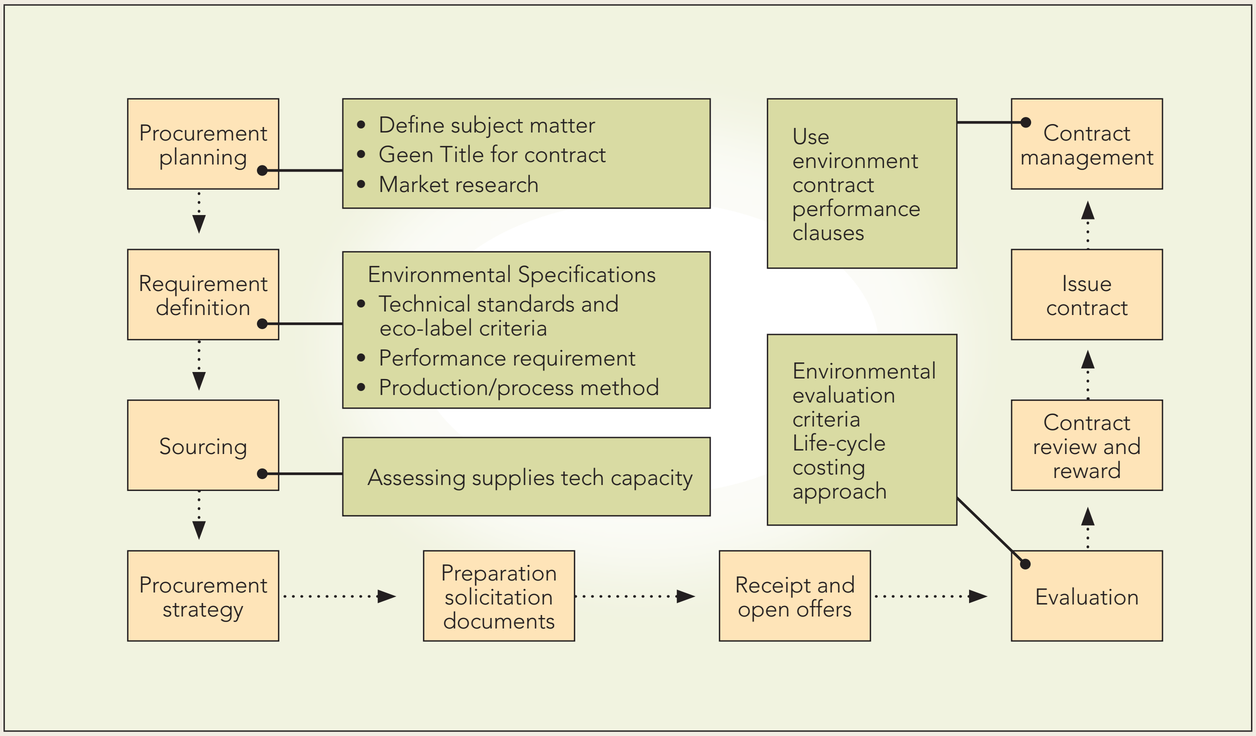
- ❑ Procurement managers have investigated at least two or three different suppliers for a given building material and asked the suppliers where they source their materials and if they are aware of any environmental impacts associated with the extraction, processing, or transportation of the materials. Environmental impacts to ask about include pollution of waterways, negative health impacts, impacts on air quality, and loss of habitat.
- ❑ Procurement managers have visited the locations where raw materials are being extracted for use in the project where practical (e.g., source of sand for cement is investigated to see if it is legal and sustainable).
- ❑ Procurement managers have consulted with government officials to determine if there are any environmental concerns with respect to the use of certain types of building materials in the project area.

5.2 Integrate Environmental Criteria into Bidding Documents

Building materials often must be procured through a bidding process, either because the quantities are very large and not available locally or because the organization has established policies requiring the use of bidding processes in order to control quality, cost, and management oversight. The bidding process then provides an excellent opportunity to integrate sustainable environmental objectives with the process of procurement. The below diagram illustrates the many opportunities to "green" procurement. For more detailed guidance on these mechanisms, see *Environmental Procurement Practice Guide,* by UNDP, on the resource CD for this module.

- ❑ Bidding documents, Terms of Reference, and other contracting documents specify that building contractors will procure building materials from sources that are environmentally sustainable.
- ❑ The specifications include requirements for the use of verifiable, certified building products (e.g., FSC-certified timber) where possible. For more information on certified building materials see Section 6 below.

FIGURE 8: ENVIRONMENTAL INTERVENTIONS IN THE PROCUREMENT CYCLE



Source: UNDP. 2008. *Environmental Procurement Practice Guide*. UNDP Practice Series.

5.3 Work Directly with Material Producers to Green Their Operations

If large quantities of building materials are going to be used, procurement managers should consider working directly with material producers to ensure that their operations are environmentally sustainable. For example, if brick is being kiln-dried for a housing reconstruction project, procurement managers can work with the brick producers to ensure that fuel wood is obtained from environmentally sustainable sources and that the air pollution from the kilns does not negatively impact local residents. The procurement officer can inform suppliers of different methods they can use to reduce pollution, sustainably harvest materials, and lower embodied energy requirements in the process of producing and furnishing the materials. Building material suppliers may be interested in how they can reduce the environmental footprint of their operations but may be unaware of the best methods to do so. Procurement managers can help play a role in greening the supply chain of a local community.

❑ Procurement managers have taken proactive steps to assist their suppliers in making the material supply chains more environmentally sustainable.

WORKING WITH BRICK PRODUCERS IN SUDAN AFTER DROUGHT

Drought is a recurrent concern for humanitarian workers in much of eastern and southern Africa and finding sustainable sources of local fuel wood can be a challenge. The Shambob Brick Producers Co-operative Society in Sudan won the United Nations Best Practices award in 2000 for assisting poorer workers with better methods for brick production that use less fuel wood. Assisted by the Intermediate Technology Development Group (ITDG) of Sudan, workers integrated more environmentally appropriate production methods into their brick-making processes, including the use of new energy-efficient kilns. Firing kilns with cheaper alternative fuels, chiefly cow dung and bagasse residues (fibrous leftovers from the juice extraction of sugarcane and sorghum stalks), had a positive effect on economic viability as well as environmental sustainability. Up to 80% of wood fuel was ultimately substituted with bagasse. More uniform finished products created with improved molding and drying methods led to a savings in overall construction time and costs. Reduction of transportation costs to benefit both the local people and environment was also a consideration. This case illustrates the innovation of using locally produced and environmentally conscious materials to benefit communities and livelihoods while creating a platform for economic and environmental sustainability.

Source: Intermediate Technology Development Group Ltd. 2001. *Building in Partnership: The Story of Shambob.*

6 CERTIFICATION AND STANDARDS

Over the past few decades, a number of international initiatives have been started in order to streamline the evaluation process used for identifying environmentally sustainable buildings and materials. As a general rule, project designers and procurement staff and logisticians should research and use certified building materials where available and practical. The building materials will typically be marked with the symbol of the certification. National governments may also have their own standards and certifications for buildings materials, so it is useful to consult government officials in the building sector to see if there are certified materials available that have a lower environmental impact. The following section discusses a few of the international certifications and standards. Even if a building material has a symbol, it is still worth enquiring about the source, because false claims about the environmental sustainability of a building product are common (i.e., "greenwashing").

FSC

Forest Stewardship Council (FSC)

The FSC is an independent, nongovernmental, not-for-profit organization established to promote the responsible management of the world's forests. The FSC was established in 1993 as a response to global deforestation. Currently FSC offers, among other initiatives and services, a certification system that provides internationally recognized standard-setting, certification, and trademark assurance related to responsible and sustainable forestry.

The FSC label is shown on certified timber products by producers to indicate to buyers that their products have been managed and harvested in accordance with FSC's set of Principles and Criteria for forest management. There are 10 Principles and 57 Criteria that address legal issues, indigenous rights, labor rights, and environmental impacts surrounding forest management on a global scale.

The FSC Web site – available at www.fsc.org – includes a comprehensive, international database of certified timber suppliers that can be consulted. The database is under "Find FSC products." By accessing the FSC database (use the "Find FSC Products" option at www.fsc.org), managers can identify names and addresses of materials suppliers whose products bear FSC certification.

NSF

NSF International

NSF International is an independent, not-for-profit organization that specializes in the certification of food, water, and consumer goods, including many building materials and components (for more complete information, please see www.nsf.org). NSF was originally founded in 1944 as the National Sanitation Foundation, and is a World Health Organization Collaborating Centre for Food and Water Safety and Indoor Environment.

NSF has developed numerous standards and protocols, and annually tests and certifies over 225,000 products in 100 countries. NSF's standards are accredited by the International Accreditation Service (IAS), the International Standardization Organization (ISO), and Standards Council of Canada (SCC), among other organizations. NSF provides a solution both for those who need to "prove" green claims amidst the growing number of false claims or greenwashing in this area, and for those who wish to be sure about what it is they are buying. NSF can verify the following types of product claims:

- Compostability
- Recyclability
- Constituent analysis
- Contaminant analysis
- Indoor air testing
- Custom-designed testing

Managers planning post-disaster reconstruction responses should consider procuring NSF-certified products.

International Organization for Standardization

The International Organization for Standardization (ISO) is a voluntary, nongovernmental certification institution that helps set industrial standards. Among other services, the ISO deals with the issues of sustainability in building construction and environmental assessment methods.

ISO 14001 is the standard for environmental management systems to be incorporated into a business, process, or initiative. The aim of the promotion of the standard is to reduce the environmental harm of a business and to decrease the pollution and waste a business produces. One of the core components of this certification is the Life Cycle Assessment process, or LCA. The most recent version of ISO 14001 was released in 2004. This standard is similar in structure and process to the widely recognized ISO 9000 quality management standard. The standards, once published, become a market-driven requirement rather than a legal requirement. The ISO itself underscores this voluntary and market-driven relationship.

As of 2008, ISO 15392 establishes internationally recognized principles for sustainability in building construction. It thus provides a common basis for communication between stakeholders such as builders and architects, product manufacturers and designers, building owners, policy makers and regulators, housing authorities, and consumers. ISO 15392 is based on the concept of sustainable development as it applies to buildings and other construction works, "from cradle to grave." Over their life cycle, construction works – including post-disaster reconstruction works – have considerable economic consequences and impacts on the environment and human health.

Project managers should try to ensure that the materials they procure are from companies that have an Environmental Management System in place that complies with the ISO 14000 family of standards.

Leadership in Energy and Environmental Design

LEED Certification – Leadership in Energy and Environmental Design (LEED) is a third-party certification program that is becoming an internationally accepted benchmark for the design, construction, and operation of high-performance "green" buildings. It is important to note that, generally speaking, whole projects – not individual building products or materials – are LEED certified.

In the United States and in a number of other countries around the world, LEED certification is the most recognized standard for measuring building sustainability. LEED certification is one way for designers to demonstrate that their building projects are truly green. Project planners and architects should consider researching how their projects can incorporate some of the LEED principles in post-disaster recovery and reconstruction settings, even if there is not time to go through the entire LEED certification process.

THE COST OF INTEGRATING GREEN FEATURES

A 2004 study by Davis Langdon Adamson, a construction cost-planning and management company, found that the first costs of constructing a sustainable building tend to match or only slightly exceed those of comparable non-green buildings. The study, *Costing Green: A Comprehensive Cost Database and Budgeting Methodology*, measured the square-foot construction costs of 61 buildings requiring certification under the LEED green building rating system against those of buildings of similar type that did not aim for sustainability. Taking into account a range of construction factors including climate, location, market conditions, and local standards, the results showed that for many of the green projects, pursuing LEED certification had little or no budgetary impact. The study's findings also underline the idea that incorporating and integrating green features into a project early is critical to the success of any green building project. "It is the choices made during design which will ultimately determine whether a building can be sustainable, not the budget set," the report concluded.

Source: Adamson, Davis Langdon. 2004. *Costing Green: A Comprehensive Cost Database and Budgeting Methodology.*

The LEED building certification infrastructure is based on ISO standards (described above), and is administered by the Green Building Certification Institute (GBCI) and 10 other third-party certification bodies with experience in certifying organizations, processes, and products to ISO and other standards. There are four levels of certification: certified (the lowest), silver, gold, and platinum (the highest). Each level is defined by a set number of points from a LEED rating system that offers 7 prerequisite points and 69 optional points. To achieve any certification a project must comply with the 7 prerequisite points. These optional points determine the LEED rating as follows:

1. Certified: between 26 and 32 points
2. Silver: from 33 to 38 points
3. Gold: from 39 to 51 points
4. Platinum: from 52 to 69 points

ANNEX 1: ADDITIONAL RESOURCES

The following organizations and publications provide a variety of tools, resources, and information that elaborate on the concepts presented in this module.

Organizations

Green Building Certification Institute: The Green Building Certification Institute (GBCI) provides third-party project certification and professional credentials recognizing excellence in green building performance and practice. GBCI administers project certification for commercial and institutional buildings and tenant spaces under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating Systems. GBCI also manages the professional credentialing programs based upon the LEED Rating Systems, including the LEED Green Associate and LEED AP credentials. While the LEED Green Building Rating System is a common standard for green building in the United States, it is now also recognized internationally as a tool for the design, construction, and operations of high-performance, sustainable buildings. LEED buildings can now be found throughout the world, and there are currently projects in more than 100 countries working toward LEED certification. *www.gbci.org*

International Organization for Standardization (ISO): ISO standards are often cited in the development of many other standards and certification processes, including LEED certification. As such they are a touchstone and ultimate resource for specifications and for the process of certifying that materials and processes meet certification standards. In particular, ISO's 14000 series of standards address various aspects of environmental management. The first two standards, ISO 14001:2004 and ISO 14004:2004, deal with environmental management systems (EMS). The other standards and guidelines in the series address specific environmental aspects, including labeling, performance evaluation, life cycle analysis, communication, and auditing. *www.iso.org*

NSF International: The letters NSF originally stood for the National Sanitation Foundation, although they no longer carry that specific meaning after the merger of the National Sanitation Foundation and NSF Testing Labs. NSF supplies listings of certified products free to anyone visiting their website. These listings are updated daily. Published Listing Books may be obtained free of charge for public health officials. New certifications for novel processes, or for innovative designs and products, may be achieved by application to the NSF. *www.nsf.org*

The Shelter Centre: The Shelter Centre is a nongovernmental organization supporting humanitarian operations. Its focus spans the transitional settlement and reconstruction needs of populations affected by conflicts and natural disasters, from the emergency phase until durable solutions are reached. Shelter Centre partners in the sector include United Nations bodies, the Red Cross Movement, international organizations, nongovernmental organizations, and academic and research groups, as well as donors The Shelter Centre supports environmentally sound reconstruction by developing and maintaining strategic or policy guidelines, technical guidelines, and technical training. *www.sheltercentre.org*

United Nations Environment Program (UNEP): Functional organization within the United Nations system that focuses on environment and global sustainability issues. UNEP has a dedicated Disasters and Conflicts section. Sustainable construction guidelines and information can be accessed through their online resources. *www.unep.org*

UN-HABITAT: UN-HABITAT's mission is to "promote socially and environmentally sustainable human settlements development and the achievement of adequate shelter for all." UN-HABITAT focuses on sustainability issues for urban populations and provides many useful studies and publications on economic as well as environmental sustainability of human settlements around the globe. It provides guidelines, case studies, trainings, and workshops related to human populations and the built environment. *www.unhabitat.org*

World Green Building Council (WGBC): The WGBC's mission is to:

- Ensure that Green Building Councils are successful and have the tools necessary to advance
- Stand as the premier international voice for green building design and development
- Foster effective communications and collaboration between councils, countries, and industry leaders
- Support effective green building rating systems
- Share best practices globally

The WGBC provides publications, trainings, and workshops in this field and promotes sustainable building practices through trade fairs, local and international initiatives, and an annual green building festival, among other activities. *www.wgbc.org*

World Wildlife Fund (WWF): Nongovernment organization offering a broad array of resources on environmental issues. WWF is involved in a number of materials certification and market transformation programs, including the Forest Stewardship Council. National level WWF offices can provide insight into sustainable materials sources at a local level. *www.wwf.org*

Publications

Arslan, Hakan. 2005. Re-design, re-use, and recycle of temporary houses. *Building and Environment 42:400-406.*

Arya, A.S. 2005. *Guidelines for Earthquake Resistant Reconstruction and New Construction of Masonry Buildings in Jammu & Kashmir State*. New Delhi: Ministry of Home Affairs.

Aursnes, I.S., and C. Foley. 2005. *Property restitution in practice: The Norwegian Refugee Council's experience.* Norwegian Refugee Council.

Barakat, S. 2003. *Housing reconstruction after conflict and disaster.* London: Overseas Development Institute Humanitarian Practice Network.

Berge, Bjørn. 2009. *The Ecology of Building Materials.* 2nd Ed. Oxford: Architectural Press.

Coburn, Andrew, Robert Hughes, Robin Spence, and Antonio Pomonis. 1993. *Technical Principles of Building for Safety.* London: ITDG Publishing.

DFID. 1999. *Sustainable Livelihoods Approach Guidance Sheets.* London: Department for International Development.

Dudley, E., and A. Harland. 1993. *Communicating Building for Safety: Guidelines for methods of communicating technical information to local builders and householders.* London: ITDG Publishing.

Halliday, Sandy. 2008. *Sustainable Construction.* Oxford: Elsevier Science & Technology.

Imhoff, D., and R. Carra. 2001. *Building with Vision.* Healdsburg, CA: Watershed Media.

Kelly, C. 2005. *Checklist-Based Guide to Identifying Critical Environmental Considerations in Emergency Shelter Site Selection, Construction, Management and Decommissioning*. Benfield Hazard Research Centre/CARE.

Kennedy, J., M. Smith, and C. Wanek. 2002. *Natural Building.* Gabriola Island, BC: New Society Publishers.

Mukerji, K., and R. Stultz. 2005. *Appropriate Building Materials: A Catalogue of Potential Solutions*. Rugby: Practical Action Publishing.

Murty, C.V.R. 2005. *Earthquake Tips: Learning Earthquake Design and Construction*. Kanpur, India: IIT-Kanpur and Building Material and Technology Promotion Council.

ProAct Network and Shelter Centre. *Brief Technical Guide: Asbestos*. www.proactnetwork.org/proactwebsite/index.php/policyresearchtoolsguidance/brief-technical-guides/asbestos (Accessed March 31, 2010)

ProAct Network and Shelter Centre. *Brief Technical Guide: Building Waste*. www.proactnetwork.org/practwebsite/index.php/policyresearchtoolsguidance/brief-technical-guides/building-waste (Accessed March 31, 2010)

ProVention Consortium. 2007. *Tools for Mainstreaming Disaster Risk Reduction: Construction Design, Building Standards and Site Selection*. Guidance Note 12.

Spence, Robin, 1992. *Energy for Building*. Geneva: UN-Habitat.

Spence, R., and D. Cook. 1983. *Building Materials in Developing Countries*. Hoboken, NJ: John Wiley and Sons.

Kibert, Charles J. 2007. *Sustainable Construction: Green Building Design and Delivery*. Hoboken, NJ: John Wiley and Sons.

The Sphere Project. 2004. *Minimum Standards in Shelter, Settlement and Non-food Items*. Sphere Handbook. Geneva: Oxfam Publishing.

Twigg, J. 2004. *Disaster Risk Reduction*. ODI Good Practice Review No.9. London: Overseas Development Institute.

UNDP. 2008. *Environmental Procurement Practice Guide*. UNDP Practice Series.

UNEP. 2006. *Environmental considerations of human displacement in Liberia: A guide for decision-makers and practitioners.*

UN-Habitat. 2007. *Building Houses, Rebuilding Communities*. Indonesia.

UN-Habitat and OHCHR. 2003. *Monitoring Housing Rights*. Nairobi and Geneva.

UNHCR. 1996 and 2005. *Environmental Guidelines*. Geneva.

UNHCR. 1998. *Refugee Operations and Environmental Management: Key Principles for Decision-Making*. Geneva.

Van der Ryn, S., and S. Cowen. 1996. *Ecological Design*. Island Press.

Winarso, H. and M. Mattingly. *Local Participation in Indonesia's Urban Infrastructure Investment Programming: Sustainability through Local Government Involvement?* Institute of Technology Badung and UCL.

Woolley, T., and S. Kimmins. 2000. *Green Building Handbook.* 2nd Ed. London: Spon Press.

WWF. 2006. *Tsunami Green Reconstruction Policy Guidelines.*

GLOSSARY

The following is a comprehensive list of the key terms used throughout the Green Recovery and Reconstruction Toolkit. In some cases, the definitions have been adapted from the original source. If no source is given, this indicates that the module author developed a common definition for use in the toolkit.

Anaerobic Filter (or Biofilter): Filter system mainly used for treatment of secondary effluent from primary treatment chambers such as septic tanks. The anaerobic filter comprises a watertight tank containing a bed of submerged media, which acts as a support matrix for anaerobic biological activity. For humanitarian aid agencies, the prefabricated biofilters that combine primary and secondary treatment into one unit can provide a higher level of treatment than do traditional systems such as precast cylindrical septic tanks or soakage pit systems. Source: SANDEC. 2006. *Greywater Management in Low and Middle Income Countries.* Swiss Federal Institute of Aquatic Science and Technology. Switzerland.

Better Management Practices (BMPs): BMPs are flexible, field-tested, and cost-effective techniques that protect the environment by helping to measurably reduce major impacts of growing of commodities on the planet's water, air, soil, and biological diversity. They help producers make a profit in a sustainable way. BMPs have been developed for a wide range of activities, including fishing, farming, and forestry. Source: Clay, Jason. 2004. *World agriculture and the environment: a commodity-by-commodity guide to impacts and practices.* Island Press: Washington, DC.

Biodiversity: Biological diversity means the variability among living organisms from all sources, including inter alia, terrestrial, and marine and other aquatic ecosystems, as well as the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems. Source: United Nations. Convention on Biological Diversity. www.cbd.int/convention/articles.shtml?a=cbd-02 (Accessed on June 18, 2010)

Carbon Footprint: The total set of greenhouse gas emissions caused directly and indirectly by an individual, organization, event, or product. For simplicity of reporting, the carbon footprint is often expressed in terms of the amount of carbon dioxide, or its equivalent of other greenhouse gases, emitted. Source: Carbon Trust. Carbon Footprinting. www.carbontrust.co.uk (Accessed on June 22, 2010)

Carbon Offset: A financial instrument aimed at a reduction in greenhouse gas emissions. Carbon offsets are measured in metric tons of carbon dioxide-equivalent (CO_2e) and may represent six primary categories of greenhouse gases. One carbon offset represents the reduction of one metric ton of carbon dioxide or its equivalent in other greenhouse gases. Source: World Bank. 2007. *State and Trends of the Carbon Market.* Washington, DC

Climate Change: The climate of a place or region is considered to have changed if over an extended period (typically decades or longer) there is a statistically significant change in measurements of either the mean state or the variability of the climate for that place or region. Changes in climate may be due to natural processes or to persistent anthropogenic changes in atmosphere or in land use. Source: UN International Strategy for Disaster Reduction. Terminology of disaster risk reduction. www.unisdr.org/eng/terminology/terminology-2009-eng.html (Accessed on April 1, 2010)

Construction: Construction is broadly defined as the process or mechanism for the realization of human settlements and the creation of infrastructure that supports development. This includes the extraction and processing of raw materials, the manufacturing of construction materials and components, the construction project cycle from feasibility to deconstruction, and the management and operation of the built environment.

Source: du Plessis, Chrisna. 2002. *Agenda 21 for Sustainable Construction in Developing Countries.* Pretoria, South Africa: CSIR Building and Construction Technology.

Disaster: Serious disruption of the functioning of a society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using only its own resources. Disasters are often classified according to their speed of onset (sudden or slow) and their cause (natural or man-made). Disasters occur when a natural or human-made hazard meets and adversely impacts vulnerable people, their communities, and/or their environment. Source: UNDP/UNDRO. 1992. *Overview of Disaster Management*. 2nd Ed.

Disaster preparedness: Activities designed to minimize loss of life and damage; organize the temporary removal of people and property from a threatened location; and facilitate timely and effective rescue, relief, and rehabilitation. Source: UNDP/UNDRO. 1992. *Overview of Disaster Management*. 2nd Ed.

Disaster Risk: Potential disaster losses in lives, health status, livelihoods, assets, and services that could occur to a particular community or a society over some specified future time period. Risk can be expressed as a simple mathematical formula: Risk = Hazard X Vulnerability. This formula illustrates the concept that the greater the potential occurrence of a hazard and the more vulnerable a population, the greater the risk. Source: UN International Strategy for Disaster Reduction. Terminology of disaster risk reduction. www.unisdr.org/eng/terminology/terminology-2009-eng.html (Accessed on April 1, 2010)

Disaster Risk Reduction: The practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events. Source: UN International Strategy for Disaster Reduction. Terminology of disaster risk reduction. www.unisdr.org/eng/terminology/terminology-2009-eng.html (Accessed on April 1, 2010)

Ecosystem: Dynamic complexes of plants, animals, and other living communities and the nonliving environment interacting as functional units. Humans are an integral part of ecosystems. Source: UN. Convention on Biological Diversity. www.cbd.int/convention/articles.shtml?a=cbd-02 (Accessed on June 18, 2010)

Ecosystem Services: The benefits that people and communities obtain from ecosystems. This definition is drawn from the Millennium Ecosystem Assessment. The benefits that ecosystems can provide include "regulating services" such as regulation of floods, drought, land degradation, and disease; "provisioning services" such as provision of food and water; "supporting services" such as help with soil formation and nutrient cycling; and "cultural services" such as recreational, spiritual, religious, and other nonmaterial benefits. Integrated management of land, water, and living resources that promotes conservation and sustainable use provides the basis for maintenance of ecosystem services, including those that contribute to the reduction of disaster risks. Source: UN International Strategy for Disaster Reduction. Terminology of disaster risk reduction. www.unisdr.org/eng/terminology/terminology-2009-eng.html (Accessed on April 1, 2010)

Embodied Energy: The available energy that was used in the work of making a product. Embodied energy is an accounting methodology used to find the sum total of the energy necessary for an entire product life cycle. Source: Glavinich, Thomas. 2008. *Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction.* John Wiley & Sons, Inc: New Jersey.

Environment: The complex of physical, chemical, and biotic factors (such as climate, soil, and living things) that act upon individual organisms and communities, including humans, and ultimately determine their form and survival. It is also the aggregate of social and cultural conditions that influence the life of an individual or community. The environment includes natural resources and ecosystem services that comprise essential life-supporting functions for humans, including clean water, food, materials for shelter, and livelihood generation. Source: Adapted from: *Merriam Webster Dictionary, "Environment."* www.merriam-webster.com/netdict/environment (Accessed on June 15, 2010)

Environmental Impact Assessment: A tool used to identify the environmental, social, and economic impacts of a project prior to decision making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment, and present the predictions and options to decision makers. Source: International Association of Environmental Impact Assessment in cooperation with Institute of Environmental Assessment. 1999. *Principles of Environmental Impact Assessment Best Practice.*

Green Construction: Green construction is planning and managing a construction project in accordance with the building design in order to minimize the impact of the construction process on the environment. This includes 1) improving the efficiency of the construction process; 2) conserving energy, water, and other resources during construction; and 3) minimizing the amount of construction waste. A "green building" is one that provides the specific building performance requirements while minimizing disturbance to and improving the functioning of local, regional, and global ecosystems both during and after the structure's construction and specified service life. Source: Glavinich, Thomas E. 2008. *Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction*. Hoboken, New Jersey: John Wiley & Sons, Inc.

Green Purchasing: Green Purchasing is often referred to as environmentally preferable purchasing (EPP), and is the affirmative selection and acquisition of products and services that most effectively minimize negative environmental impacts over their life cycle of manufacturing, transportation, use, and recycling or disposal. Examples of environmentally preferable characteristics include products and services that conserve energy and water and minimize generation of waste and release of pollutants; products made from recycled materials and that can be reused or recycled; energy from renewable resources such as biobased fuels and solar and wind power; alternate fuel vehicles; and products using alternatives to hazardous or toxic chemicals, radioactive materials, and biohazardous agents. Source: U.S. Environmental Protection Agency. 1999. Final Guidance on Environmentally Preferred Purchasing. *Federal Register*. Vol. 64 No. 161.

Greening: The process of transforming artifacts such as a space, a lifestyle, or a brand image into a more environmentally friendly version (i.e., "greening your home" or "greening your office"). The act of greening involves incorporating "green" products and processes into one's environment, such as the home, workplace, and general lifestyle. Source: Based on: Glavinich, T. 2008. *Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction.* Hoboken, New Jersey: John Wiley & Sons, Inc.

Hazard: A potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological, and biological) or induced by human processes (environmental degradation and technological hazards). Source: UN International Strategy for Disaster Reduction. Terminology of disaster risk reduction. www.unisdr.org/eng/terminology/terminology-2009-eng.html (Accessed on April 1, 2010)

Impact: Any effect caused by a proposed activity on the environment, including effects on human health and safety, flora, fauna, soil, air, water, climate, landscape and historical monuments, or other physical structures, or the interaction among those factors. It also includes effects on cultural heritage or socioeconomic conditions resulting from alterations to those factors. Source: United Nations Economic Commission for Europe. 1991. *The Convention on Environmental Impact Assessment in a Transboundary Context.* www.unece.org (Accessed June 22, 2010)

Indicator: A measurement of achievement or change for the specific objective. The change can be positive or negative, direct or indirect. They provide a way of measuring and communicating the impact, or result, of programs as well as the process, or methods used. The indicator may be qualitative or quantitative. Indicators are usually classified according to their level: *input* indicators (which measure the resources provided), *output* indicators (direct results), *outcome* indicators (benefits for the target group) and impact indicators (long-term consequences). Source: Chaplowe, Scott G. 2008. *Monitoring and Evaluation Planning.* American Red Cross/CRS M&E Module Series. American Red Cross and Catholic Relief Services: Washington, DC and Baltimore, MD.

Integrated Water Resources Management: Systemic, participatory process for the sustainable development, allocation, and monitoring of water resource use in the context of social, economic, and environmental objectives. Source: Based on: Sustainable Development Policy Institute. Training Workshop on Integrated Water Resource Management. www.sdpi.org (Accessed June 22, 2010)

Life Cycle Assessment (LCA): A technique to assess the environmental aspects and potential impacts of a product, process, or service by compiling an inventory of relevant energy and material inputs and environmental releases; evaluating the potential environmental impacts associated with identified inputs and releases; and interpreting the results to help make a more informed decision. Source: Scientific Applications International Corporation. 2006. Life Cycle Assessment: Principle's and Practice. Report prepared for U.S. EPA.

Life Cycle Materials Management: Maximizing the productive use and reuse of a material throughout its life cycle in order to minimize the amount of materials involved and the associated environmental impacts.

Life Cycle of a Material: The various stages of a building material, from the extraction or harvesting of raw materials to their reuse, recycling, and disposal.

Livelihoods: A livelihood comprises the capabilities, assets (including both material and social resources), and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and can maintain or enhance its capabilities and assets both now and in the future, without undermining the natural resource base. Source: DFID. 1999. *Sustainable Livelihoods Approach Guidance Sheets.* London: Department for International Development.

Logframe: Logical framework, or logframe, analysis is a popular tool for project design and management. Logframe analysis provides a structured logical approach to the determination of project priorities, design and budget and to the identification of related results and performance targets. It also provides an iterative management tool for project implementation, monitoring and evaluation. Logframe analysis begins with problem analysis followed by the determination of objectives, before moving on to identify project activities, related performance indicators and key assumptions and risks that could influence the project's success. Source: Provention Consortium. 2007. *Logical and Results Based Frameworks.* Tools for Mainstreaming Disaster Risk Reduction. Guidance Note 6. Geneva, Switzerland.

Primary Wastewater Treatment: Use of gravity to separate settleable and floatable materials from the wastewater. Source: National Research Council. 1993. *Managing Wastewater in Coastal Urban Areas.* Washington DC: National Academy Press.

Project Design: An early stage of the project cycle in which a project's objectives and intended outcomes are described and the project's inputs and activities are identified.

Project Evaluation: Systematic and impartial examination of humanitarian action intended to draw lessons that improve policy and practice, and enhance accountability. Source: Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP). Report Types. www.alnap.org (Accessed June 25, 2010)

Project Monitoring: A continuous and systematic process of recording, collecting, measuring, analyzing, and communicating information. Source: Chaplowe, Scott G. 2008. *Monitoring and Evaluation Planning.* American Red Cross/CRS M&E Module Series. American Red Cross and Catholic Relief Services : Washington, DC and Baltimore, MD.

Reconstruction: The actions taken to reestablish a community after a period of recovery subsequent to a disaster. Actions would include construction of permanent housing, full restoration of all services, and complete resumption of the pre-disaster state. Source: UNDP/UNDRO. 1992. *Overview of Disaster Management.* 2nd Ed.

Recovery: The restoration, and improvement where appropriate, of facilities, livelihoods, and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors. Source: UN International Strategy for Disaster Reduction. Terminology of disaster risk reduction. www.unisdr.org/eng/terminology/terminology-2009-eng.html (Accessed on April 1, 2010)

Recycle: Melting, crushing, or otherwise altering a component and separating it from the other materials with which it was originally produced. The component then reenters the manufacturing process as a raw material (e.g., discarded plastic bags reprocessed into plastic water bottles). Source: Based on: Glavinich, Thomas E. 2008. *Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction.* Hoboken, New Jersey: John Wiley & Sons, Inc.

Resilience: The capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures. Source: UN International Strategy for Disaster Reduction. Terminology of disaster risk reduction. www.unisdr.org/eng/terminology/terminology-2009-eng.html (Accessed on April 1, 2010)

Response (also called Disaster Relief): The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety, and meet the basic subsistence needs of the people affected.

Comment: Disaster response is predominantly focused on immediate and short-term needs and is sometimes called disaster relief. The division between this response stage and the subsequent recovery stage is not clear-cut. Some response actions, such as the supply of temporary housing and water supplies, may extend well into the recovery stage.

Source: UN International Strategy for Disaster Reduction. Terminology of disaster risk reduction. www.unisdr.org/eng/terminology/terminology-2009-eng.html (Accessed on April 1, 2010)

Reuse: The reuse of an existing component in largely unchanged form and for a similar function (e.g., reusing ceramic roof tiles for a reconstructed house). Source: Based on: Glavinich, Thomas E. 2008. Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction. Hoboken, New Jersey: John Wiley & Sons, Inc.

Secondary Wastewater Treatment: Use of both biological (i.e., microorganisms) and physical (i.e., gravity) processes designed to remove biological oxygen demand (BOD) and total suspended solids (TSS) from wastewater. Source: National Research Council. 1993. *Managing Wastewater in Coastal Urban Areas.* Washington DC: National Academy Press.

Site Development: The physical process of construction at a building site. These construction-related activities include clearing land, mobilizing resources to be used in the physical infrastructure (including water), the fabrication of building components on site, and the process of assembling components and raw materials into the physical elements planned for the site. The site development process also includes the provision of access to basic amenities (e.g., water, sewage, fuel) as well as improvements to the environmental conditions of the site (e.g., through planting vegetation or other environment-focused actions).

Site Selection: The process encompasses many steps from planning to construction, including initial inventory, assessment, alternative analysis, detailed design, and construction procedures and services. Site selection includes the housing, basic services (e.g., water, fuel, sewage, etc.), access infrastructure (e.g., roads, paths, bridges, etc.) and social and economic structures commonly used by site residents (e.g., schools, clinics, markets, transport facilities, etc.).

SMART Indicator: An indicator that meets the SMART criteria: **S**pecific, **M**easurable, **A**chievable, **R**elevant, and **T**ime-bound. Source: Based on: Doran, G. T. 1981. There's a S.M.A.R.T. way to write management›s goals and objectives. *Management Review:* 70, Issue 11.

Sustainable Construction: Sustainable construction goes beyond the definition of "green construction" and offers a more holistic approach to defining the interactions between construction and the environment. Sustainable construction means that the principles of sustainable development are applied to the comprehensive construction cycle, from the extraction and processing of raw materials through the planning, design, and construction of buildings and infrastructure, and is also concerned with any building's final deconstruction and the management of the resultant waste. It is a holistic process aimed at restoring and maintaining harmony between the natural and built environments, while creating settlements that affirm human dignity and encourage economic equity. Source: du Plessis, Chrisna. 2002. Agenda 21 for Sustainable Construction in Developing Countries. Pretoria, South Africa: CSIR Building and Construction Technology.

Sustainable development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Source*:* World Commission on Environment and Development. 1987. *Report of the World Commission on Environment and Development: Our Common Future.* Document A/42/427. www.un-documents.net (Accessed June 22, 2010)

Tertiary Wastewater Treatment: Use of a wide variety of physical, biological, and chemical processes aimed at removing nitrogen and phosphorus from wastewater. Source: National Research Council. 1993. *Managing Wastewater in Coastal Urban Areas.* Washington DC: National Academy Press. p. 58

Vulnerability. *Human* vulnerability is the relative lack of capacity of a person or community to anticipate, cope with, resist, and recover from the impact of a hazard. *Structural or physical* vulnerability is the extent to which a structure or service is likely to be damaged or disrupted by a hazard event. *Community* vulnerability exists when the elements at risk are in the path or area of the hazard and are susceptible to damage by it. The losses caused by a hazard, such as a storm or earthquake, will be proportionally much greater for more vulnerable populations, e.g., those living in poverty, with weak structures, and without adequate coping strategies. Source: UNDHA. 1997. *Building Capacities for Risk Reduction.* 1st Ed.

Watershed: An area of land that drains down slope to the lowest point. The water moves through a network of drainage pathways, both underground and on the surface. Generally, these pathways converge into streams and rivers that become progressively larger as the water moves downstream, eventually reaching a water basin (i.e., lake, estuary, ocean). Source: Based on: Oregon Watershed Enhancement Board. 1999. *Oregon Watershed Assessment Manual.* www.oregon.gov Salem.

ACRONYMS

The following is a comprehensive list of the acronyms used throughout the Green Recovery and Reconstruction Toolkit.

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
ADRA	Adventist Development and Relief Agency
AECB	Association for Environment Conscious Building
AJK	Azad Jammu Kashmir
ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action
ANSI	American National Standards Institute
BMPS	best management practices
BOD	biological oxygen demand
CAP	Consolidated Appeals Process
CEDRA	Climate Change and Environmental Degradation Risk and Adaptation Assessment
CFL	compact fluorescent lamp
CGIAR	Consultative Group on International Agricultural Research
CHAPS	Common Humanitarian Assistance Program
CIDEM	Centro de Investigación y Desarrollo de Estructuras y Materiales
CO	Country Office
CRISTAL	Community-based Risk Screening Tool – Adaptation and Livelihoods
CRS	Catholic Relief Services
CVA	community vulnerability assessment
DFID	Department for International Development
DRR	disaster risk reduction
EAWAG	Swiss Federal Institute of Aquatic Science and Technology

ECB	Emergency Capacity Building Project
EE	embodied energy
EIA	environmental impact assessment
EMMA	Emergency Market Mapping and Analysis Toolkit
EMP	environmental management plan
ENA	Environmental Needs Assessment in Post-Disaster Situations
ENCAP	Environmentally Sound Design and Management Capacity Building for Partners and Programs in Africa
EPP	environmentally preferable purchasing
ESR	Environmental Stewardship Review for Humanitarian Aid
FAO	Food and Agriculture Organization
FEAT	Flash Environmental Assessment Tool
FRAME	Framework for Assessing, Monitoring and Evaluating the Environment in Refuge Related Operations
FSC	Forest Stewardship Council
G2O2	Greening Organizational Operations
GBCI	Green Building Certification Institute
GBP	Green Building Programme
GIS	geographic information system
GRR	Green Recovery and Reconstruction
GRRT	Green Recovery and Reconstruction Toolkit
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GWP	Global Water Partnership
HQ	headquarters
HVAC	heating, ventilation, and air conditioning
IAS	International Accreditation Service
IASC	Inter-Agency Standing Committee

IAIA	International Association for Impact Assessment
IBRD	International Bank for Reconstruction and Development
ICE	Inventory of Carbon and Energy
ICT	information and communication technology
IDA	International Development Association
IDP	internally displaced peoples
IDRC	International Development Research Centre
IFC	International Finance Corporation
IFRC	International Federation of Red Cross and Red Crescent Societies
IFMA	International Facilities Management Association
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
IRC	International Rescue Committee
ISAAC	Institute for Applied Sustainability to the Built Environment
ISDR	International Strategy for Disaster Reduction
ISO	International Standards Organization
IT	information technology
ITDG	Intermediate Technology Development Group
IUCN	International Union for the Conservation of Nature
ISWM	integrated solid waste management
IWA	International Water Association
IWMI	International Water Management Institute
IWRM	integrated water resource management
IWQA	International Water Quality Association
IWSA	International Water Supply Association

KW H	Kilowatt hour
LCA	life cycle assessment
LEDEG	Ladakh Ecological Development Group
LEED	Leadership in Energy & Environmental Design
M&E	monitoring and evaluation
MAC	Marine Aquarium Council
MDGS	Millennium Development Goals
MSC	Marine Stewardship Council
NACA	Network of Aquaculture Centers
NGO	non-governmental organization
NSF-ERS	National Science Foundation - Engineering and Research Services
NWFP	North Western Frontier Province
OCHA	Office for the Coordination of Humanitarian Affairs
PDNA	Post Disaster Needs Assessment
PEFC	Programme for the Endorsement of Forest Certification
PET	Polyethylene terephthalate
PMI	Indonesian Red Cross Society
PVC	Polyvinyl chloride
PV	photovoltaic
REA	Rapid Environmental Assessment
RIVM	Dutch National Institute for Public Health and the Environment
SC	sustainable construction
SCC	Standards Council of Canada
SEA	Strategic Environmental Impact Assessment
SIDA	Swedish International Development Agency

SKAT	Swiss Centre for Development Cooperation in Technology and Management
SL	sustainable livelihoods
SMART	Specific, Measurable, Achievable, Relevant, and Time-bound
SODIS	solar water disinfection
TRP	Tsunami Recovery Program
TSS	total suspended solids
UN	United Nations
UNDHA	United Nations Department of Humanitarian Affairs
UNDP	United Nations Development Programme
UNDRO	United Nations Disaster Relief Organization
UNEP	United Nations Environment Program
UNGM	United Nations Global Marketplace
UN-HABITAT	United Nations Human Settlements Programme
UNHCR	United Nations High Commissioner for Refugees
UNICEF	The United Nations Children's Fund
USAID	United States Agency for International Development
USAID-ESP	United States Agency for International Development- Environmental Services Program
VROM	Dutch Ministry of Spatial Planning, Housing and the Environment
WEDC	Water, Engineering, and Development Centre
WGBC	World Green Building Council
WHO	World Health Organization
WWF	World Wildlife Fund

Soon after the 2004 Indian Ocean tsunami, the American Red Cross and the World Wildlife Fund (WWF) formed an innovative, five-year partnership to help ensure that the recovery efforts of the American Red Cross did not have unintended negative effects on the environment. Combining the environmental expertise of WWF with the humanitarian aid expertise of the American Red Cross, the partnership has worked across the tsunami-affected region to make sure that recovery programs include environmentally sustainable considerations, which are critical to ensuring a long-lasting recovery for communities.

The Green Recovery and Reconstruction Toolkit has been informed by our experiences in this partnership as well as over 30 international authors and experts who have contributed to its content. WWF and the American Red Cross offer the knowledge captured here in the hopes that the humanitarian and environmental communities will continue to work together to effectively incorporate environmentally sustainable solutions into disaster recovery. The development and publication of the Green Recovery and Reconstruction Toolkit was made possible with support from the American Red Cross.