6 GREEN GUIDE TO

CONSTRUCTION

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.

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Jeffrey Klenk, 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 design, architecture, and construction management.

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MODULE 6: GREEN GUIDE TO CONSTRUCTION

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INTRODUCTION

1.1 Module Objectives

This training module is concerned with two key aspects of sustainable construction: 1) *sustainability principles of design and architecture*, focusing on architectural design, building materials, and the lifecycle of the building; and 2) *construction management*, with a focus on the principles and practices that seek to minimize, through environmental protection, the impact of the construction process on people and communities recovering from disaster.

Specific learning objectives for this module are as follows:

1. Describe the key principles of environmentally sustainable building design and architecture to protect people and communities recovering from disaster.
2. Describe the key principles of environmentally sustainable on-site construction management.
3. Demonstrate how to apply the key principles of sustainable building design and construction management to a community-based project.

1.2 The Green Recovery and Reconstruction Toolkit

This is Module 6 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 taking advantage of opportunities to improve the environment. Module 1 provides a brief introduction to the concept of green recovery and reconstruction to help 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

Module 6 is intended for construction supervisors, field engineers, contractors, housing project managers, humanitarian shelter delegates or program managers, spatial planners, and other technicians responsible for planning and implementing post-disaster long-term housing construction and reconstruction efforts.

1.4 Module Key Concepts

1. Sustainable construction is the application of the principles of sustainable development to the comprehensive construction cycle, from the extraction and processing of raw materials through the planning, design, and construction of buildings and infrastructure to their final deconstruction and waste management.
2. Strategies for achieving sustainable construction include 1) refuse to build (i.e., elect not to build if alternatives are available), 2) reduce resource use, 3) reuse materials, 4) recycle materials, 5) repair existing infrastructure, and 6) recover the energy of the materials.
3. Environmentally sustainable construction should actively account for and address flexibility of use, building and material life span, local climate variability, energy efficiency, solid-waste management, and waste and wastewater systems.
4. On-site construction management should include attention to the handling of materials, equipment, and waste; pollution prevention; workforce education; and environmentally aware construction site planning and layout.
5. In order to minimize the waste of construction materials and resources, project designers should consider building with standard material dimensions.
6. During a recovery and reconstruction response, the community must actively participate in decision making and, ideally, should undertake most of the activities to gain a sense of ownership of the project. Community participation is not only essential to the long-term success of a project but also helps to reduce the waste of limited financial and natural resources.

1.5 Module Assumptions

This training module assumes that participants are familiar with the design, construction, operation, and/or management of building or other construction projects. As this module focuses on how to integrate environmental issues into these processes in a disaster-recovery and reconstruction setting, it is also assumed that participants are committed to the goals of this integration and will continue learning about and advocating for such integration after the close of the training. The technical content of this module highlights many key issues of environmental sustainability.

The module recognizes that there is a continuum of activities to support disaster survivors, from their initial need for emergency shelter until they achieve permanent housing. The module does not directly address the disaster response needs or environmental impact of the emergency phase, although many of the same principles apply to that initial phase, including those related to camp management. Sustainable disaster response is especially relevant for transitional shelter and permanent buildings, such as houses, schools, markets, and health centers.

1.6 Key Module Definitions

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

Construction: Construction in this module 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.

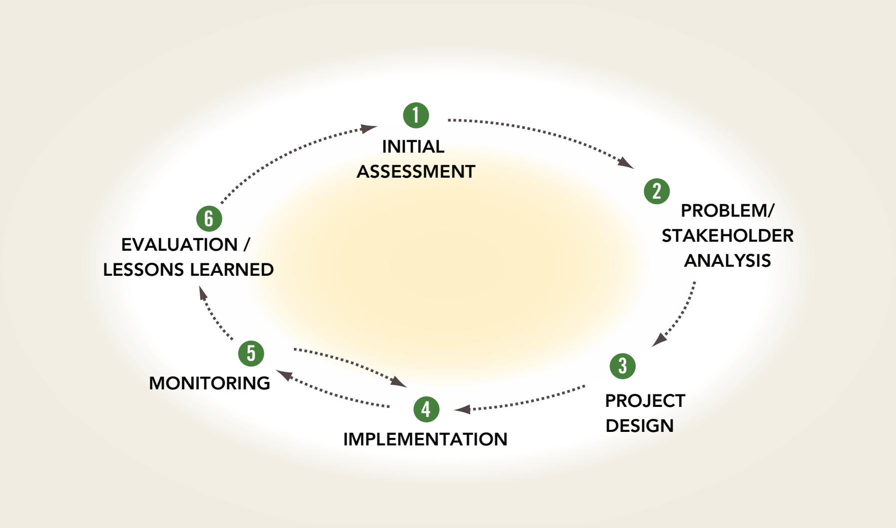
Green Construction: Green construction is planning and managing a construction project in accordance with the building design in order to minimize the impact of the construction process on the environment. This includes 1) improving the efficiency of the construction process; 2) conserving energy, water, 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.

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.

2 PROJECT CYCLE AND SUSTAINABLE CONSTRUCTION

In planning and carrying out disaster-response activities, many humanitarian agencies follow a standard project management cycle as depicted in Figure 1:

FIGURE 1: STANDARD PROJECT MANAGEMENT CYCLE

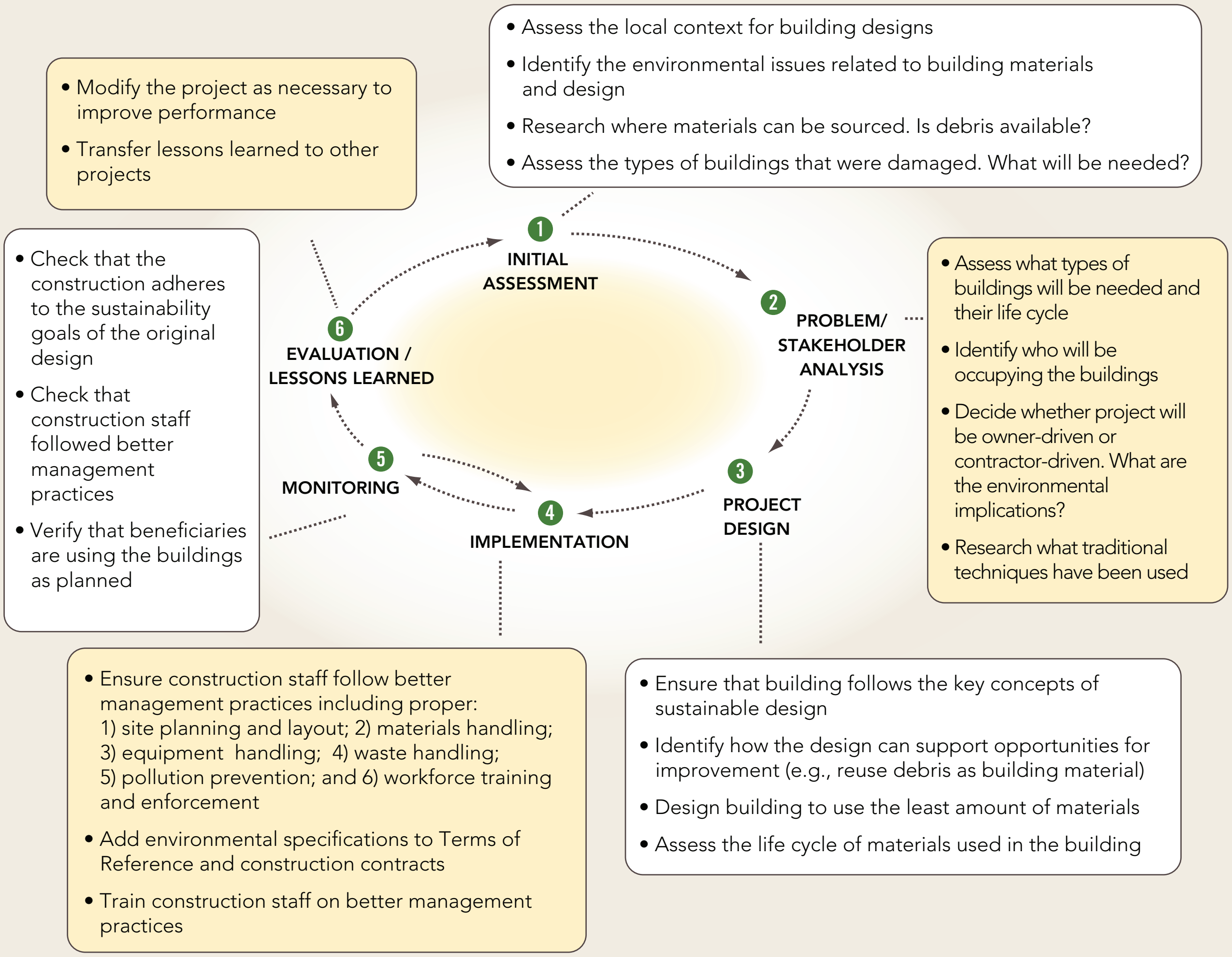


As indicated by the cycle, a well-managed project is by definition a set of logically sequenced, related activities undertaken to produce a planned output. The standard project management cycle pictured here identifies a sequence of activities – assessment, analysis, design, implementation, monitoring, and evaluation. A clear aim of this representation is to stress 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.

The majority of the technical content in this training module falls under Step 3 of the project management cycle (project design) as further discussed in Section 3, and Step 4 (implementation) as further discussed in Sections 3 and 4.

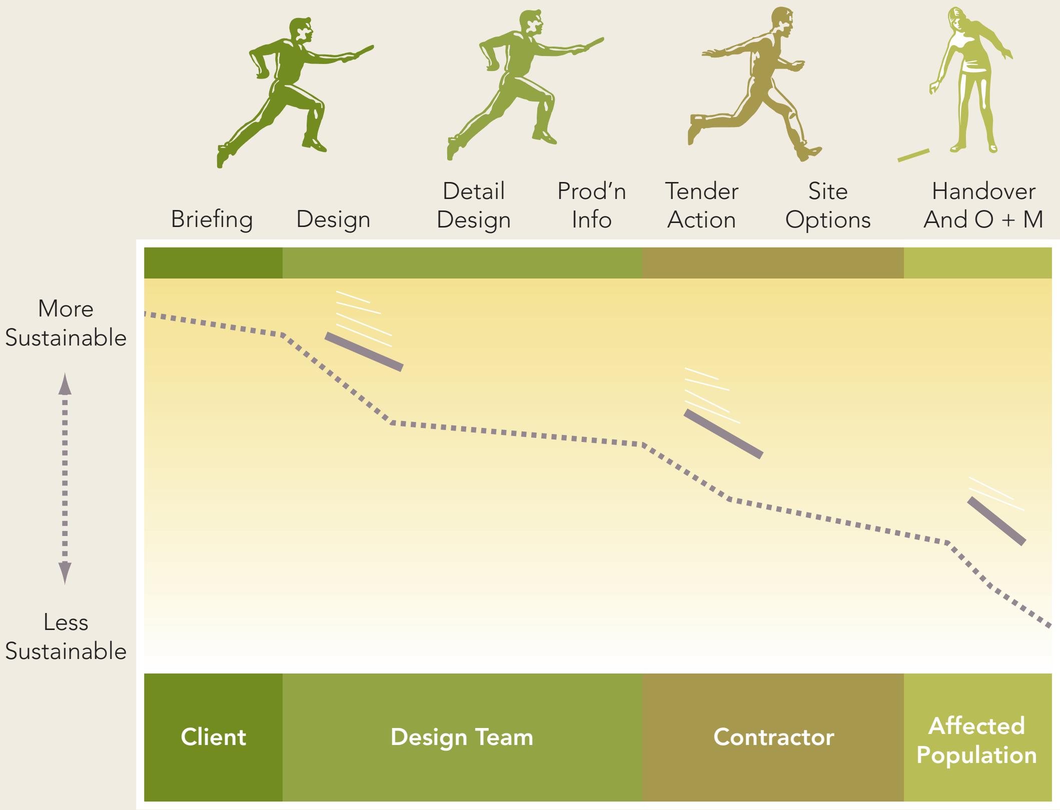
FIGURE 2: PROJECT MANAGEMENT CYCLE AND SUSTAINABLE CONSTRUCTION CONSIDERATIONS



In the aftermath of a disaster, it is all too common that planning decisions are based purely on building "something" to accommodate affected populations, resulting in unintended environmental impacts that harm communities over both the short and long terms. These impacts can include the pollution or destruction of environmental assets such as forests, fishing grounds, agricultural lands, coastal sand dunes, or mangroves that people depend on for their livelihoods. Poorly designed or constructed infrastructure can also lead to a costly waste of building materials, not to mention the toll on the social and cultural assets of the affected populations that the response was originally intended to assist.

The importance of careful and thorough planning throughout the project cycle is illustrated by Howard Liddell's concept of the "green baton," pictured in Figure 3. This concept compares the construction process to a relay race in which the responsibility for construction of the building passes between the various people involved, from the donor to the designer (in consultation with the community) and then to the contractor and so on. Each member of the construction team must ensure that his or her part in the construction process achieves its environmental objectives before he or she can transfer responsibility to the next member of the project team. For example, the **donor** can require that the project framework have a specific indicator to measure environmental performance. The **design team** can take steps to ensure that its building design includes energy efficiency. Similarly, the construction **contractor** should take steps to ensure that he or she minimizes the production of solid waste at the construction site. Each member of the project team has a role to play. At each stage of the construction process, there is the risk that a project will not fulfill its potential in achieving sustainability objectives. The sustainability "baton" could be dropped, particularly as responsibilities are transferred from the community to the design team to the contractor (or project implementer) and back to the community.[1]

FIGURE 3: SHARING RESPONSIBILITY AT EVERY STAGE IN THE PROJECT CYCLE



It should be noted that while the green baton concept stresses the importance of taking action to address environmental sustainability at every stage of the project cycle, it is never too late to improve project performance. For example, if the opportunity to design a building with sustainable building materials has been missed, there may still be an opportunity to site the building in a more environmentally sustainable location or to institute better construction management practices during the construction phase.

1 Halliday, Sandy. 2008. *Sustainable Construction*. Oxford: Elsevier.

3 CONCEPTS IN SUSTAINABLE DESIGN

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, until their final deconstruction and management of the resultant waste. It is a holistic process aiming to restore and maintain harmony between the natural and built environments, while creating settlements that affirm human dignity and encourage economic equity.[2] In essence, sustainable construction seeks to "Do No Harm" by supporting human dignity while minimizing negative impacts on the natural environment.[3]

Because there are several different components to sustainable construction, the GRRT presents the materials through a series of three different modules. This module covers sustainable design and architecture, as well as construction management at the field level. Module 4, Green Guide to Strategic Site Selection and Development, focuses on spatial planning, and Module 5, Green Guide to Materials and the Supply Chain, focuses on the material selection and procurement process.

3.1 The Need for Environmentally Sustainable Design

While the construction industry is of primary importance to humankind as a provider of shelter, it has also been inextricably linked to environmental degradation and ecosystem destruction. Construction activity is one of the most serious contributors to global CO_2 emissions, and has caused many other negative effects throughout the world, such as land degradation, air and water pollution, intensive energy consumption, waste, and deforestation. The WorldWatch Institute estimates that 40 percent of the world's raw materials and energy consumption is by buildings, and that 55 percent of the wood cut for nonfuel purposes is for construction. This situation contributes to environmental problems such as acid rain, air pollution, species biodiversity and habitat loss, deforestation, and toxic runoff from mines and mine wastes.[4] The massive rebuilding effort that occurs after a disaster requires an enormous amount of building materials, and is therefore a part of the global demand for raw materials. Communities need to rebuild the infrastructure that took decades or even centuries to build within a much shorter recovery timeframe, meaning that there will be a rapid and intense demand for materials as well as for land if homes are being relocated. What may have been sustainable rates of extraction for minerals, sand, or clay before the disaster are likely to become unsustainable in the years immediately following a disaster, particularly if the goal is to rebuild the same level of infrastructure as previously existed.

According to a humanitarian worker familiar with efforts to rebuild after the 2004 tsunami in Sri Lanka:

> "[W]e are witnessing greater damage from the reconstruction efforts than from the tsunami itself, especially haphazard clearing of mangroves, mining of sand dunes, and inappropriate dumping of debris, causing water contamination and blocked drainage canals."[5]

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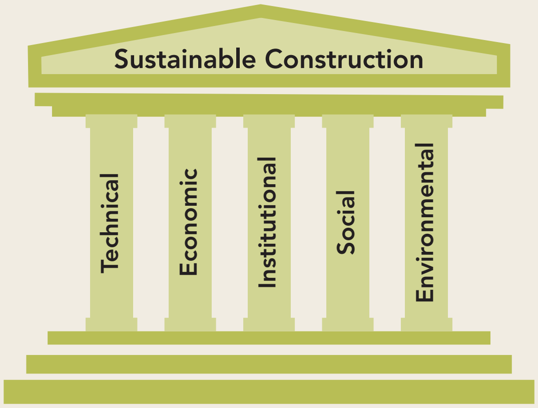
2 du Plessis, Chrisna. 2002. *Agenda 21 for Sustainable Construction in Developing Countries. Pretoria*, South Africa: CSIR Building and Construction Technology.

3 Kennedy, Joseph E., ed. 2004. *Building Without Borders: Sustainable Construction for the Global Village*. Gabriola Island, British Columbia: New Society Publishers.

4 Roodman, David M., and Nicholas Lenssen. 1995. *A Building Revolution: How Ecology and Health Concerns Are Transforming Construction*. Worldwatch Paper #124, Washington, D.C.

5 Channa Banbaradeniya, IUCN Sri Lanka. Personal Communication. As cited in : Sudmeier-Rieux, K., H. Masundire, A. Rizvi, S. Rietbergern. 2006. *Ecosystems, Livelihoods and Disasters: An integrated approach to disaster risk management.* Gland, Switzerland: IUCN.



Some of the numerous challenges confronting project managers in sustainable construction may include selecting and procuring appropriate building materials, achieving cost-effective designs, identifying and applying environmentally appropriate construction practices, and gaining community acceptance and ownership. In addition, project managers in post-disaster settings often face considerable time and spending pressures as donors and the public look for quick and tangible results. The pressure to move quickly can be perceived as being in conflict with sustainable construction considerations; however, as described in this module, better planning does not have to take more time or resources. In fact, environmentally sustainable construction will save resources and protect people over the long term.

A common framework for considering the various components that make up sustainable construction is the "five pillars" approach[6], which includes the following:

Technical. Technical issues of sustainable construction call for practical, robust, and technically feasible solutions that aim to construct durable, reliable, and functional structures and seek to ensure quality in creating the built environment.

Economic. Economic concerns of sustainable construction efforts include the need for cost-effective solutions that ensure financial affordability for beneficiaries, the promotion of employment to support livelihoods, the selection of environmentally responsible suppliers and contractors, and the investment of social and human-made capital to maximize knowledge transfer.

Institutional. Institutional concerns include ensuring that laws and regulations are designed – and enforced – to promote sustainability, and that the institutions responsible for protecting the environment are supported, engaged, capable, and funded.

Social. Social concerns of sustainable construction include improving the quality of human life, facilitating culturally specific construction planning, and seeking the fair distribution of the social costs and benefits of construction (including long-term, intergenerational equity concerns).

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6 Adapted from:

Roseberry, Rachel. 2008. *A Balancing Act: An assessment of the environmental sustainability of permanent housing constructed by the international development community in post-disaster Aceh*. University of Sussex.

United Nations Environment Programme (UNEP) and Swiss Resource and Consultancies for Development (SKAT). 2007. *After the Tsunami: Sustainable Building Guidelines.*

Environmental. Environmental concerns of sustainable construction include ensuring that the following occur:

- Environmental considerations – including environmental impact assessments – are incorporated into all aspects of construction.
- The construction decision-making process supports actions that minimize environmental impact and resource extraction; reduce the use of energy, water, materials, and land; and prefer renewable resources to nonrenewable. The construction process also minimizes the use of potentially harmful materials (e.g., asbestos), and other nonreusable and/or nondegradable materials that can have negative effects on the environment following a disaster.
- Ecological diversity is maintained and/or restored.

The concepts mentioned here apply equally to all types of buildings, including schools, health centers, community centers, religious buildings, markets, and (most applicable in a disaster-recovery scenario) shelters. Depending on their specific requirements and function, different types of buildings may present different challenges when it comes to achieving environmental sustainability. For instance, health centers must deal with medical waste during their operation and maintenance. Although most of the concepts covered in this training module can also apply to the construction of other types of infrastructure, such as water and sanitation systems and roads, the focus here is on buildings. While we acknowledge that a full understanding of sustainable construction requires the full consideration of all five pillars of concern, this training module focuses on the environmental pillar.

The following section discusses the principles of environmentally sustainable construction in further detail. The key points are summarized in the box below.

KEY PRINCIPLES OF ENVIRONMENTALLY SUSTAINABLE CONSTRUCTION

- Actively consider the full life cycle of building materials, including the economic and environmental cost (also see Module 5, Green Guide to Materials and the Supply Chain, for additional information).
- Use existing materials and resources where possible.
- Sourcing and procurement decisions must consider the local appropriateness of the material, legality, cost, transport distance, and impact on the environment (also see Module 5 for additional information).
- The life span of the building, its various uses, and its flexibility should be actively considered in building design.
- Building designs should address local climatic variability and energy efficiency.
- The use of buildings typically produces solid waste, and this should be factored into building design and maintenance.
- Site selection should take into account the availability of freshwater resources. Designs should consider ways to reduce building waste and minimize water pollution.
- Community participation and analysis of existing building practices are essential for successful building construction and the minimizing of environmental impact and wastage.

CASE STUDY: ENVIRONMENTALLY SUSTAINABLE RECONSTRUCTION BENEFITS SURVIVORS OF 1999 COLOMBIA EARTHQUAKE

In the aftermath of a major earthquake in Colombia in 1999, a significant reconstruction effort was required in economically vital coffee-growing regions. As part of this effort and with the assistance of NGOs working on the recovery, the World Bank used a community participatory framework to develop a comprehensive environmental management plan (EMP) to guide the reconstruction process. Columbia-based project staff drafted a plan that focused on five main areas of impact: demolition, erosion control, transport of construction materials, waste management, and public safety. The EMP was intended to ensure that all phases of the reconstruction process supported sustainable natural resources use. The project provided several key lessons on the importance of sustainable construction:

- Proper debris removal at an early stage allows for the recycling of construction materials into the rebuilding effort, eliminating both the need for an abundance of costly new materials and the potential for serious impact on the surrounding natural environment.
- Reconstruction can be used to improve environmental conditions over the long term, lowering the risk of future damage. For example, attention given to the repair and upgrade of water and sewage lines to eliminate leaks provides for long-term sustainability of water supplies that benefit both communities and the environment.
- The EMP was also used for mainstreaming disaster-risk reduction into land-use planning. Under the new land-use plans created by the project, over 13,226 homes and other infrastructure were relocated from areas of high disaster risk.
- The adoption of the EMP allowed for the consideration of sustainability throughout the entire reconstruction process, from siting through project completion.

In recognition of the role that the environmental management plan played in reducing human exposure to disaster, the project was awarded the United Nations Sasakawa Award for Disaster Reduction. The success of this project demonstrates how a reconstruction process guided from start to finish by a firm commitment to sustainable values can yield positive results for both people and the environment.

Source: The World Bank. 2000. *Colombia Earthquake Recovery Project.*

3.2 Design to Increase Material Efficiency

The intensive demand for raw materials in reconstruction ultimately leads to impacts on the environment and the people who depend on it. 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. 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. Some of these materials are **aluminum** for roofs and structural elements; **stone** for structures and walls; **fossil oils** for tars, waxes, paints, and plastics; and **plants** (e.g., thatch and timber) for structures, walls, and doors; there are many others as well. In order to ensure that the recovery effort following a disaster does not lead to communities that are even more vulnerable, staff involved in building design should take steps to ensure that their material choices take advantage of opportunities to maximize the environmental performance of their projects.

Sustainable design should consider not only the immediate impact of a particular material but the potential longer-term impacts at each stage of the material's life cycle. The life cycle of a building material refers to its various stages, from raw material extraction or harvesting to processing, transportation, and packaging and then to its reuse, recycling, or disposal. Understanding the life cycle of a building material is a key part of understanding the environmental implications of material choice and being able to make decisions that will increase a building's environmental performance. A detailed discussion of this topic is included in Module 5, Green Guide to Materials and the Supply Chain. A brief discussion is provided below, because material choice is a key aspect of sustainable design, alongside the other concepts such as designing for climate, energy efficiency, and water and waste systems.

The creative use and reuse of existing materials is still a largely untapped resource that offers much potential – especially in a post-disaster context. As building designers seek to implement sustainable construction practices, it becomes critical right from the outset to make fundamental design decisions about whether or not – and how – existing materials will be used or reused.[7] The decisions to make use of existing resources should be based on 1) structural integrity, 2) whether or not the materials constitute a potential health hazard, 3) the economic value, and 4) cultural acceptance. Additional information on reusing and recycling building materials is contained in Module 5, Green Guide to Materials and the Supply Chain. As noted in The Sphere Project:[8]

> *Customary users, extraction and regeneration rates, and the ownership or control of these resources should be identified. Alternative or complementary sources of supply may…reduce any long-term adverse impact on the local environment. Multiple sources and the reuse of salvaged materials, alternative materials and production processes (such as the use of stabilised earth blocks) should be specified, together with the adoption of sustainable practices such as complementary replanting or regeneration programmes.*

PROBLEMS AND SOLUTIONS IN ACEH, INDONESIA AFTER THE 2004 TSUNAMI

Following the 2004 Indian Ocean tsunami the demand for raw materials in Aceh, Indonesia was extremely high. Timber and other locally procured natural resources (such as sand, gravel, mountain stone, clay, and limestone) were extracted at an unprecedented rate. In order to minimize over extraction of one resource, several agencies changed housing design and diversified material use.

In a housing project funded by the German Red Cross, local women produced and used batako blocks (bricks made of limestone, sand, and some cement, mixed and then pressed together to dry in the sun) through an enterprise development project set up by partner organizations. Project stakeholders stopped using timber in their housing projects, and switched to batako bricks to avoid using clay and the wood fuel needed in manufacturing clay bricks.

It is important to note however that when switching between different types of building materials, in addition to being environmentally sustainable, it is crucial to ensure that the new building material meets all of the essential characteristics that are necessary for long term use, for example local acceptance, hazard resistance, durability, and cost-effectiveness. In some instances, timber may have advantages over blocks in areas with a high seismic hazard.

Additionally, it is also important to ensure that the builders have proper knowledge and skills in the use of the new material; the use of blocks, or reinforced concrete, requires specific techniques to control material quality and construction practices if the resulting buildings are to be seismic resistant.

Source: Roseberry, Rachel. 2008. *A Balancing Act: An assessment of the environmental sustainability of permanent housing constructed by the international development community in post-disaster Aceh.* University of Sussex.

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7 Halliday, Sandy. 2008. *Sustainable Construction.* Oxford: Elsevier.

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

From a design perspective, there are various options that project managers can consider to maximize the efficiency of materials selection. These include:

3.2.1 Refuse to Build

This refers to a design decision not to build; i.e., the construction activity is deemed by the project managers to be unnecessary or, for whatever reasons, undesirable. As an alternative, project managers could create projects that leverage the use of existing buildings, such as locating a new training center inside an existing government building or supporting the relocation of people to the homes of family members.

3.2.2 Reduce Resource Use

A design decision to reduce the amount of resources in the construction project, based on the understanding that the reduction will not detract from a good design solution, should be considered. Opportunities to reduce space requirements, material requirements, or other specific building elements should be weighed.

3.2.3 Build with Standard Material Dimensions

Building with standard material dimensions wherever possible reduces both the waste stream and material costs, as the need for cutting, altering, or fabricating materials by construction crews will be much reduced. Building with standard material dimensions has its roots in the building planning and design.[9]

3.2.4 Reuse Materials

A design decision to reuse an existing component in largely unchanged form and for a similar function should be considered. An example would be a brick reused as a brick or a blue tarp reused for roofing. A key concept of industrial ecology is that “waste” is seen not as garbage but as a resource in the wrong place that has not achieved its full potential. Designing for reuse involves consideration of the material and the technique for assembly of the material so as to enable reuse and replacement of components, either in part or in whole. Decision factors include ease and profitability: that is, components have to be worth reusing to enable a market for reused goods to develop, and easy enough to reuse to make it profitable to do so. A good example is the use of lime mortar, which enables bricks to be reused, whereas reuse of bricks joined by cement mortar is often extremely difficult and not cost effective.

In post-disaster settings, reuse of debris is common: e.g., damaged wood boats can be used for timber building material, and broken cement blocks can be used for fill. By supporting the reuse of materials in building construction, project managers can also provide economic opportunities for disaster-affected people by creating a market for the deconstruction of existing structures and reuse of materials. Use of local materials and vernacular architecture (methods of construction that use locally available resources and traditions) are often the norm. As a result, buildings are often constructed with an inherent capacity to be dismantled and their components reused. Building deconstruction practices may offer a source of high-quality materials to assist in improving quality of life. 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 normal, everyday use or by the effects of the disaster. A process to assess the quantity of disaster debris that is available, as well as transportation and any processing costs for these materials, should be taken into account in project budgeting.

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9 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.

Recycling and reuse can be greatly facilitated if emergency shelter or transition planners design for easy disassembly of shelters. Transitional housing structures should be designed in such a way that existing materials can be reused in permanent housing construction projects. Charles Kibert proposes the following "principles of design for disassembly"[10]:

- Use recycled and recyclable materials
- Minimize the number of types of materials
- Avoid toxic and hazardous materials
- Avoid composite materials, and make inseparable products from the same material
- Avoid secondary finishes to materials
- Provide standard and permanent identification of material types
- Minimize the number of different types of components
- Use mechanical rather than chemical connections
- Use an open building system with interchangeable parts
- Use modular design
- Use assembly technologies compatible with standard building practice
- Separate the structure from the cladding
- Provide access to all building components
- Design components sized to suit handling at all stages
- Provide for handling components during assembly and disassembly
- Provide adequate tolerance to allow for disassembly
- Minimize the number of fasteners and connectors
- Minimize the types of connectors
- Design joints and connectors to withstand repeated assembly and disassembly
- Allow for parallel disassembly
- Provide permanent identification for each component
- Use a standard structural grid
- Use prefabricated sub-assemblies
- Use lightweight materials and components
- Identify points of disassembly permanently
- Provide spare parts and storage for them
- Retain information on the building and its assembly process

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10 Kibert, Charles J. 2003. Deconstruction: the start of a sustainable materials strategy for the built environment. *UNEP Industry and Environment*, April-June: 84-89.

3.2.5 Recycle Materials

Recycling means melting, crushing, or otherwise altering a component and separating it from the other materials with which it was originally manufactured. The component then re-enters the manufacturing process as a raw material. Examples include crushing lightweight concrete blocks into aggregate, turning high-quality plastics into recycled-content flowerpots, or recycling metals. Project managers should consider using building materials with recycled content where practical to reduce demand on natural resources and to lower the project's human and environmental impact. For example, fly ash from coal-fired power plants can be incorporated into cement production. When selecting building materials, project designers may also want to consider how their designs can support the future recycling of the building's materials once the need for the building has ended. A design decision to recycle a building component in whole or in part should be considered if it cannot be easily reused.

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 a raw material.

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 Edition*. Oxford: Architectural Press.

RECYCLING DISASTER DEBRIS

How a community manages disaster debris depends on the types of 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 sub-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. 2008. *Planning for Natural Disaster Debris.*

3.2.6 Repair Existing Infrastructure

A common consequence of disaster is a large number of damaged but existing buildings. Decisions about whether and how to repair preexisting infrastructure should be made. Many residents will repair their houses on their own without assistance. Key decision factors include structural safety, ease, and cost. A strategy to conserve resources and reduce demand on natural resources is to repair existing infrastructure, where practical, instead of rebuilding with all new materials.

3.2.7 Recover Energy

The costs and benefits of any decision to burn demolished products to produce energy should be carefully weighed. This is a form of "low-grade" recycling, because raw materials are lost and only the energy stored within them is recovered. Burning materials in energy plants to produce electricity is one example; burning waste wood in stoves is another. Decision factors include transport costs and toxicity.

3.2.8 Consider Sourcing and Procurement

Design decisions around the use of new materials should include consideration of where the materials are coming from and whether those sources are environmentally sustainable. The realities of a post-disaster setting can make sourcing materials difficult. However, project managers should make an effort to procure materials in a way that does not degrade the environment or negatively impact local communities. This will help project designers meet the humaitarian imperative of "Do No Harm." Sourcing and procurement decisions must be weighed in light of the local appropriateness of the material, legality, cost, transport distance, and impact on the environment. As explained in The Sphere Project: *"Multiple sources, alternative materials and production processes, or the provision of regionally or internationally sourced materials or proprietary shelter systems are required if the local harvesting and supply of materials is likely to have a significant adverse impact on the local economy or the environment"*.[11] See Module 5, Green Guide to Materials and the Supply Chain, for further information on sourcing and procurement.

3.3 Design for Flexibility and Life Span

Sustainable construction should consider the use of preexisting structures in construction design. This includes, for example, the incorporation of materials from emergency or transitional shelters in the construction of permanent housing. From the onset of a disaster, project managers should consider shelter and transitional housing designs that employ components that can be reused, reducing future waste from construction modifications. See The Sphere Project (2004) Shelter and Settlement Standard 6.

A key factor in this use of preexisting structures is the expected life cycle of the project. If, for example, the homes being constructed are expected to be used for many generations, then designers should make use of resources that promote durability, reduce maintenance concerns, and are locally accessible. In some situations, durability may need to be considered in terms of the ability to repair or replace certain materials or elements, rather than the simple longevity of the initial construction. This failure to consider the home's life cycle has proved costly in a number of post-disaster responses. In the 2004 Indian Ocean tsunami response, for example:

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

[O]rganisations built houses consisting mostly of timber, which they originally considered to be the permanent home for the tsunami victims. Within a year, many issues, including termite damage, splitting and buckling of the timber structures, as well as other quality control issues were constant features of a majority of the homes.[12] [AUTHOR'S NOTE: The issue was not whether timber is a "durable" or "permanent" material – consider the longevity of Fourteenth-Century Japanese temples or surviving English Tudor houses – but the quality of the wood that was used. The main problems were that many aid organizations did not fully control for quality or fully preserve the timber they were using, and that the Indonesian Bureau of Recovery and Reconstruction subsequently decided that all reconstruction had to be done in masonry.]

3.4 Design for Climate

Most buildings and cities up to the beginning of twentieth century evolved in a manner that was responsive to climate; they were designed to be spatially efficient. Traditional cold-climate settlements avoid windy hilltops and cold valleys in order to reduce energy demands and increase comfort, and the reverse occurs in warm climates. Traditional buildings tend to be responsive to climate, protecting from sun or wind where necessary and opening up to sun where this is a benefit. Shaded areas, courtyards, openings, and trees and shrubs were typically part of building strategies to passively adapt to microclimates and airflow. In more recent times, there has been increasing reliance on artificial energy inputs, and typical strategies for designing for climate have been underemphasized. Designing for climate can be an important strategy for post-disaster building designers in order to reduce energy demands and increase the comfort level of their buildings as further described below.

3.4.1 Solar Orientation

Solar orientation is concerned with the annual changes in the sun's path. Most traditional designers understand that these seasonal changes make it possible to build a house that is more naturally cool in the summer and warm in the winter. A house with good orientation can lower costs while increasing comfort and reducing demand on natural resources.

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12 Roseberry, Rachel. 2008. *A Balancing Act: An assessment of the environmental sustainability of permanent housing constructed by the international development community in post-disaster Aceh*. University of Sussex.

DESIGNING FOR CLIMATIC VARIATIONS IN TAMIL NADU, INDIA

A study published by the Institute for Applied Sustainability to the Built Environment (ISAAC) reveals the importance of integrating both environmental and cultural considerations into post-disaster reconstruction. After the 2004 tsunami, settlements in Tamil Nadu, India, sustained critical damage to their housing units. Widespread replacement of damaged traditional structures with industrially produced reinforced concrete cement (RCC) was determined by this study to have been an ill-advised choice in reconstruction. The study affirms that the use of modern construction technologies, such as the use of RCC, while often touted as being the only choice for multi-hazard-resistant housing, may not be the best choice for sustainable reconstruction. Considerations of cost analysis, design elements for **climatic adaptation** (roof design, ventilation, etc.), and the environmental impact of materials are all critical variables in reconstruction. Based on this study, it was recommended that in Tamil Nadu traditional coconut and straw thatched houses would have been the best building choice for producing economic viability, **sustaining climatic comfort**, and lessening environmental impact.

Source: Barenstein, Jennifer and Daniel Pittet. 2007. *Post-disaster Housing Reconstruction: Current Trends and Sustainable Alternatives for Tsunami-affected Communities in Coastal Tamil Nadu.* Institute for Applied Sustainability to the Built Environment (ISAAC).

3.4.2 Site Modification

A building should be sited where it will have good winter sun, summer shade, mild breezes, and protection from severe winter winds. If a less-than-ideal site must be used for the construction, the site can often be improved by landscaping. Big shade trees to the east and west are most important. Windbreaks can be used to block severe winds and channel cooling breezes. Additional information about site modification, planning, and development is in GRRT Module 4, Green Guide to Strategic Site Selection and Development.

ECO-HOUSING IN SRI LANKA: SOIL AND VEGETATION CONCERNS

A main priority of the Damniyangama Eco-Housing Demonstration Project was to reestablish vegetation cover, which had largely been destroyed. Landscaping was planned to maximize indoor ventilation, provide shading, and promote evaporative cooling. Plants were also used as windbreaks.

Other considerations included reduction of soil erosion and the provision for subsistence farming. Multipurpose tree species were selected that had economic value. The trees were selected in cooperation with the community to avoid potential conflicts. Drainage canals were constructed according to the existing drainage pattern to prevent soil erosion. The existing drainage pattern was not disturbed. Runoff from the construction area was diverted through drainage canals with a minor negative impact on the environment.

Source: UNEP. 2006. *Eco-housing Guidelines for Tropical Regions.* Bangkok.

3.4.3 Insulation

Although spatial orientation is the first step of proper design, insulation is also necessary to save the heat from sunny winter days for cold nights. Thick mud walls, for example, are well suited to arid desert climates with high daytime temperatures and low nighttime temperatures because of the slowness in their thermal-transfer qualities. The walls of straw-clay and straw buildings also provide excellent insulation and allow for exceptional comfort and performance in extreme environments. Fuel use for heating in Ulaan Bator, Mongolia, for example, was cut by 50-70 percent in straw bale buildings as compared with conventional structures.[13] In poorer or

13 UNDP. *Energy-Efficient Straw-Bale Housing. East Asia: Mongolia.* UNDP Fact Sheet 8.

nonindustrial areas, the use of two single-pane windows together, approximating a double-pane installation, can provide added insulation. Insulated shutters and drapes can also improve window performance.

Insulated attics or roofs are particularly important. For buildings in hot climates that are not air conditioned, thermal insulation should not be used on the walls, as this will trap heat inside the building. Use insulation only for roofs exposed to direct solar radiation. Protect structures from excessive heat gain by using appropriate insulation materials. For example, bonded mineral wool can be used for under-deck roof insulation. Resin-bonded mineral wool is available in the form of slabs and rolls. These materials are available with or without the lamination of aluminum foil. Or, instead of roof insulation, a roof garden on the exposed roof area, or a shaded roof, helps to reduce heat ingress.[14]

3.4.4 Weatherization

Weatherization or weatherproofing is the practice of protecting a building and its interior from the elements, particularly from sunlight, precipitation, and wind, and of modifying a building to reduce energy consumption and optimize energy efficiency. Airflow can account for half of the heat loss in a well-insulated but leaky building. The idea is to design a house with controlled airflow – when and where it is wanted. Air quality must be considered to ensure adequate air exchange, e.g., if cooking with gas or wood occurs inside or near the house, measures must be taken to ensure proper ventilation.

3.4.5 Thermal Mass

Thermal mass is the mass in a building (including the structure and the furnishings) that is used to absorb heat during the day and then to release the heat as the building cools in the evening. Materials with a high thermal mass are energy efficient. As mentioned above, heat from sunny winter days can be saved for nighttime. To do so requires using thermal mass inside a well-insulated shell. For example, a thick plaster layer on straw bale walls provides considerable mass, which can then be augmented with an exposed concrete, adobe, or other high-mass floor; adobe seating (bancos); masonry; or water tanks. Doubled plasterboard helps retain heat in frame houses, while in traditional homes stone wall facings or partitions increase working thermal mass. The more thermal mass, the more stable the temperature of the building. This is why the same thermal mass also helps save the coolness of a summer night for the following hot day. However, exterior insulation is still needed to prevent overheating in the summer and chilling in the winter.

3.4.6 Ventilation

Adequate ventilation is important to ensure fresh air, cooling for comfort, and heat removal from the building structure. A well-ventilated building design must consider climate, adjacent topography, and vegetation, as well as local wind and airflow patterns, all of which impact building ventilation. Natural ventilation can be of two types. One is caused by wind pressure, and the impact depends on wind direction and speed as well as on the building's shape. Wind-pressure ventilation can provide either single-sided or cross ventilation. Another type of natural ventilation is caused by the density difference of air that results from the difference in temperature between the inside (warmer) and outside air. This is also called the "stack effect." If the inside air is colder, then a reverse stack effect can also be produced, which will bring in warm air from outside.[15]

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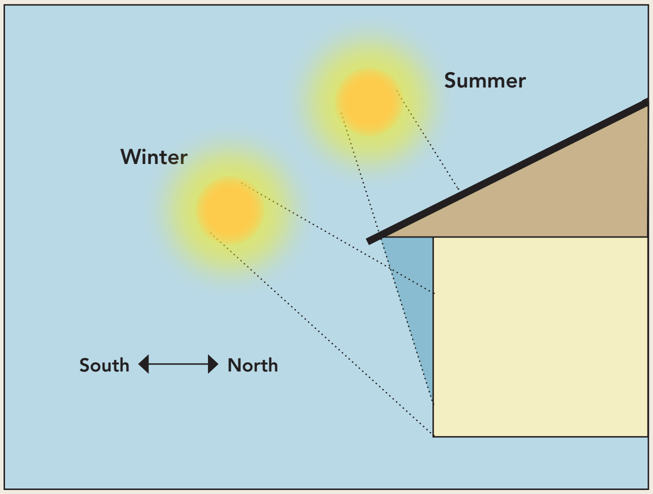
14 UNEP. 2006. *Eco-housing Guidelines for Tropical Regions.* Bangkok.

15 UNEP. 2006. *Eco-housing Guidelines for Tropical Regions.* Bangkok.

Proper window placement and interior design can capture cool breezes in the summer and increase comfort significantly. Insulated screened vents can be more economical than operable windows. Doors and windows placed at the front and rear of each home make use of natural through-draft cooling. Inlet openings in buildings should be well distributed and should be located on the windward side at a low level. Outlet openings should be located on the leeward side. Interior airflow can be improved if the doors are cut one or two inches above the floor level, and if vents and windows are placed above the doors. In hot climates, raised floors and high ceilings increase ventilation and improve comfort. Cool air for ventilation can be drawn from shaded areas near the ground and from landscaping, which tends to stay cooler in hot climates.



3.4.7 Shading

Orientation and shading are the keys to keeping a house cool in the summer. Properly sized overhangs and/or arbors will keep out hot summer sun but let in desirable winter sun. Arbors, vertical fins, shutters, shades, or trees can be used to shade windows. Design matters: A large window in the wrong place can make a home uncomfortable without air conditioning, and if residents are forced to use air conditioning the cost of operating the home will be increased.

Additional information on site selection and development is contained in Module 4, Green Guide to Strategic Site Selection and Development.

3.4.8 Climate-Specific Issues

Different types of designs are appropriate for different climates, because housing and shelter needs vary depending on the climate. Homes, shelters, and other constructions should be designed and supported to withstand the worst local weather conditions. Seasonal variations have a considerable impact on the type and cost of structure that is needed.

Consider the following climate-specific issues:

Hot, dry climate

Settlements: In hot dry climates, shade from the sun is a primary consideration during the day. Cold is also a concern in hot dry climates, because the nights can be surprisingly chilly, especially in arid areas. Dust is also a problem, so shelters should be designed to be closed during sandstorms. Narrow streets and enclosed settlements maximize the shade created by buildings; they use the thermal mass of buildings to keep the settlement cool, and can reduce the dust blown by wind. If, however, buildings are sited too closely together, fire can spread more easily, especially if the buildings are made from easily flammable materials.

Buildings: Thermal mass in buildings should be ensured by constructing thick walls and insulating roofs, making them cool in the day and not too cold at night. If building with plastic sheeting, provide double-skinned roofs with ventilation between the two layers to minimize heat radiation. Doors and window should be positioned away from the direction of the prevailing winds, which are likely to be very hot. Traditional houses are often placed in compounds, which offer protection, shade, and fencing for livestock. Consider the possibility of providing external shade for outdoor activities, depending on the climatic and cultural contexts.

Hot, humid climate

Settlements: In wet environments, the chosen site should be above the flood plain and out of the way of seasonal rivers or the highest annual tide. The ideal slope for a site should provide adequate drainage during the wet season, but should not be so steep as to threaten the stability of the buildings. In hot and humid climates, settlements should be open, with individual dwellings sited far apart from each other, to increase airflow. Trees and foliage should be kept wherever possible, to provide shade.

Buildings: Roofs should have a sufficient pitch for rainwater drainage: above 30° for normal tiles and thatch and above 20° for well-lapped corrugated iron sheeting. Generous overhangs help to protect the openings from water penetration during rainy seasons. Sufficient openings for good ventilation and air convection both in the walls and on the roof should be provided. Care should be taken to ensure that materials do not suffer from dampness and rot. Large openings, doors, and windows are advantageous in a warm-wet climate, provided they are effectively protected from the penetration of solar radiation, rain, and insects.[16] Raising buildings on stilts, at least 30 cm above ground, enables cooling of the floor from below and helps prevent moisture problems. It also gives flood protection in flood-prone areas.

Cold climates

Settlements: Local climatic variations should be considered when siting a settlement. For example, wind may be funneled through gaps in mountains, or the site may be shaded from the sun in deep valleys. Particularly at high altitudes, it can be significantly colder in the shade than in the sun. Wind and moisture increase cooling.

Buildings: In cold climates, insulation and draft reduction are key to keeping houses warm. Designing a warm room with a thermal buffer zone is a common approach to the problem. Some level of air infiltration must be permitted, which means that the infiltrating air must be warmed, possibly by body heat or by artificial sources. Ventilation is necessary to prevent respiratory diseases caused by cooking or heating smoke. Houses with thick walls and insulated roofs can be very cold if they have leaky or broken windows or doors. Plastic sheeting can be used to create thermal buffer zones. In the case of windows, two sheets are significantly better than one because they approximate the effect of double glazing. Stoves and heaters are an essential part of the heating strategy for a shelter in a cold climate. Big rooms should be partitioned to reduce air volume to be heated. Once the room has been heated, it is important to ensure that the heat does not escape. Insulation from the ground using mattresses is another effective measure; heat conducts quickly from the body into the cold ground, and warm air in the transitional shelter will rise, making the floor area the coldest.

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16 UNEP. 2006. *Eco-housing Guidelines for Tropical Regions*. Bangkok.

For additional information on the use of post-disaster tents in cold climates, see "Design of Humanitarian Tents for Use in Cold Climates" by Pete Manfield, Joseph Ashmore, and Tom Corsellis in the journal *Building Research and Information* 32: 368–378.

ADAPTING TO CLIMATE IN SRI LANKA

In the Damniyangama Eco-Housing Demonstration Project, a number of passive cooling measures were implemented to reduce energy demand over the long term, which benefited the community. These included:

- Situating buildings according to wind patterns to ensure adequate natural ventilation inside the houses
- Creating inlet and outlet openings of nearly equal areas at the same level in the buildings, with inlets placed on the windward side and outlets on the leeward side
- Ensuring that inlet openings were not obstructed by adjoining buildings or trees
- Placing windows in living rooms to open directly to an open space, and building in two windows in each room
- Using roof tiles as roofing material to minimize heat gain
- Using trees and vegetation to increase humidity levels, improve shading, and cool the immediate environment
- Installing efficient lighting systems for energy conservation

Source: UNEP. 2006. *Eco-housing Guidelines for Tropical Regions.* Bangkok.

3.5 Energy Efficiency

3.5.1 Building

Fossil fuels supply 80 percent of the world's primary energy at present,[17] but resource depletion and long-term environmental impacts may limit their use in the future. As a large consumer of energy, the construction industry can play a great role in achieving energy efficiencies. Sustainable construction designers must aim to provide long-lasting, healthful, and useful buildings while conserving ever-decreasing resources and using energy-efficient designs and environmentally neutral energy sources and mechanisms. Due to the expected long life of permanent housing, the operating phase will consume the largest proportion of energy resources compared to the overall life cycle of the structures. Optimizing the use of energy, therefore, is crucial in sustainable construction efforts.

Good passive solar design will reduce the demand for fuel wood or other forms of energy inputs required for heating. Almost half of the wood used in the world is used as firewood, the collection of which is often a full-time task for one or more family members. The removal, first of trees and then of stumps, shrubs, and anything else that can be burned, creates rings of devastation around urban areas. More than a billion people are harvesting firewood faster than it grows, and 100 million people are chronically short of energy sources.

The energy usage of a building can be improved by reducing energy demand, increasing energy efficiency, and/or using renewable sources of energy. Maximizing energy efficiencies, reducing the use of fossil fuels, and increasing the use of renewable energy sources will all be permanent features of sustainable development – and essential aims of any sustainable construction design.

17 UNEP. 2006. *Eco-housing Guidelines for Tropical Regions.* Bangkok.

When seeking to maximize energy efficiencies, project managers should avoid decreasing the quality of life. For example, these efficiencies should not lead to reduced ventilation and higher concentrations of pollutants inside a dwelling. Care should also be taken to avoid increasing the hours of usage of energy-efficient equipment. This could cancel out any benefits from energy efficiency.

The use of renewable forms of energy, based on solar, wind, and biomass energy, can help reduce the demand for polluting fossil-fuel or fire-wood-based energy sources. The most likely application of renewable energy in the housing sector would be based on solar, wind, or biomass energy. Before installing renewable technologies, attempt to reduce energy consumption and increase energy efficiency. This could considerably reduce the initial investment.

BIOGAS IN NEPAL REDUCES ENERGY COSTS AND WASTE DISPOSAL REQUIREMENTS

"One fine day I told my husband that I wasn't going to risk my life by collecting wood from the forest anymore and that we were going to get a biogas stove, even if we had to take a loan," says Jari Maya Tamang, 41, as she stands proudly next to the first biogas plant in her village.

Jari Maya took a microcredit loan and became the first to install a toilet-attached biogas plant in Badreni, a small village on the edge of Chitwan National Park in Nepal's Terai. Today, 80 percent of the 82 households in Badreni have installed toilet-attached biogas plants with the support of WWF. The Terai has a dense population, high biodiversity, and fragile ecosystems. Deforestation is a major issue. Sixty-one percent of all households in the Terai rely on firewood for cooking, and 49 percent source their wood from nearby government-managed forests. A typical family uses an average of between 1.3kg and 2.5kg wood every day, and evidence suggests that this is not sustainable. With a population of more than 6.7 million in the Nepal Terai, the problem of deforestation will become acute without environmentally sound interventions.

Alternate waste management and energy promotion is an important strategy to deal with farm and household solid waste, reduce pressure on the forests, and improve local livelihoods in the Terai. In Nepal, the locally designed and developed fixed-dome biogas plant design is popular. This model is considered to be reliable, functional, and simple; it has a low maintenance cost and a durable design.

In Nepal, one medium-sized biogas plant (the most popular one) costs around US$500. Biogas technology is still out of reach for the majority of people in the region who are poor; however, local NGOs have funded microfinance schemes through grassroots partners like Community Forest User Groups. This arrangement has made it easier for poor and disadvantaged communities to easily access loans at lower interest rates to construct the biogas plants. The household latrine is situated by design to feed the biogas plant, which also uses barnyard wastes.

Source: Gurung, Trishna. 2007. Biogas: saving nature naturally in Nepal. wwf.panda.org (Accessed on June 28, 2010)

3.5.2 Lighting and Pumps

Photovoltaic solar power (converting light to energy) can be used for lighting and to satisfy low power requirements. To operate pumps, grain mills, and (for example) village welding, more powerful generators are needed, particularly those with engines of between 5hp and 10hp, which most African villages are already importing from India.[18] These generators are currently petrol-based, but could also operate on liquid, solid, or gaseous biofuel if sufficient research were carried out.

18 UNEP. 2006. *Eco-housing Guidelines for Tropical Regions.* Bangkok.

3.5.3 Cooking Fuel

As fuel shortages intensify, the price of firewood and charcoal increases, often costing as much as the food it cooks. Lack of wood makes it hard to cook food properly, to purify water, and to bathe and clean clothes in areas with certain waterborne parasites – all of which increase health risks. As firewood consumption increases and all trees and shrubs are removed and burned, it is harder to maintain agricultural productivity. Deforestation also leads to an increase in erosion and landslides. Eventually dung and crop residues are burned, leading to a gradual decline in agricultural productivity because nutrients are not returned to the soil.

COORDINATING FUEL STRATEGIES IN HUMANITARIAN CRISES

A number of organizations working on humanitarian crisis response are actively promoting fuel-efficiency and alternative energy sources and technologies. In April 2009, an interagency task force co-chaired by the World Food Programme (WFP), the UN High Commissioner for Refugees and the Women's Refugee Commission launched new guidelines for addressing this issue in humanitarian crises.

The guidelines define agency roles and responsibilities needed for developing coordinated fuel strategies in humanitarian crises and help humanitarian workers choose the most appropriate fuel strategies for their particular setting. These tools have been distributed to field offices of major UN agencies and nongovernmental organizations worldwide. The International Network on Household Energy in Humanitarian Settings (Fuel Network) established in 2007 provides a forum for sharing of information, initiatives and technological innovations regarding household energy related issues.

Source: van Dorp, Mark. 2009. *Dealing with energy needs in humanitarian crisis response operations.* IUCN and Institute for Environmental Security.

Some suggested resources on how sustainable energy can be integrated into project design may be found by consulting the Global Network on Energy for Sustainable Development sponsored by UNEP (www.gnesd.org) or reviewing "Access to Energy for the Base of the Pyramid" by Hystra (2009) or www.hystra.com.

GUIDANCE FOR INTEGRATING CLIMATE ADAPTATION INTO CONSTRUCTION

The recovery and reconstruction period after disasters is an important opportunity for project planners to incorporate **climate adaptation** into their recovery activities to make projects more resilient to a changing climate and reduce future disaster risk. There are two main categories of climate adaptation: **facilitating transitions to new conditions**, and **building resilience and buying time** to adapt to extreme weather events. Facilitating transitions to new conditions is needed when what people once knew as 'normal' is no longer the norm, such as changes in freshwater systems due to melting of snow packs, and sea level rise. Building resilience to extreme weather events helps people and nature withstand shocks and get back to normal after extreme events such as severe storms, drought or flood. In practice one or both of these approaches may be needed in a particular part of the world; building resilience can be a short-term measure while in the longer term a transition is needed to a new state – buying time in order to facilitate change.

Many of the measures proposed in this module can be applied to help with climate extremes once it is known how people and ecosystems are vulnerable to climate change and climate variability: for example, ventilation and shading for people in extreme heat; strengthening structures to withstand storms; and avoiding construction in flood-prone areas. If sites are likely to become more vulnerable in the future, greater margins of safety may be introduced: for example, coastal setbacks to allow for sea level rise, including space for beaches and mangroves to migrate upwards if the topography permits. In valleys below glaciers, there may be special risk from glacial lake outburst floods which occur when lakes formed by melting glaciers breach their unstable retaining banks, and vulnerable sites should be avoided for reconstruction. If a natural resource species used in construction or for fuel is declining in an area, try to reduce pressure and dependency on it by finding alternative materials, or promoting renewable energy or fuel efficiency.

Consider this climate adaption checklist when designing building construction projects:

- Project planners have contacted local government officials or experts to determine the predicted impacts from climate change within the project area.
- The project includes specific measures to address predicted changes in climate extremes in the next 5-10 years (e.g., worsening drought, greater frequency of flooding, more intense cyclones)?
- The project design incorporates the consequences of longer term, regional climate change effects (e.g., heat stress from rising temperatures, reduced stream flow due to loss of snow pack, sea level rise from melting ice caps)
- Alternative activities have been considered in terms of their ability to account for future climate risks.

For more information on the role of climate adaptation in disaster risk reduction see Module 9, Green Guide to Disaster Risk Reduction.

3.6 Solid Waste

Settlements produce solid waste. The inclusion of home gardens and compost areas within home designs can be one technique for addressing solid waste in a community. However, where communities are using more plastic and moving away from organic waste production, the problem of nonbiodegradable waste is a new issue that needs to be considered in the building design process. Additional information on this topic is contained in Module 7, Green Guide to Water and Sanitation.

3.7 Waste and Wastewater Systems

Site selection needs to take into account the availability of freshwater sources for cooking, drinking, and bathing, as well as whether these freshwater sources are sustainable and protected from polluting sources over the long term. Upstream mining or logging, for example, can contaminate gravity-fed systems. Building design should incorporate roof catchment and rain tanks to reduce dependence on centralized systems and groundwater resources, which can be limited in some areas.

Designers should consider ways to reduce household water demand, such as the use of dry composting toilets or of systems that separate wastewater. "Black" water is heavily contaminated wastewater, such as toilet wastewater. Black water is difficult to treat because of high concentrations of mostly organic pollution. "Grey" water is wastewater that is generated from processes such as washing dishes, laundry, and bathing. Grey water can be reused for watering plants or crops, reducing demand and increasing the efficiency of water use.

Black water must be treated sufficiently to ensure that neighboring water sources are not contaminated. People often use nearby streams and rivers for bathing, water collection, fishing, and other livelihood activities. It is crucial that wastewater treatment systems be operational. The use of septic tanks and treatment wetlands can be successful solutions. See Module 7, Green Guide to Water and Sanitation, for more information on this topic.

3.8 Local Community and Cultural Acceptance

The vast majority of buildings in the world are not "designed" or built by architects or qualified professionals. This implies that in every community there is a wealth of local knowledge and skill – not only with regard to building traditions and techniques but also with regard to strategies for coping with the particular settings and hazards of each area. In many parts of the world, techniques have been developed over many years to deal with differences in local climate and to resist and recover from natural disasters. In a reconstruction effort, then, it is important to recognize and evaluate local traditions, skills, and knowledge.

3.8.1 Local Acceptance

It is clear that architecture is one way in which communities express their common cultural or religious beliefs. In many cases, the construction process itself may be imbued with meaning. Therefore, for a design to be sustainable – not simply from an ecological standpoint but from a socioeconomic perspective as well – the layout and planning of a construction project must be considered in response to the local community's needs and desires.

Vernacular architecture can be ecologically sensitive, as it often uses natural local materials – assuming that these local materials are not under threat and their extraction can be sustained. As the builders are often members of the community, the construction process can itself support economic and social sustainability through livelihood support and networking.

At the same time, there may be communities who have abandoned traditional disaster-resistant construction techniques because of the unsustainability of building materials, or have rejected the "old ways" in favor of modern methods of construction, which may carry higher status. An assessment of the local community's views concerning traditional versus modern techniques is critical before attempting to propose solutions that may be rejected for reasons that may be unclear to outsiders. In many cases, the eventual designs will contain some tradeoffs between what is best from an environmental point of view and what is acceptable to the affected community in terms of culture or aspirations. In some cultures, for example, doors or apertures may only open in certain compass directions, regardless of the path of the sun or optimum directions for passive heating or passive ventilation. In other cultures, privacy or separation of space for women is the deciding factor in the placement and orientation of buildings.

EARTH BLOCKS IN SOUTH AFRICA

One major success story in sustainable construction efforts is the development of modern versions of earth block. Earth block is a traditional material made by compressing soil into block forms. Through the use of simple modern machinery and techniques, a stronger version of the traditional earth block can be created that is both environmentally friendly and affordable. Earth block can be made almost entirely from local materials, eliminates the costs and environmental effects of transporting building materials from off site locations, and serves as a source of livelihoods for local communities.

Earth block construction has been a highly successful enterprise in several developing countries. Several pilot projects in South Africa have used earth block made with simple machinery that can use human or motor power to produce high-quality stabilized earth block. Both traditional and modern houses are being built from earth blocks in South Africa. This technology is attracting significant attention from developed-country sustainable building movements, which are attempting to find more natural, ecologically friendly building materials and methods.

Source: Kibert, Charles J. 2003. Deconstruction: the start of a sustainable materials strategy for the built environment. *UNEP Industry and Environment April-June: 84-89.*

Using building techniques that are clearly understood by the community can help to ensure the longevity of the project. Through training programs, project managers can ensure that knowledge of construction methods remains with the community even after the intervention has ended. © Daniel Cima/American Red Cross

3.8.2 Community Participation and Analysis of Existing Practice

As communities begin to see housing options that meet their real needs, the opportunities for participation increase and entry points for introducing environmentally sound solutions expand. The best source of local knowledge and examples of existing practices will be found in the community itself. To best inform the design, from interior layout to site location, the end user should be included in each step of the reconstruction process. Poor practice resulting in abandoned or misused housing is an enormous waste of resources and can have major negative environmental impacts.

CASE STUDY: INTEGRATING TRADITIONAL PRACTICES IN NORTHERN IRAQ (1991)

In northern Iraq in 1991, the International Rescue Committee (IRC) conducted interviews of villagers to determine several aspects of the reconstruction process, including the division of labor, the bill of quantity, and the support families required to rebuild their own homes. The project adopted a standard design for construction of traditional stone housing. Compressed flat roofs used by locals for drying food supplies were included in this design. Villagers provided the labor for rebuilding their own homes, while the logistics and key procurement items (e.g., tools, windows, doors, and roofing) were provided by the IRC. When villagers complained of erosion resulting from rain on mud joints in the masonry, a component of cement was added to the mixture. This example clearly illustrates the integration of traditional practices and community involvement with new methodologies for long-term building solutions.

Source: Richard Jacquot, Global Emergency Operations Team Leader, Mercy Corps, October 12 2009. Personal communication.

3.8.3 Construction Techniques and Knowledge Sharing

Wherever possible, project managers should attempt to adapt and improve existing construction methods instead of introducing new techniques that may be difficult to understand. Improved methods will then be easier to teach to the local community and the builders within it, and are more likely to be sustainably adopted. Using building techniques that are clearly understood by the community can help to ensure the longevity of the project. To achieve this, it is critical that knowledge of these methods remain with the community; as part of the process project managers should include training to ensure knowledge transfer to the local construction sector. It is important that the construction be easy to maintain and that building components be easily sourced or repaired by the local community at a relatively low cost.

STRAW BALE CONSTRUCTION IN CHINA

In northwestern China, the Adventist Development and Relief Agency (ADRA) introduced straw bale construction in 1998, and the technique has grown steadily. ADRA's success is directly related to its intensive training program and successful partnerships with local partners in an effort to increase the capacity of the local community and make sure the techniques are well understood. All buildings are designed by local builders or architects who have been mentored by a specialist working with the program since its beginnings. ADRA has focused its efforts on developing local talent; the project's goal is to transfer the straw-bale technology to Chinese builders, who will then build architecturally sound structures without external technical assistance.

Source: Kennedy, Joseph E., ed. 2004. *Building Without Borders: Sustainable Construction for the Global Village.* Gabriola Island, British Columbia: New Society Publishers.

4 CONCEPTS IN CONSTRUCTION MANAGEMENT

4.1 Background

Management of the construction process can be one of the most critical determinants of sustainability. Indeed, long-term sustainability will depend on whether sustainable design features are effectively implemented during the construction stage. A poorly conceptualized or executed construction phase can result in buildings that are expensive to build and difficult or expensive for the family or community to maintain.[19] Even worse, poor planning of the construction process and/or inadequate preparation of the construction site can lead to profound and long-lasting negative impacts on the communities who have to deal with a degraded environment. Poorly managed construction sites are notorious for polluting air, land, and water resources. It is, therefore, essential to minimize the environmental impact of the construction by considering the entire process – from site layout and preparation to waste disposal or reuse – before the construction begins.

The management of construction sites can impact environmental quality through wastes, runoff, the tracking of sediments off-site, improper disposal of wastes and hazardous materials, dumping, leaks, and spills. Proper care in these areas will reduce the exposure of polluting substances on water sources, public and occupational health, and ecosystems. Whether the construction project uses heavy earth-moving equipment or handheld tools, steps should be taken to incorporate environmental sustainability into the management of the work site.

> Better management practices involve being aware of the environmental impacts of construction. This should not require more effort, more cost, or more time at the construction site.

In the post-disaster humanitarian aid setting it can be hard to control construction management because construction activities may be undertaken by homeowners themselves through owner-driven construction projects or cash-for-work activities with relatively little technical oversight or on-going monitoring. In these cases, it is recommended that organizations conduct specific training sessions on environmentally sound construction management practices with homeowners and other individuals involved in the construction process.

INSTITUTING CONTROLS FOR MORE ENVIRONMENTALLY SOUND CONSTRUCTION MANAGEMENT

The physical construction of a building is often undertaken by a large team of people from one or more contracting companies as well as by homeowners themselves. In the post-disaster humanitarian setting, there may be an even larger number of people involved in construction, including donors, technical staff at aid agencies, and government representatives. With so many different people involved in construction at different stages in the process, it can be difficult to ensure that environmental construction management practices are well understood by the construction team. Project managers can ensure these practices are being followed by:

- Including specifications for environmental practices in the Terms of Reference for contractors and aid beneficiaries
- Conducting regular training sessions on the material contained in this module at field sites with construction staff and monitoring
- Including environmental indicators into monitoring plans for on-site construction (e.g., verifying that all paint containers are covered and located in washout areas)
- Assigning someone to serve as an environmental monitor
- Developing checklists to ensure that construction management meets environmental performance objectives

19 United Nations Environment Programme (UNEP) and Swiss Resource and Consultancies for Development (SKAT). 2007. *After the Tsunami: Sustainable Building Guidelines*

4.2 Construction Site Planning and Layout

A goal of sustainable construction is to reduce the negative impact on the site during construction to preserve the natural setting and habitat.[20] Environmentally sensitive construction planning can minimize construction waste, resource use, and potentially negative site impacts. Project managers should seek to ensure that:

- ❑ Potential health hazards and responses are identified in advance and environmental guidelines are written into project documents.
- ❑ Construction boundaries are established and measures taken to cordon off construction sites from residential zones.
- ❑ Trailer, storage, and laydown areas are identified and established.
- ❑ All subcontractors are informed of the areas in which they will need to work.
- ❑ Vehicle and equipment movement is restricted.
- ❑ Construction debris is recycled or reused wherever possible.
- ❑ Measures are enacted to minimize contamination of air and water resources on the site, including the use of recycled grey water for construction purposes and proper management of storm water and wastewater.
- ❑ Site erosion and sediment runoff is prevented with effective perimeter sediment control measures.
- ❑ Plans are drawn up for restoring affected areas to their natural states after the construction.

4.3 Materials Handling

4.3.1 Storage

Liquid materials such as paints, solvents, and fuel should be contained and covered. Materials and equipment should be stored in such a way that they are protected from public access and do not interfere with public spaces, streets, rights of way, or private property. Where necessary, plastic sheeting or other covers need to be made available to protect stockpiles.

4.3.2 Wet Materials and Liquids

"Wet" materials such as concrete, paint, stucco, and other liquids should be handled in a designated washout area. Concrete washouts are self-contained troughs used to capture and temporarily store concrete and liquids when the chutes of concrete mixers and hoppers of concrete pumps are rinsed out after delivery. Washout facilities consolidate solids for easier disposal and prevent liquid runoff.

This wash water is alkaline and contains high levels of chromium, which can leach into the ground and contaminate groundwater. It can also migrate to a storm drain, increasing the pH levels of area waters and harming aquatic life. The washout area should use a barrier such as a plastic lining to prevent runoff into the

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20 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.

street and gutter. Arrangements should be made for the safe and appropriate disposal of washout material. Tarps should be placed under concrete mixers, wheelbarrows, or mixing trucks to prevent spills. Residual materials should be cleaned and disposed of properly. Spillages into the street or public spaces should be prevented; solids that are improperly disposed of can clog storm drainpipes and cause flooding. Installing concrete washout facilities prevents pollution and is a matter of good housekeeping at the construction site.

SELF-INSTALLED CONCRETE WASHOUTS

There are many design options for concrete washouts, but they are preferably built below-grade to prevent breaches and reduce the likelihood of runoff. Above-grade structures can also be used if they are sized and constructed correctly and are diligently maintained. One of the most common problems with self-installed concrete washout facilities is that they can leak or be breached as a result of constant use. Care should be taken to use quality materials and inspect the facilities on a daily basis.

Concrete washout facilities should never be placed within 50 feet (15 meters) of storm drains, open ditches, or water bodies. They should be placed in a location that allows convenient access for concrete trucks, preferably near the area where the concrete is being poured. Appropriate gravel or rock should cover paths to concrete washout facilities if the facilities are located on undeveloped property. These areas should be far enough away from other construction traffic to reduce the likelihood of accidental damage and spills. The number of facilities installed should depend on the expected demand for storage capacity. On large sites with extensive concrete work, washouts should be placed in multiple locations for ease of use by concrete-truck drivers.

For additional guidance on concrete washouts, refer to:

U.S. Environmental Protection Agency. Concrete Washout. www.cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=117. (Accessed on March 31, 2010)

4.3.3 Water and Wind Protection

All materials should be covered and securely protected from wind and rain with a water-repellent covering during the entire construction process. This will prevent the spreading, mixing, wetting, contamination, or loss of materials. During the rainy season, extra tarps or bags should be kept on hand to prevent these materials from getting wet or washing off.

4.4 Equipment Handling

4.4.1 Storage

Construction equipment should, if possible, be kept on-site to reduce the transport of sediment, hazardous materials, or other contaminants to and from the site. In particular, all earthmoving equipment should be stored on-site. Drip pans should be placed under equipment not in use.

4.4.2 Maintenance

Maintenance of construction equipment should also be conducted on-site to avoid safety issues in public spaces and to avoid spills or leaks from discharging outside of the perimeter controls. Tarps should be placed beneath vehicles during maintenance to control spills.

4.4.3 Vehicles

If vehicles or other equipment are stored on-site, tarps should be placed beneath them overnight or during periods when they are not being operated. Pumpers should be surrounded by perimeter controls such as gravel bags, sandbags, or straw wattles. Effective tracking controls (shaker plate and/or gravel) should be in place at the job site entrance to prevent construction traffic from tracking mud and debris into the street.

4.4.4 Cleanup

Construction equipment should be cleaned in designated washout areas with controls in place to prevent untreated nutrient-enriched wastewater or hazardous wastes from being discharged to surface or ground waters.

4.5 Waste Handling

One of the goals of sustainable construction is minimizing waste. Waste management is a vital function that must be planned and implemented with care throughout the construction phase. Even with the most careful construction planning, some degree of construction waste will inevitably be produced. Project managers should, therefore, consider the overall impact of the project and its aims with regard to waste management and minimization. Measures must be taken to properly handle and dispose of waste.

4.5.1 Waste Cleanup

Waste receptacles such as dumpsters or trashcans should be used to contain construction waste. Alternatively, labor can be regularly employed to remove waste from the site to appropriate disposal facilities during the workday. Waste receptacles should be covered with tarps after the workday and the area around the receptacles should be kept clean. Waste receptacles must be kept on-site.

4.5.2 Disposal

Construction waste should be disposed of properly. No dumping of materials either on- or off-site should be allowed. Used oil, antifreeze, solvents, and other automotive-related chemicals are wastes that require special handling and disposal. Some can be recycled at designated facilities, but other chemicals must be disposed of at a hazardous waste disposal site. Local government agencies can sometimes help identify such facilities. See Module 4, Green Guide to Strategic Site Selection and Development, for further information on proper waste disposal procedures.

4.5.3 Sanitation Facilities

Construction worker sanitation facilities (e.g., portable toilets/latrines) should be made available on-site. Portable toilets should not be allowed to leak. Drip pans or other measures should be put into place to ensure that spills are controlled.

4.6 Pollution Prevention

Much pollution from construction sites can be prevented by carefully controlling runoff and the tracking of dust and other materials from the construction site. When material is tracked off-site by shoes or vehicles, it is no longer in the controlled environment of the construction site and creates risks for public health and environmental degradation, especially through water quality. Construction materials and sediments will enter the water system if cleaning, rain, and wind transport are not controlled. Degradation of water quality can affect the health of water-based ecosystems such as rivers, lakes, coastal zones, and oceans, and can in turn affect the livelihoods of the communities that depend on these ecosystems and water sources.

4.6.1 Hazardous Materials

Toxic materials, including liquid wastes such as paints and solvents, should be contained in hazardous-material drums. Drums should not be dumped in drains, sewers, or streets, but should be taken to an appropriate disposal facility. Liquids should be disposed of properly and should not be allowed to wash into drains, streets, or sewers.

4.6.2 Runoff

Perimeter sediment controls should be established to prevent materials and washed-out residues from running into drains or streets or from entering the water table. Examples of controls can be sand or gravel bags, silt fences, or straw wattles.

Wattles are made from straw that is bound into a tight tubular roll. When straw wattles are placed on the face of slopes, they intercept stormwater runoff, reduce its flow velocity, release the runoff as sheet flow, and provide removal of sediment from the runoff. By interrupting the length of a slope, straw wattles can reduce erosion.

Water drains should be protected; materials from the construction site should not be allowed into drains, as this will pollute water systems. Of special protection concern are downstream drains and inlets; perimeter controls should be used to protect these drains and remove debris and residue daily.

4.6.3 Cleanup

Maintenance and cleaning of equipment and vehicles should be done on-site, in designated areas with controls for runoff and the tracking of dust. Equipment and vehicles should be washed in designated washout areas, not in the street. The washout areas should be cleaned regularly and wastes should be disposed of properly. Disposal of "wet" construction materials should be handled in the washout area. This includes paint, stucco, and concrete. Plastic-lined pits should be used to collect and contain liquids, and to prevent runoff into the street and gutter.

4.6.4 Dirt and Grading

Stockpiled dirt and gravel must be stored on-site and covered. Dust control should be maintained throughout all phases of construction. During the rainy season, additional gravel, bags, tarps, and polyethylene sheeting must be stored on-site for emergency repair.

4.6.5 Tracking Controls

Tracking controls, such as a coarse gravel bed, should be used at each entrance to the construction site to limit off-site sediment tracking. Hand or mechanical sweeping should be used to clean up any materials that get tracked off-site. Any material that is tracked off-site or into the street should be cleaned up and disposed of using brooms or other handheld or mechanical sweeping equipment. If possible, a wet/dry vacuum should be kept on-site to clean up spills.

4.7.6 Training and Enforcement

It is crucial that the workforce understand the importance of a clean site, and the connections between improper material handling, improper waste disposal, and the consequences of environmental degradation for the quality of life in the community. Best management practices must be enforced on-site by the appropriate personnel.

Whether the construction project uses heavy earth-moving equipment or handheld tools (such as a trowel shown in the photo above), steps should be taken to incorporate environmental sustainability into the management of the work site. Workers must be trained on proper handling and disposal of construction materials in order to protect human and environmental health. © Daniel Cima/American Red Cross

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

Association for Environment Conscious Building (AECB): Nonprofit professional organization that provides sustainable construction standards and guidelines. *www.aecb.net*

Builders Without Borders: Nongovernmental organization that provides information on sustainable construction with an emphasis on straw, earth, and other local and affordable materials. *www.builderswithoutborders.org*

Earthquake Engineering Research Institute: Nonprofit organization that provides in-depth information on housing construction methods and earthquake-resistant construction through its world housing encyclopedia. *www.world-housing.net*

iREC Information and Research for Reconstruction: Academic institution that provides a variety of papers, publications, and conference proceedings related to sustainable building and reconstruction. *www.grif.umontreal.ca/pages/irecpublicns.html*

Practical Action, formerly the Intermediate Technology Development Group: Nongovernmental organization that provides materials on disaster mitigation, disaster-risk reduction, and earthquake-resistant housing construction. *www.practicalaction.org*

ProAct Network: Nongovernmental organization that provides resources on waste management and asbestos hazards in post-disaster situations. *www.proactnetwork.org*

Shelter Centre: Nongovernmental organization supporting the humanitarian community in post-conflict and disaster shelter and housing. Provides information on transitional shelter construction and best practices. *www.sheltercentre.org*

Women's Refugee Commission: The Women's Refugee Commission is an expert resource and advocacy organization that monitors the care and protection of refugee women and children. The organization provides guidelines for fuelwood at *www.womensrefugeecommission.org/programs/firewood* and *www.fuelnetwork.org*.

Publications

Barenstein, Jennifer D., and Daniel Pittet. 2007. *Post-disaster Housing Reconstruction: Current Trends and Sustainable Alternatives for Tsunami-affected Communities in Coastal Tamil Nadu*. Institute for Applied Sustainability to the Built Environment (ISAAC).

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

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

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.

Halliday, Sandy. 2008. *Sustainable Construction.* Oxford: Elsevier.

Aron, Jean-Elie, Olivier Kayser, Laurent Liautaund and Aileen Nowlan. 2009. *Access to Energy for the Base of the Pyramid*. Hystra/Ashoka. *www.hystra.com/opensource/energy.html*

Kennedy, Joseph E., ed. 2004. *Building Without Borders :Sustainable Construction for the Global Village*. Gabriola Island, British Columbia: New Society Publishers.

Kibert, Charles J. 2003. Deconstruction: the start of a sustainable materials strategy for the built environment. *UNEP Industry and Environment April-June: 84-89.*

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

Roseberry, Rachel. 2008. *A Balancing Act: An assessment of the environmental sustainability of permanent housing constructed by the international development community in post-disaster Aceh.* University of Sussex.

UNEP. 2006. *Eco-housing Guidelines for Tropical Regions*. Bangkok.

United Nations Environment Programme (UNEP) and Swiss Resource and Consultancies for Development (SKAT). 2007. *After the Tsunami: Sustainable Building Guidelines*.

U.S. Environmental Protection Agency. National Menu of Stormwater Best Management Practices. www.cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

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.