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UNEP Sustainable Buildings and Climate Initiative
Promoting Policies and Practices for Sustainability

Sustainable Reconstruction in Disaster-Affected Countries

Practical Guidelines

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ISBN 978-3-908156-18-5

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Preface

In 2007, Skat – Swiss Resource Centre and Consultancies for Development – in partnership with Sustainable Building and Climate Initiative (SBCI) of UNEP – United Nations Environment Programme – developed guidelines for integrating measures for more sustainable reconstruction efforts following the Indian Ocean tsunami, and published *After the Tsunami – Sustainable Reconstruction Guidelines for South-East Asia*.

Since then, a more generically applicable version of the Guidelines has been in high demand. Disasters such as the 2008 Sichuan earthquake in China, the massive earthquake that struck the Caribbean nation of Haiti in January 2010, which resulted in up to 80 per cent of the buildings in the epicentre being destroyed, as well as the tsunami and earthquake hitting north-eastern Japan with devastating consequences in early 2011, only reinforce the urgent need to provide such assistance.

Indeed, integrating sustainable building principles during reconstruction is key to the principle of 'building back safer'[1] – that is, not only to improve resilience to natural hazards in the future, but also to ensure that the opportunity is seized to shift towards buildings and structures that are as energy efficient, low greenhouse gas emitting and climate-mitigating as possible.

[1] '*Building back safer*', instead of 'Building back better' emphasises even more strongly the notion of disaster preparedness for safe living in buildings which are resistant to future hazards.

Acknowledgements

These practical guidelines were compiled by Skat – Swiss Resource Centre and Consultancies for Development

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The author would like to acknowledge and thank the following persons for their contributions and support for this publication:

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Peggy Messner, Pakistan Straw Bale and Appropriate Building (PAKSBAB), USA

Marianne Pecnik, Consultant

Laura Petersberger, Institutional Business Development, Leica Geosystems AG, Switzerland

Rüdiger Wagner, VP Imaging, Geospatial Solutions Division, Hexagon Geosystems

Acronyms and abbreviations

ACM	Asbestos-containing materials
ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action
CAP	Community Action Planning
CBO	Community-based Organisation
CDC	Community Development Council
CEB	Compressed Earth Blocks
CFS	Cold-formed Steel
CFW	Cash for Work
CVA	Capacity and Vulnerability Assessment
DM	Disaster Management
DRR	Disaster Risk Reduction
EIA	Environmental Impact Assessment
EMMA	Emergency Market Mapping and Analysis Toolkit
ENA	Environmental Needs Assessment
ENAT	Environmental Needs Assessment Team
ESR	Environmental Stewardship Review
FEAT	Flash Environmental Assessment Tool
FAO	Food and Agriculture Organization
FSC	Forest Stewardship Council
GCI	Galvanised Corrugated Iron
GEO-CAN	Global Earth Observation – Catastrophe Assessment Network
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographic Information Systems
GPS	Global Positioning System
GRR	Green Recovery and Reconstruction
LENSS	Local Emergency Needs for Shelter and Settlement
LIDAR	Light Detection and Ranging
LIS	Land Information System
LPG	Liquefied Petroleum Gas
M&E	Monitoring and Evaluation
MTPTC	Ministère des Travaux Publics, Transports et Communications (Haiti)
MoU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NGO	Non-governmental Organisation

OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ODR	Owner-driven Reconstruction
OSM	OpenStreetMap
PAKSBAB	Pakistan Straw Bale and Appropriate Building
PASSA	Participatory Approach to Safe Shelter Awareness
PHAST	Participatory Hygiene and Sanitation Transformation
PV	Photovoltaic
REA	Rapid Environmental Impact Assessment
Rs	Rupees
SBCI	Sustainable Building and Climate Initiative
s.ft.	Square Feet
SIM	Subscriber Identity Module
Skat	Swiss Resource Centre and Consultancies for Development
SMS	Short Message Service
SUN	Sustainable United Nations
SWM	Solid Waste Management
SWOT	Strengths, Weaknesses/Limitations, Opportunities and Threats
T Shelter	Temporary/Transitional Shelter
TWIG	Technical Working Group
UDDT	Urine-diverting Dehydration Toilet
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-HABITAT	The United Nations Human Settlements Programme
UNICEF	United Nations International Children's Emergency Fund
UNITAR	United Nations Institute for Training and Research
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNOSAT	Operational Satellite Applications Programme
US	United States (of America)
USA	United States of America
VCA	Vulnerability and Capacity Assessment
VIP	Ventilated Improved Pit
WASH	Water Supply, Sanitation and Hygiene Promotion
WATSAN	Water Supply and Environmental Sanitation
WHO	World Health Organization
WS&S	Water Supply and Sanitation

Glossary

Black water	Heavily contaminated waste water, e.g., toilet waste water. Black water is also known as 'brown water'; black water is heavily polluted and difficult to treat because of high concentrations of mostly organic pollution.
Buffer zone	A buffer zone is a land area designated for safety purposes that includes the highest sea level previously flooded (e.g., the tsunami level), together with an additional buffer area.
Building code	A set of ordinances or regulations and associated standards intended to control aspects of the design, construction, materials, alteration and occupancy of structures that are necessary to ensure human safety and welfare, including resistance to collapse and damage.
Capacity	The combination of all the strengths, attributes and resources available within a community, society or organisation that can be used to achieve agreed goals.
Capacity development	The process by which people, organisations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems and institutions.
Climate change	The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".
Climate change adaptation	Adaptation to climate change (global warming) is a response to climate change that seeks to reduce the vulnerability of natural and human systems to climate change effects. That is, the capacity and potential for humans to adapt (called adaptive capacity) is unevenly distributed across different regions and populations, and developing countries generally have less capacity to adapt. Adaptive capacity is closely linked to social and economic development. Adaptation can be defined as adjustments of a system to reduce vulnerability and to increase the resilience of the system to change in the climate system.
Collective centres	Transitional facilities housed in pre-existing structures.
Community	A group of households that identify themselves in some way as having common interests, connections, values, resources or needs as well as physical space. A social group of any size whose members reside in a specific locality, share government and often have a common cultural and historic heritage.
Community rehabilitation	Community rehabilitation involves mobilising community members and providing them with, or enabling them to provide for themselves, a safe, secure and enabling environment. Community rehabilitation entails restoring infrastructure and basic services, such as energy, water, sanitation, healthcare, education and access to information, as well as providing less-tangible forms of support, such as counselling and groups for awareness-building.
Contingency planning	A management process that analyses specific potential events or emerging situations that might threaten society or the environment and establishes arrangements in advance to enable timely, effective and appropriate responses to such events and situations.
Coping capacity	The ability of people, organisations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters.
Disaster	A serious disruption of the functioning of a community or a society, causing widespread human, material, economic or environmental losses and impacts and which exceed the ability of the affected community or society to cope using its own resources.
Disaster mitigation	Actions taken to eliminate or minimise the effects of disasters, including measures to eliminate or reduce risks or prevent hazards from developing into disasters.
Disaster preparedness	Disaster preparedness minimises the adverse effects of hazards through effective precautionary actions, rehabilitation and recovery measures to ensure the timely, appropriate and effective organisation and delivery of relief and assistance following a disaster. Preparedness measures include plans of action for potential disasters, maintenance and training of emergency services, the development and exercise of emergency population-warning methods combined with emergency shelters and evacuation plans, the stockpiling of supplies and equipment, and the development and practice of multi-agency coordination.

Disaster prevention	The body of policy and administrative decisions and operational activities related to preventing, managing and mitigating the various stages of disasters at all levels.
Disaster recovery	The restoration of an affected area to its previous state. Disaster recovery involves policies, decisions and activities developed and implemented after immediate needs in disaster areas have been addressed. Recovery activities include rebuilding destroyed property, re-employment and the repair of other essential infrastructure. Recovery efforts are most effective and most widely accepted by communities when mitigation measures are implemented swiftly.
Disaster risk management	The systematic process of using administrative directives, organisations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster.
Disaster risk reduction	The concept and practice of reducing disaster risk through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.
Early-warning system	The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.
Earthquake	A sudden motion or trembling caused by a release of tension accumulated within or along the edge of the earth's tectonic plates.
Ecosystems	Distinct units of the biosphere, including living organisms (plants, animals, micro-organisms) and non-living components, their interactions and other processes specific to the ecosystem's physical area.
Embodied energy	The quantity of energy required to acquire primary material, and manufacture, handle and transport to the point of use a product, material or service.
Energy conservation	The practice of reducing the amount of energy used to obtain an outcome or produce an output.
Environmental degradation	The reduction of the capacity of the environment to meet social and ecological objectives and needs.
Environmental Impact Assessment (EIA)	Process by which the environmental consequences of a proposed project or programme are evaluated, undertaken as an integral part of planning and decision-making processes with a view to limiting or reducing the adverse impacts of the project or programme on human health and the environment.
Exposure	People, property, systems or other elements present in hazard zones that are thereby subject to potential losses.
Flood	A general and temporary condition of partial or complete inundation of normally dry land areas from: (1) the overflow of inland or tidal waters; (2) the unusual and rapid accumulation or run-off of surface waters from any source; or (3) mudflows or the sudden collapse of shore land.
Geographic Information System (GIS)	A computer system for the input, editing, storage, retrieval, analysis, synthesis and output of location-based (also called geographic or geo-referenced) information. GIS may refer to hardware and software, or include data.
Grey water	Waste water that is generated from processes such as washing dishes, laundry and bathing.
Hazard	A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. A natural hazard is a natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
Host families	A transitional settlement option sheltering the displaced population within the households of local families or on land or in properties owned by them.

House owner-occupant	Occupant owns his/her house and land, or is part-owner, such as when repaying a mortgage or a loan. Ownership may be formal or informal.
House tenant	Occupant rents the house and land, formally or informally.
Hyogo Framework for Action	The agreed framework of actions to reduce disaster risks from 2005–2015 established by more than 190 countries following the World Conference on Disaster Risk Reduction held in Kobe, Hyogo, Japan, January 2005.
Indicator	Quantitative or qualitative factor or variable that provides a simple and reliable means to measure achievement or to reflect the changes connected to an operation.
Informal landholders	Those who occupy or use land without formal recognition or protection from the law. They are often recognised by customary law or local practices.
Landslide	Downward movement of a slope and materials under the force of gravity.
Land tenant	Occupant owns the house and rents the land, formally or informally.
Land-use planning	The process undertaken by public authorities to identify, evaluate and decide on different options for the use of land, including consideration of long-term economic, social and environmental objectives and the implications for different communities and interest groups, and the subsequent formulation and promulgation of plans that describe the permitted or acceptable uses.
Lease	Agreement between a landowner and a tenant. Usually, a landowner grants a tenant limited possession and use of land for a fixed period of time in exchange for the payment of rent.
Livelihoods	The ways in which people earn access to the resources they need, individually and communally, such as food, water, clothing and shelter.
Livelihoods rebuilding	The provision of support to major occupation sectors (e.g., fishery, agriculture and tourism) as well as families with specific needs (e.g., home-based work for single-person households).
Microfinance	A broad range of small-scale financial services (such as deposits, loans, payment services, money transfers and insurance) to poor and low-income households and their small enterprises.
Mitigation	The lessening or limitation of the adverse impacts of hazards and related disasters.
National platform for disaster risk reduction	A generic term for national mechanisms for coordination and policy guidance on disaster risk reduction that are multi-sectoral and interdisciplinary in nature, with public, private and civil society participation involving all concerned entities within a country.
Occupancy with no legal status (squatter)	Occupant occupies land or property without the explicit permission of the owner.
Photovoltaic (PV) cell	A device that converts sunlight directly into electricity using cells made of silicon or other conductive materials.
Pollution	Harmful substances (gases, liquids and solids) that have been released into the environment.
Preparedness	The knowledge and capacities developed by governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions.
Prevention	The outright avoidance of adverse impacts of hazards and related disasters. For example, disaster prevention expresses the concept and intention to completely avoid potential adverse impacts through action taken in advance.
Quarry	A site from which rocks, gravel, sand or clay is extracted in substantial quantities.
Recovery	The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors.

Recycling	Systems and processes for collecting, sorting and reprocessing used products, substances and materials into raw material suitable for reuse.
Renewable energy	Renewable energy resources capture their energy from natural energy sources, such as sunlight, wind, hydropower, biogas and geothermal heat that are self-replenishing (as opposed to non-renewable energy sources, e.g., oil, gas and coal, that can be used only one time).
Resilience	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
Response	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. Disaster response is predominantly focused on immediate and short-term needs and is sometimes called ‘disaster relief’.
Retrofitting	Reinforcement or upgrading of existing structures so that they become more resistant and resilient to the damaging effects of hazards. Retrofitting should entail measures that assist in improving buildings so they consume less energy and provide healthier indoor environments.
Reuse	The employment of a product, substance or material, once again for its original purpose or for a different purpose, without prior processing to change its physical or chemical characteristics.
Risk	The combination of the probability of an event and its negative consequences.
Risk assessment	A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend.
Risk management	The process of measuring or assessing risk and developing strategies to manage it. Strategies include avoiding the risk, reducing the negative effect of the risk and accepting some or all of the consequences of a particular risk.
Stakeholders	Agencies or individuals who have a direct or indirect interest in an intervention or project, or who can affect or are affected by the implementation and outcome of it.
Sulphur dioxide (SO^2)	A gas that causes acid rain. Burning fossil fuels, such as coal, releases SO^2 into the atmosphere.
Sustainability	The notion that societies can plan and organise their economic, political and social activities in a manner that will meet their needs and express their greatest potential in the present, while preserving ecosystems, biodiversity and natural resources for future generations.
Sustainable reconstruction	Reconstruction activities that are guided in their planning, design and implementation by the goal of sustainability.
Transitional shelter	Shelter that provides a habitable covered living space and a secure, healthy living environment with privacy and dignity for those within it during the period between a conflict or natural disaster and the achievement of a durable shelter solution.
Users	The beneficiaries and residents of reconstructed buildings.
Vulnerability	The characteristics and circumstances of a community, system or asset that make it subject to the damaging effects of a hazard. The relative lack of capacity of a community or ability of an asset to resist damage and loss from a hazard. The conditions determined by physical, social, economic, political and environmental factors or processes that increase the exposure of a community to the impact of hazards.
Waste management	Strategies and systems for collecting, transporting, processing (waste treatment), recycling or disposing of waste materials.

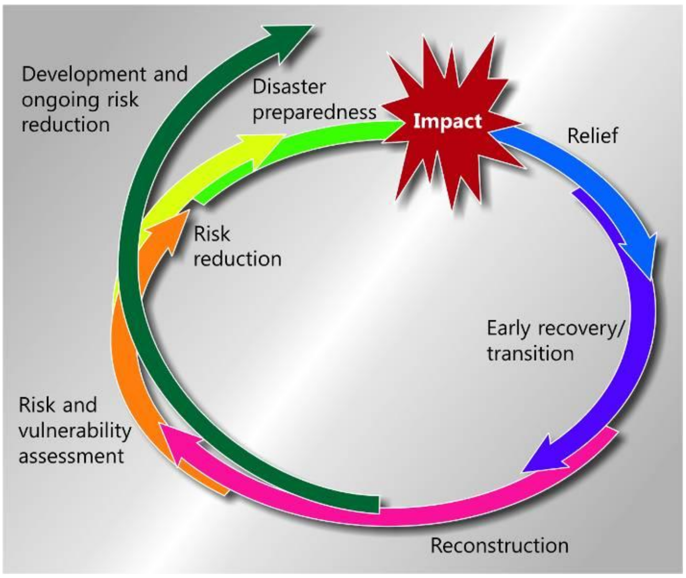
0. Introduction

0.1 About this manual

Scope

In post-disaster settings, the urgency and scale of the need for shelter poses a tremendous challenge. These practical guidelines provide guidance regarding the key aspects of sustainable reconstruction.

The guidelines focus mainly on the **reconstruction phase**, in particular on permanent housing. Yet, the manual can be applied in some aspects also to the early recovery phase and the provision of transitional shelter. The manual takes into account, also, risk-reduction measurement in order to prepare for any upcoming disaster.



The manual concentrates mainly on the **Reconstruction** phase.[2]

Although the focus of this manual is on housing, the reader will likely find some of the information applicable to other types of buildings (health facilities, schools, public buildings, etc.).

The guidelines concentrate on the physical aspects of reconstruction, which provide the basis for, and go hand in hand with, community rehabilitation and the rebuilding of livelihoods. The manual will not go into the details of community rehabilitation and livelihoods rebuilding.

While the manual is intended to be as comprehensive as possible, it cannot be considered complete and does not represent a scientific study of sustainable reconstruction practices. Nor, on the other hand, does it provide ready-made solutions for construction projects, each of which differs according to locations, budgets and other conditions.

[2] Adapted from: University of Westminster, 2009, *The Built Environment Professions in Disaster Risk Reduction and Response – A guide for humanitarian agencies*, Max Lock Centre, University of Westminster, London, UK

Objective

The guidelines' main objective is to help improve the design and reconstruction of houses in disaster-affected countries and, in so doing, to minimise the negative impacts of poorly constructed houses on the environment. The aim is to raise awareness of sustainable reconstruction and to improve resilience to natural hazards in the future. This is to encourage project managers as well as planners to adapt this approach wherever possible in their projects. Implementing agencies, where possible, are asked to support the reconstruction of buildings and structures that are as energy efficient and low greenhouse gas emitting as possible. This manual serves as a reference.

Questions of sustainability

Conventional reconstruction efforts often failed because of a one-sided approach, e.g., one that focuses only on technical or construction aspects. There were cases where houses were constructed but without the necessary infrastructure, water supply and sanitation, because of one-dimensional attitudes and, among other challenges, institutional constraints, bureaucracies, etc. Often, conventional reconstruction neglects important social and livelihoods issues which result in a poorer economic situation for beneficiaries with interrupted social relations.

Compared to conventional reconstruction, sustainable reconstruction is an integrated approach to reconstruction based on the well-known definition of sustainable development by Gro Brundtland.[3] In contrast to conventional reconstruction, environmental, technical, economic, social and institutional concerns are considered at each stage and activity of a sustainable reconstruction programme to ensure the best long-term result, not only in house design and construction activities, but also in the provision of related infrastructure such as water supply and sanitation systems. As a result of buildings' enhanced performances during construction, use and demolition phases, sustainable reconstruction offers a variety of environmental, economic and social benefits.

Sustainable reconstruction also looks beyond the structure of a single house to how neighbourhoods are laid out from a spatial planning point of view. The design of houses, infrastructure and green and open spaces of a neighbourhood shapes the larger settlement and, therefore, has a larger effect on the community's and the users' energy use, biodiversity and quality of life. In contrast to conventional reconstruction, sustainable reconstruction aims at using environmentally friendly building materials and technologies.

The exact criteria for sustainability may differ from one location to another. Implementers will need to work together with users and other relevant stakeholders to define the scope and application of sustainable reconstruction in their specific context.

Environmental

- Environmental characteristics of construction materials that are safe, durable and not acquired from sources that are overexploited or threatened (unsustainably harvested wood, etc.)
- Low generation of waste during materials' production and construction; high potential for reuse or recycling of construction materials

[3] Development is sustainable when it "*meets the needs of the present generation without compromising the ability of future generations to meet their own needs*" (Brundtland Commission, *Our Common Future*, 1987).

- Sustainable energy supply, if possible, making use of renewable energy sources
- Building design adjusted to local climate (use of natural lighting and cooling systems, etc.)

Technical

- Practical, technically easy and feasible solutions; field-tested construction technologies
- Compliance with technical specifications
- Awareness about safe building and quality of construction
- Flexible house design/adaptability to the users' needs and living conditions
- Cultural appropriateness of house design and spatial planning of the neighbourhood

Institutional

- Environmental governance
- Environmental Impact Assessment included in the project
- Comprehensive building codes and their enforcement
- Reliable local authorities with efficient provision of building permits and planning permissions
- Clarified land and house property ownership
- Capacity-building activities of communities

Socio-economic

- Economic feasibility (building costs and overall affordability)
- Low-cost building design without compromising on quality
- Enterprise development and employment creation
- Positive effect on local economy: community involvement in production and construction support and strengthening of local skills (vocational training)
- Home-based income generation

Women produce fly-ash blocks Skat

Why is sustainable reconstruction necessary?

Sustainable reconstruction offers the chance to improve the quality of buildings, the environment and living conditions in disaster-affected regions. Disasters due to natural hazards create enormous pressure to provide survivors with adequate permanent housing as rapidly as possible.

The urgent need for housing normally leads to numerous or large-scale reconstruction programmes and huge demand for construction material, and the potential environmental impact of reconstruction can become considerable. Improperly managed resource exploitation for construction materials can result in deforestation, pollution of water resources, damage to coral reefs and depletion of locally available materials. The construction process in itself can result in waste generation, water and air pollution.

The mitigation of natural disaster risks, however, requires building a culture of prevention. Disaster management should not be overlooked in the rush to restore life to pre-disaster conditions. The pressure to regain equilibrium as quickly as possible must be balanced with seizing opportunities for long-term risk reduction and community improvements through sustainable reconstruction.

Sustainable reconstruction is designed to address such challenges by providing an integrated framework for action. High-quality well-constructed houses and safe and sustainable environments are human rights. Adequate housing is essential for human survival with dignity. Without secure housing, basic rights to family life and privacy, freedom of movement, assembly and association, health and development are compromised.

Principles of sustainable reconstruction

It is important to integrate the principles of sustainability strategically from the earliest stages of reconstruction in order to avoid major failures during reconstruction. The key principles, which should be kept in mind at all stages of reconstruction, are summarised below:

1. *Learn from experiences, which dealt with effective and efficient reconstruction, and from traditional building technologies which survived disasters*

Many mistakes can be avoided by observing and finding out what concepts and, in particular, what construction practices, functioned well before a natural disaster occurred. Traditional knowledge and building practices have often evolved over long periods of trial and error, and are often both practical and resource efficient.

Traditional house built on stilts Skat

2. *Establish and maintain a well-functioning project-management process*

A well-functioning management process is the backbone for the success of any reconstruction project. Contracts and roles and responsibilities should be clarified as early as possible.

3. *Ensure local participation in decision-making processes*

The active participation of local stakeholders in crucial decisions throughout the project process fosters a strong sense of ownership and acceptance for the project, and helps to facilitate care and maintenance of buildings following construction. This is especially true if the users are also the owners of the houses; rented-out dwellings tend to deteriorate more quickly than do owner-occupied homes.

Relevant stakeholders – future house users, community leaders, responsible public authorities, service providers, etc. – can deliver important information and provide support that may be crucial to the project's success and sustainability.


Consultation with community members Skat

Ideally, relevant stakeholders should be consulted during the early project-definition phase, as well as during planning and implementation phases. This can be done through a stakeholders' workshop, during which invited stakeholders set project criteria and develop ideas.

At this stage, the responsible local governmental reconstruction agency can also be consulted in order to ensure their support.

4. Anchor the project in the local context

Projects should be anchored in the local context by taking any or all of the following measures:

- Exploring the availability of local know-how
- Considering traditional/cultural requirements
- Working together with and not against the local authorities
- Cooperating with local service providers
- Using high-quality local materials when possible
- Building on and optimising local construction technologies.


Local production of building elements Skat

Anchoring reconstruction projects in the local context can contribute measurably to community buy-in and a project's success and sustainability. Local institutions and organisations included in the project process are strengthened and improved.

5. *Coordinate with other donors to identify potential synergies*

Responsible local authorities should coordinate all ongoing and planned reconstruction activities, at least at community level. In addition, however, project officials should contact other development organisations (international and national) to determine jointly the geographical and social distribution of reconstruction schemes based on local needs.

Identifying and monitoring the reconstruction activities of other donor organisations and ensuring your project is complementing, not duplicating, other efforts can save financial and other resources. Normally, there are reasonable opportunities to economise on costs of access roads, water and sanitation systems and other infrastructure.

Donor coordination can also help to ensure the equitable distribution of reconstruction benefits to communities, especially to areas that are less politically popular.

6. *Determine communication and knowledge-sharing strategy*

Maintaining effective communication among all the stakeholders is crucial. Numerous sources have reported incidences of hostility towards development agencies by beneficiaries. There has been a lack of clear and regular communication between implementers and future users about options, plans, actions, responsibilities and difficulties encountered in the course of reconstruction projects.

It cannot be overemphasised that all agencies owe beneficiaries the opportunity to know what is being discussed, planned, negotiated, rejected or accepted on their behalves. The internationally accepted guidelines of the Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP) provide successful lines of communication. (See ALNAP, 2005, *An ALNAP Guide for Humanitarian Agencies*, Active Learning Network for Accountability and Performance in Humanitarian Action, UK.)

It is also important to ensure regular reporting and documentation of positive and negative experiences. This is important not only for any necessary handing-over to future project managers, but also for the sharing of lessons learnt at international and local level.

7. *Develop a risk strategy*

Developing a strategy for how to overcome any potential risks to the project is essential. Risk strategies safeguard the project’s continuation, completion and, ultimately, its sustainability.

Strategies should be developed with relevant local stakeholders. The strategies should define how potential obstacles – whether political, economic, security-related or from subsequent disasters – should be tackled.

8. *Conduct regular monitoring and evaluation (M&E)*

Regular self-monitoring and evaluation is critical for measuring the progress of reconstruction projects. M&E can be carried out in a rather simple fashion by selecting key indicators (amounts of money spent on different activities, amounts of materials used and timeliness of completion of activities) and then collecting measurements and summarising them on a regular basis (weekly or fortnightly).

If any indicator shows a deviation from the budget or from construction plans, then the cause for the deviation should be identified, so that remedial measures can be taken. In addition, an external evaluation can assist by providing a second and independent assignment on crucial issues.

M&E can be complemented with 'impact monitoring', which is used to assess the environmental and social impacts of project activities. Impact monitoring provides valuable information about whether the project is in conformance with best sustainability practices (and if not, how it can be improved). Impact monitoring is also very useful for building the project partners' credibility with the local community, national authorities and international donors.


Quality check at construction site Skat

9. Choose the lifespan of houses to be built

Selecting temporary or permanent shelter options has a huge influence on the house design as well as the project's implementation procedures, budget and time-frame. It is important to decide early in planning for how long the houses should last.


Permanent housing solution in Sri Lanka Skat

10. Provide adequate temporary shelters

Reconstruction programmes that are seeking to produce quality results require time for realisation. While housing projects are being developed, displaced residents need adequate temporary shelters that ensure humane living conditions and enable residents to re-establish life as quickly as possible. Programme budgets should anticipate this need.


Temporary shelter in Haiti Skat

11. *Consider reusing and recycling temporary housing components for permanent houses to be built in the future*

Components such as well-maintained sanitary and kitchen facilities can be reused in new reconstructed houses; good-quality materials such as steel beams can be reused also.

12. *Consider the overall development concerns and priorities of your organisation*

Most organisations involved in reconstruction activities have internal guidelines and standards for their activities, including environmental policies. Ensuring that your organisation development goals, procedures and priorities are integrated into your project from the start can help to align projects with sustainable reconstruction objectives and avoid unnecessary costs.

13. *Follow principles of bio-climatic and adaptable design*

Buildings should be designed to be thermally comfortable in their climate zone with no or minimal need for mechanical heating, cooling or ventilation. Buildings should also be designed to enable occupants to modify or 'tune' their buildings to suite their particular functional requirements. Adaptable design enables this by, for example, promoting strong structural design with flexible interior space-planning.

Climate zones

Reconstruction is carried out in different climate zones, wherever a disaster happened due to an earthquake, flood, cyclone or tsunami. The guidelines focus on the following climate types:

Tropical climates

Minimum average monthly temperature is above 18°C, with a rather constant temperature throughout the day and the year. Seasons are often determined by rainfall and winds. Humidity and cloudiness create diffuse solar radiation.

Semi-arid/arid areas (dry climates)

Semi-arid and arid climates have average temperatures above 0°C in winter and above 18°C in summer. A hot-arid climate has strong sunshine with direct sun radiation. Winter nights are cold in certain regions.

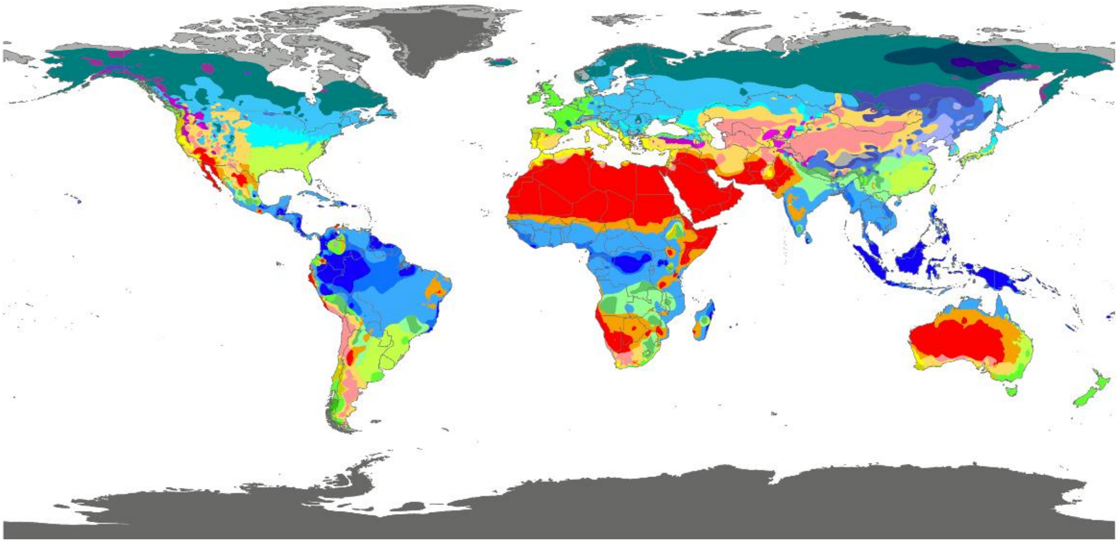
Temperate climates

These climates have an average temperature above 10°C in their warmest months (April to September in the northern hemisphere; December to March in the southern hemisphere) and a coldest month average between −3°C and 18°C.

Continental climates

These climates have an average temperature above 10°C in their warmest months, and a coldest month average below −3°C. These usually occur in the interiors of continents and are characterised by very cold/snowy winters and hot summers.

World map of Köppen-Geiger climate classification[4]



The division into different climate zones is rather approximate. Climate in mountains and microclimates can differ from the above-listed climate zones. Vegetation, topography, landscape and neighbouring buildings can each have an influence on temperatures, sun radiation, humidity and winds. In agglomerations, the microclimate can be affected by pollution, lack of winds, heat production by buildings and street surfaces and shading, and is often different from that of the surrounding rural areas.

Cross-cutting issues

Cross-cutting issues can be crucial for the success of sustainable reconstruction. Therefore, at least the following aspects should be considered:

Poverty alleviation

Sustainable reconstruction aims at improving the living conditions of people affected by disasters. Reconstruction efforts generally should target reducing the level of poverty by enhancing livelihoods, economic situations, health conditions, education and empowerment of those in need. In addition, any reconstruction programme must not make people poorer than they were before the disaster.

Local material production generates income Skat

[4] University of Melbourne in www.en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification

Minorities/marginalised people

Minorities and marginalised people are frequently excluded from reconstruction programmes. Therefore, sustainable reconstruction efforts should always proactively include any minority and marginalised communities as they are often severely affected by disasters. Often, minorities and marginalised people are neglected by local authorities and live in risk-prone areas.

Gender

In many disaster-affected countries, women, in particular, take an active part in disaster-relief initiatives and are often the main users of houses, working at home, taking care of children and elderly in the house, etc. Women's local knowledge and expertise are therefore extremely rich but largely untapped resources.

Women actively participate in a planning workshop Skat

Women are scarcely represented and often excluded from planning and decision-making processes. Interventions are often targeted only at men. Integrating women into decision-making would greatly enhance post-disaster reconstruction efforts. Both women and men can be effectively incorporated into housing design and construction activities through events, meetings and ongoing consultation processes. Care should be taken to ensure that opportunities for women and men to provide input are arranged in ways that are sensitive to the daily routines and time constraints of women and men in the target communities.

Governance

Ensuring all necessary political will (local, regional and national) is crucial for successful reconstruction. Supervision and effective coordination by the national governmental authorities are needed to ensure sustainability of reconstruction programmes. Likewise, capacity building and/or forming of new governmental bodies and institutions are important. Any reconstruction project must adhere to national rules and regulations, and national building codes must be respected and adjusted to the present situation if this is required by the relevant national bodies.

0.2 Target group

The guidelines have been designed for assisting consultants, international agencies, NGOs and government institutions as well as local authorities engaged in reconstruction activities.

A house cannot be built without fundamental knowledge of building materials and technologies. Therefore, reconstruction implementers should, as far as possible, engage qualified personnel such as project supervisors, planners and architects. These should not only have technical and organisational capacities, but also be excellent in managing teams and have good interpersonal relationships. Successful reconstruction projects are typically managed by implementers who are highly committed to the project and are good team leaders.

This manual was designed to assist such field personnel in their efforts to meet the many challenges that arise in reconstruction projects.

0.3 How to use the manual

Key challenges that face those reconstructing houses include choosing and obtaining building materials and technologies, achieving cost-effectiveness and affordability, gaining access to information, using environmentally sound and energy-efficient building practices, and winning institutional and community acceptance. The guidelines, therefore, address the following aspects of sustainable reconstruction:

Environmental – Environmental aspects/impacts on the environment

Technical – Practical, safe, robust and technically feasible solutions/user-friendliness

Institutional – Laws and regulations and their enforcement/governmental bodies

Socio-economic – Cultural aspects/livelihoods/cost-effective solutions.

The manual should be used as a flexible tool. Regardless of the stage of a project, a project manager can consult the manual at any point:

Glossary – explains the most important terms in relation to sustainable reconstruction

Information boxes – contain case studies, examples or checklists

List of links – for further reading and information resources.

0.4 Overview

The guidelines are organised according to the typical main steps of a reconstruction project. They focus on permanent housing. Yet, certain aspects are also applicable to temporary shelter programmes. The main steps are outlined in the following table, with key recommendations for each stage summarised. Each of these issues is more fully elaborated in the individual chapters.

	Steps	What to do?
Preparation		
	Assessment	Select and carry out the necessary assessments: ■ Environmental Impact Assessment ■ Community assessment ■ Damage assessment ■ Mapping and geospatial information ■ Any other…
	Set-up	■ Decide on the objectives ■ Identify the resources (funds, assets, human resources) ■ Establish project structure (office, staff, etc.) ■ Define decision-making, communication and monitoring procedures
	Community	■ Define criteria for selection ■ Identify and select a community
	Partners	■ Define the other partners ■ Identify roles and responsibilities ■ Make clear contracts
	Approach	Select appropriate approaches: ■ Donor- or owner-driven; mixed approach ■ Reconstruction at the same site or relocation
	Project definition	■ Develop a project document, based on environmental, technical, economic, social and institutional conditions ■ Develop management tools, including an action plan, time schedule, budget, risk strategy and monitoring plan ■ Clarify what rights the beneficiaries/users will have (to sell, rent) ■ Integrate action plan and budget for training/instruction concerning future maintenance ■ Undertake necessary tenders
	Site selection	■ Assess risks from natural hazards ■ Carry out an Environmental Impact Assessment ■ Check land property ownership and the right to build ■ Ensure location meets the users' needs ■ Identify surrounding settlements/activities ■ Assess stability of soil ■ Assess access to water, sanitation, energy, transport
Planning phase		

	Disaster preparedness	Select appropriate measures for disaster preparedness: ■ Vulnerability analysis ■ PASSA – Participatory Approach to Safe Shelter Awareness ■ Community-based risk assessment ■ Contingency plans
	Site plan	■ Check existing master plans ■ Indicate houses, access roads, infrastructure and services, green, recreational, commercial and religious areas ■ Indicate buffer zones to water catchment, agricultural land, sensitive natural areas ■ Identify required disaster-preparedness measures ■ Identify if any existing structures can be reused/integrated with the new buildings ■ Ensure compliance with zoning and other regulations ■ Explore expectations of future users ■ Maintain social networks
	Building design	■ Select a house shape that suits the climate and culture, and that is earthquake, cyclone and flood resistant ■ Choose building designs and materials that are energy efficient, environmentally appropriate, low-cost and practical ■ Select building components (supporting frame, foundation, floors, walls, roof) and technologies according to climate and ensure their resistance to natural hazards ■ Make sure that materials used are environmentally friendly, non-toxic, derived from sustainable sources, of good quality and socially accepted ■ Consider reuse or recycling of building material and temporary shelters ■ Design kitchens and stoves to ensure cultural acceptance, hygiene, smoke-less cooking and safety
	Infrastructure	■ Select an appropriate water-supply and sanitation system ■ Integrate a sustainable solid-waste-management system ■ Select a sustainable power system that, to the extent that is possible, uses renewable energy sources ■ Opt for access roads with adequate surface and space for extension ■ Establish telecommunication connections
Implementation		

	Project management	■ Establish a team for the implementation ■ Prepare a time line ■ Make use of local sustainable construction technologies ■ Produce the technical documentation ■ Prepare a bill of quantities and detailed budget ■ Undertake tenders ■ Maintain safe, healthy and socially just working conditions
	Quality control	■ Perform quality control of materials and works ■ Use regular monitoring for control of use of materials, environmental impact and workplace safety
	Environmentally friendly site management	■ Ensure that construction waste is disposed of properly ■ Store fuel and chemicals in contained areas to avoid leakage ■ Minimise transport as far as possible
	Material banks	■ Establish a material bank to facilitate the provision of the needed materials, if appropriate ■ Provide training for masons, labourers, engineers, as needed
	Controlled demolition	■ Consult with the local authority about demolition issues ■ Establish a step-by step activities plan ■ Sign agreements with the relevant partners
	Reuse of debris	■ Review the local possibilities for reuse of debris ■ Identify the kinds of debris materials which are appropriate for reuse
	Maintenance	■ Design the house for easy and self-evident care and maintenance ■ Ensure all materials can be worked/repaired locally ■ Fully test any and all systems (water, toilets, energy, waste disposal, cleaning, etc.) ■ Provide a checklist of regular actions needed (cleaning of storm-water drains, vegetation control, pest control) ■ Provide training/instructions for cleaning, small repairs, etc. to users and house owners

1. Preparation phase

The preparation phase of a reconstruction project is essential for the success of a sustainable reconstruction project. Preparations, such as defining the partners, approach, necessary assessments and planning, need to be carried out thoroughly.

1.1 Assessment

Housing reconstruction projects have various, often quite complex aspects. In order to ensure that reconstruction is sustainable and best reflects the needs of affected families, programmes should have included comprehensive assessment and analyses.

Reconstruction processes entail environmental challenges but also opportunities, such as a higher demand for local natural resources for construction materials and the risk for increased water and air contamination. ‘Building back safer’ encourages activities that reduce environmental impacts of the reconstruction process to avoid extreme exploitation of natural resources on which communities depend for their livelihoods.

The following issues should be noted:

- Consider the potential impacts on biodiversity. Check with national and local experts (e.g., at universities or local nature-oriented NGOs) to learn whether there are any sensitive habitats for flora or fauna in the area. Such areas should always be avoided for housing projects.

- Estimate the potential negative environmental effects (impact on freshwater supplies, generation of waste and waste water, noise and air pollution) from establishing housing in the selected area.

- Assess whether existing systems support effective management of these challenges or whether new systems are required.

- Estimate the environmental impacts, if any, from existing or planned activities nearby on the planned reconstructed houses (noise, pollution, smell, etc.).

It is recommended that an Environmental Impact Assessment is undertaken in a post-disaster situation in order to minimise negative effects of reconstruction on people and the environment.

Environmental Impact Assessment

An Environmental Impact Assessment (EIA) intends to foresee environmental impacts at an early stage in reconstruction design, to select measures to minimise unfavourable impacts, to form programmes that avoid harm to the local environment and to provide important recommendations for a ‘Build back safer’ programme. Using an EIA can have environmental and economic advantages by reducing costs and length of programme implementation, and fulfilling obligatory environmental laws and regulations.

Yet, how and when EIA is applied is often a matter of statute and guided by international standards (ISO 14000).[5] Also, there is not one generic form of EIA – the scale and cost can vary significantly.

Generally, an EIA consists of three steps:

1. Information collection through site visits, interviews with local residents and experts, and data collection from authorities and expert organisations; the EIA should, at a minimum, describe:

- disturbances to sensitive and/or protected flora/fauna
- release of pollution to air and water, and generation of waste during the houses' construction and use
- access to water and the capacity of water resources to provide sufficient volumes for the needs of the households
- noise disturbances
- potential measures to minimise any negative effects (based on technical and economic evaluations).

2. Verification of the EIA findings through public consultations with concerned stakeholders (local populations, future tenants, authorities and concerned NGOs).

3. Decision-making on whether the project is environmentally acceptable and, if so, what measures shall be taken to minimise negative impacts.

There are a number of tools which are used to undertake an EIA in a post-disaster situation:

Environmental Stewardship Review for Humanitarian Aid (ESR)

The ESR can be applied in any kind of reconstruction programme. It can be carried out in a short time (less than half a day). It entails a field visit to the proposed project site and consultation with project planners and other experts. It was developed in particular for recovery programmes.

On the positive side, the ESR can be finalised in a short amount of time by a non-expert with some expert consultation. It includes guidance on how to carry out the analysis.

Yet, the tool is project focused; it is not designed for identifying broad environmental issues at regional level associated with a disaster.

Rapid Environmental Impact Assessment in Disasters (REA)

The REA can be utilised in the first 120 days after the disaster. It includes an 'Organisational Level Assessment' which is carried out by the project team which guides the REA. It entails also a Community Level Assessment to capture the environmental issues from the perspective

[5] The ISO 14000 environmental standards exist to: (a) minimise how operations (processes, etc.) negatively affect the environment (i.e., cause adverse changes to air, water, or land); (b) comply with applicable laws, regulations and other environmentally oriented requirements; and (c) continually improve in the above.

of the communities and groups themselves affected by the disaster.

The tool is designed to be used by a non-expert.

The REA covers a broad range of environmental issues; however, it does not offer answers for the identified challenges.

Flash Environmental Assessment Tool (FEAT)

The FEAT tool is specially designed to be utilised in the first days directly after a disaster. FEAT is a quick tool to identify environmental impacts and to start first-response activities. The tool concentrates on how to measure and tackle the effects of release of chemical composites.

FEAT requires a professional level of environmental knowledge. It does not replace thorough environmental assessments, which may be suitable at later stages of the reconstruction programme.

Environmental Needs Assessment in Post-Disaster Situations: A Practical Guide for Implementation (ENA)

Originally, the ENA guide has been compiled for a core group of experts who will form an Environmental Needs Assessment Team (ENAT), with particular use by the ENA Team Leader.

The tool touches upon environmental aspects of a broader post-disaster needs assessment.

The methodology is flexible and permits classification of the broader environmental issues connected with a disaster. It entails comprehensive data-gathering.

Certain environmental expertise is required. The assessment takes up to four days on average.

(Further information about all four tools can be obtained from: World Wildlife Fund, American Red Cross, 2010, Toolkit Guide – Green Recovery and Reconstruction: Training Toolkit for Humanitarian Aid: Module 3.)

In general, the assessment phase of a sustainable reconstruction programme is very crucial and is the basis for later programme activities.

It is recommended that the following common types of assessments are considered:[6]

- Household survey: assessment of the level of damage to the buildings, the type of buildings before the disaster, land ownership, income, livelihoods, infrastructure preferences, family sizes, gender issues, etc.
- Baseline survey: assessment of the conditions before any reconstruction activity to define the pre-operation situation to develop indicators that will be used to assess achievement of the outcomes and impact expressed in the programme's design
- Stakeholder analysis: preparation of a list, at least, of the relevant stakeholders and their priorities
- Analysis of available local construction materials, including their quality, supply chains, advantages, disadvantages, etc.
- Analysis of local building practices
- Map of seasonal variations on availability of materials and labour

[6] Adapted from: RedR in Oxfam, 2008, *Beyond Brick and Mortar – Hand Book on Approaches to Permanent Shelters in Humanitarian Response*, Oxfam International, Oxford, UK

- Assessment of locally available skills and capacities for sustainable reconstruction
- Analysis of livelihoods
- Capacity and Vulnerability Assessment (CVA) of the community
- Assessment of potential constraints on scheduling of reconstruction measures during seasons and festivals.

Community assessment

Community assessments are essential for the reconstruction and the entire development process. The benefits include field verification of satellite mapping, gaining knowledge about the community that has been affected and identifying community resources and skills that can be integrated into the reconstruction activities.

Community assessment assumes that communities know best their own exposures to disaster risks.

Interview with a community member Skat

Everybody has the right to have an assessment of his/her house: for safety and equality reasons! How should this requirement be organised along with a large workload of assessments?

The following key questions can help in community assessments:[7]

- Why were people vulnerable to the hazard that occurred?
- Did vulnerabilities differ amongst various groups of people (e.g., men/women, owners/tenants, landowners/landless people, able/disabled)?
- Has the disaster further worsened the pre-disaster vulnerabilities?
- Who are the individuals or groups of people that are particularly at risk and will need special attention in reconstruction?
- What is the probability of disasters happening in this area? Does it have particular geographic features that make it vulnerable?
- Are there any other risks besides those directly related to the disaster?
- What are the local capabilities, amongst residents as well as construction workers and contractors, to build in a disaster-resistant manner?
- Are the required resources for reconstruction – human resources with the right skills and materials – available?

[7] Adapted from: IFRC – International Federation of Red Cross and Red Crescent Societies/Practical Action, 2010, *PCR Tool 3 – Learning from Disasters*, Switzerland/UK

Vulnerable groups should always be included in the community assessment process. Vulnerable groups consist of displaced people, women, the elderly, the disabled, orphans and any group exposed to potential discrimination. Vulnerable groups may require that particular steps be taken in reconstruction. Good practices include:[8]

- actively involving vulnerable group members in assessment and in all stages of decision making
- obtaining information about the needs of the affected group from both men and women
- collecting data disaggregated by sex, age, health status, economic status, etc., and then using the disaggregated data in both programme planning and monitoring
- paying special attention in assessments to groups that experience social exclusion (such as the handicapped, widows and female heads of households)
- assessing disaster impact on the informal social protection systems on which vulnerable groups depend.

Damage assessment

A damage assessment is an assessment of the total or partial destruction of physical assets, both physical units and reconstruction costs. One of the objectives of structural damage assessments is to analyse why some buildings were badly damaged and others less so.

A well-qualified team of engineers or architects with experience in sustainable reconstruction together with representatives/technical personnel from local authorities should carry out the damage assessment to ensure a certain quality of the results of the assessment.

The following key questions in damage assessments will help:[9]

- What made people's housing vulnerable to the hazard?
- What were the commonly used construction technologies and what were their strengths and weaknesses?
- What kind of aspects influenced disaster resistance within particular technologies?

Housing damage differs significantly but are often categorised according to the anticipated level of effort required to return the residents back to their homes. These categories usually entail:

- Affected: Structure is inhabitable with no additional risk to the resident. Often following earthquakes, it is common to see residents in the affected area whose structures received no damage whatsoever, but who are too scared to return because they are unable to assess the safety of their homes. Their homes may even have suffered some cosmetic damage but are nonetheless safe to inhabit. Typically, each of these structures and their

[8] Adapted from: Abhas, K. J., 2009, *Safer Homes, Stronger Communities – A Handbook for Reconstructing after Natural Disasters*, The World Bank

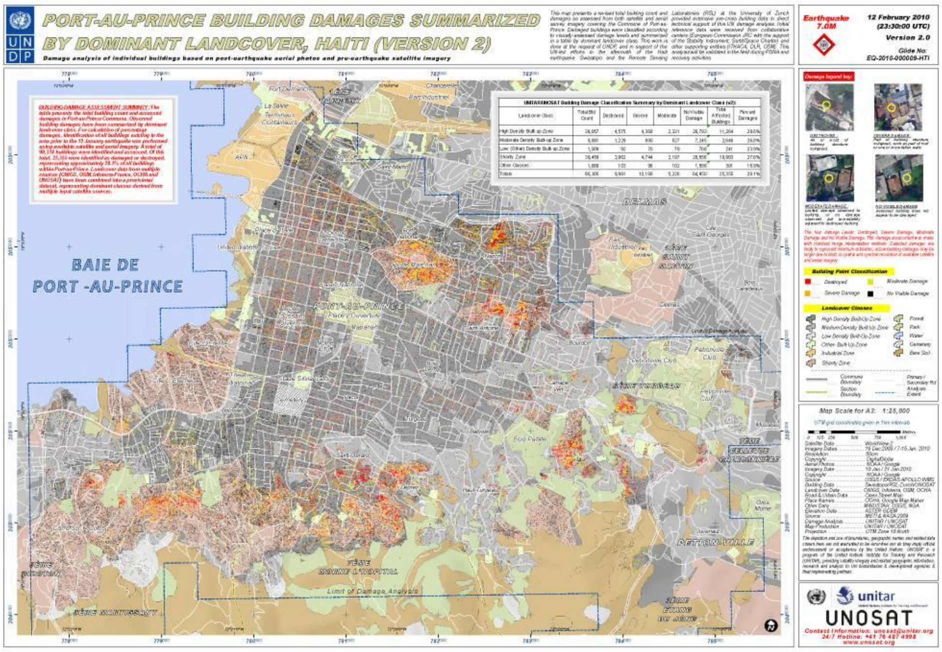
[9] Adapted from: IRP – International Recovery Platform/UNDP – United Nations Development Programme India, 2010, *Guidance Note on Recovery – Shelter*, International Recovery Platform Secretariat, Kobe, Japan

residents require nothing more than checking and reassurance from a trained architect or structural engineer who can certify the safety of the home.

- Minor damage: Structure has sustained damage that makes it uninhabitable, but minor temporary repairs can be made to enable the resident to return. For example, houses that may have lost parts of a roof or roof shingles in a cyclone may be able to return home after installing a waterproof tarp. Permanent repairs will be required in the long run, but the habitability of the home reduces the burden on temporary shelter services.
- Major damage: Structure has sustained damage that will require significant work to repair, and is unsafe to residents in its current state.
- Destroyed: Structure is permanently uninhabitable. In these cases, the home cannot be repaired and must be demolished if it is still standing.

Mapping and geospatial information

First and foremost, it is essential to identify suitable land for relocation and/or permanent housing reconstruction in the same area as before the disaster. This process requires a very close coordination between the affected communities and the relevant local authorities. Risk mapping is an important part which involves special surveys on the exposure of sites to natural risks.



Port-au-Prince building damages summarised by dominant land cover, Haiti

UNOSAT

From topocadastre to digital elevation models, geospatial information is a key element and topographic mapping a key task of any sustainable disaster risk and reconstruction strategy. A national or local cadastre ideally contains up-to-date information on land boundaries, ownership, building types and more. In combination with other geospatial information such as elevation, land use and infrastructure, this forms a geospatial data set that plays an essential role in identifying risk areas, automatically reporting changes, developing and monitoring the implementation of risk-reduction strategies as well as developing and monitoring the implementation of contingency plans, including the identification of suitable land for relocation and/or permanent housing reconstruction. Particularly the latter requires a very close coordination between the affected communities and the relevant local authorities, and accurate and up-to-date base data helps to create trust, eliminates uncertainty and helps to speed up implementation.

There are several tools which are used in the mapping process. In the following, a selection of common techniques is briefly discussed.

Remote sensing and photogrammetric mapping

Remote sensing and photogrammetric mapping techniques derive accurate geospatial information such as land use, elevation, infrastructure and geographical patterns from a distance, typically from a satellite or through aerial imaging techniques. Remotely sensed data is used to update the national cadastre, assess properties and monitor man-made change as well as natural disasters, such as floods, fires and volcanoes.

Remote sensing can also be used to provide regular updates on flooded land, which can help in calculating the amount of land required for relocation. In the post-disaster phase, monitoring systems are used to control with high accuracy the chosen area for reconstruction and, for example in the case of a landslide, to verify that the area is now stable and the movements are finished.

When linked with Geographical Information Systems (GIS) data, remote sensing can contribute to assessments of the situation after a disaster, as well as of the impacts from the past or any future disaster.

Geographical Information Systems (GIS)

Geographical Information Systems help to manage geospatial information, including data related to land, water, transport, information on the population, and socio-economic indicators. GIS data combines all geospatial data inclusive of remotely sensed imagery to assist in the decision-making process such as to predict, monitor and calculate disaster impacts.

Information derived from GIS in combination with global-positioning technology and a local reference network plays an important role in disaster risk assessment as well as emergency response.

One of the most popular uses of GIS is the Global Positioning System (GPS) which uses satellite information. Users can easily know where they are relative to their destination and how to reach it.

Geospatially enabled web

The use of Google Earth, Bing Maps and other web-based service providers can help in deriving some geospatial information as it is easily accessible via the internet and is mostly free.

However, as data provided by such services may not be accurate enough and may not be updated regularly, it should not replace local expertise and well-maintained local geospatial infrastructure including reference networks, up-to-date topocadastre, GIS and regularly updated imagery.

Google Earth: The use of Google Earth and also Google Maps can help to map settlements and villages, such as by identifying boundaries, streets, density of buildings, rivers, seashores, etc. It is easily accessible via the internet and is free. Yet, one has to keep in mind that the information obtained from Google Earth and Google Maps might not reflect the current reality. The information is updated only from time to time.

Open Street Map (OSM): Less cost intensive than the aerial imaging techniques is the Open Street Map (OSM) method. It is at the low-budget end and easy to apply. OSM is a collaborative effort to create a free editable map of the world. The maps are created using data from portable GPS devices, aerial photography, other free sources or simply from local knowledge. Registered users can upload GPS track logs and edit the data using the given editing tools. The initial map data is built from scratch by volunteers performing systematic ground surveys using handheld GPS units and notebooks, digital cameras, or voice recorders. This data is then entered into the OSM database. More recently, the availability of aerial photography and other data sources from commercial and government sources has greatly increased the speed of this work and has allowed land-use data to be collected more accurately.

Further links:

www.openstreetmap.org

haiti.openstreetmap.nl/

www.reliefweb.int/rw/rwb.nsf/doc114?OpenForm

www.esri.com

Further assessments

Further assessments include an analysis of the local construction industry and material suppliers. The future cooperation with the local/regional building industry is essential for the success of any reconstruction programme. Identifying good-quality and reliable companies for implementation is crucial. For this, the following steps are recommended:

- Contact local/regional associations of engineers and architects to receive information and references about local partners.
- Contact relevant local authorities and ministries to obtain references and further information, lists of contractors, material suppliers, etc.
- Conduct interviews with the responsible representatives of the building companies, suppliers, architects, engineers, planners, etc.
- Obtain information about prices of construction costs (price per m^2/m^3), hiring personnel and technical expertise.
- Identify typical local building practices.
- Obtain information about sources of construction material.
- Become familiar with usual procedures of warranties/guarantees, tender procedures, legal issues, laws and regulations.
- Assess the logistical challenges, transport and access issues.

1.2 Set-up of a reconstruction project

A well-functioning management process is the backbone for the success of any reconstruction project. The following key reconstruction project-management practices are recommended:

- Clarify expectations of partners and stakeholders (donor, national and local partners, implementers, etc.).
- Select reliable and skilled local partners.
- Clarify contracts and roles and responsibilities between the partners as early as possible in the process.
- Decide on the project's most important objectives.
- Agree on responsibilities and tasks, and enter a formal written agreement with partners (Memorandum of Understanding).
- Set a time-frame according to the major milestones formulated in the objectives.
- Confirm available budget.
- Select the location and target group/community.

Other preparation activities include the establishment of an office and management structure:

- Prepare office facilities and infrastructure.
- Establish the project team's professional staff, ensuring that they have adequate skills.
- Select a multidisciplinary team, according to the project's objectives, including qualified engineers (with technical background and substantial experience in housing construction), social workers (with experience in community mobilisation and participatory decision-making processes), economic specialists, etc.
- Formulate team members' job descriptions.
- Agree on decision-making, communication and monitoring procedures.
- Establish an office-management budget.
- Open a bank account.

1.3 How to identify and select a community

At the beginning of a reconstruction programme, the project team together with the key stakeholders should tackle the following questions:

- Who is entitled to housing?
- What type of housing solution are beneficiaries entitled to receive?
- How much housing assistance will they be given?

Beneficiaries are diverse Skat

The following table provides an orientation about the various categories of potential beneficiaries and related responsibilities:[10]

Categories	Type of stakeholder
Squatter (no legal status)	Squatter, if status remains informal; otherwise moves to another category
House tenant	Landlord
House owner-occupant or house landlord	Owner-occupant or landlord
Apartment tenant	Landlord (public or private)
Apartment owner-occupant or apartment landlord	Owners as a group or landlord
Land tenant	Tenant, unless tenure is not secure

One of the challenges is how to identify the most vulnerable and how to integrate them equally in the project. The following table gives an overview about guiding questions, which help to identify and select the beneficiaries:[11]

[10] Adapted from: Abhas, K. J., 2009, *Safer Homes, Stronger Communities – A Handbook for Reconstructing after Natural Disasters*, The World Bank

Criteria	Guiding questions	Issues	Recommendations
Critical points	Should all people who suffered housing losses be entitled to aid or should assistance be targeted only to specific categories of people? Is having legal status in the country a requirement? Should households not affected by the disaster be assisted if they have housing problems similar to those who were affected? How will those with a need for housing who have migrated into the disaster region after the disaster be treated?	Categories may be economic, geographic or related to some aspect of pre-disaster housing condition, but any choice can create inequitable outcomes in certain situations.	The reconstruction programme must have enough resources and administrative capacity to carry out the selection process of beneficiaries.
Assistance	Is the unit of entitlement the house, the family or the household? Is a single-person household treated differently? How is assistance calculated for a household with multiple families?	If pre-disaster housing provision was inadequate, multiple households or extended families may be sharing a single house unwillingly. Or, on the contrary, a single family may own or live in more than one house.	Make an early decision on the unit of assistance and the extent to which the goal is to address pre-disaster housing deficits.
Economic status	Is income below a certain level a qualification or do all income levels qualify?	Income records may be inaccurate, destroyed in the disaster or non-existent.	Ensure there is a feasible process for qualifying according to income.
Social issues	Do social characteristics, such as gender, class or incapacity, override income as a factor in those cases where there is an income interrupt?	Women and members of other vulnerable groups may need housing assistance.	Consider using community members to help identify those who truly need assistance.
Renters versus owners	Who gets the assistance? Renters? Owners? Both?	It is equally important for rental housing to be rebuilt yet, during reconstruction, renters may need assistance for temporary shelter.	Consider requiring owners to let renters return at similar pre-disaster rents as a condition of owners receiving assistance.
Informal tenure-holders	Is a squatter or informal settler entitled to the same housing assistance as is a property owner?	Squatters may need assistance in addition to housing. This assistance will require planning for a more comprehensive set of services. Squatters often move to a disaster area after a disaster to obtain housing assistance.	Ensure sufficient resources are available to carry out a full-service resettlement programme. Carefully examine whether it may be necessary to exclude families that have migrated after the disaster to the disaster-affected area.

[11] Adapted from: Abhas, K. J., 2009, *Safer Homes, Stronger Communities – A Handbook for Reconstructing after Natural Disasters*, The World Bank

Absentee owners versus owner-occupants	Should owners living elsewhere be entitled to housing assistance or only residents of the disaster area? Are owners of houses under construction entitled to assistance?	This issue is related to the question of the unit of assistance. If the primary motivation is to resettle residents, absentee owners may not qualify. If the neighbourhood is a concern, broader eligibility will help prevent the negative effect of abandoned properties. If the owners are migrants, their money transfers may be supporting other households in the affected area.	Try to use housing assistance as an incentive for owners to sell or rent.

After the selection process is finalised, a contract should be signed between the implementing agency and the renter and/or owner (of the land/house). The contract should at least include the time-frame, conditions, contributions (financial, labour, in-kind) and issues of maintenance.

1.4 Defining the partners

Who is doing what is a major question to address before and during reconstruction initiatives. The following paragraphs explain the various roles and responsibilities of the key players.

Roles and responsibilities

In any reconstruction activity, it is crucial to determine the roles and responsibilities of the key actors.

In cases of natural disasters, governments and local administrations in the disaster-affected areas are overwhelmed with many tasks and challenges. A huge overload, lack of knowledge and often difficult management create a great deal of stress for the key actors. Therefore, it is essential to become as familiar as possible with the local governmental structures, power relations, procedures and also potentials for problem-solving. In order to better coordinate reconstruction, the responsible local authorities need to sign official written agreements with the implementing organisations to ensure legality, protection of staff members and endorsement of programme activities.

Competencies of authorities

Central and local governments have key roles in mobilising the relevant authorities to undertake, commission and supervise the planning. They should provide the legal mandate for the reconstruction plan and technical expertise if needed. In addition, they are responsible for developing the overall reconstruction policy or strategy.

In particular, local governments should create mechanisms to encourage community participation and be committed to executing plans developed under community participation. They approve plans and prepare the regulatory framework for reconstruction activities, and undertake communication campaigns/training to ensure the reconstruction's conformity with codes and laws. Local governments approve construction plans as well, enforce building codes and land-use regulations, undertake inspections on site and execute any sanction measures if needed.

A challenging example – Port-au-Prince:[12]

The responsibility for spatial planning of metropolitan Port-au-Prince rests with the central government, which also takes care of most management, maintenance and provision of infrastructure and basic services. The municipalities are marginalised.

There is no legally approved master plan for metropolitan Port-au-Prince. Several plans with different geographic and thematic scope have been developed, most with assistance from donors, but they have neither been endorsed nor institutionalised. In practice, they have not served as a proper framework for spatial and social development but only as inspiration for a few random interventions.

Aside from the absence of an adequate master plan, the statistics and basic information concerning metropolitan Port-au-Prince are scattered and only randomly updated. Neither the central government nor the municipalities have databases or registers with reliable information on numbers of inhabitants, infrastructure, legal status of land or access to services.

According to the Ministry of Planning, there are more than 50 institutions that share the responsibility for managing metropolitan Port-au-Prince (Republic of Haiti, 2003). The responsibilities for metropolitan development and management are dispersed in a maze of government institutions, agencies, departments and divisions without any coordinating agency. Duplication and gaps are common.

Technical experts

Further, the roles of professionals should be clearly divided. Technical experts basically undertake technical assessments, analysis and data collection to support planning and implementation. They provide technical options and recommendations based on the findings of assessments and give assistance and quality control in the implementation of plans and compliance with laws and codes. Furthermore, planners and technical experts develop and carry out reconstruction activities which are in accordance with plans and building codes. They make sure that programme actions stick to governmental policies and technical information and offer feasible and sustainable options to the community and local authorities to facilitate informed decision-making. In addition, they train communities based on their needs in planning, reconstruction features and the policy framework.

The tasks of the selected professionals are summarised in the following paragraphs. Please note also that certain professional titles do not always refer to the same role within the building processes.

Architects

The architect’s job is to understand the complex needs of clients and users of building projects and, in collaboration with multidisciplinary teams, to develop and realise designs based on these. Architects’ services cover new buildings, conversions and refurbishment through a series of ‘work stages’ including: inspecting and surveying sites and existing buildings; consulting with clients and users on their requirements; coordinating the work of other professionals; testing design ideas to establish feasibility; developing selected options and preparing reports and design information ranging from site layouts to the technical details of construction and specification for estimating costs; meeting regulatory requirements; ensuring good performance; guiding construction; and aiding future maintenance. Architects can also manage the procurement process for building-related projects.

[12] Forsman, A., 2010, *A Situational Analysis of Metropolitan Port-au-Prince, Haiti – Strategic citywide spatial planning,* UN-Habitat, Nairobi, Kenya

Engineers

Civil engineering, along with structural engineering, involves the safe design, construction and maintenance of infrastructure – roads, buildings, dams, bridges, power generation, safe water supply, drainage, wastewater treatment and reuse, railways and telecommunications – with a good understanding of the specific physical and environmental risks. Engineers play leading roles in delivering transport, energy and waste solutions for complex projects. In addition to managing the project procurement process, engineers also oversee the implementation of health-and-safety measures and the integration of landscaping – particularly trees to improve microclimates, stabilise soils and control the water table. Trees modify microclimates and can assist in bio-climatic building design.

Site supervision Skat

Planners

Planners advise donors, politicians and other decision-makers dealing with local and regional development processes. The role of the planner is to help manage the development of cities and regions, towns, villages and rural areas by producing and implementing plans and policies based on evidence. Planners analyse social, economic, demographic and environmental issues to inform the physical and economic development of an area. They are involved in establishing housing, transport and infrastructure, social, economic and other needs, and play an important role in regenerating socially and economically deprived areas, and in livelihoods creation. To be effective, they must engage with the communities whose lives and livelihoods are being affected.

Surveyors

Chartered surveyors are involved in land management and measurements, land tenure and boundary issues through planning, environmental impact assessment and investment appraisal. They manage the whole construction process to ensure best use of resources and build quality, and the planned maintenance of buildings. They should work collaboratively with teams of other professionals, funders, contractors and local community partners, helping to build capacity and partnerships.

Surveyors at work Skat

Community

In the ideal case, the affected people as well as the larger community develop a joint vision for the future of the community, and for how the upcoming reconstruction could contribute to this. The community should develop a consensus on policy and strategic issues that concern the community members at large. The community participates in the land-use, physical and strategy planning processes. If possible, the community contributes in the development of detailed plans, such as zoning, settlement and housing design.

From an early stage, house owners and users can be engaged in the clearance work of debris before and during the reconstruction/repair works.

Builders

Builders play a crucial role in providing quality construction. Besides external quality control, building companies undertake an internal quality monitoring through their own site supervisors. They are responsible for timely delivery of completed buildings and infrastructure, and should cooperate with all technical experts and the community. Builders closely coordinate with material suppliers and should carry out transparent and neat bookkeeping. In addition, builders should adhere to just, safe and healthy working conditions for their workers.

Suppliers

Material traders play key roles in providing building materials and equipment. They are responsible for supplying only good-quality products and gear. They should store materials in safe and dry places. Construction materials should be certified and comply with relevant regulations and codes. In particular, suppliers should offer wood which comes only from qualified and approved origins (environmentally friendly plantations).

1.5 Selection of approach

Technical assistance can be delivered in several different ways including cash grants and owner-driven, donor-driven and integrated approaches combined with income generation/livelihoods components.

Donor-driven

Donor agencies hire contractors (commercial enterprises), who provide entire implementation of the construction and related services. Contractors should be required to use sustainable building technologies in an effective, professional and quality-conscious manner. This approach is often comparatively expensive and frequently has low support and buy-in from future residents of the houses.

Donor-driven projects are often the weakest in terms of stakeholder participation. Beneficiaries typically have minimal or no access to reconstruction decision-making processes. As a result, there is a high risk that donors will plan and implement projects without understanding or taking into account the needs of the end users and, in turn, that the new houses will not be sufficiently appreciated by the users.

Stakeholder inputs to donor-driven projects are rather restricted to the use of certain construction materials or methods, but sometimes extend to the entire house design.

Mixed donor/owner-driven approach

Contractors set up all solid construction parts, while the users take responsibility for smaller components and finishing works, such as painting, installing doors and windows, furniture, floors, kitchen/bath equipment, etc.

This approach also depends on the extent of the users' resources, whether cash or in-kind (labour) contributions, from savings or small loans (community or state loan system, micro-credit, etc.). This mixed donor/owner-driven approach is often cheaper and receives more acceptance and support from future residents.

Owner-driven

Donor agencies provide affected families with phased cash grants and the families manage the rebuilding of their houses on their own. Users can contribute with their own resources, if available, whether cash or in kind. This strategy often requires that the families involved receive training.

The drawback of this approach is that programme coordinators and donors may have difficulties knowing and controlling how owners use cash for reconstruction. Donors may not have much control over the quality of implementation. On the other hand, the residents' support and buy-in is often high under this approach.

Cash grants

Cash grants are a remarkably effective means of support to beneficiaries if they have access to their own land and have the skills and sufficient capacities to manage reconstruction/repairs works on their own. A cash grant gives residents the opportunity to access and buy materials to repair or reconstruct their homes. In addition, beneficiaries receive training on disaster-resistant construction.

With regard to resettlement activities, a lump sum of money is paid to families who have identified a new place to move to. A cash grant for building up or securing livelihoods can be provided as well. Monthly meetings or training sessions offer guidance to the families in restarting their lives.

Cash for Work

Cash for Work (CFW) is an interesting option for households who already possess their own land. CFW is provided to disaster-affected people in order to pay them to clear the land of either debris or organic material. Those people would then have access to a shelter on their own land (if appropriate to safety standards) and a small unconditional grant to assist them to re-enter the employment market or local economies.

1.6 Reconstruction at the same site or relocation

Reconstruction, and the planning process that goes with it, affects whole communities. On the individual level, beneficiaries need to determine what is best for them. But on a community level, each of these personal decisions has a wider impact. The decisions of several households to leave their homes, or the denial of the same to agree to an acquisition of their homes depending upon relocation, are only two illustrations of circumstances that can disrupt a comprehensive reconstruction effort. Programme managers will face the challenge of finding adequate solutions for the whole community.

Therefore, it is vital to take important decisions together with the community and relevant authorities such as whether residents stay at the current location or move to new one. One of the key questions is where to accommodate people in the meantime.

If there is no temporary shelter provided, affected people locate and secure their own temporary shelter in existing units. There are a number of options available to victims looking for such alternatives, which include:

- In-situ temporary shelter (on the site of the permanent reconstruction)

  In certain instances, it is possible for residents of damaged or destroyed housing to remain on their own property through the provision of temporary shelter solutions. This is most commonly facilitated through the provision of tents; prefabricated or easily assembled robust structures can be used also. If the permanent structure is only moderately damaged, the affected family may return immediately through the provision of minor repairs, such as tarps to cover damaged roofs, with more permanent construction coming later. If the structure is more severely damaged, the family will have to find another location near to their property where their presence does not interfere with the demolition and reconstruction of the structure.

  There are a number of positive implications to long-term shelter recovery associated with this approach, including:

  - It is easier for victims to maintain their livelihoods and community networks, which are critical components of long-term shelter reconstruction.
  - Affected families are better able to join in the design and reconstruction of their home given their proximity.
  - There is less disturbance to the community because formal and informal social networks may be sustained.
  - The need to identify and provide additional property for other shelter locations is minimised.
  - In-situ temporary shelter helps to ensure affected families are more involved and invested in their own reconstruction efforts.
  - If constructed on site, temporary shelter options can be modified or recycled to improve the quality and function of the permanent structure.
  - Affected families who are actively involved in their reconstruction efforts might be in a better position to lobby for improved access to infrastructure and services.

- Renting a house or apartment

  - Rental assistance allows disaster-affected people to temporarily relocate outside the affected areas and may increase the likelihood that they return once recovery has occurred given that the rental property is not a viable long-term option.
  - Rental assistance can allow for more immediate yet dignified shelter.

- The primary challenges associated with rental assistance include rapidly escalating costs that occur when long-term housing options are not available.
- Rental assistance that allows affected people to relocate into hotels, motels and other available housing can be an effective solution in the short term, but rather costly. The question of who pays for it needs to be clarified.

Recommendations for the decision to rebuild or relocate communities:

- Consider whether relocation is really needed or if damaged houses can be rebuilt at the same location to make the reconstruction process smoother and to cause less disruption to people and the environment.
- Ensure that all consultations with the affected people are finalised before a decision is made public.
- Be aware that relocation will involve more environmental resources than will rebuilding.
- Consider the fact that relocation requires many steps and actions engaging various stakeholders.
- Note that keeping disaster-affected people in the same location decreases the number of steps to recovery, but may also raise concerns about safety and risk prevention.

1.7 Project definition

The project-definition stage is crucial for attaining a well-functioning and sustainable reconstruction concept.

One of the main activities of the project-definition stage is developing a project document based on environmental, technical, economic, social and institutional conditions.

The project documents also include all necessary information on the selected approach (see previous chapters), a sound action plan (log-frame matrix), time schedule, budget and monitoring plan.

Establishing an action plan

An action plan contains major milestones, time-frames and costs, and identifies the parties responsible for each activity.

The Logical Framework Matrix (‘log-frame’) is a useful tool for structuring and describing the action plan. Below is an example (not complete) of how a log-frame might look for a housing project.

Log-frames come in many different forms. Project implementers should use the form they feel most comfortable with. It is also possible to include/exclude elements, as long as the log-frame maintains its overall logical approach and links wider objectives and needs with specific results, activities and indicators.

Sample log-frame matrix:

<table>
<tr><th>Overall objective</th><th>Indicators</th><th colspan="3">Assumptions</th></tr>
<tr><td>Long-term vulnerability to disasters of Tsunami-affected communities in … region is substantially reduced.</td><td>1.1 Human development index of …region is improved by ….</td><td colspan="3">No other major natural disasters occur.</td></tr>
<tr><th>Project purposes</th><th>Indicators</th><th colspan="3">Assumptions</th></tr>
<tr><td>1. 1,259 families in four villages are rehabilitated in safe and sustainable habitat.</td><td>1.1 Percentage of reconstructed houses that comply with regional safety and environmental standards.</td><td colspan="3">Regional safety and environmental standards exist and applicable.</td></tr>
<tr><th>Results</th><th>Indicators</th><th colspan="3">Assumptions</th></tr>
<tr><td>1. Development of three village settlements in safe locations with necessary community infrastructure and facilities.
2. Reconstruction of 1,259 houses that are technically safe for multiple hazard situations (e.g., cyclone and earthquake resistant) and environment friendly (shelter & basic amenities)</td><td>1.1 Settlement design approved by village community representatives.
1.2 Settlement layouts and design of community. infrastructure approved by concerned government agency.
2.1 Physical development of villages as per drawings and approvals.</td><td colspan="3">1. Village community representatives have the good will and commitment to support the reconstruction initiative.
2. Good architect and planners are available.</td></tr>
<tr><th>Project activities</th><th>Means of verification</th><th>Assumptions</th><th>Costs</th><th>Time frame/ responsible person</th></tr>
<tr><td>1.1 Procurement of land title from the government

2.1 Approval of designs by village community and concerned local authority.
…and so on</td><td>1.1 Copy of letter with notification from the government received

2.1 Protocol of approving session</td><td>1. Appropriate land is available

2. Local authority has high commitment to the reconstruction project</td><td>1.1 Working hours
1.2 Land title fees
2.1 Working hours</td><td>1.1 by 30 Nov 2008/ Roger N.

2.1 by 15 January 2009/ Peter M.</td></tr>
<tr><th>Risks</th><th>Risk mitigation concept</th><th>Activities to mitigate risks</th><th colspan="2">Expected outcome</th></tr>
<tr><td>a. to achieving results
1. Unexpected natural disaster occurs (e.g., big earthquake)

2. Substandard construction material is delivered to the site</td><td>1. Earthquake resistant settlement

2. Quality management and control</td><td>1.1 Houses are built to be earthquake resistant from the foundation upwards
2.1 Establish a working strategy for how to control quality of delivered material</td><td colspan="2">1.1 Houses resistant to earthquakes of specified magnitudes

2.1 Material is controlled regularly at site</td></tr>
<tr><td>b. to achieving project purposes
1. Missing commitment by local implementers</td><td>1. Strategy…
2. …</td><td>1.1 …
1.2 …
2.1 …</td><td colspan="2">1. …
2. …</td></tr>
<tr><td>c. to achieving overall objective
1. Political instability</td><td>1. …
2. …</td><td>1.1 …
1.2 …
2.1 …</td><td colspan="2">1. …
2. …</td></tr>
</table>

Time schedule

A project time schedule should include all steps of the reconstruction project. The schedule is a time plan for ensuring that materials, services and works are carried out in a logical sequence and timely manner.

Careful forethought and planning are required for sound site organisation. It is recommended that a strategy for handling time delays is developed. The strategy should be based on local resources and opportunities.

Preparing a Bar Chart is essential to determine the feasibility of completing work on time. This chart lists the sequence of building activities with the corresponding time phases for completing each activity. It takes into account holidays, extreme weather conditions and other causes that are likely to generate delays. A simplified Bar Chart is presented in Annex IV.

Budget

Together with the time schedule and the log-frame, the project budget is the key management tool for any cost-effective sustainable reconstruction project. The project manager prepares a budget which considers necessary financial allocations according to the time plan.

Usually, the project manager establishes a cost calculation during the early planning phase so that he/she can calculate all project costs. While the costs included in the budget should include only those activities that are carried out within the project itself, it is strongly recommended that a life-cycle approach be taken for identifying the most cost-effective housing designs (see box).

Life-cycle costs include:

- investment (plot, materials, transport, construction, labour, machines, fuel)
- operation (energy, electricity)
- maintenance (repairs, replacement)
- demolishing and recycling/disposal (labour, fuel, transport, machines, material).

Manage life-cycle costs through:

- defining the project’s scope, level of quality and budget
- monitoring these three components.

Life-cycle costs can be minimised through:

- compact and simple house design, which is faster to construct and easier to maintain
- avoiding complicated roof shapes
- avoiding many angles in external walls
- using local and robust materials.

When calculating project costs, include not only costs for materials and work, but also for transport, energy, permitting/licensing, insurance, monitoring/evaluation, construction-waste handling and connections to existing infrastructure (roads, pipes, sewerage, electricity, phone line, etc.).

Additional recommended steps include:

- factoring in inflation or potential price rises for materials and services, and developing a strategy for coping with them; it is often quite reasonable to assume up to 50 per cent increase in the price for some services or materials
- determining together with users the level of their contributions (in kind or in cash)
- assessing whether the donor would allow a higher budget for environmental or social benefits
- exploring co-funding opportunities.

Tendering

The tendering requirements are essential in determining what implementation approach is most suitable, what the total project costs will be and how long the process will take. Check requirements of the tendering process by the government or your own organisation.

The following steps in a tendering process are recommended:

- Draft an initial tender describing the work that is required.
- Procure information about (local) contractors, visit companies and conduct interviews.
- Compile a short list of contractors qualified to undertake the work.
- Draft and send out tender documents or make a public tender announcement.
- Receive tenders from contractors who formulate and send back tenders at a specific date.
- Open tenders in public or by a selected committee.
- Undertake tender analysis.
- Ensure that bidding documents, Terms of Reference, and other contracting documents indicate that contractors will procure construction materials from sources that are environmentally sustainable.
- Draft document proposal for awarding contract (it might be required to review the bill of quantities or planning/implementation documentation).
- Select contractor and undertake contracting.

1.8 Site selection

Carefully finding a suitable site is a key step that can determine the success or failure of a reconstruction programme. Reconstruction settlements in hazardous areas are vulnerable to earthquakes, floods, landslides, cyclones, etc. An assessment of potential risks at reconstruction sites is, therefore, crucial to avoid repeated destruction.

Site selection should be made based on a careful determination of principal or pre-existing land rights, including customary rights and, in the case of resettlement, the rights of neighbouring communities. Where such rights exist, local consent or a lease contract should be agreed upon in order to avoid host community tensions.

Another challenge is that beneficiaries may not accept particular site locations for various reasons, including the site's history or other sociocultural issues. Site selection should be based on the informed approval of persons displaced by the disaster.

Reconstruction actors should provide information on site risks to allow displaced persons to make informed decisions. Even in cases where the government provides plots for reconstruction or resettlements, programme managers need to collect the same information to be aware of existing disputes and claims.

Please refer to Annex IV for an overview about the various roles and responsibilities in the site-selection process.

In order to select a suitable construction site, project managers should consider a number of issues and should verify facts and recommendations with intended users and local stakeholders. The key factors to consider when choosing a site include:

Environmental aspects

- Assess whether the reconstruction activities infringe upon any wild animals' territory to avoid human-wildlife conflicts.
- Avoid any environmental degradation, such as erosion and deforestation. Consider the local environmental resources to prevent damage to agricultural livelihoods and land.
- Choose an appropriate number of people at the new site that will not lead to excessive resource requirements and will not unsustainably utilise locally existing natural resources.
- Assess the site's existing vegetation. Check whether it is necessary to clear trees or bushes from the site or, alternatively, to reforest the site to create a cooler microclimate or stabilise soils.

Technical aspects

- Assess risks from natural hazards (e.g., tidal waves, storm surges, landslides, heavy rainfall, earthquakes and cyclones) and avoid rebuilding in unsafe zones. As part of the assessment, check municipal flood records.

Recommended steps on how to assess flood safety:

- Consult local authorities for flood records.
- Ask neighbours and older residents about previous flooding.
- Identify benchmarks from high tides, if possible.

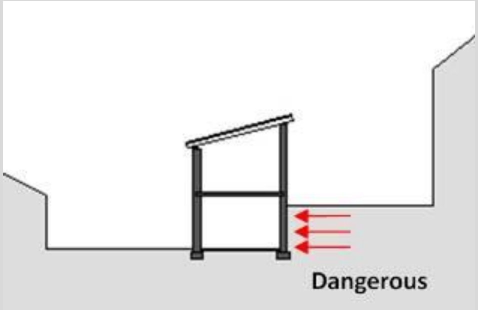
- Select a site that is out of reach of storm surges and tidal waves. Check with the responsible local authority whether there are any buffer zones, i.e., safety zones that extend beyond the highest previous level of flooding.
- Analyse access to clean water, roads, shops and markets, schools and health facilities, and employment.
- Analyse conditions and technical requirements for water supply, sanitation, waste management and power supply.
- Check for existing connections to municipal water mains. Assess their condition and the measures needed to connect the site to the municipal mains.
- Check whether local reconstruction materials are available at the site or nearby in order to minimise transport costs.
- Note that vegetation can help mitigate the effect of hazards to settlements. In areas vulnerable to natural hazards, use trees with long root structures (in cyclone areas, put them together with bushy shrubs as windbreaks).
- Try to create a ‘bio-shield’ (e.g., trees, bushes) in tsunami-prone areas to slow the tsunami wave.
- Assess site topography: when possible, favour elevated (but flat) sites in order to avoid flooding and use shallow bedrock conditions for seismic protection.
- Check the slope stability (angle, soil type, drainage, etc.).
- Assess soil characteristics. This provides important information for determining: foundation type (strip or slab); depth for drilling water wells; and where to dig holes for septic tanks (rocky ground is not very suitable).
- Consider whether land filling is needed to elevate new buildings above likely flooding levels. Fill material should come from deep borrow pits or controlled sources to avoid causing landslides.
- Assess impacts from nearby industries and airports (e.g., noise, pollution, etc.) and determine how to minimise disturbances.
- Check water quality through chemical/physical testing. Determine whether groundwater is contaminated and, if so, arrange the delivery of water supplies from safe sources.
- Identify the groundwater table’s depth. This will be important information for purposes of establishing foundation depth and size as well as the depth and distance required between latrine systems/septic tanks and water tanks.

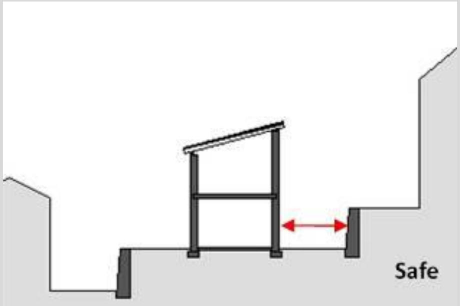
- Assess the site's existing buildings and infrastructure. Determine whether demolition works will be needed or whether, alternatively, existing buildings can be recycled or integrated into the new constructions.
- Ensure that the slope of the site does not exceed 5 per cent.
- Ensure that pest breeding spots have been limited in the site.
- Choose sites that create beneficial microclimates and orientations to increase the effectiveness of bio-climatic design strategies. If considering on-site electricity generation through PV panels, ensure that suitable unshaded and well-oriented areas are set aside for installation of panels.

Placement of houses on sloped sites

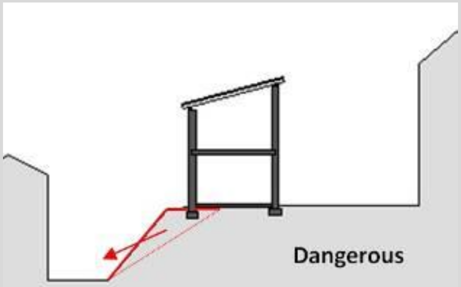
In earthquake-affected regions, the following guidelines should be taken into account

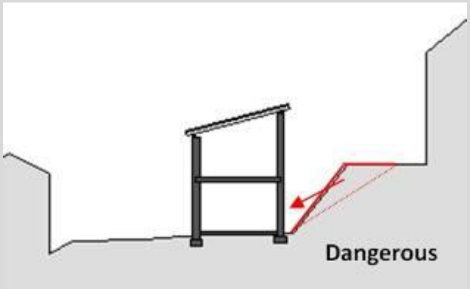
- The house should not be cut into the slope, as the flanking wall might collapse due to horizontal forces.



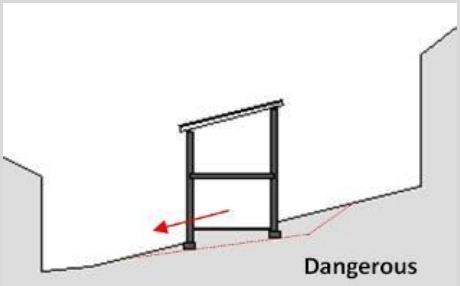


- The house should not be located close to steep slopes or cliffs or it might collapse due to falling rocks or landslides.

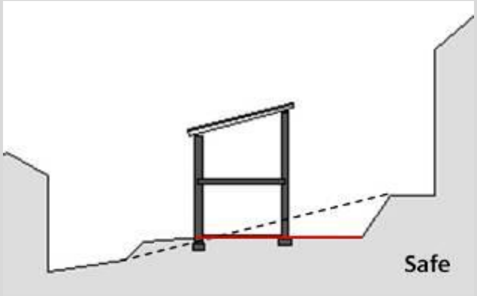


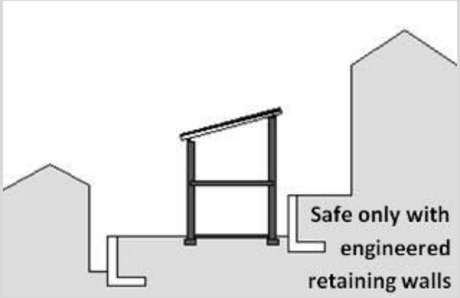


- When siting houses on soft, sandy undergrounds, select massive and heavy houses styles. For rocky soils, choose light and flexible structures.
- The house should not be placed onto the slope or it might slip down.



- If a sloped area cannot be avoided, a platform should be built first and the house should be placed at a secure distance from the adjacent slopes.





- Avoid multiple floor levels.

(Adapted from: Minke, G., 2001)

Field assessment of site quality

- Favour sites on open and even topography over hills and steep slopes.
- Favour several buildings on terraces over having a large building with foundations at different levels.
- Avoid sites that are likely to liquefy during an earthquake.
- Avoid building on unstable slopes that could fail or slide during an earthquake.
- Buildings of up to two floors can be built on solid rocks. Buildings on solid rocks and firm soils endure better than do buildings on soft sandy, clay or silty grounds.

For more information on how to assess soil strength, please refer to Annex IV.

Social aspects

- Use an appropriate participatory decision-making process to select an appropriate site.
- Ensure users' acceptance of site location.
- Ensure the location's accessibility to road networks, town, jobs, shops and markets, health facilities and other infrastructure.
- Consider whether neighbouring settlements of different ethnic groups are an issue.
- Assess the issue of resettlement. Relocating residents without their definite acceptance of the new site may lead to resistance, users' moving back to their former locations and other problems.
- Check whether the new area meets the population's need in terms of social infrastructure and economic activities.
- Inform and prepare affected people. It is important to achieve full participation of the target group.

Legal aspects

- Make sure that formal land titles are available.
- Support the restoration of pre-disaster lease agreements, if needed.
- Consider using the following documents which may help where formal land titles are unavailable:
  - Signed statements of ownership verified by neighbours and/or community leaders
  - Placement of property or boundary markers by survivors in consultation with neighbours
  - Informal maps of land plots and existing trees, burial locations, ritual locations and public areas agreed through community procedures
  - Signed statements of inheritance verified by family members
  - Signed statements of guardianship of orphans verified by community members.
- Clarify who will be the landowner in order to avoid future conflicts and even the eviction of residents.
- Use gender-sensitive databases: post-disaster tenure documentation databases should include fields to record: (1) details of women's rights to land, including rights other than ownership; and (2) marital land co-owned by a husband or wife.
- Support the collection of supporting evidence documents. Where formalisation of land rights will enhance tenure security for landholders, reconstruction programme beneficiaries should be assisted to collect evidence for requests to record or register formal legal rights to their land, wherever possible in the names of men and women.
- Consider what kind of rights the owners should have (e.g., to sell, rent, assign to heirs, etc.).
- Use simple boundary identification. Often, community members and programmes need only identify basic parcel layouts and sites for utilities and public facilities.[13] Formal surveying of boundaries is expensive, time-consuming and may be difficult or impossible to achieve at the required national standard.
- Aim at resolving disputes. Interim tenure documentation should not be issued where rights to land remain uncertain, but the parties should rather be referred to mediation and arbitration procedures.
- Clarify with local authorities the building permits required at the site.

[13] Formal surveying of boundaries is expensive, time-consuming and may be difficult or impossible to achieve at the required national standard.

2. Planning phase

The planning process is a crucial step towards sustainable reconstruction. It involves a variety of professionals and experts and includes the following steps:

- Determine the priorities for sustainable development in the affected region.
- Create an overall concept for the reconstruction, based on the assessments, analyses, and consultations with all relevant stakeholders (community, governmental bodies, other development agencies, etc.).
- Check whether the planned reconstruction complies with the national laws and regulations, building codes and standards (for the Sphere standards, please see Annex III).
- Undertake a site survey.
- Develop a site/settlement plan based on the findings and analyses; consult with the beneficiaries, governmental authorities and development agencies.
- Check whether the site plan contains sufficient disaster-preparedness components.
- Develop a building design, based on aspects of climate, energy efficiency, low consumption and disaster prevention.
- Obtain approvals.
- Prepare detailed technical construction plans for buildings and infrastructure.

2.1 Disaster preparedness

Disaster preparedness aims at decreasing to the lowest possible level, the potential loss of human lives and harm to buildings and infrastructure, as well as to the natural environment. This requires communities and authorities to ensure quick and effective actions in response to disasters, including early-warning systems and well-prepared contingency planning.

Disaster risks can be tremendously reduced, where local authorities, in partnership with the local communities, have started to map disaster risks. Good practices show that it usually depends upon the effectiveness and quality of institutions and governments.

In order to be well prepared for future disasters, a vulnerability analysis should be carried out.

Vulnerability analysis

Communities often lack a good understanding of hazards and their associated risks. If they want to become more resilient, they need to develop skills to analyse and understand the hazards that affect their lives. In order to reach this level of resilience, organisations can work directly with communities to carry out systematic vulnerability analyses, and/or train community leaders to facilitate community analyses. An analysis of vulnerabilities can be carried out in a participatory way, and can help to identify at-risk households within a community and those most in need of support.
An analysis of hazards can include the following key considerations:[14]

[14] Adapted from: IFRC – International Federation of Red Cross and Red Crescent Societies/Practical Action, 2010, *PCR Tool 3 – Learning from Disasters*, Switzerland/UK

- Identify what different hazards have affected the community or particular groups, both on a regular basis and as one-offs.
- Prioritise the different hazards, e.g., according to severity, numbers affected or frequency.
- Explore further the prioritised hazards with the following questions and tools:
  - What is the typical frequency and duration of this hazard; has it changed over time?
  - Are there any warning signs that indicate that a hazard event is likely to occur; are there any early-warning systems?
  - Are there any underlying causes of the hazards and does the community understand them, or how to address them?
  - Which groups within the community are most affected and how?
  - Which communal or individual assets are affected and how?
  - How do different groups typically respond immediately after the hazard occurs (are there contingency plans, safe areas, emergency resources, response organisations, etc.)?
  - What particular long-term coping strategies do these people (and particularly vulnerable groups) use to recover from the hazard impact?
  - Based on the issues raised, what opportunities and capacities are available, or could be strengthened, to help people cope and recover when hazards and stresses occur?

Suggested tools to use are group discussion, hazard mapping, storytelling and the EMMA toolkit to analyse changes to market systems, etc.

Sustainable reconstruction efforts in hazard-prone areas can be enhanced through the integration of disaster preparedness and risk-reduction elements. Any reconstruction programme should go beyond mere housing provision. What does ‘preparing for disasters’ mean? What are the ‘ingredients’ of good governance to enhance community contracts, participative budgets, PASSA – Participatory Approach to Safe Shelter Awareness, contingency planning and simulations?

PASSA – Participatory Approach to Safe Shelter Awareness

The purpose of the PASSA methodology is to provide communities with tools to improve their living conditions, build safer housing and design more sustainable settlements by using a step-by-step method. PASSA tools offer communities knowledge and training to solve their own housing problems and aim at encouraging changes in behaviour and attitudes.
The method includes the following activities:[15]

- Develop a **historical profile**: To allow the community to identify hazards and vulnerabilities that exist in the community using local historical knowledge.
- Identify **frequency and impact of hazards**: To enable the community to classify the most important shelter hazards using pictures, photos, etc.

[15] Adapted from: IFRC – International Federation of Red Cross and Red Crescent Societies, 2010, *Participatory Approach for Safe Shelter Awareness (PASSA)*, case study sheet, , Geneva, Switzerland

- Undertake **community mapping and visits**: Map the community's housing conditions and identify potential hazards.
- Classify **safe shelter and unsafe shelter**: Use three-pile sorting drawings and sets of cards to facilitate the categorisation of safe, unsafe and in-between housing and settlement components in the community.
- Identify **options for solutions**: Use the safe and unsafe piles from the previous activity to enable participants to identify options for safe housing and understand how effective each solution is at improving housing safety.
- **Plan for change**: Facilitate development of a community action plan to improve housing safety.
- Establish a **problem box**: Allow the community to review previous decisions and validate all steps and decisions taken.
- Install a **monitoring plan**: Enable the community to monitor and evaluate progress and outcomes against the agreed community safe housing plan.
- **Measure achievement**: Use various tools to facilitate the identification of key results.

Community-based risk assessment

Community-based risk assessment should not be undertaken only to gather information, but rather to form a core component of community-based disaster risk management. Just by being engaged through participatory assessment processes, the community's awareness and understanding of risks are enhanced.

Equally important, through 'learning by doing', is that communities become aware of their own resources, capacities and ways for managing risk. This can create a sense of ownership and empowerment, generating a culture of prevention within vulnerable communities.

During and after a community-based risk assessment, local disaster risk-management plans should be developed. These should include contingency plans, defining not only what to do in case of a disaster, but also who will be responsible for distinct activities.

Contingency plans

Contingency planning is an important component within the broader framework of disaster preparedness, which includes early-warning mechanisms, capacity building, creation and maintenance of stand-by capacities, and stockpiling, among others.
Contingency planning is a process that includes four broad components. Local governments and organisations may follow these steps:[16]

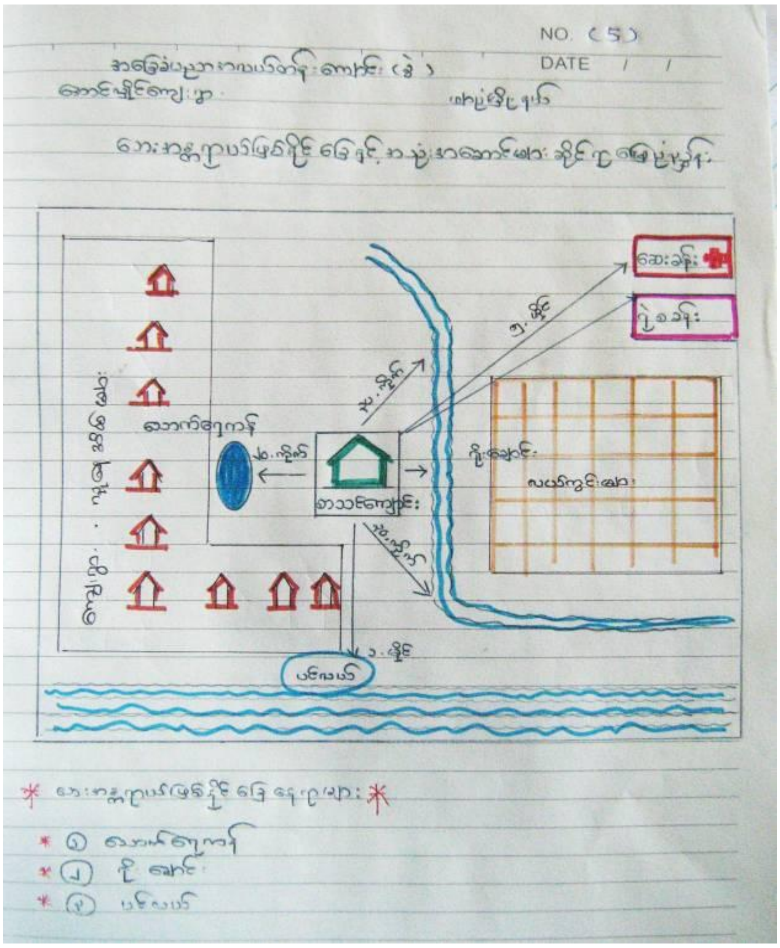
- **Preparation:** Prepare for and organise contingency-planning process.
- **Analysis:** Analyse hazards and risks, build scenarios and develop planning assumptions.
- **Response planning:** Define response objectives and strategies; define management and coordination mechanisms; develop and approve response plan.

[16] Adapted from: UN OCHA – Office for the Coordination of Humanitarian Affairs, *Disaster Response Preparedness Toolkit*: www.ocha.unog.ch/drptoolkit/PContingencyPlanning.html

- **Follow-up and continuation of the process:** Enhance preparedness and continue the planning process.

A good disaster contingency plan consists of organising resources, assessing risks, developing a plan, implementing the plan and monitoring it. The plan is a constantly changing document and needs regular updates. The plan needs to be flexible because communities and resources change over time. The goal of a contingency plan is to decrease or prevent the loss of life. The plan aims at reducing property damage resulting from natural hazards. Communities need to understand that contingency plans might be different for different types of emergencies, depending on the type of hazard (flooding, earthquake, cyclone, etc.).

The following steps are recommended at household level:



A locally prepared contingency plan

Skat

- **Organise your resources:** Take an inventory of resources that would be needed and available in the event of various emergencies. Resources can be other people as well as organisations. Create an emergency list of contacts. Create an inventory of household items and family assets. Keep it in a water and fireproof safe.

- **Assess your risks:** Determine the potential problems in your household and in your community. Include cyclones or wind storms in your plan if you live in an area prone to these meteorological events.

- **Develop a plan and set priorities:** Make an evacuation map of your home. Include each room and possible escape routes from each room. Consider where your family would meet if a disaster happened while your children were at school and you were at work. Learn how to turn off your utilities.

- **Implement the plan and monitor its progress:** Hold regular trainings at home. Make sure everyone knows where to go and what to do in an emergency.

- **Make an emergency kit:** Include blankets, food, water, a flashlight and batteries. If possible, include a first-aid kit, extra clothes, a toolkit, tape, a tow line, a utility knife and extra medication, if applicable.

A **Community Risk Register** may be applicable. Such a register maps all hazards and threats for the concerned district. This helps the community and the responsible local authority to prioritise the top risks. The authorities together with the communities identify how to treat these risks through reduction of either impact or probability. This includes everything from a small correction to long-term measures.

Rules of thumb – how to select the best flooding response strategy:

- Buildings should be elevated (but avoid complicated stilt constructions).
- Access-ways to buildings have to be safe and waterless.
- Any land fillings or new dams should allow running off of water from heavy rains or tidal waves.
- Flooding response strategy should not create any unwanted water ponds.

Roles and responsibilities in disaster preparedness

Partnerships are essential but also it is necessary for communities to be self-supporting and sustaining. Disaster preparedness requires that the concerned parties around and within a community overtake the necessary roles and responsibilities. There is a great need for better coordination and stronger partnerships between communities, local authorities and national governments, with the aim to recognise and accept each other's responsibilities and tasks within disaster prevention.

On the one hand, national governments need to do more, such as to clarify financial needs of communities; on the other hand, communities and families have certain responsibilities for making their homes safer.

Governments not only need to provide financial support for disaster-preparedness activities in communities, but also to encourage families and individuals to invest in their own assets' exposure to natural hazards. Financial support could be mobilised through credit/microfinance schemes specifically for risk-reduction measures.

Local governments should have key roles as 'risk reducers':[17]

- They provide infrastructure and services (some perhaps are contracted to private enterprises or NGOs).
- They guide where development takes place – for instance influencing where settlements develop and where they do not, and what provision they have to avoid floods or fires.
- They regulate hazardous activities that can cause disasters (industries, transport accidents).
- They have an influence on land availability (land-use regulations, zoning, bureaucratic procedures for buying or obtaining land and for deciding what can be built on it); the quality of land-use management influences the proportion of poorer groups having to live on hazardous/disaster-prone sites.

[17] Adapted from: AURAN – African Urban Risk Analysis Network, Investigating urban risk accumulation in six countries in Africa, 2007, International Federation of Red Cross and Red Crescent Societies/ProVention Consortium: www.proventionconsortium.org/themes/default/pdfs/urban_risk/AURAN_May07.pdf

- They encourage/support household/community action that reduces risk (for instance, better-quality housing, safer sites and good infrastructure).
- They provide 'law and order', which should also act to protect the poor from risk.

The communities are the first responders in any emergency situation and are also the ones that have to deal with a whole range of disaster issues. With regard to enhancing communities' disaster preparedness, awareness-raising of school children is essential. Children should be educated in what they can contribute to prepare their families for emergencies of all kinds. The children's interest could stimulate parents to take action in preparing for emergency situations due to disasters. This may create a generation of people who are conscious of how they can protect and help themselves in a range of incidents.

Because of the participatory nature of the community assessment, local authorities are usually involved to assure their consent with planned risk-reduction measures and, to a certain degree, with strengthening sustainability. In general, the process should bring communities and local authorities into closer contact and partnerships with other stakeholders with the aim to reduce potential disaster risk.

There is a range of methods available for community-based risk assessment. This permits a flexible use of different tools to adapt to particular contexts. Generally, a mix of tools and methods is used, such as focus-group discussions, semi-structured interviews, observations, random walks, seasonal calendars, historical profiles, household vulnerability assessments, livelihoods analyses, institutional and social network analyses, Venn diagrams, and collection and review of secondary data.

These participatory approaches also provide opportunities to share technical information with communities, although this often requires a non-technical language which enables communities to find the significance of their exposure to any risks in their daily lives.

As a mix of qualitative and quantitative approaches, community-based risk assessment often concentrates on the vulnerability and capacity aspects of risk. The Red Cross Red Crescent approach uses the Vulnerability and Capacity Assessment (VCA), while hazard assessments are often integrated, in that, they currently tend not to utilise much scientific or technical information. However, as data availability and resolution increasingly improve, technical hazard analyses are becoming more available at the local level. Still, local use of technical data continues to be challenged by information delivery, sometimes due to a lack of local capacity for understanding or processing scientific/technical information.

The following checklist of disaster risk issues shows what to consider in a sustainable reconstruction programme:[18]

Assessments

- Map the history of hazards, in particular the location, frequency, magnitude and severity, resulting impact and vulnerabilities.
- Assess local construction practices and their effectiveness in addressing disaster risks in the past.

[18] Adapted from: Oxfam, 2008, *Beyond Brick and Mortar – Hand Book on Approaches to Permanent Shelters in Humanitarian Response*, Oxfam International, Oxford, UK

Planning and design

- Always seek specialists' advice on design and technical standards to address hazard risks.
- Assess the suitability of the reconstruction site and detail a plan for site-preparation works.
- Coordinate with the key stakeholders involved in reconstruction to exchange good practices and knowledge.
- Ensure that the programme team has appropriate knowledge and expertise in disaster risk reduction (DRR) and disaster-preparedness integration in the reconstruction programme.
- Indicate the essential design considerations which are necessary to address specific hazard risks.
- Review existing codes of practice for hazard resistance to assess whether they are adequate or whether they need to be adapted to the given context.
- Study the good practices and challenges of other reconstruction programmes to assess the suitability of codes of practice and norms.

Materials and technologies

- Use only new construction technologies which are properly tested for addressing hazard risks.
- Establish a reconstruction-management system which is competent to give the technical input and supervision required for dealing with hazard risk conditions, to monitor construction material quality and to build on local capacities.

Community aspects

- Support communities to develop contingency plans and rescue plans, and to make them understand the various hazard threats.
- Facilitate the integration of DRR aspects into other sector interventions to develop a one-programme approach.

Prepare rescue plans together with the community Skat

Communication and disaster preparedness

Good communication is often a challenge in dealing with disasters. In order to ensure effective disaster preparedness, it is essential that the following questions are addressed:

- How do people behave when they obtain risk information?
- What is the role of social networking in sharing disaster risk information?
- How do new means of communication support a better exchange of risk information to enhance the communities' resilience?

Preparing for a future disaster

Planning for an emergency and for how communities and authorities would respond, when and with whom, drafting checklists, preparing emergency kits, and knowing where to evacuate to, are essential steps of preparedness.

All the steps should consider environmental concerns to ensure a sustainable response and reconstruction.

The whole community needs to know where to evacuate to Skat

The following steps are recommended:

- Identify clearly where temporary shelters will be installed in the case of a disaster.
- Make sure that protected zones are not infringed.

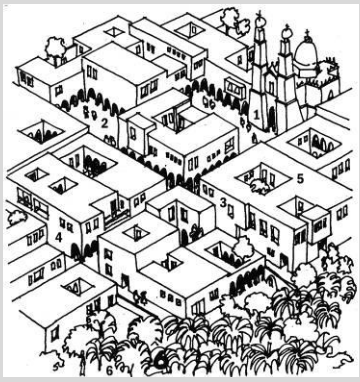
2.2 Site plan

Before developing the site plan, check the overall master or settlement plan of the region, town or village, if any, to ensure compliance with its requirements. Planners need to verify its relevance and to see whether there is need for revision.

A master plan should address any climate-responsive requirements:[19]

Tropical climate

- Foresee squares with sufficient vegetation and trees.
- Plan commercial areas with porticos for protection from rain.
- Provide open spaces for ventilation.
- Plan for large streets lined with shading trees.
- Provide large covered public areas.
- Plan for streets that follow the natural landscape levels with drainage towards canals, rivers and lakes.



Van Lengen, J., 2008

Semi-arid/arid and hot climate

- Foresee small squares with high buildings that provide shading in the streets.
- Use porticos to shade commercial and public areas.
- Make sure that main streets are located north-south so that one side is always in the shade.
- Plan for buildings that are joined to each other and have interior courtyards.
- Locate parks on lower ground level to receive rainwater drainage as irrigation.

[19] Adapted from: Van Lengen, J., 2008, *The Barefoot Architect*, Shelter Publications, Bolinas – California, USA

Even if the disaster caused an extreme modification of topography, landscape or shoreline, existing settlement and regional development plans can provide valuable information about the community vision and values for future development. They can also indicate: available resources, such as water, agricultural resources and wood; areas of religious and cultural importance; and main types of industries.

- Check existing master, regional or settlement development plans.
- Verify their relevance.
- Obtain important information from those plans as a basis for the new planning.

After a suitable location has been selected, a detailed site plan needs to be developed. A site plans is usually prepared by a planner or architect and should be based on the site analysis.

The plan addresses prevailing natural hazards and local climate conditions. It contains all necessary information about further potential risks, density of houses, roads, vegetation and access to infrastructure.

Buildings should be designed in such a way that they have the least impact on the surrounding environment or nearby ecosystems. Careful planning is required to establish the buildings' orientation on the plots, where infrastructure (piping and other services) is laid, the integration of suitable vegetation, the arrangements of external and internal spaces, and sociocultural requirements.

The following key aspects need to be considered in the detailed site-planning process:

Environmental aspects

- Carry out an Environmental Impact Assessment (EIA) to identify potential negative impacts on the environment and opportunities to avoid or mitigate such impacts (see also Chapter 1.1).
- Comply with coastal conservation zones and safety buffer zones. Local and national land planning authorities can provide such information.
- Protect existing vegetation, such as trees, bushes, etc.
- Plan to replant additional trees:
  - Vegetation is important to provide shading and to cool air and improve air quality.
  - Vegetation has an absorptive capacity for many pollutants, including some greenhouse gases.
  - Vegetation provides storm and flood protection, can contribute to local food or materials production, and has aesthetic and recreational value, enhancing an area's overall quality.
  - Vegetated mounds can serve as additional buffers against storms or tidal waves.
- Situate houses on plots in a manner that minimises land-use impact and optimises the land's value in order to protect natural resources and scarce land for agriculture.

Technical aspects

- Check whether you need to develop a new site plan or whether a former plan is still useable or valid.
- Make the site plans flexible for future extensions, new accesses and necessary adjustments due to changes in the users' needs and habits.
- Make sure that the site is accessible through a public transport system (foresee bus stops, check with local authorities about new bus services lines, etc.).
- Consider plans to establish/improve the local public transport network.
- Ensure access through adequate road networks which allow also for future growing demands.
- Provide road surfaces that limit water erosion and dust.
- Avoid any steep roads.
- Consider roads with sufficient drainage to avoid flooding and surface erosion.
- Ensure that space is provided along roads for pedestrians, bicycles and carts.
- Make sure that sufficient space is provided for utilities – water, sanitation, energy and solid-waste services.
- Foresee the growth of requirements for utilities – water, sanitation, energy and solid-waste services – in the site plan.
- Consider arranging the houses in clusters (rather than in rows) in areas at risk from cyclones.
- Face house openings towards the sea and consider dominant wind directions when designing buildings, to take advantage of natural ventilation.

- Cluster houses in a staggered pattern to allow proper ventilation. Zigzag patterns avoid wind-tunnel effects.
- Use natural topography: place new houses at higher levels than previous, destroyed ones. An 'island design' for villages can be appropriate. For example, in the Indian Ganges basin, increasing village heights to above normal water level is a traditional response to floods.
- Consider using infrastructure that mitigates flooding: culverts, bridges and drainage canals can be used to regulate seasonal monsoon flooding.
- Keep in mind minimum distances between water wells and septic tanks. The minimum distance is 15 to 20m. (See also section on Water Supply and Sanitation, Chapter 2.8).
- Consider the new settlement's distance to the next village/town (for shopping and job opportunities).
- Include communication needs (i.e., telephone, IT).
- Orient houses on the land to optimise the use of sun and wind.
- Plan for the east and west façades of houses in hot climates to be shaded in order to minimise solar heating, especially during morning and afternoon hours, and heat gain of external walls, thus minimising indoor temperatures and improving users' comfort.
- Foresee and integrate the selected system for water supply, sanitation, waste management and power systems: centralised (public or privately owned) or decentralised (independent, at household level).
- Arrange contracts with service providers or the municipality as early as possible to avoid delays in the provision of water and electricity later.
- Plan for waste-collection locations and required waste separation and composting areas.
- Use public lighting that minimises energy and maintenance requirements.

Economic aspects

- Use land efficiently to preserve or enhance its economic potential.
- Ensure that the distance between houses meets the needs of the residents, e.g., whether they need gardens, private outdoor spaces to dry clothes or grow fruit and vegetables, etc.
- Arrange streets and paths to economise on land use, while providing good access to houses and facilities.

Social aspects

- Maintain existing social relationships within the community when resettling whenever possible. The social network among families and within neighbourhoods is usually very important for the sustainable development of communities, including poverty reduction.
- Plan for neighbourhoods to include green and recreational areas.

Institutional aspects

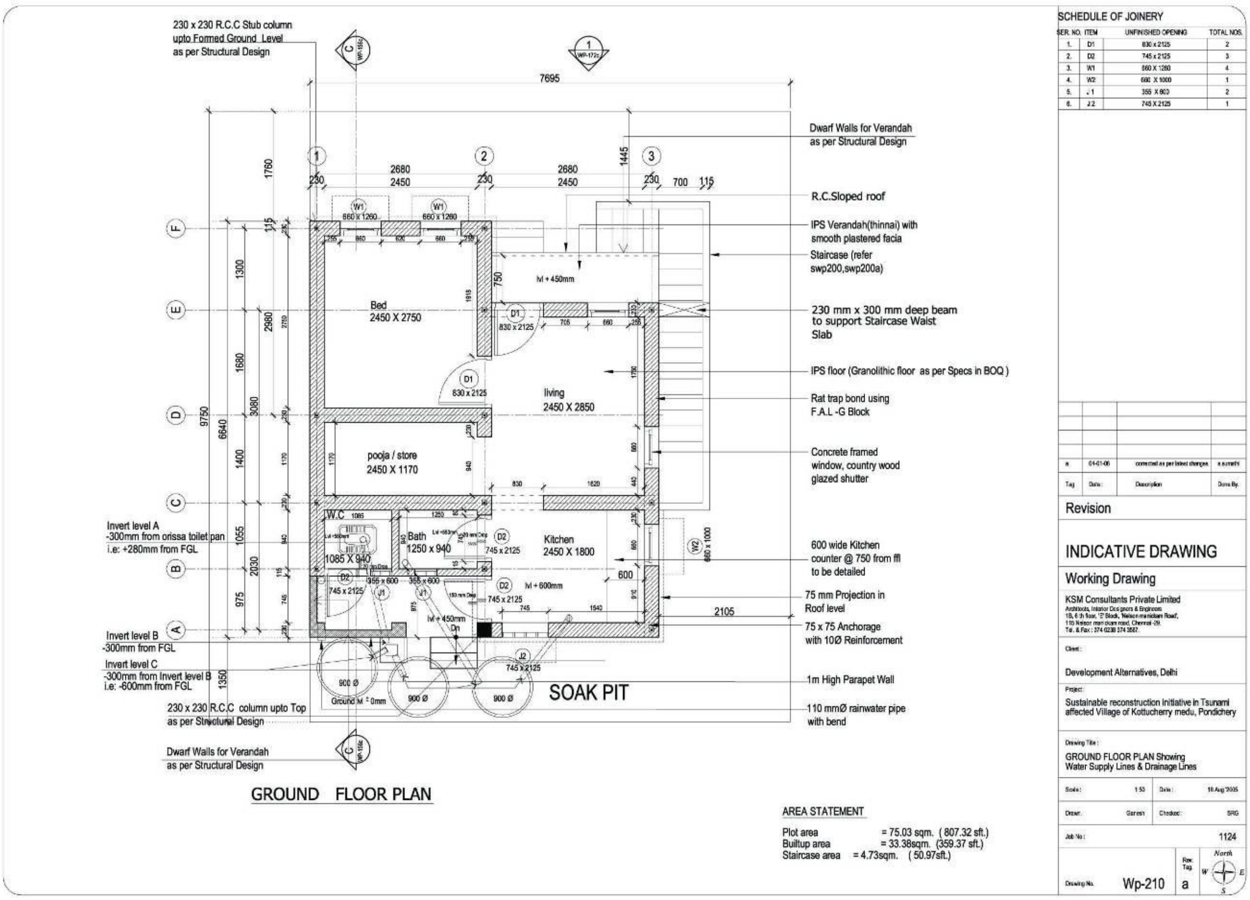
Comply with building codes, laws and regulations, such as by maintaining:

- minimum distance to neighbouring industrial areas and the airport
- minimum sizes of the plots and their subdivisions
- minimum distances between houses
- minimum plot density (normally, the house should not cover more than 55 per cent of the plot)
- heights of houses, numbers of floors
- purpose and usage of houses
- street width (6 to 9m, depending how many plots are to be accessed).

2.3 Building design

Building design is the core issue of every sustainable reconstruction project.

An important aspect of a sustainable building design is the extent to which the house can accommodate user needs, climate conditions and local natural hazards, such as earthquakes, floods and storms. Well-designed buildings minimise environmental impacts and risks, while meeting user needs. The choice of cooling, solar and ventilation systems, for example, has a direct impact on a building's energy efficiency and conservation.



Key sustainable house design recommendations are:

- Favour solutions that are environmentally sustainable and energy efficient.
- Use house designs that are resistant to natural hazards, such as earthquakes and floods.
- Favour simple, low-cost, robust and practical solutions.
- Consider flexible designs that are easy to upgrade and expand.
- Consider the whole life cycle of a building when designing it: construction, maintenance, reuse, demolition and recycling phases.
- Use designs and materials that allow for easy recycling.
- Ensure easy maintenance through the use of modest and basic house styles. In many cases, maintenance and later renovation turn out to be technically complicated and, therefore, more expensive. Materials and tools needed to work the materials should also be locally available.
- Ensure cost-effectiveness in all construction activities.
- Incorporate the users' needs and cultural requirements.

Reuse of temporary shelters

Temporary shelters can be reused when they are still in good condition. Temporary shelters, therefore, should be planned and constructed to allow them to be either integrated into, or disassembled/recycled for use in, the final buildings.

This requires a well-developed site plan, indicating the permanent plots. Plots should be large enough to accommodate one family on a long-term basis. One option is to install the temporary shelter at the back of the plot, so that construction of the permanent housing can be carried out.

The temporary shelter can be reused later as an annex, for storage or as a bathroom. This approach requires a robust temporary structure and already-prepared infrastructure (sanitation, pipes, latrine, etc.).

Another option is to provide a solid foundation with a ground floor slab where the temporary shelter is built so that it can be reused later for the permanent house.

The Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP) lists four categories of temporary housing. These categories differ in terms of the post-disaster utilisation of the structure or of its basic construction materials and include:[20]

- **Upgradable:** While being inhabited, the temporary shelter is improved over time to become a permanent shelter. This is achieved through maintenance, extension or by replacing original materials with more durable alternatives.
- **Reusable:** Following the construction of a permanent housing solution, the temporary shelter is used for a purpose other than housing, such as a shelter for animals, a kitchen, or for storage (applicable in rural and less-dense urban areas).

[20] Adapted from: Shelter Centre, 2010, ALNAP Innovations – Case study No 5: *Transitional shelter – understanding shelter from the emergency through reconstruction and beyond:* www.alnap.org/pool/files/innovationcasestudyno5-shelter.pdf

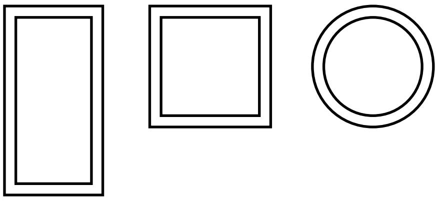
- **Resellable:** The temporary shelter is inhabited while parallel reconstruction activities are taking place. Once reconstruction is complete, the temporary shelter is dismantled and its materials are used as a resource to sell. Therefore, materials need to be selected for their suitability for resale after the shelter is dismantled.
- **Recyclable:** The temporary shelter is inhabited while parallel reconstruction activities are taking place. The temporary shelter is gradually dismantled during the reconstruction process and the materials from the transitional shelter are used in the construction of a durable home.

The shape of a building is crucial to ensuring that it is built sustainably. Certain shapes can better minimise or withstand the impact of earthquakes, floods, tidal waves, storms, cyclones and climate conditions.

The checklist below contains the most important points to consider when thinking about sustainable building shape.

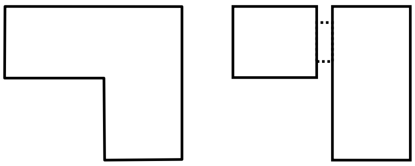
The shape of the house has an important effect on its stability. The following rules should be taken into account:

- The more compact the building's shape, the better its stability. A square shape is, therefore, better than a rectangular one, a circular plan better than a square one.



bad good ideal

- L-shaped plans are less stable. An alternative is to separate house parts from each other.



dangerous safe

- For better resistance to floods, consider elevating the ground floor and building an extra floor or using a flat roof that residents could flee to, if necessary. Flat roofs offer the added advantage of providing storage space for the residents' assets (e.g., grain, farming tools). A temporary or permanent protective structure (e.g., light roof construction made of wood or bamboo) can be built on top of the roof.

A private house on stilts Skat

Elevating the ground floor of a school Skat

Ten key principles of typhoon-resistant construction[21]

Various reconstruction projects are located in typhoon-prone regions. The most important principles of typhoon-resistant construction are:

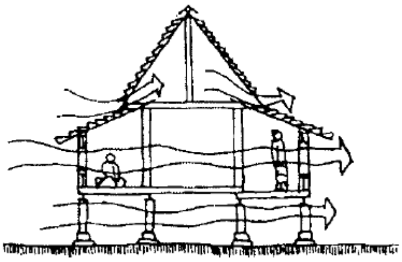
- Use landscape and topography to protect the building.
- Plant wind-breaks in the form of hedges, dense trees or other vegetation.
- Simplify the house's form to minimise obstruction to the wind.
- Pitch the roof between 30° and 45° to lower wind suction.
- Separate verandas from the house's main structure.
- Tie the structure together firmly and use diagonal bracing.
- Attach the roof covering securely.
- Pay attention to the size and positioning of openings.
- Ensure that openings can be closed with outside shutters.

To accommodate the local climate, research the climate zone in which the project will be located. The following rules are recommended according to the prevailing climate:

Tropical climates

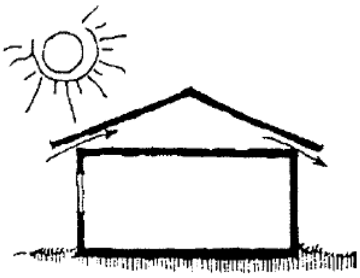
- Construct buildings on elevated locations, as a general rule, or close to hills where there is better air circulation.
- Disperse the houses to allow cool winds to circulate.
- Use the natural airflow to lower internal temperatures and reduce the impacts of heat and humidity on the building and its users.
- Ensure that the house's shape is of 'open' character, allowing airflow through many openings, such as windows, louvres and doors. Openings should be placed on opposite sides of the house to improve cross-ventilation.

[21] J. Norton in: Wakely, P., You, N., 2001, *Implementing the Habitat Agenda – In Search of Urban Sustainability*, Development Planning Unit, University College London, London, UK



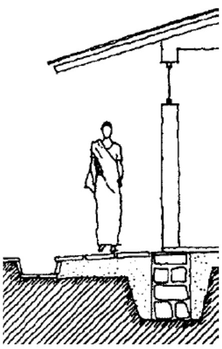
(Source: Astrand, 1996)

- Consider creating openings in the roof to enable warm and humid air to exit.
- Elevate the house from the ground to allow airflow underneath the building and prevent humidity coming from the ground.
- Install verandas around the building to protect façades from rain.
- Build thin walls to prevent humidity being stored. Use light materials such as wood, bamboo and reeds (in rural areas). Note, however, that light walls are less resistant to strong storms or floods than are solid walls.
- Utilise large window openings to improve ventilation.
- Ensure that, in humid tropical climates, the roof is sloped, in order to drain rainwater.
- Use detached or double roofing, which allows better air circulation and provides protection from the sun.



(Source: Astrand, 1996)

- Place the houses with their longer axes to the prevailing wind direction, where possible, in order to maximise airflow.
- Design houses with short building depth to allow wind flow throughout the house.
- Consider using large overhanging roofs, which provide good shading and protection against heavy rains.



(Source: Astrand, 1996)

Semi-arid/arid (dry) climates

- Construct buildings in higher areas of hills (if available) where there is better air circulation.
- Connect buildings to minimise exposure of façades to sun radiation.
- Construct the ground floor directly on the earth in order to benefit from cool ground temperatures.
- Build inner courtyards to ventilate the rooms (low-rise buildings).
- Install heavy and thick walls to decrease heat penetration during daytime and cold penetration at night-time. Use materials such as bricks, blocks, stones or adobe (in rural areas).
- Utilise small wall openings to avoid intake of sun and dust.
- Ensure that, in dry and hot climates, roofs are flat.

Temperate climates

- Install buildings in a way that allows exposure to the sun.
- Use vegetation and slopes to protect the buildings from winds.
- Construct thick walls to avoid heat losses from inside to the outside.
- Utilise materials such as brick, blocks, wood or adobe (in rural areas).
- Northern hemisphere: install big windows on the southern façade and small ones on the northern façade, to allow maximum sun radiation into interior spaces to warm them up.
- Southern hemisphere: install small windows on the southern façade and large ones on the northern façade.
- Use the sun's radiation to heat rooms.
- Insulate the ground floor from the cold earth underground.
- Ensure that, in temperate climates, roofs are sloped, with an average pitch.

Continental climates

- Construct thick walls to avoid heat loss from inside to the outside.
- Utilise materials such as brick, blocks, wood or adobe (in rural areas).
- Northern hemisphere: install big windows on the southern façade and small ones on the northern façade, to allow maximum sun radiation into interior spaces to warm them up.
- Southern hemisphere: install small windows on the southern façade and large ones on the northern façade.
- Use the sun's radiation to heat rooms.
- Insulate the ground floor from the cold earth underground.
- Ensure that, in continental climates, roofs are sloped, with an average pitch.

Cooking facilities

Kitchens play a crucial part in sustainable reconstruction if they are planned carefully to improve hygiene and the indoor environment in homes. Often kitchens in developing countries – tsunami-affected areas – are dirty and unhealthy because inadequate attention is given to their design. Further, an adequate stove uses energy more efficiently. A kitchen provided by donor funds and equipped with modern technology can be difficult to use if the stoves and refrigerators are inappropriate to the local fuel, or if the traditional food is cooked in special pots that do not fit with modern stoves. Moreover, the kitchen is where most of a household's energy is consumed in developing countries.

Therefore, consider the issue that the design of the kitchen and its relationship to the other rooms of the house are closely linked to the choice of stove and where it is located. There is not a ready-made solution for a well-functioning kitchen. Instead, the following checklist may be a guide to help find the right solution:

- Consider whether cooking is carried out indoors or outdoors, according to the culture and climate; is a veranda needed?
- Assess whether the kitchen is linked directly with the dining area or not; where does the family eat?
- Consider sufficient ventilation of the kitchen.
- Assess the functions of the kitchen; is it also used for laundry, bath, storage, etc.?
- Select the right stove and equipment to suit the locally available fuels, pots and customs.
- Equip the stove with a chimney.
- Consider whether food is prepared in standing, sitting or squatting position, thus whether a counter or other appropriate furniture is needed.
- Separate toilet and animals from the kitchen in order to maintain hygiene.
- Ensure that water is readily available.
- Plan for work surfaces, floors and walls that are easy to clean. This requires water-resistant materials (e.g., ceramic tiles, polished concrete).
- Provide the kitchen with good natural lighting.

A kitchen in Sri Lanka Skat

2.4 Building technologies

Sustainable construction practices should be low-cost, practical and environmentally appropriate. When selecting the most appropriate construction system, project managers should choose one that best suits local conditions, such as the availability of building material and skilled workers.

Depending on local conditions, project managers may want to choose from among the following sustainable building systems:

Prefabrication

Entire walls, floors and roofs are ready-made in the factory and transported to the building site. Prefabrication allows for quicker and easier construction and can help to reduce labour costs and ensure quality control. Because construction with wall modules is rather complicated, good planning and organisation are essential. Skilled staff and special equipment are often needed.

It is also important to ensure that prefabricated houses are designed to suit local conditions, such as climate, subsoil, culture, etc. For example, the routine for cleaning houses differs among cultures. It can be common to wash floors with a lot of water, in which case floors and the lower parts of walls must be designed to withstand water. In too many instances, prefabricated houses that don't meet this basic requirement have been exported to developing countries.

Prefabricated building elements Skat

On-site construction

All raw materials and construction products are transported to the construction site for assembly. Some elements, such as windows or doors, may be prefabricated. Concrete elements used for the foundation, columns and beams can be produced on site. Individual elements should not weigh more than 150kg so that three workers can move them safely. Concrete elements should be cast in wood or steel moulds.

The on-site construction method is more labour intensive and it requires regular quality control on site. Raw materials should be available locally.

On-site construction Skat

Building elements

The main building elements are the foundation, supporting frames, floors, walls (with doors and windows), ceiling and roof. Simple building techniques help to ensure sustainable reconstruction. Local workers will need to have enough skill to ensure that the houses are built safely and with good-quality methods. If needed, additional training may be appropriate.

When assessing the building elements to be used, the following steps are recommended:

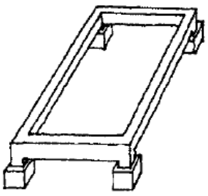
- Check whether the material and technology can be used and understood by the local workers.
- Check whether special skills, experience or equipment is required.
- Assess whether repairs and replacements will be possible with local resources.
- Select building elements that are easy to disconnect, when possible, in order to enable future recycling and reuse.

Foundation

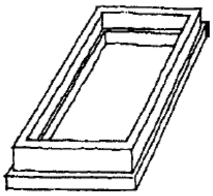
The quality and lifespan of a house depends to a great extent on how the foundation is made. A poor foundation can soon lead to damage and deterioration that is difficult to repair.

The type of foundation to be used should be selected early in the planning process, because it will influence the building's overall design. Key criteria for consideration when selecting a foundation include: ground quality, which can be determined through a soil investigation; the building's anticipated load, i.e., its weight when fully occupied; and the availability of equipment and skilled workers.

Pad footing



Strip footing



(Source: Astrand, 1996)

Checklist for earthquake-safe foundations

The ground under the building needs to be strong enough to support the building, even if it is flooded or exposed to earthquakes. A proper assessment of the underground and removal of overlying earth of poor quality is essential in all cases.

- Check soil type and water level.
- Assess soil strength for seismic design of foundations in accordance with country codes.
- Avoid using isolated footings with no ties.
- Use reinforced concrete strip footings under load-bearing walls.
- Avoid building in areas with soft clays and loose-to-medium-density sand, which is waterlogged and may liquefy during an earthquake. Seek expert advice on piled foundations and structural design.

Skat

For further information on how to assess the **strength of natural soils**, please refer to the **Annex IV**.

Supporting frame

The supporting frame ('skeleton') of a building is often subject to local traditions and preferences. In situations where access to materials may be restricted, alternative frame systems may need to be considered. There are at least three basic frame systems:

Concrete frames: Concrete frames are widely used in reconstruction. Columns and beams are cast together into a frame. Gaps are filled with bricks or blocks. Bricks of lower quality can be used as filling material for external and internal walls. Good masonry skills are required for this approach. In order to withstand earthquakes and other natural hazards, strong connections are required between vertical steel reinforced concrete columns and ring beams. (A ring beam is a horizontal beam that follows the shape of the house, so named because it would look like a ring if it were round. The roof often rests directly on a ring beam.) Also important for earthquake resistance are robust connections between supporting walls and non-supporting walls. Unsecured walls may fall outwards.


Concrete frame Skat

Timber frames: Timber frames are often more resistant to earthquakes and other natural disasters than are concrete frames, and are easier to work with. Adequate carpentry skills, however, are required. In a situation where timber is scarce or likely to come from illegal logging, timber framing is not recommended.


Timber frame Skat

Steel frames: Steel frames are primarily used for constructing larger houses. The material is very strong but is difficult to work with without specialised tools and expert knowledge. Because steel frames are typically quite expensive, they are not often used for single-family houses.

Floor

The choice of floor – technology used and surface – depends on its intended use. Consider the expected load, wear and tear, cleaning manner, slipperiness and resistance to moisture and insects.

In **tropical climates**, direct contact of the floor with the ground does not provide good cooling. To improve floor cooling:

- raise the floor and ventilate the space underneath (minimum 30cm above surrounding ground level); elevated floors also help avoid moisture problems
- use a light material that does not store warm temperatures, such as wood
- elevate houses on pillars; this offers protection from floods but elevated houses may be more susceptible to earthquakes.

To improve **earthquake resistance**, consider the following measures:

Concrete floors

- Anchor concrete ground floors into the foundation and the concrete wall columns.
- Fix suspended concrete floors securely on their upper and lower sides to the concrete wall columns.

Timber floors

- Fasten each floor beam securely to the ground beam with metal straps.

Walls

The construction technique used for walls depends on the number of floors, the anticipated loads and the risk of cyclones or earthquakes. The choice is also influenced by the building material to be used and availability of skilled workers.

Walls should be adapted to the local climate and require as little maintenance as possible. In regions with heavy rains, extended overhangs should be used to protect outer walls.

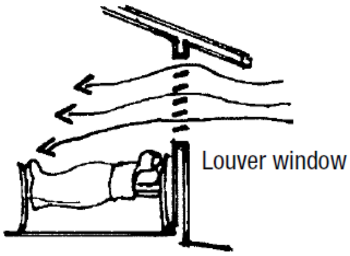
Walls play a crucial role in a house’s resistance to earthquakes. Earthquakes affect buildings mainly with horizontal forces. The major danger due to the horizontal movements of the earth is that building walls and, consequently, roofs might collapse.

The main aim of constructing earthquake-resistant houses is to avoid walls being able to collapse and to ensure that roofs are well secured to walls. In order to make houses as resistant to earthquakes, storms and floods as possible, the following measures are recommended:

- Ensure that walls are reinforced sufficiently. If possible, have a qualified engineer calculate the required reinforcement and control the quality of installation on site regularly.
- Make sure that ring beams are well connected in each corner and with the reinforcement of walls and columns.
- Note that experience has shown that walls made of cement or fired bricks resist floods much better than do mud walls.

Windows, doors and other openings

Windows and doors provide natural light, ventilation and communication with the outside. Especially in tropical climates, all kinds of wall openings are important to ensure good ventilation and cooling of the house.



(Source: Astrand, 1996)

In earthquake-prone areas openings in walls must be placed carefully as they destabilise the wall system, particularly in massive house styles (i.e., made of bricks, blocks, adobe, etc.). The following steps are recommended:

- Ensure that lintels penetrate the wall on both sides in order to achieve sufficient bondage (a lintel is a horizontal beam that usually supports the masonry above a window or door opening); or, better, use the ring beam itself as a lintel.
- Plan for the window's width to not exceed 1.2m and to not cover more than one-third of the wall's width.
- Ensure that the length of walls between openings is at least one-third of their height and not less than 1m.
- Ensure that, in general, doors open towards the outside so that residents can escape more easily in the case of an earthquake. A second door at the back of the house is recommended in case the main door is blocked.

Roof

The quality and state of the roof is extremely important. The roof protects against weather, wind, heat and cold. To some extent, roofs also protect external walls from sun and rain.

Traditional roofs (made of burnt clay, thatch or earth) require a great deal of maintenance and are often not suitable in urban areas. In addition, thatch roofs are a fire hazard.

Flat roofs are critical in areas with heavy rains. Highly skilled workers, excellent-quality building materials and regular maintenance are required to keep flat roofs watertight.

Roof is tightly connected to columns Skat

In temperate and continental climates, consider insulating roofs. Insulation reduces heat gain through roofs, keeping temperatures inside to a minimum. In arid and semi-arid climates, overhanging roofs provide shade to walls and windows and are particularly useful to minimise the heating of sun-exposed walls.

In earthquake-prone areas, roofs should be as light as possible. To achieve the best earthquake resistance, roofs should be well connected to all walls and columns. The supporting frame and pillars, however, should always be able to support the roof without the walls, so that, even if a wall collapses, the roof does not fall down.

In cyclone-prone areas, roof slopes of at least 30° reduce wind suction forces. Strong connections of all roof components to the roof structure are required.

2.5 Construction materials

Building materials are made either from naturally available sources like inorganic materials (e.g., clay, stone, steel) or from organic raw materials (e.g., wood, straw).

The appropriateness of a particular building material can never be generalised. Whether a specific building material is sustainable or not, depends on the local context. For example, compressed earth blocks (CEB) might be appropriate in one location but not in another, depending on the availability of soil of sufficient quality. The quarry of soil must also not jeopardise ecologically sensitive areas, agricultural lands or other livelihoods sources.

The following summarises key issues regarding sustainable building materials:

An often-reported challenge is that suppliers sometimes deliver unspecified or illegally sourced timber to construction sites. The World Bank and Forest Watch estimate that Indonesia's annual timber demand is 73 million m^3, while the potential legal supply is only 6 million m^3. By this estimate, only about 8 per cent of the country's timber is legally sourced. In addition, sources indicate that it is easy to obtain forged certificates of authenticity in Indonesia.[22] This example illustrates the importance of supporting the use of environmentally sustainable building materials in reconstruction activities. It is important, therefore, to:

- avoid illegally logged timber and favour certified timber; because timber certificates can be falsified, be careful to investigate the certificating authority's reliability and the authenticity of the certificate
- favour wood from plantations managed by certified companies.

Concrete and brick production requires large supplies of sand, gravel and appropriate clay. In the reconstruction process, when demand is high, many people are taking raw material from the closest riverbeds or mountains. Such practices are highly destructive and can have devastating effects, e.g., on wetlands, coral reefs or forest ecosystems.

Quality check of blocks Skat

[22] ADB-ETESP – Spatial Planning and Environmental Management, 2006, *Draft Guidelines: Environmentally Friendly Construction Material Procurement*, Asian Development Bank

To follow a more sustainable approach:

- Use only raw materials that are produced in an environmentally acceptable manner, and avoid using materials extracted from sensitive areas.
- Check the origin of sand. Avoid the use of coral sand and inappropriately quarried supplies.
- Find out whether quarry sites are rehabilitated afterwards.
- Investigate the purchasing policy or green procurement guidelines of your organisation, if they exist: the use of hazardous materials, such as asbestos, is not acceptable, nor is using unsustainably manufactured products, such as illegally logged rainforest timber.

The intelligent use of building materials can lead to a significant reduction in a project's environmental impact. Using local materials, for example, can minimise transport-related emissions. The use of local materials also helps to preserve local cultural identity and knowledge in project areas. In summary:

- identify and verify that supplies and raw materials come from environmentally friendly practices and suppliers
- favour locally produced building materials.

In order to safeguard the health of the residents:

- do not use toxic materials
- do not use materials containing chlorofluorocarbons (CFC), e.g., in refrigerators or air conditioners
- do not use asbestos.

Locally produced blocks Skat

Asbestos risks and how to avoid them

Asbestos is a mineral that occurs in nature. It has been used in over 3,000 products, including a variety of building products, such cement roofing sheets, insulation and pipe lagging, because of its high tensile strength, relative resistance to acid and temperature, varying texture and flexibility. It does not evaporate/dissolve, burn or undergo significant reactions with other chemicals, which makes asbestos useful, but also non-biodegradable and environmentally cumulative.

Exposure to asbestos can cause lung disease and cancer, depending on the concentration in the air and the length of exposure. All forms of asbestos are carcinogenic, and no safe level of exposure is known. When fibres penetrate the lungs and become lodged within the lung linings/pleurae, cancer of the pleura may develop. A cancer of the intestine (stomach, pharyngeal, colorectal) which is caused by asbestos ingestion has also been identified.

The International Labour Organization and the World Health Organization have called for a ban of the production of all types of asbestos, which kills over 100,000 people annually. Asbestos products are already banned in 40 countries, including all European Union states. Countries in which Asbestos-containing Materials (ACM) are being used should:

- develop certification/specifications for all ACM products
- establish standards for the work environment
- regulate asbestos handling, disposal and toxicity testing, and the use of personal protective equipment.

The best and recommended way to avoid the risks and unnecessary deaths associated with exposure to asbestos is to avoid using building products with ACM. If ACM products have already been installed, removal is not recommended. Instead, the materials should be encapsulated with paint and air quality should be monitored periodically.

In cases where ACM products are being used in the workplace, workers should be provided with personal protective equipment, including well-tested respirators, to ensure that no asbestos fibres can enter their lungs. The proper use of respirators requires training, maintenance and good storage. After work, washrooms should be made available and workers should take showers. Clothing should not be brought home but cleaned at the premises.

For easier reuse and recycling of materials:

- avoid sophisticated compounds and composites in building materials
- avoid complicated bonding agents and adhesives, when not necessary
- select building materials that are easy to disconnect and detach.

To save natural resources and energy:

- check whether you can use recycled material
- find out if there is material available from demolished buildings nearby
- reuse debris, if it is suitable: timber and roofing materials are robust and cost-effective materials that may be easily reused
- recycle debris: rocks, sand and concrete slabs can provide excellent fill for concrete if they are first washed, sorted and crushed/grinded to smaller fractions.

Example: Compressed Earth Blocks

To produce Compressed Earth Blocks (CEB), soil (raw or stabilised) is slightly moistened, poured into a steel press and compressed. Make sure that the soil is of good quality; it should not contain any humus or other organic materials that can decompose.

The usage of stabilisers (cement, lime, gypsum) will ensure a much better compressive strength and water resistance.

Advantages of CEBs:

- Good thermal insulation
- No wood required in the production process
- Very regular in size and shape
- Lower production cost and energy input compared with those of fired bricks
- Can be locally produced (lower transportation costs and levels of emissions).

Houses built with building materials of insufficient quality, low-quality concrete or inadequate steel reinforcement were usually badly damaged by natural disasters. Project managers should give special attention to using high-quality building materials. Try to ensure that the delivered material is of good quality by regularly material testing the aggregates (sand and stone), water and cement used.

- Aggregates must be free from clay, loam, leaves or any other organic material. Clay or dirt coating on aggregates prevents adhesion of the cement to the aggregate, slows down the setting and hardening process, and reduces the strength of the mortar.
- Water should be of drinking quality without pronounced taste. Water containing salt (e.g., seawater) should never be used for mixing concrete as the salt reduces the strength of the concrete, and also corrodes steel reinforcement in the concrete.
- The most common type of cement is ordinary Portland cement. Although freshly produced cement is normally of sufficient quality, it can lose quality through poor storage and transport.

Example: Concrete Hollow Blocks

Concrete block construction has gained importance and concrete blocks have become valid alternatives to fired clay bricks. The essential ingredients of concrete are cement, aggregate (sand, gravel) and water. Concrete blocks are produced in a large variety of shapes and sizes. They offer a number of advantages:

- They offer good thermal insulation through their air cavities.
- No fuel or timber is required.
- They can be produced by small-scale to large-scale enterprises.
- They are lighter in weight than are bricks.
- Construction of walls is easy and quick.
- Voids can be filled with steel bars and concrete, achieving high earthquake resistance.
- Cavities can be used for electrical installation and plumbing.

The cost of building materials often determines what types of materials are used. The cheapest materials, however, are not always the most suitable ones. Factors such as quality, durability, maintenance cost and reliability of supply must also be taken into consideration. It is particularly important to consider the maintenance and potential repair cost of materials over the entire life cycle of the building in order to optimise overall long-term cost savings. Other important economic considerations that may affect the appropriateness of materials include the following:

- Using locally produced materials can save transport costs, strengthen the local material production industry, stimulate local job creation and avoid taxes on imported material.
- Production of building materials at the construction site is often cheaper than is using prefabricated materials/elements and may also enable better quality control.
- Prices of building materials can increase suddenly, especially in post-disaster situations, where urgent demand often exceeds supply significantly. It is wise to plan for some financial reserves in order to avoid overstretching the project budget.

It has happened in reconstruction programmes that beneficiaries abandoned their newly reconstructed houses because they did not feel comfortable with the materials used. Therefore, it is important that beneficiaries accept and feel comfortable with the construction materials chosen. To help ensure community satisfaction and the cultural appropriateness of materials:

- consult with the community regarding whether certain materials are considered to be low standard or otherwise inappropriate
- assess whether local raw materials are being extracted or collected under safe and healthy working conditions.

In addition, it is crucial that the selected materials comply with relevant legal standards, national building codes and local regulations regarding safety, environmental sustainability, etc. To help ensure compliance:

- use only earthquake-proven and specified materials and related construction technologies
- check the specifications and sources of delivered material regularly
- reject materials, if needed
- support awareness campaigns focusing on the importance of using legal building materials
- maintain transparent dealings with suppliers at all times.

2.6 Procurement

Construction materials are often purchased through procurement because quantities are very large and might not be locally available. Another reason for going through a bidding process is that the donor and/or implementing organisation has guidelines whereby bidding is obligatory. Procurement offers a very good opportunity to include sustainable and environmental aspects in the bidding process.

Check requirements (by the government or your own organisation) of the procurement process. If sustainability aspects are not already required, include them, such as materials from certified sources, classified specifications, etc.

Procurement should not only consider costs, availability, time-frame, etc. but it should verify that the source of material is sustainable and legal. Also, one should pay attention to the energy used for transportation and pollution created.

It is recommended that the organisation uses or establishes green procurement policies that are used for the bidding process in order to manage criteria for sustainable sources, quality and costs.

The following steps in a procurement process are recommended:

- Investigate at least two or three different suppliers for a certain construction material and ask the suppliers about the source of materials.
- Visit the locations where raw materials are being extracted (source of sand for cement, timber, etc.) to see whether they are legal, environmentally friendly and sustainable.
- Consult with the responsible government departments to check whether there are any environmental and social concerns with regard to types of construction materials.
- Ensure that bidding documents, Terms of Reference, and other contracting documents indicate that contractors will procure construction materials from sources that are environmentally sustainable.
- Verify that material specifications include requirements for the use of certified and reliable building products (e.g., FSC certified timber).

It is recommended that building materials from certified sources are used. A few international standards and certifications are listed below.[23] Even if a material is labelled with a certification, it is recommended to double-check the source of the material. It happens at times that false or fake labels are used.

NSF International [www.nsf.org]: NSF International is a non-profit and independent organisation that focuses on the certification of consumer goods, food, water and various construction materials. NSF standards are approved by the International Accreditation Service (IAS), the International Standardization Organization (ISO) and Standards Council of Canada (SCC), among other organisations. NSF approves the following aspects of products: compostability, recyclability, constituent analysis, contaminant analysis, indoor air testing and custom-designed testing.

FSC – Forest Stewardship Council [www.fsc.org]: The FSC is a non-governmental and independent organisation which promotes responsible management of the world's forests. FSC provides a certification system that relates to internationally approved standards and trade brand guarantee with respect to sustainable and responsible forestry. The FSC label is displayed on certified timber products by producers to point out to buyers and suppliers that their products have been harvested and treated according to FSC principles and criteria.

ISO – International Organization for Standardization [www.iso.org]: The ISO is a non-governmental certification agency which sets industrial standards. Among other issues, the ISO is engaged with sustainability concerns in building construction and environmental assessment methods. ISO 14001 deals with approved standards for environmental management systems. ISO 15392 entails the general principles of sustainable construction, such as environmental, social and economic aspects.

[23] Adapted from: Module 5 in: World Wildlife Fund, American Red Cross, 2010, *Toolkit Guide – Green Recovery and Reconstruction: Training Toolkit for Humanitarian Aid*, Creative Commons, San Francisco, USA: http://green-recovery.org/

Further reading

UNDP – United Nations Development Programme, 2008, *Environmental Procurement*, UNDP Practice Series:
http://www.greeningtheblue.org/sites/default/files/UNDP-Environmental%20procurement_0.pdf

FAO – Food and Agriculture Organization of the United Nations, 2007, *Procurement of Timber for Tsunami Reconstruction in Indonesia*:
www.fao.org/forestry/11702-0255f091f08a3485b42f6d8822b8f6689.pdf

The team of Sustainable United Nations (SUN)[24] developed various best-practice guidelines for a sustainable procurement:
www.unep.fr/scp/sun/facility/reduce/procurement/guidelines.htm

Module 5 in: World Wildlife Fund, American Red Cross, 2010, *Toolkit Guide – Green Recovery and Reconstruction: Training Toolkit for Humanitarian Aid*, Creative Commons, San Francisco, USA: http://green-recovery.org/

World Wildlife Fund, 2006, *Tsunami Green Reconstruction Policy Guidelines:*
http://www.proactnetwork.org/proactwebsite/media/download/resources/EA-Tools/WWF_Green%20Reconstruction%20Policy%20Guidelines_2006.pdf

Reuse of debris material (see also Chapter 3.6)

The reuse and recycling of construction materials must be considered carefully during the planning phase.

Reusing or recycling of materials from damaged or destroyed buildings has various benefits. It helps to minimise the environmental impact of reconstruction, the materials are immediately available and reduce the amount of debris to be cleared and, finally, it helps to reduce construction costs.

Pure materials like bricks, wood, concrete, stone and metal sheets are best for reuse or recycling.

- Use concrete, old bricks and stones as fill material to construct roads.
- Employ metal sheets and bricks for fencing.

Brick masonry rubble provides a good source of materials for use as aggregate in concrete.

Rubble can also be processed and transformed into construction material, ready to use on site. Rubble-crushers are used for this purpose. One innovative prototype presents the gabion house, which uses caged rubble as building blocks and is currently being assessed for earthquake and hurricane resistance.

Generally, all types of composite materials (e.g., prefabricated solid foam-metal or foam-plaster elements) are difficult to separate and recycle.

[24] SUN is based in the Division of Technology, Industry, and Economics Sustainable Consumption & Production Branch, United Nations Environment Programme.

2.7 Retrofitting and repairs

Retrofitting

Retrofitting aims at strengthening old or existing buildings to make them earthquake and hurricane resistant, in order to reduce their vulnerability.

The current challenge is that retrofitting remains limited in reconstruction. A large number of buildings that can easily be retrofitted are still being demolished and replaced, or continue to be in use in very vulnerable conditions.

Retrofitting should be carefully planned, noting the following key points:

- Always involve a well-qualified engineer/architect and skilled contractors as retrofitting can be tricky and dangerous.
- Restore a house that is damaged to its undamaged pre-earthquake/hurricane condition.
- Assess the vulnerability of the structure by means of a vulnerability assessment.
- Assess one room or part of a building at a time to decide what needs to be done.
- Prepare a retrofitting scheme for the whole building in order to ensure proper synchronisation of all retrofitting activities.
- Prepare drawings necessary for implementation of retrofitting and prepare quantity and cost estimates for materials.

Retrofitting may include the following measures:

- Reinforcing walls
- Installing cross-walls
- Connecting walls to each other
- Strengthening foundations
- Minimising the number of openings
- Installing reinforcements around openings
- Installing connection ties
- Strengthening retaining walls.

Reinforcement and connection of external walls Skat

Installed props during retrofitting Skat

Further reading

Build Change/Degenkolb Engineers, 2011, *Seismic Evaluation and Retrofit Manual*, MTPTC Training, April – May 2011

Build Change/Degenkolb Engineers, 2011, *Seismic Evaluation and Retrofit Companion, Examples and Documentation*

Desai, R., Desai, R., National Centre for Peoples' Action in Disaster Preparedness (NCPDP), *2007, Manual for Restoration and Retrofitting of Rural Structures in Kashmir*, UNESCO/UNDP, Gujarat, India

Patel D., Patel, D., Pindoria, K., 2001, *Repair and strengthening guide for earthquake-damaged low-rise domestic buildings in Gujarat, India*, Gujarat Relief Engineering Advice Team (GREAT) Publications, Gujarat, India

Schacher, T., 2009, *Retrofitting – Some basics*, PowerPoint presentation, SAH construction course, Walkringen: www.constructiongroup.ch/system/files/retrofitting+some+basics.pdf

Housing repair

"*In some instances, the cheapest and quickest method of providing adequate housing is to repair the damaged stock*."[25]

In particular, this could be a good solution when the local population has not been significantly displaced. The scale of damage will vary; therefore, assessments will be necessary to determine the materials and levels of skill required for repairing the houses. Repair can be far less traumatic for survivors of disasters, than is moving into emergency shelters or communal centres and undertaking comprehensive reconstruction, as residents are often able to remain in their homes.

Subject to the scale of damage and availability of local skills, people can undertake their own repairs. This can help the community to return, as quickly as possible, to some form of normality.

If damage to an area is minimal, and the local community can provide materials and resources, agencies can support efforts through the provision of advice and by subsidising the cost of materials. Alternatively, agencies may choose to support the repair efforts by means of housing repair toolkits, which can be tailored to specific needs or can target specific areas such as roofs and windows.

Repairs are often limited to essential works necessary to ensure houses are habitable such as repairs to: roofing, load-bearing walls and structural frames; bathrooms or latrines; and cooking spaces or kitchens. Depending on the region's climate, works to windows, doors and internal plastering may also be considered essential.

Reconstruction programmes will need to assess the viability of such work by addressing technical issues, costs, training requirements and the production of guidelines relevant to the local context.

Below are some of the issues that should be considered in a repair or retrofit programme:[26]

[25] Barakat, S., 2003

[26] Adapted from: Abhas, K. J., 2009

Issue	Relevance
Relocation	The repair or retrofit option is unlikely if a house has to be relocated.
Damage level	The level of damage to the house must be fully considered prior to a decision about whether repair or retrofit is the appropriate option.
Cost of the repair or retrofit option versus reconstruction	To be justifiable, the total cost of the repair or retrofit option should generally be lower than that of demolition and reconstruction.
Willingness and capacity of community to repair or retrofit their houses	Participation of the community and families in the discussion on repair or retrofitting work is essential. Retrofitting is often not viewed as a viable or desirable option. Without local support, this option could meet with passionate objection. Communication, training and public outreach are all necessary elements of a successful repair or retrofit programme.
Architectural, historical, cultural and socio-economic value of damaged houses	If particular houses or buildings have high architectural, historical, cultural or socio-economic value, considerable effort in overcoming technical and cost difficulties to prevent demolition may be justified. The owner may be offered extra financial or technical assistance, if the house is considered part of the community's heritage, to encourage preservation of the property.

Training of home-owners:

Training of home-owners and unskilled people is an essential tool for quality control. However, this does not mean delegating quality assurance to the families; it means making them aware of quality parameters and empowering them to be fully part of the process. Responsibility for quality control, technical monitoring and supervision of the site should stay with professionally trained staff.

2.8 Water supply and sanitation

Housing that depends on weak infrastructure is likely to become useless in the event of a disaster, even if the structure of the housing itself is solid and/or not affected by the disaster. Households need various essential infrastructure and services. For example, residents and businesses need access to infrastructure (such as water supply, sanitation, electricity, roads and transport, communication, etc.), people need access to their livelihoods and children need access to education.

2.8.1 Water supply

Water is normally either provided through pipes from a communal water supply for the wider area or derived from local water sources for smaller units or individual households.

There are three types of water sources that can be tapped: surface water, groundwater and rainwater:

Surface water includes lakes, rivers, ponds and other open freshwater sources. Surface water is often the easiest water source to access. Surface water, however, is vulnerable to pollution and must thus be protected or treated. It can also be affected by wide seasonal variations in turbidity and flow.

Groundwater is found underground in aquifers, making it better protected from pollution than is surface water but still susceptible to bacterial contamination from ineffective or disrupted sanitation systems and chemical pollution (fluoride, chloride, arsenic, etc.). Wells or boreholes are used to extract groundwater.

Rainwater can be collected either from an existing roof structure or from a ground-level catchment area and can provide a useful supplementary source of good-quality water. Storage tanks are usually required to make the best use of rainwater and to protect it from pollution.

Safe water supply together with safe sanitation is extremely important for public health and for economic development. Water-supply and sanitation planning must therefore be an integral part of planning for sustainable reconstruction.

Water-supply system options

Options for water supply include:

- centralised piped water-supply systems
- decentralised piped water-supply systems
- individual water-supply systems on household level
- water distribution by trucks, by carts or in bottles.

All systems can be applied also in a combined way.

Centralised piped water-supply systems consist of following components:

- Water abstraction of groundwater or surface water resources in the immediate proximity of the city up to far distances from it, depending on the availability of resources. Groundwater is abstracted by using several wells equipped with pumps, whereas abstraction of surface water requires specific intake facilities. In larger cities, use of several water sources is frequently required.
- Water treatment for removing harmful chemical substances and disease-causing bacteria as well as undesirable particles, colour, etc., from the raw water. The type of treatment technology required depends very much of the specific quality of raw water. A typical basic treatment for surface water is sand filtration and disinfection with chlorine. Chlorine is also frequently added to treated water for preventing recontamination of water in the distribution system.
- Transmission main pipes and, if required by topography, pumping stations for transportation of water from the location of water abstraction to the entry points of the distribution system.
- Reservoirs for storage of water before it enters the distribution systems. Reservoirs are needed in order to satisfy peak demands during times of maximum water consumption.
- Distribution networks for the distribution of water to the user. The network is generally composed of primary and secondary main pipes and distribution branches. Distribution networks in larger cities are generally divided into different supply zones, especially if topography requires different pressure zones. Distribution networks contain valves for isolating zones or shutting down certain areas for maintenance.
- Supply points can be either public standposts or household connections.

Centralised systems are often complex using several water sources sometimes located at considerable distances, with different supply zones in the distribution network and sophisticated treatment technology. Operation and management of centralised systems require considerable technical and organisational capacities and are generally assured by municipal or corporate-owned utilities.

Decentralised piped water-supply systems are based on the same components as are larger centralised systems but use water sources available in close proximity, supply smaller areas and often use only basic treatment technologies.

Decentralised systems require safe water resources in close proximity to the supply zone. Decentralised systems can be managed by utilities but also by community-based schemes, which makes them a potential alternative solution for self-supply of communities in situations with very deficient public water supplies.

Individual water-supply systems for single households based on shallow wells or rainwater harvesting are typical rural water-supply options and, in some situations, may also be appropriate in peri-urban settings.

Example: Rainwater harvesting

Rainwater harvesting is a low-cost option for providing safe drinking water. In the Maldives, for example, the primary source of drinking water is rainwater stored in tanks. Approximately 75 per cent of the country's population collects water from communal rainwater storage tanks or individual household tanks.

Rainwater harvesting systems require each house to have a tank with a lid, roof guttering and water-saving plumbing. Rooftop catchment systems gather rainwater using gutters and downpipes made of galvanised iron (GI) or PVC, which lead it to one or more storage containers. The containers are simple pots or large ferro-cement tanks. A detachable downpipe is fitted to exclude the first run-off during a rainstorm, which is usually contaminated with dust, leaves, insects or bird droppings.

Rainwater collected from rooftop catchments should not be considered a primary water supply but merely a supplementary supply that is particularly useful at household level.

Rainwater is normally soft, saturated with oxygen. Micro-organisms and other matter suspended in the air are entrapped in the rainwater, but ordinarily these impurities are not significant. It is essential nevertheless that roofs, reservoirs and containers be kept clean in order to avoid any contamination of the collected water.

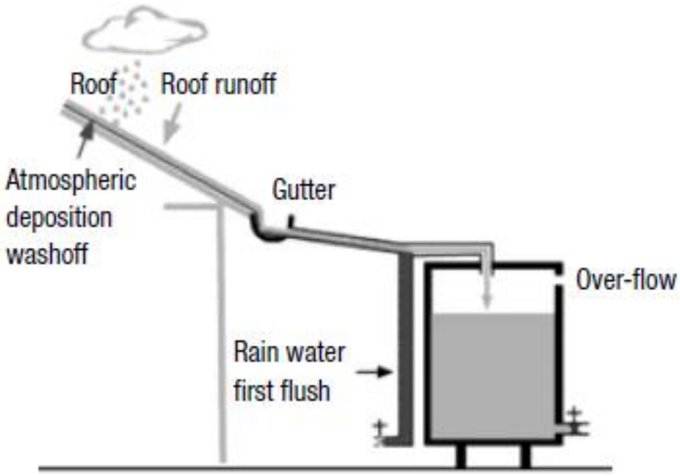
All rainwater collection systems should be equipped with filters on the inlet in order to prevent foreign bodies and contaminants from entering collection tanks. Regular maintenance is a must.

The operation of rainwater-collection systems requires thorough introduction training so that households will take responsibility for maintaining the quality of their supply by cleaning gutters and sealing tanks.

To meet current and future demands for clean drinking water, each household should be equipped with an individual rainwater-collection system. This would increase overall capacity and decrease water-supply vulnerability to future flooding.

- Use local knowledge and experience for rainwater harvesting.
- Use new and innovative technologies only if they are well tested and approved.
- Use local resources (materials and labour) to build or improve rainwater harvesting systems.

- Involve all stakeholders to find the best solution for rainwater harvesting systems.



Further reading

Briefing Note on Rainwater Harvesting in North Darfur, ProAct Network, September 2010

Water supply by carts, tankers or bottles is common when no other systems of water supply are available and are therefore frequently encountered in post-disaster situations where existing infrastructure or organisational structures have collapsed. Such water supply cannot be considered as acceptable in the long term as it is very costly and inadequate quantities of water per person are being supplied.

Comparison of suitability and requirements for different types of water-supply system:

Water-supply systems	Suitability according to WHO/UNICEF JMP criteria	Required capacities	Investment needs
Centralised piped water-supply systems	Improved water supply, if properly managed	High operation and maintenance capacities of utilities required	High public investment
Decentralised piped water-supply systems	Improved water supply, if properly managed and favourable local conditions	Good community organisation and technical skills required	Low/no public investment, in-kind community contribution possible
Individual water supply	Improved water supply, if properly managed and favourable local conditions	Good awareness and information of households required	Low/no public investment, medium investments by individuals
Tanker/bottled water supply	Unimproved water supply	Basic awareness and information of households required, high running costs for households	Medium public/private sector investments

Assessment of water-supply infrastructure

A thorough assessment of the state of water-supply infrastructure is the first important step for post-disaster reconstruction in order to allow decisions about which parts of the infrastructure are still functional and which can potentially be rehabilitated or whether complete reconstruction is more efficient.

For centralised, piped water-supply systems, assessment should start with interviews with management staff and users in order to determine the pre-disaster state of the infrastructure and level of service as well as the main damage to infrastructure and deterioration of service caused by the disaster. This will allow a focus on the main damage caused by the disaster and on the elements of infrastructure needing detailed assessment.

The following points of assessment of infrastructure for large piped water-supply systems affected by disasters have to be considered:

Water source
Natural disasters may affect the quality of water resources used for the water-supply system, e.g., through salinity intrusion in coastal groundwater or surface water bodies or chemical and microbial contamination of water resources. Alternative water sources may need to be developed if long-term contamination is likely.

Facilities for water production
Facilities for water production are frequently among the most seriously affected by natural disasters and as they are key elements of water-supply infrastructure, they need most urgent

attention for rehabilitation of systems. Damage from natural disasters to facilities for water production may include the following:

- Wells are often located in flood-prone areas and may be contaminated or damaged from flooding.
- Water intake facilities located on river shores may be damaged from flooding.
- Reservoirs and water treatment facilities are prone to damage from earthquakes.
- Transmission main pipes are vulnerable to flooding when located close to water courses and are vulnerable to damage from earthquakes.

Distribution network

The status of the distribution network will generally be closely linked to the situation of the housing infrastructure. Earthquake and flooding may severely damage distribution networks.
Areas with individual water supply may also be severely impacted by disasters; shallow wells are especially prone to contamination from flooding.

Planning reconstruction of water-supply infrastructure

Based on the assessment of the state of the water-supply infrastructure, objectives for reconstruction need to be defined. In general, the minimum objective will be to restore the pre-disaster level of service with better resistance against damage from disasters. However, if the pre-disaster level of water supply was already unsatisfactory, the objective of sustainable reconstruction should be to improve water supply beyond repairing damage from the disaster. The objectives for the level of service will depend on following factors:

- Settlement/site-planning context: reconstruction on existing perimeter or relocation in other areas
- Level of damage to infrastructure/rehabilitation needs
- Institutional capacities for managing centralised piped water-supply systems
- Investment budget available for reconstruction.

In the following, some important design considerations for piped water-supply systems are discussed.

Quantity of water supplied

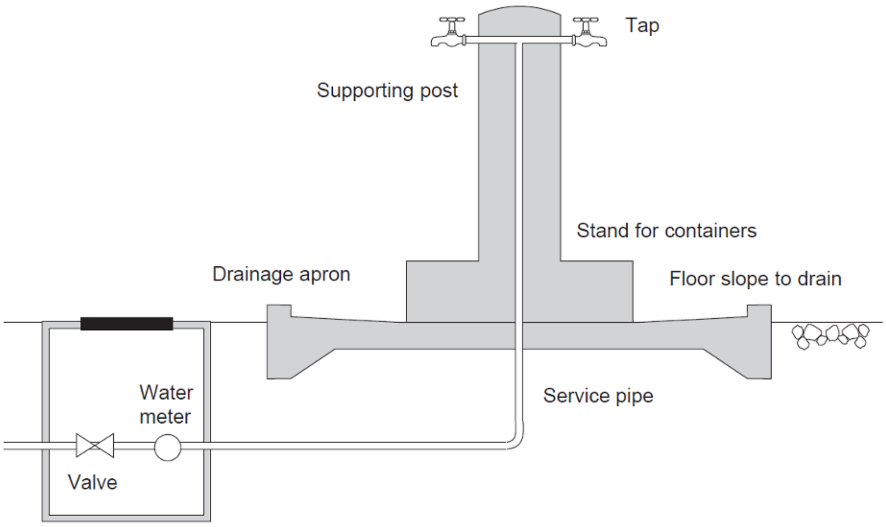
When designing water-supply systems, one main criterion is the quantity of water to be supplied. In general, an allocation of 20 litres per day (l/d) per person allows for consumption needs, hand-washing and basic food hygiene, but not for the needs of bathing and laundry. Fifty litres per day is considered to be the minimum water-use rate to satisfy all needs for consumption and hygiene, whereas 100 l/d is considered the optimum for household connections (WHO, 2003).

Improving water supply beyond the level of basic needs also allows for productive use of water (e.g., in small-scale food production) and supports income generation in poor households.
Quantity of water is closely related to the type of supply point: public standposts are unlikely to supply more than 20 l/d when the distance to the household exceeds 100m. On-plot taps supply, on average, 50 l/d whereas connections with plumping and several taps inside the house are able to supply 100 l/d or more.

System design should be based on targeted water consumption rates and on locally measured consumption rates in areas with existing good water supplies.

Type of supply points in piped systems:

- **Public standposts** located in streets where people collect water with containers. Water use can be free of charge or against fee collection (water kiosk). Household connections serve individual households; in general, water fees are collected based on metered consumption or lump-sum fees.



Public standpost[27]

- **Household connections**, including connections with a single tap in the yard or plumbing and several taps inside the house.

Household connections offer the best level of service and are generally the preferred option. However, public standposts may allow a service to poor populations which cannot afford connection fees for household connections. Standposts may also be used as initial supply points while individual households are being connected gradually.

Continuity of supply

Supply in piped systems can be continuous or intermittent. For continuous supply, pipes in the distribution pipes are maintained under pressure at all times and consumption through supply points is possible at any time. For intermittent supply, water is supplied to different supply zones on a rotational basis and water is supplied only during limited periods. Intermittent supply is usually used for rationing water when the capacity of water production is not sufficient to satisfy the total demand; however, frequently, the reason for intermittent supply is that deficient management of the system does not allow for maintaining permanent pressure in the distribution network.

Water quality from networks operated with intermittent supply cannot be considered safe, as low or negative pressure in pipes during times without supply allows contamination to enter the

[27] WEDC, 2000, *Services for the urban poor – sections 1–6: Guidance for policymakers, planners and engineers*; Cotton, Andrew; WEDC, Loughborough

pipes. Continuous supply should therefore be the objective whenever sufficient water resources are available.

Specific considerations for the design of water supplies include:

Environmental aspects

Water resources are normally continuously replenished. If too much water is withdrawn, however, the source may eventually be depleted. For this reason, it is very important to manage water resources and protect them from overexploitation.

- Consider demand management measures (water tariffs, leak control, water-saving technologies and reuse), which are effective ways of preserving overstressed water resources.
- Ensure that wells are well covered or sealed with lids in order to reduce the hazard of contamination (through floods or accidental spills of toxic substances).

Technical aspects

- Consider seasonal fluctuations in water sources (rivers, lakes) and ensure that water withdrawal does not exceed the source’s capacity at the minimum water levels.
- Use water-distribution designs that are simple, user-friendly and easy to maintain.
- Ensure that water-supply systems are built and maintained with local material and know-how, which the users can afford and know how to apply. This way, the systems will stand a better chance of being used in a sustainable manner
- Avoid placing water-supply systems (pipes, etc.) in locations where the water might easily be contaminated if the system were damaged, e.g., just next to sewage pipes.
- Note that water sources should be protected and properly signalled, prohibiting people from dumping waste or otherwise contaminating the area.
- Consider the distance between a groundwater well and the sea; if it is short and groundwater is pumped at too high a rate, there is a risk of saltwater intrusion into the groundwater. Wells too close to the sea should, therefore, be avoided, and withdrawal of water from such wells should be controlled.

Economic aspects

- Note that financial planning for water-distribution systems has to account for initial investment costs as well as for the management, operation, maintenance, replacement and extension/upgrading of services, including long-term support services.
- Select an approach to developing the system that is affordable and acceptable to system users.

Sociocultural aspects

The form and design of water use in households is culturally conditioned. In many countries, the water supply is mounted outside the house. In other countries, there is only one single tap in the entire household, while still others have highly elaborate and distributed water access points for different functions and in different designs throughout the house (in bathroom, kitchen and toilets).

- Learn the users' preferences before designing the system.
- Remember that the design of water supplies is sometimes gender specific. Do not forget to identify any specific requirements from the female and male users in this aspect.

Institutional aspects

Water-supply systems can be operated privately, by the public or as public-private partnerships.

- Define the formal arrangement and responsibilities for sharing costs, etc., from the beginning.
- Clarify the responsibility for servicing the system and paying associated costs from the outset.
- Formulate a common management strategy if there are many users of the same water source. This is essential.
- Note that appropriate regulations should govern land use near water sources to ensure protection of the supply.

Water treatment

Clean and safe drinking water is a necessity of life. Water sources, however, are often brackish (containing dissolved salts) and/or contain bacteria and, therefore, cannot be used for drinking. By testing water supplies through chemical/physical analysis, it can easily and reliably be determined whether treatment is needed.

Keep in mind that treatment processes are often expensive and normally require regular attention. Specialists should help communities decide on which treatment methods are to be used.

Example: Solar distillation

Distillation is one of many processes that can be used for water purification at household level. Distillation, however, needs much more energy than does pumping water and is, therefore, normally considered only where there is no local source of fresh water that can be easily accessed.

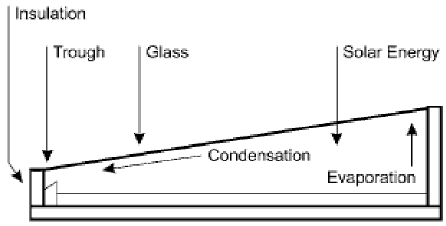
Solar distillation uses sunlight as the energy source. In the distillation process, water is evaporated, thus separating dissolved matter from water vapour that is condensed into pure water.

One option for the household level is the single-basin still. Solar radiation is transmitted through a glass cover. The radiation is absorbed as heat by a black surface that is in contact with the water to be distilled. As the water is heated, it gives off water vapour. The vapour condenses at the glass cover, which has a lower temperature because it is in contact with the outside air, and runs down a gutter into a water storage tank.

To treat larger quantities of drinking water (more than 1m³/day) reverse osmosis should be considered as an alternative to solar stills. A sophisticated version is the photovoltaic-powered *reverse osmosis system*, which requires commercially available equipment.

Seawater reverse osmosis uses a very fine filter membrane that allows pure water to pass through, but captures salt particles. The seawater is pressed through the membrane, against the natural osmotic pressure (hence the name ‘reverse osmosis’). The process requires energy input.

Photovoltaic-powered reverse-osmosis systems derive energy from solar panels fed by the sun’s radiation. This system is still experimental, however, and requires further development.



Single-basin still Skat

Further reading

Solar Distillation – Practical Action: www.practicalaction.org/practicalanswers/

Desalination

Desalination plants can consistently supply high-quality water. Desalination, however, is an expensive option and has much higher operation and maintenance requirements than, for example, rainwater harvesting and groundwater extraction.

The overuse of desalination can also have the long-term effect of encouraging mismanagement and depletion of groundwater reserves!

2.8.2 Sanitation

Good environmental sanitation is as important for public health as is water supply. Sanitation systems provide the collection of used water in households and human waste – its conveyance, treatment and disposal or reuse.

Sanitation and waste water can be divided into latrine waste water (also known as ‘black water’), other domestic waste water (‘grey water’), typically coming from cleaning and washing, and ‘storm-water’, which is rainwater that is collected from roofs and hard surfaces around the buildings.

Black water is the most challenging to dispose of in an acceptable way, as it contains high levels of organic pollutants, often contains harmful bacteria, generates a foul smell and, if left unattended, attracts flies and pests.

Grey water, on the other hand, can often be reused for irrigation or outdoor cleaning. In more developed areas, black water is transported to a central wastewater treatment facility, where it is treated before being released. Very often, however, black water commonly flows from pour-flush latrines and cistern-flush toilets into septic tanks, and, to a lesser extent, into holes in backyards.

Sanitation and waste water often constitute an urgent problem in disaster-struck regions. Groundwater under or near a pit or septic tank may become polluted, which can be a serious problem when it affects the quality of drinking water drawn from nearby wells and boreholes.
Disrupted sanitation or the lack of proper sanitation to begin with, can result in epidemics of cholera and other diseases. A particular concern in reconstruction projects is the possibility that latrine pits and shallow wells will be installed in close proximity on neighbouring plots. Therefore, it is crucial to select the appropriate sanitation system.

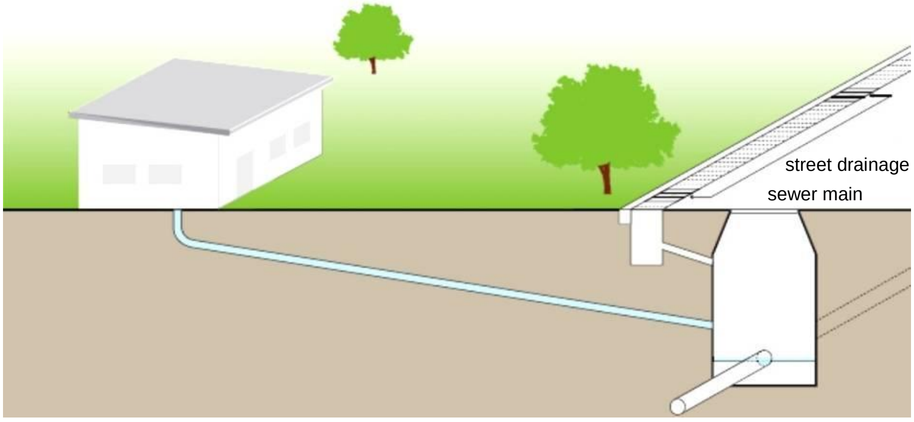
Sanitation systems can be:

- centralised systems with large gravity sewer systems and central wastewater treatment plants
- decentralised wastewater collection and treatment systems
- on-site sanitation systems.

Many technological options are available for sanitation, which can also be applied in a combination of systems for different situations within the same area. Some of the most important options are listed below. These are **selected options only**; for a complete overview of options, *Compendium of Sanitation Systems and Technologies* (EAWAG, 2008) is recommended.

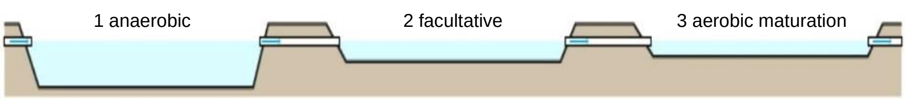
Centralised gravity sewerage and wastewater treatment

Gravity sewers are large networks of underground pipes that convey household waste water including from flush toilets and storm-water to a centralised treatment facility using gravity.
Such systems typically serve densely populated areas, sometimes entire urban areas. The gravity sewer system is designed with many branches, typically subdivided into main sewer lines along main roads and a network at the neighbourhood and household level.
Because the waste is not treated before it is discharged, a constant downhill gradient must be guaranteed in order to avoid accumulation of solids. When a downhill grade cannot be maintained, a pump station must be installed. Access manholes are placed at set intervals along the sewer, at pipe intersections and at changes in pipeline. This technology provides a high level of hygiene and comfort for the user at the point of use. However, because the waste is conveyed to an off-site location for treatment, the ultimate health and environmental impacts are determined by the treatment provided by the downstream facility.



Gravity sewerage, manhole and household connection[28]

Various technologies are available for **central wastewater treatment**, ranging from technically sophisticated systems like activated sludge treatment to efficient low-tech systems such as waste stabilisation ponds. Important criteria for choosing the appropriate treatment technologies are required effluent standards, available investment capital, existing management capacities and available land.



Waste stabilisation ponds: a very efficient wastewater treatment technology which has low maintenance needs but high land requirements[29]

Planning, construction, operation and maintenance require expert knowledge. Gravity sewers are expensive to build and, because the installation of a sewer line is disruptive and requires extensive coordination between the authorities, construction companies and the property owners, a professional management system must be in place.

Decentralised or community-based systems

Decentralised wastewater collection and treatment systems are based on simplified sewer systems for collection of waste water that has been partly treated. Those systems typically serve limited areas such as smaller neighbourhoods.

Simplified sewers describe sewerage networks that are constructed using smaller-diameter pipes laid at a shallower depth and at a flatter gradient than are conventional sewers, allowing for a more flexible design associated with lower costs and a higher number of connected households.

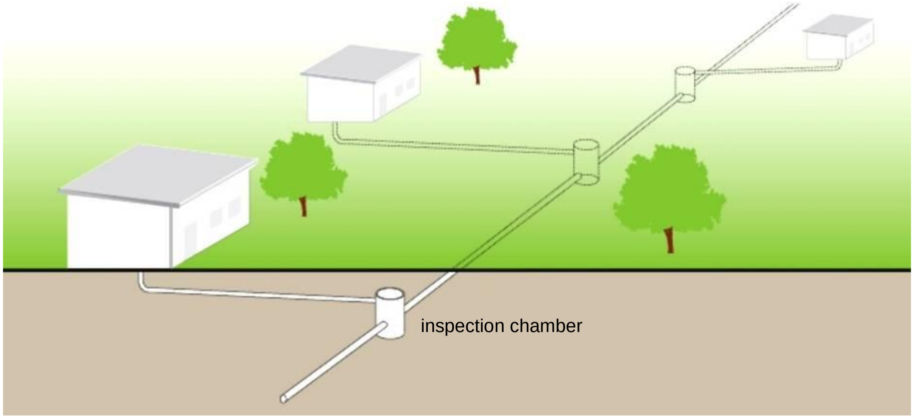
[28] EAWAG, 2008, *Compendium of Sanitation Systems and Technologies*, Tilley, E., Lüthi, C., Morel, A., Zurbrügg, C., Schertenleib, R.; EAWAG SANDEC, Dübendorf, Switzerland

[29] EAWAG, 2008, *Compendium of Sanitation Systems and Technologies*, Tilley, E., Lüthi, C., Morel, A., Zurbrügg, C., Schertenleib, R.; EAWAG SANDEC, Dübendorf, Switzerland

Expensive manholes are replaced with simple inspection chambers. Each discharge point is connected to an interceptor tank to prevent settleable solids and trash from entering the sewer. As well, each household should have a grease trap before the sewer connection. Another key design feature is that the sewers are laid within the property boundaries, rather than beneath the central road.

Because simplified sewers are laid on or around the property of the users, higher connection rates can be achieved, fewer and shorter pipes can be used and less excavation is required as the pipes will not be subjected to heavy traffic loads. However, this type of conveyance technology requires careful negotiation between stakeholders since design and maintenance must be jointly coordinated.

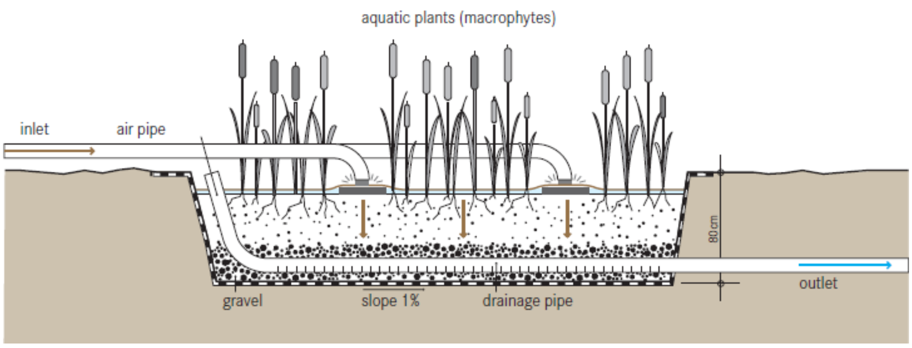
Simplified sewers can be installed in almost all types of settlements and are especially appropriate for dense settlements. Operation and maintenance of simplified sewers can be carried out by municipal utilities or community groups.



Simplified sewer system with collection pipes on-plot and inspection chambers functioning as settling tanks[30]

Waste water collected in simplified sewers can be treated in small-scale wastewater treatment plants or discharged into a branch of a conventional sewer system.
Various technologies are available for decentralised wastewater treatment to suit local conditions and requirements regarding effluent standards, available investment capital, existing management capacities and available land. In general, decentralised systems need to be easier to operate and maintain than are central wastewater treatment plants because of lower capacities on a local level. Natural treatment systems such as constructed wetland are especially suitable for such small-scale treatment plants.

[30] EAWAG, 2008, *Compendium of Sanitation Systems and Technologies*, Tilley, E., Lüthi, C., Morel, A., Zurbrügg, C., Schertenleib, R.; EAWAG SANDEC, Dübendorf, Switzerland



Example of a small-scale wastewater treatment plant: vertical flow constructed wetland[31]

On-site systems

An on-site system provides most functions of a sanitation system on the site of the housing and generally serves one individual household. The systems are most common in low-density settlements in peri-urban and especially in rural areas. Waste and waste water is collected, treated and stored on site. Disposal or reuse may also happen on site.

On-site sanitation frequently involves separate systems for different household wastes, e.g., separate facilities for collection of faeces and urine and for grey water (waste water from kitchen and bathing).

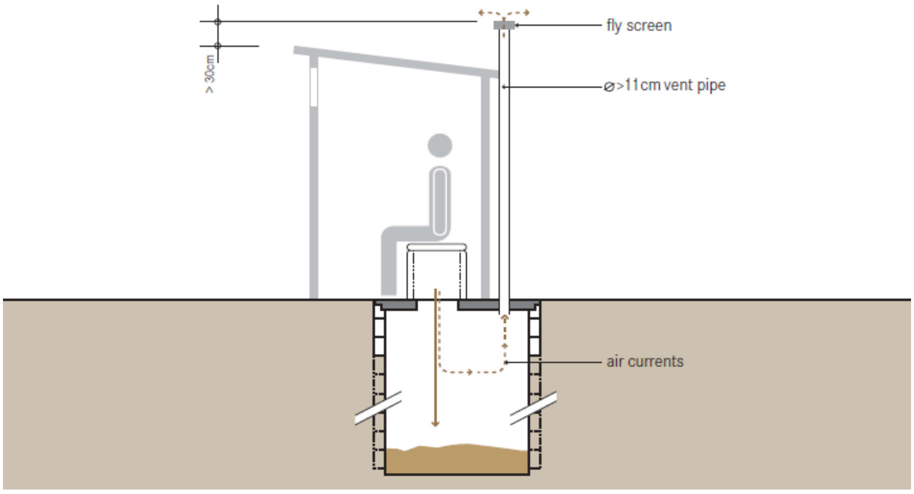
On-site sanitation is user based; investment, maintenance and operation are, to a large extent, provided by the households. However, the quality of on-site sanitation depends very much on the awareness, know-how and resources of households. Awareness-raising and provision of information, as well as financial support, are often required to assure sustainability and safety of on-site sanitation.

Further, most on-site sanitation requires some collective services, e.g., sludge from septic tanks or latrines needs to be collected, treated and disposed of safely. These services need to be organised by community groups, public utilities or private service providers.

Many on-site sanitation systems and technologies exist; some of the most common ones are described in the following:

Ventilated improved pit latrines
A ventilated improved pit latrine is a waterless toilet that collects faeces and urine in a simple earth pit. A superstructure and venting system make the latrine safe and hygienic to the user. Liquids are drained into the underground and, in order to avoid microbial contamination of drinking water, latrines have to be placed at a certain minimum distance (>30m) from water sources such as shallow wells. Solids accumulate in the pit; when the pit is full, either it needs to be emptied or a new latrine needs to be built nearby.

[31] EAWAG, 2008, *Compendium of Sanitation Systems and Technologies*, Tilley, E., Lüthi, C., Morel, A., Zurbrügg, C., Schertenleib, R.; EAWAG SANDEC, Dübendorf, Switzerland

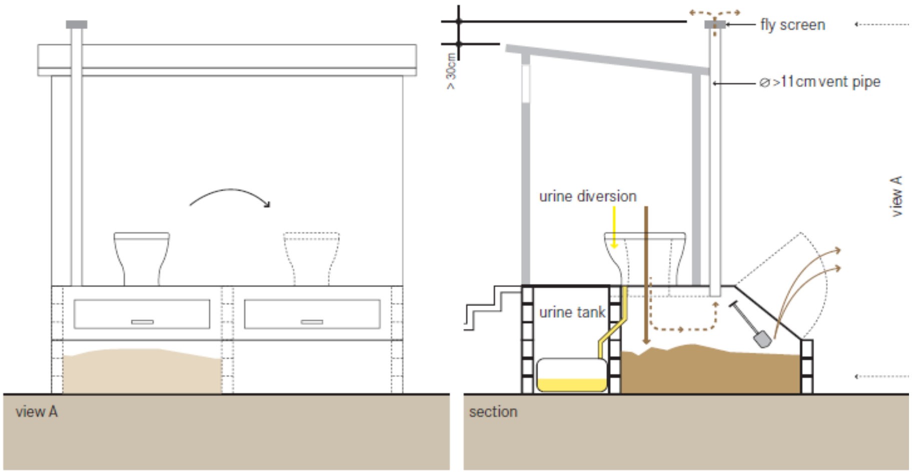


Ventilated improved pit (VIP) latrine[32]

Urine-diverting dehydration toilets (UDDT)

A urine-diverting dehydration toilet (UDDT) is a different type of waterless toilet, where urine is collected separately in containers and faeces are collected in sealed chambers. The separation of urine allows complete drying of faeces. A double-vault system for faeces collection, where one vault receives faeces and the other vault stores previously collected faeces for about six months, ensures that no fresh faeces need to be handled when emptying the chamber. UDDTs do not need replacement as do VIP latrines and do not contaminate groundwater; additionally, dried faeces and collected urine can be used as fertilisers, e.g., on site in gardens. If no space for on-site reuse is available, collection systems are required.

These toilets can be constructed above ground or one metre deep in subsoil formation. They provide a cheap and relatively labour-free option. Only the regular emptying of pits is required.



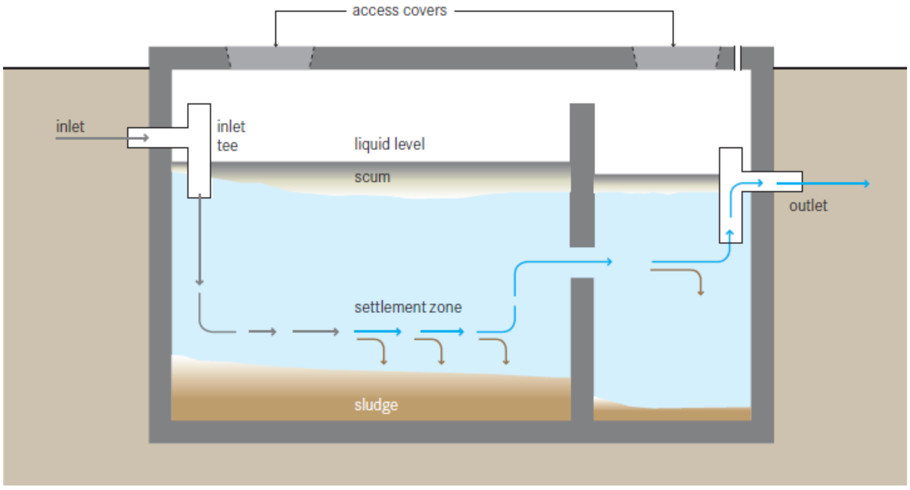
Double-vault urine-diverting dehydration toilet[33]

[32] EAWAG, 2008, *Compendium of Sanitation Systems and Technologies*, Tilley, E., Lüthi, C., Morel, A., Zurbrügg, C., Schertenleib, R.; EAWAG SANDEC, Dübendorf, Switzerland

[33] EAWAG, 2008, *Compendium of Sanitation Systems and Technologies*, Tilley, E., Lüthi, C., Morel, A., Zurbrügg, C., Schertenleib, R.; EAWAG SANDEC, Dübendorf, Switzerland

Septic tank

Flush toilets or pour-flush toilets can be connected to septic tanks which collect and pre-treat urine, faeces and flushing water and, optionally, also grey water. Treatment in a septic tank is based on settling and anaerobic digestion of solids; the solid-free effluent is then either infiltrated on site or needs to be collected in a simplified sewer system. The digestion of solids reduces accumulating sludge greatly; nonetheless, the septic tanks require de-sludging every few years.



Septic tank[34]

Septic tanks are usually a combination of small-scale pre-sedimentation tanks and soak-pits from which sewage migrates freely into the ground. The most widely used small-scale sedimentation tanks can typically hold 1 to 2m³ of black water, providing one household with suitable capacity for approximately six to 10 months, after which it requires maintenance and sludge removal. In many cases, however, tanks are sealed or are located under topsoil, making regular maintenance nearly impossible. Also, tanks are often too small to provide adequate retention time and settling. As a result, most of the untreated sludge moves directly into soak-pits and, from there, sometimes into freshwater resources, causing contamination.

Shared facilities

Shared sanitation facilities such as public toilet blocks are sometimes used in densely populated poor neighbourhoods. Technologies for public toilet facilities are similar to those used for on-site sanitation; alternatively, sometimes small-scale wastewater treatment is used.

Public toilets are particularly common as temporary solutions in post-disaster situations, as they can be installed quickly and can serve large numbers of users. However, shared facilities cannot be considered to be a sustainable and safe sanitation solution on the long term and, in post-disaster reconstruction, should be replaced by improved solutions as quickly as possible.

[34] EAWAG, 2008, *Compendium of Sanitation Systems and Technologies*, Tilley, E., Lüthi, C., Morel, A., Zurbrügg, C., Schertenleib, R.; EAWAG SANDEC, Dübendorf, Switzerland

Public toilet in India[35]

Reusing grey water

Grey water, which includes that which is generated from processes such as washing dishes, as well as other kitchen waste water, and water from laundry and bathing, comprises the majority of residential waste water.

The lack of proper sanitation can result in epidemics of cholera and other diseases. Because it contains little or no pathogens and 90 per cent less nitrogen than does black water (toilet water), grey water does not require the same treatment process.

By designing plumbing systems to separate it from black water, grey water can be reused for irrigation and exterior washing without pre-treatment. It is important not to store to use grey water but to use it immediately to avoiding degradation of its quality.

The benefits of reusing grey water include reduced water consumption, a lower load for septic tanks or treatment plants, less energy use and good plant growth. When this reuse is planned for a new house, the home's wastewater treatment system can be significantly reduced, resulting in cost savings and a lower impact on the environment because water is conserved.

Situation assessment and definition of objectives

A thorough assessment of the state of sanitation infrastructure is the first important step for post-disaster reconstruction. Interviews with management staff and users may be the best starting point in order to determine the pre-disaster state of infrastructure and level of service as well as main damage to infrastructure and deterioration of service caused by the disaster. This will allow a focus on the main damage caused by the disaster and the elements of infrastructure which need detailed assessment. Damage from natural disasters to sanitation facilities include the following:

[35] GTZ, 2007, *Data sheets for ecosan projects*, 023 – ACTS Eco-friendly Public Toilet Centre, Bangalore, India; Gnanakan, K., S.S. Wilson, Wafler, M., Heeb, J.; Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, ecosan program

- Sewers may be clogged with silt and debris after flooding or may be ruptured after earthquakes.
- Wastewater treatment plants may be damaged from earthquakes or flooding, particularly when located close to water courses.
- Damage to on-site sanitation facilities will be closely linked to the condition of building infrastructure.

Planning reconstruction of sanitation infrastructure

Based on the assessment of the state of the sanitation infrastructure, objectives for sustainable reconstruction need to be defined. In general, the minimum objective will be to restore the pre-disaster level of service. However, if the pre-disaster level of sanitation was already unsatisfactory, the objective of reconstruction should be to improve the situation beyond repairing damage caused by the disaster. The objectives for the appropriate level of service will depend on following factors:

- Planning context: reconstruction on existing perimeter or relocation to other areas
- Level of damage to infrastructure/rehabilitation needs
- Institutional capacities for managing centralised sewer systems
- Investment budget available for reconstruction.

For sanitation, there is no one-size-fits-all solution, sanitation situations always should be tailored to the specific situation, which can vary from one neighbourhood to the next.

Many sanitation systems have components integrated into building infrastructure, e.g., flush toilets, septic tanks, etc. Sustainable reconstruction from scratch of entire neighbourhoods or relocations, therefore, offers the chance of rethinking sanitation systems and applying solutions more advantageous than were the common systems prior to the disaster.

Investment and management of decentralised and on-site sanitation systems is highly dependent of the involvement of individual households. It is therefore very important to focus particularly on awareness-raising and distribution of information, as well as ensuring participation of users in sanitation planning.

Considerations for sustainable sanitation systems involve:

Environmental aspects

- Avoid placing sanitation systems upstream from freshwater sources.
- Place soak-pits or infiltration trenches (only for grey water, without faeces) at least at a 30m horizontal distance from any groundwater source.
- Position the base of any soak-pit at least 1.5m above the water table.
- Locate disposal sites that are downhill of groundwater sources.
- Ensure that untreated sewage is not discharged into any freshwater source (e.g., lake, river or groundwater) or into the sea.
- Consider recycling grey water.

Technical aspects

- Ensure that septic tanks are easy to access for sludge removal and maintenance.
- Place septic tanks at least 30m away from the nearest groundwater source, 3m from the nearest house and 3m from any property line.
- Ensure that storm-water drainage is adequate. The lack of adequate or properly maintained storm-water drainage systems can result in flooding and associated side effects.
- Locate outfalls for post-treatment residual fluids at adequate distances from shorelines and villages, with consideration of tides, currents, etc., to safely dilute discharges.
- Ensure that all necessary pipes comply with required standards, including the minimum inclination to allow flow of waste water.
- Consider the separation of black water from grey water, to minimise the volumes that will need more extensive treatment.

Economic aspect

- Carry out financial planning so that initial investment costs of sanitation systems and their management, operation and maintenance are accounted for.

Sociocultural aspects

- Pay attention to traditional and culturally accepted practices for handling waste.
- Ensure that on-site sanitation is user based; decisions on on-site systems should therefore be primarily in the hands of the users.
- Consider the availability of local skills and knowledge, and assess training needs.
- Ensure that the design of sanitation facilities is also gender specific. Do not forget to consult with users to identify any gender-specific requirements.

Institutional aspects

- Decide what system will be used: a centralised public system or decentralised household-managed systems.
- Decide who will be responsible for managing the system and for paying associated costs.
- Ensure that institutional arrangements are in place for the provision of collection services that are necessary to sustainably operate individual (on-site) systems, e.g., disposal services.

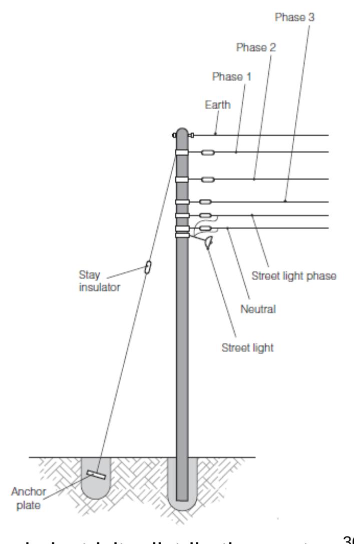
2.9 Electricity/Power

Households use energy for cooking, lighting, heating/cooling of air and water, for powering refrigerators and other household equipment, and often also for other electric equipment such as TV, radio and computers.

A power supply is necessary to provide increased levels of street and security lighting and to run simple household appliances. The principal benefits of domestic connections are largely related to convenience and communication (e.g., charging mobile phone batteries), and possibly for status and productive uses.

During planning of housing reconstruction, it is very important to consider the energy needs of the inhabitants, including objectives regarding sustainable energy supply as well as exploring ways of improving energy efficiency in housing.

The cost of conventional power supply is influenced by the proximity of the reconstruction area to existing three-phase power supply lines. Where extensions to the primary distributor system are required along with new transformers and ancillary equipment, the costs become very high. Conventional power supply requires distribution through systems of conductors and transformers; the options include either overhead lines or underground cables, the latter being expensive and uncommon. Overhead lines may be bare or insulated and either suspended between poles or attached to the face of buildings; in this latter case the lines have to be insulated.



Local electricity distribution system[36]

The structure of connection and consumption fees needs to be carefully considered in order to make the power supply affordable for the poorest households. Full-cost connection fees where the entire costs of connection and of the meter have to be paid initially are often prohibitive for poor households. Fee schemes where connection fees are staggered and collected with consumption fees are preferable. Due to high settlement density, power supply to poor

[36] WEDC, 2000, *Services for the urban poor – sections 1–6: Guidance for policymakers, planners and engineers*; Cotton, A.; WEDC, Loughborough

neighbourhoods can often be realised at a very low cost per capita. Billing and collection costs can be considerably reduced by efficient management or modern technologies. For example, prepaid card systems eliminate the need for meter reading, billing, collection and enforcement. Full advantage has to be made of such options to bring down costs of power connections to poor households.

Renewable energy solutions are often more expensive to purchase and install than are conventional sources. Because renewable energy is virtually free, however, the economy of renewable energy sources over the lifespan of the building is normally much better than it is for conventional systems.

Solar energy

Few options for independent power supply exist. Photovoltaic panels are generally too expensive to be affordable for poor residents. However, solar panels for production of hot water are affordable and help reduce costs for electricity consumption.

Solar energy can be used to provide lighting, mechanical power and electricity. Sunlight is converted to electricity using photovoltaic (PV) cells, also known as 'solar cells' or 'solar panels'. Photovoltaic cells produce electricity as long as light shines on them, they require little maintenance, do not pollute and they operate silently. A reliable supplier of solar panels and appropriate installation is required. Prices for solar panels can differ from region to region. Solar panels can be easily installed on roofs or be placed beside houses.

Photovoltaic panels, used to produce electricity

Solar panels for hot-water production[37]

Another challenging issue is that of clean cooking fuels. Energy in the form of cooking fuel is generally the dominant energy need of the poor. The cost of charcoal is often only marginally lower than the cost of domestic cooking gas (LPG). Subsidising the initial costs of LPG stoves and cylinders may allow substitution of charcoal or firewood with LPG, which would have many positive health and environmental benefits.

[37] Bruce Sutherland, City of Cape Town: UN-HABITAT – United Nations Human Settlements Programme, 2009: *Sustainable Urban Energy Planning – A handbook for cities and towns in developing countries*, UN-HABITAT, UNEP, ICLEI – Local Governments for Sustainability

As far as possible, energy consumption should be reduced through good planning and building design, and by making use of renewable energy sources, such as solar, wind and hydro power, geothermal and bio-power mass energy systems. The benefits of using renewable energy include long-term competitive price stability, reduced vulnerability to fuel supply disruptions and minimised emissions of greenhouse gases.

Technical aspects

- Consider the benefits of sustainable reconstruction which offers a good opportunity to install renewable energy systems, especially when the systems can be installed in a large number of buildings at the same time.
- Select the renewable energy system most suitable for the area of reconstruction. National meteorological organisations usually have maps and data available to estimate how many windy days or sunny days the area has in a year.
- Be aware that some renewable energy sources (wind, solar) should have a conventional back-up system for days with unsuitable weather conditions.

Social aspects

- Ensure that sustainable power and renewable energy systems are well adapted and sensitive to the users' culture.
- Avoid, as far as is possible, indoor cooking and heating with fuel wood or coal; these kinds of energy sources, when used indoors, can cause serious indoor pollution with associated health problems.
- Ensure that training is offered as it is necessary for the construction and maintenance of alternative energy solutions.

Institutional aspect

- Some governments are actively promoting renewable energy sources and providing incentives, such as soft loans and tax reductions, for users to install such systems.

Social infrastructure

Neighbourhoods of a certain size require social infrastructure, either within the community or outside. Social infrastructure includes:

- Schools
- Kindergartens
- Administration
- Shops
- Health centres
- Sport facilities
- Community halls.

The provision of social infrastructure is an essential part of a functioning neighbourhood and should be integrated in any reconstruction programme. Social infrastructure building can be in the form of simple structures, yet their intense utilisation by many people should be taken into account.

Social infrastructure buildings can be constructed with the same materials and technologies as are the housing buildings, or in another suitable form. The location should be well selected, in order to be easily reachable by the community members.

2.10 Solid waste

Solid-waste management is one of the most challenging environmental issues in disaster-affected regions. Waste-disposal practices vary between areas, depending on access to disposal facilities, local tradition and the degree of governmental or municipal intervention.

Quite often there is no regular and controlled waste collection at all. Existing laws, regulations and administrative arrangements concerning waste collection and treatment are often not put into practice. It is also common to find that lack of proper waste management is not perceived as a major problem. It is essential that all stakeholders gain awareness of the need for more-sustainable approaches to waste management.

It is common to find that planners overemphasise the provision of waste-management infrastructure, such as truck fleets and dump sites, but neglect to plan how and by whom waste should be segregated, collected, treated and disposed of. A long-term support programme for waste management should be included in any reconstruction plan.

A major challenge of waste management is the disposal sites themselves in cities and surroundings, which are often uncontrolled, unmanaged and typically located along vegetation lines or shores, causing pollution threats to rivers, natural water systems and groundwater. Impacts on groundwater supplies, the coastal zones and reefs are quite evident. In the absence of alternatives, residents often burn their waste in backyards or uncontrolled locations in the city, causing local air pollution, smell and health hazards from the production of dioxins and other toxic compounds.

Waste materials are generally not segregated at the source. Where markets for recyclables exist, it is more likely that segregation is being achieved at household level.

In order to meet waste-management challenges, the following steps are recommended:

- Approach solid-waste management in a holistic way. Settlement planning, community organisation, an administrative framework, water-resources management, environmental protection and resource recovery aspects should all be fully considered.
- Assess the strengths and weaknesses of the former waste-management system, as a good starting point, and identify how it can be built upon.
- Collect and market systematically recyclables such as metals, paper and plastics. Sometimes, this is economically unattractive for a single household, but may become interesting if organised on neighbourhood or city scale.
- Encourage separate collection and treatment of the organic or ‘wet fraction’ which will allow the production of compost and reduce the amounts of residual waste that has to be hauled to the disposal facility and the associated costs of that activity.

- Consider low-cost, affordable waste-management technologies and systems.
- Organise waste management properly so that it can become a source of income for small transport entrepreneurs or community-based enterprises.
- Charge at least a part of the costs of solid-waste management to the residents as an incentive for them to reduce waste, to raise awareness and to ensure regularity and quality of collection and disposal services.

Technical aspects

Selected waste-management solutions must be practical and easily manageable. Technologies used should be gradually upgraded. For example, it is often better to organise primary collection with locally available means of transport, such as handcarts, horse-drawn carriages or tractors with trailers, instead of relying on costly and maintenance-intensive specialised equipment like compactor trucks.

Likewise, to build a fully engineered and controlled sanitary landfill with leachate control and landfill gas recovery may be the optimum solution but, in order to eliminate uncontrolled burning and dumping, the designation of smaller dump sites on carefully chosen, easily accessible locations may be a better approach to improving conditions until a more comprehensive long-term solution can be implemented.

- Provide drainage trenches downhill of landfill sites on sloping areas.
- Secure and fence off disposal sites.

Rough estimate of solid-waste generation per person:

Each person is likely to produce 0.5 – 1.0 litres of waste per day with an organic content of 25 to 35 per cent.

These figures are likely to vary greatly, however, and estimates should be made locally.

Environmental aspects

- Consider activities that will raise environmental awareness among families and facilitate the introduction of environmentally friendly, healthy, effective, efficient and sustainable waste-management systems.
- Ensure that waste is deposited only on designated sites, which are chosen to minimise the risk of water pollution, uncontrolled burning, access by animals, vector proliferation and the scattering of waste by the wind.
- Locate disposal sites downhill from groundwater sources.
- Locate sites at least 50m from surface water sources.

Institutional aspects

- Assess all stakeholders and their real and potential responsibilities regarding waste management.
- Consider the local administrative and political situation.
- Review local legislation and regulations on waste management.
- Discover who owns the proposed site for waste disposal.

Social aspects

- Assess which solid-waste-management system the residents and the responsible institutions are accustomed to: collection at household level or at centrally located collection sites within a neighbourhood?
- Explore, support and promote community participation in all aspects of the planning, organisation, implementation, supervision and financing of waste-management activities. The best results in waste management are achieved if the community assumes it as their own interest to use the system.
- Note that effective solid-waste management in a city can be achieved only if all citizens at all income levels are served by the system.
- Seek waste-management mechanisms which will attain full coverage for all social groups. If restricted municipal budgets, accessibility limitations or incapacity to pay service fees exclude some of the households from proper waste management, environmental and health improvements in other neighbourhoods will remain at risk.

As a whole, there is no ready-made solution for solid-waste management that fits every situation. Each set of local conditions may well have different requirements, and the right solution for a given place and time will have to be sought. As many desired improvements are related to people's awareness, habits and customs, a practical and realistic step-by-step approach involving as many stakeholders as possible is more likely to bear more cost-effective and appropriate results than centrally planned proposals based on technology inputs and huge investments.

The location of disposal sites should be determined through consultation with key stakeholders including local authority officials, families' representatives and relevant organisations. Appropriate locations should avoid negative impacts from smell, smoke, water pollution, insects and animals on the neighbourhoods.

3. Construction

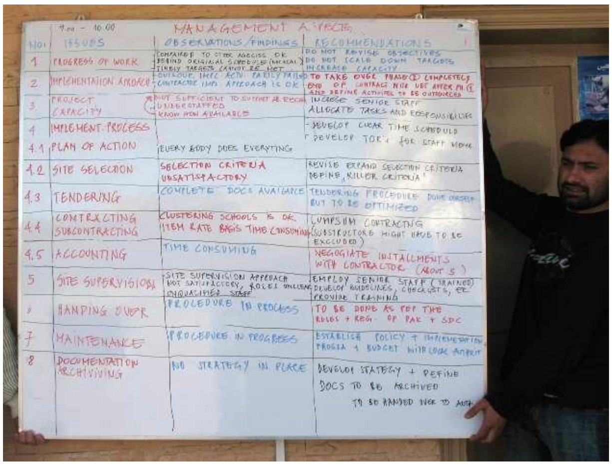
The construction phase is in many ways an important stage in the implementation process of reconstruction activities. Not only can many disturbances be generated from the construction itself, but also the housing's long-term durability depends on whether the sustainable features of the housing design are implemented effectively during the construction stage. A badly planned construction phase can, for example, result in malfunctioning ventilation, energy or water systems in buildings with substandard foundations, making them vulnerable to flooding and earthquakes, or in buildings that are difficult and expensive to maintain, and more expensive to build.

Construction site Skat

Therefore, functioning project management, quality control, environmentally friendly site management, careful handling of construction waste, material banks, controlled demolition and reuse of debris are essential.

3.1 Project management

A functioning management of a reconstruction programme is very crucial and is the basis for good-quality provision of buildings and infrastructure.



Managing the stages of reconstruction Skat

Consideration of the following steps is recommended:[38]

- Establish a team for the management of the implementation; if appropriate, continue with the team that was formed during the planning phase.
- Follow up on initial assessments, stick to the planning and follow jointly agreed decisions with the key stakeholders.
- Establish an agenda for the construction phase.
- Facilitate locally accepted and practical construction technologies for the buildings.

[38] Adapted from: RedR in Oxfam, 2008, *Beyond Brick and Mortar – Hand Book on Approaches to Permanent Shelters in Humanitarian Response*, Oxfam International, Oxford, UK

- Support the selection of sustainable technologies: systems for sanitation, drainage, solid waste, etc.
- Prepare the bill of quantities with technical specifications.
- Prepare detailed cost estimate for the building.
- Draft the cost estimate for site preparation.
- Undertake a tender process for procurement of labour, construction materials, contractors, etc.
- Produce tender documents.
- Set Green Procurement priorities in selecting materials and services that minimise any environmental impact.
- Prepare a comparative short analysis based on the received tenders.
- Meet and negotiate with potential suppliers and contractors.
- Agree with contractor and provide contract.
- Write work order.
- Select reliable suppliers for procuring quality materials on a regular basis.
- Analyse the social, financial, technical and human resources inputs provided by all the partners and the community.
- Provide skills training for construction workers and the community, based on identified knowledge gaps.
- Set safety procedures of the construction site.
- Establish performance standards.
- Conduct soil testing.
- Establish systems for record keeping and documentation.
- Ensure regular monitoring of construction activity, use of materials, quality, etc., as a routine.
- Use mechanisms for participatory monitoring, if appropriate.
- Facilitate a real-time evaluation with feedback, if necessary.
- Measure construction work already done on the construction site.
- Conduct testing of construction materials, such as the cube test for concrete, checking of water used for construction, etc.
- Check and certify bills regularly.
- Release orders for payments.
- Establish construction yard, if appropriate.
- Produce scale models of the prototype building.
- Construct model building, if appropriate.
- Facilitate community meetings at all stages of the programme to engage all stakeholders in the processes, wherever possible.

3.2 Quality control

Regular quality control is crucial Skat

Quality control, which entails a professional monitoring and evaluation system, is essential in sustainable reconstruction. Any deviations from the plans or standards should be corrected without delay. Ensuring that the reconstruction programme meets the required standards is often a challenge. In post-disaster rehabilitation, availability of good-quality material, skilled workers and trained supervision staff with adequate technical and social skills might be missing. Organisations with little or no experience in construction and inadequate knowledge of development principles and standards may be engaged because of an overwhelming scale of reconstruction demand. Therefore, a regular quality control of construction standards and, at the same time, adherence to humanitarian and development principles of disaster response are crucial.

Adequate quality control in reconstruction is essential to maintain minimum standards and codes of conduct.

The following steps are recommended:[39]

- Supervise regularly the reconstruction work to oversee the diverse activities in order to keep technical and humanitarian standards.
- Engage a project manager with adequate construction management and technical skills. This is an important requirement.
- Support training and capacity building of the construction workers together with feedback and supervision support to keeping technical and humanitarian standards.
- Communicate the technical and humanitarian standards to the communities and other stakeholders.
- Train the community to monitor the realisation of those standards.
- Monitor safety standards, which are jointly agreed with the partners. This is to enhance the personal safety of the construction workers.
- Share communication of standards, feedback by the monitoring team and recommendations for improvement with the field staff and implementation team, to make sure that those are transferred to the implementation actions.
- Use only those construction materials with approved quality standards or tested products, wherever possible.
- Utilise construction material, which is suitable for the climatic environment of the area.

[39] Adapted from: RedR in Oxfam, 2008, *Beyond Brick and Mortar – Hand Book on Approaches to Permanent Shelters in Humanitarian Response*, Oxfam International, Oxford, UK

- Employ only skilled personnel with adequate technical and social qualifications as far as possible.
- Facilitate payments on time in order to ensure timely delivery of materials of the necessary quality.
- Ensure quality checks through different methods such as regular technical supervision, reporting, community monitoring committees and material testing.
- Set up coordination mechanisms to share experiences amongst organisations and partners to maintain technical and humanitarian standards of urban reconstruction.

Employ skilled staff Skat

An independent external quality control, provided by inspectors, for example, helps to ensure the quality of any reconstruction programme. Also, those inspectors may be useful to issue the certificates of completion that approve the acceptable completion of homes before beneficiaries are allowed to move into them.

The most critical elements of a reconstruction should be checked regularly; these are:[40]

- **Foundations** need to be sufficiently deep, massive and strong enough to resist damage by floods and earthquakes. Building on unstable ground or steep slopes should be avoided, as it would require expensive foundations to make a building safe. Building on slopes of above 10 per cent is not recommended. Care needs to be taken when starting to build walls above the plinth layer, as this may become a point of weakness.

Preparing foundations Skat

- **Structural frames** should be avoided unless local builders have good knowledge of frame construction. Poorly constructed and inadequately jointed frames of reinforced concrete, steel or timber can put inhabitants at high risk. On the other hand, if frames are well built and compatible infill or cladding materials are used, the result can be a high level of safety.
- **Masonry walls** need to be built with a proper bond in all directions. Walls must be straight (horizontally) and plumb (vertically). Check for this using a spirit level and plumb-line. If

[40] Adapted from: IFRC – International Federation of Red Cross and Red Crescent Societies/Practical Action, 2010, *PCR Tool 10 – Quality Control*, Switzerland/UK

walls are built with distortion, even if it is not visible to the naked eye, this may be a source of weakness.

- **Doors and windows** need to be evenly distributed, and not placed too close to corners or intersections of walls, as this weakens the walls' resistance to earthquakes. Lintels above those openings need to be of sufficient strength and length.
- **Roof structures** need to be anchored well to a wall plate or structural frame; they also need to be interlinked well. During earthquakes and (strong) storms, the building needs to maintain structural strength, with the roof moving together with the walls and keeping them together. If the roof becomes detached and starts to move independently, this can speed up the collapse of a building. The structure needs to be completed to a high standard. Roof rafters and purlins need to be cut or cast to the correct length, with little margin for error. Joints between members need to be well made and fit closely together. Sufficient nails and screws of the correct specification need to be used to tie joints together so that they do not become points of weakness.
- **Roof coverings** of pitched roofs, whether sheets or tiles, need to be tied securely to the frame. Where walls are at risk of being damaged by rain or humidity, roofs also need to provide sufficient overhang.

3.3 Environmentally friendly site management

An important aspect of environmentally friendly site management is the minimisation of construction waste. A certain amount of construction waste will unavoidably be generated. It is important to have a system for handling that waste. A 'site waste-management plan' assists in identifying the volume and type of construction and demolition waste, and sets forth how waste disposal will be minimised and managed. Because construction waste can often be recycled or reused, the separation of different kinds of waste is recommended.

Soil contamination during construction can be avoided through the appropriate storage of fuel and chemicals, e.g., in a secondary containment of fuel tanks and chemical containers.

Additional recommendations include:

- Minimise dust and noise emissions during the construction phase as far as possible through cleaning and covering the site and minimising wind exposure.
- Maintain good working conditions with effective health and on-site safety procedures. Provide workers with safe transport to the site and home if needed.
- Organise transport of materials, workers, etc., to and from the site carefully as this will lower emissions and save costs. Streets might be impassable. Some streets and bridges will not support heavy trucks. A good practice, therefore, is to ask for local advice when making transport plans.

Maintain good working conditions Skat

3.4 Material banks

One of the challenges in reconstruction is the immense and sudden need for construction materials and services at a rapid pace. A material bank should be established to facilitate supply and increase availability, for example, of high-quality prefabricated building elements. Prefabricated elements must be of standard quality and accelerate the process of reconstruction, while their manufacture must provide jobs to local people. Moreover, construction material banks can help in guiding house owners and contractors in constructing appropriate homes.

Due to its large scale of operations, a material bank can also become an economical supply chain for providing bulk building materials, e.g., cement and steel, and trained masons for speedy reconstruction. Community contracts for bulk purchase of materials can be signed.

Supported by mobile units and neighbourhood construction teams, a material bank ensures that building elements manufactured within controlled conditions of qualified supervisors are delivered at the doorsteps of affected families and their construction needs are responded to.

The functions of a material bank can entail:

- Production and supply of building material and elements
- Training in production of building elements for producers and craftspeople
- Training for masons, welders, carpenters, etc.
- Demonstration of building technologies – equipment, products, production processes and applications through demonstration construction
- Provision of building elements on demand to the community or neighbourhood
- Keeping record of skilled masons and craftspeople trained in construction and construction material production
- Providing expert advice.

3.5 Controlled demolition

Waste remaining on the building site from buildings and infrastructure destroyed in the disaster should be handled carefully, removed and transported to an interim storage area at a location identified and agreed with community leaders and the local governmental authority.

Demolishing unsafe structures, reuse of rubble and removal of debris are crucial elements of sustainable reconstruction. Debris and highly damaged buildings situated on private land need careful consideration, appropriate gear and a right of access to be made available.

Demolition works in Haiti Skat

The following key points are recommended for consideration:

- Consult with the local authority before undertaking any demolition activities.
- Sign an agreement clearly stating the scope of each demolition and each party's responsibilities.
- Inform property owners prior to the beginning of demolition or removal activities.
- Ensure that property owners understand and agree with the activities to be undertaken.
- Consult with the relevant authorities prior to considering the demolition or removal of buildings (or parts of them) marked as National Heritage.
- Demolish structures or remove rubble only when written authorisation has been provided by the local authorities and after the local authorities have made provable attempts to contact the owner.
- Note that in the event that an owner refuses to clear the site, the local authority may grant written authorisation.
- Do not enter a plot for the purpose of demolition or removal unless the owner or the relevant local authority has granted official access.

3.6 Reuse of debris

Reusing or recycling of materials from damaged or destroyed buildings has various benefits. It helps to minimise the environmental impact of reconstruction, reduces the amount of debris to be cleared and finally helps to reduce construction costs. Also, the materials are directly available.
Pure materials like bricks, wood, concrete, stone and metal sheets are best to reuse or recycle.

- Use concrete, old bricks and stones as fill material to construct roads.
- Employ metal sheets and bricks for fencing.

Brick masonry rubble provides a good source of materials for use as aggregate in concrete.

Case study: Recycled material – earthquake, Yogyakarta, Indonesia, 2006[41]

In the housing recovery effort in Yogyakarta following the earthquake, brick masonry from damaged and destroyed structures was used extensively to make cast-in-place concrete for the permanent structures. In doing this, construction costs were significantly reduced. Crushing of the brick masonry wall rubble was performed using both manual and mechanical means. Through the process, brick rubble was crushed into fine aggregate required in the mixing of mortar and concrete. The manual process was performed through the use of a simple hammer, while the mechanical process required the use of a mobile stone-crusher. Using the mechanical device, one stone-crusher operator and six support workers could create 15 cubic metres of aggregate each day, relying on only 0.6 litres of oil per cubic metre. Several stone-crushers were deployed throughout the affected area and rubble-crushing was conducted extensively.

[41] Satyarno, I., in: IRP – International Recovery Platform/UNDP – United Nations Development Programme India, 2010, *Guidance Note on Recovery – Shelter*, International Recovery Platform Secretariat, Kobe, Japan

Rubble can also be processed and transformed into construction material, ready to use on site. Rubble-crushers are used for this purpose. One innovative prototype presents the gabion house, which uses caged rubble as building blocks and is currently being assessed for earthquake and hurricane resistance, for example, in Haiti.

Case study: Red Cross Red Crescent Societies – rubble recycling and permanent housing, a pilot project, the Gabion Core House, Haiti[42]

A gabion is a wire cage that can be stacked vertically in a wall and then packed with various materials. Normally gabions are used as retaining walls but, in the case of the gabion house, their design has been modified to allow them to be stacked to form a load-bearing, masonry wall.

To enable the gabions to effectively perform together as a load-bearing wall:

- they must be laid in stretcher bond
- they must be wired together, both vertically and horizontally
- the roof structure (a light one!) should be tied very strongly to the gabion-type walls
- the lids should be removed so that the courses ‘mesh’ and transfer load
- the masonry material must be packed tightly to avoid subsidence
- they must be protected from the weather, in this case by plaster made from crushed rubble
- they must be restrained at the top; this is achieved by spacing 12mm threaded rods at intervals of approximately 2m around the perimeter wall
- the walls must be very well connected in the corners!
- the gabion-type wall must be used only as external walls; use light wooden dividers as internal walls.

In the case of the Haiti post-earthquake context, the gabion core house was developed to utilise as much rubble as possible from the vicinity of the construction site. To achieve this, compacted rubble is also used in trenches for footings and sub-floor build-up, and the material is crushed in a small jaw-crusher to produce sand and aggregate. The impetus to develop such a project came from the high cost of mechanically clearing and dumping the material.

[42] Red Cross Red Crescent Societies, 2011, *Shelter Technical Brief, Haiti Earthquake Operation – First 12 Months*, International Federation of Red Cross and Red Crescent Societies, Geneva, Switzerland

4. Handing-over and maintenance

Newly built houses and infrastructure need regular maintenance so that they function well. During the planning and implementation phase, maintenance issues should already be discussed with the beneficiaries and the partners.

As soon as the beneficiaries move into the house, they should be introduced to the technical installations, such as water supply, sanitation, electricity and waste disposal (sorting), and advised on how best to maintain their new home, e.g., carrying out small repairs and keeping the housing neat and clean.

The main questions concerning the maintenance of residential buildings are: Who is responsible for the maintenance? Who does it? Who finances it?

Maintenance requires regular inspection, economic resources and knowledge. It is a good investment to include a training component for maintenance in reconstruction projects. Maintenance might be impossible if a new material, that is not locally available, is introduced.

The most cost-effective strategy for keeping urban buildings functioning well is to provide regular maintenance and repair defects while they are still small. Buildings that are not maintained at all have only a limited lifespan. Good maintenance, on the other hand, can lengthen a building's lifespan substantially, thus saving resources and prolonging the time before the building will need to be partly or completely rebuilt.

Shortage of funding is often given as a reason for poor maintenance. Remarkable results, however, can be achieved with very limited financial means, if maintenance is regular and systematic. Very often, poor maintenance results from lack of awareness amongst practitioners and the building's users.

To ensure proper maintenance, the following steps are recommended:

- Indicate to users that maintenance is needed continuously and without interruption in order to guarantee the building's good functioning.
- Analyse attitudes towards maintenance. Possibly the greatest challenge to establishing good maintenance is making involved stakeholders aware of its benefits. Find out the attitudes toward maintenance and habits of concerned stakeholders (users, owners, local craftsmen, contractors and local authorities).
- Clarify who is responsible for maintenance and who controls its quality. How will it work in practice? What would hinder good maintenance?
- Provide basic training in maintaining the building when handing over completed buildings to users. According to the users' level of knowledge, this may include information about general cleaning, small repairs and clearing gutters and storm-water drains, and how to use the sanitary facilities.
- Do not hand over buildings unless all systems have been tested and confirmed to be functioning.

- Complete the legal requirements for registration of building and land with local authorities.
- Formulate minimum maintenance standards according to the building design and materials used. Technical specifications, drawings and other references to completed construction works can help in the creation of standards. A good question to ask when developing minimum acceptable house standards is: will they be sufficient to preserve the building shell against weather and theft or must comfort and a nice, clean appearance also be assured? The answer to this question will help determine the scope and efforts of maintenance and related costs.
- Note that maintenance will be easier in buildings with simple designs and good-quality materials and where there has been a sufficient standard of workmanship.
- Clarify who will pay for any needed repairs and maintenance costs. Users, if possible, should assume responsibility if reasonably possible.
- Provide tools for maintenance of buildings with community contribution where possible.
- Train local craftsmen, if necessary, to seal leaking roofs, adjust locks and hinges, and replace water tap seals, broken window panes, etc.
- Avoid complicated technical installations (plumbing, electric systems, etc.) so that any future repairs will be easier.
- Promote and facilitate insurance for the buildings.

Example of a priority list

Cleaning

- Cleaning of inside and outside parts of the building
- Removal of debris from gutters and storm-water drains
- Cutting of grass, if needed
- Cutting of trees and bushes when growing too close to the building, damaging surfaces or dropping leaves into gutters and onto roof

Preventing water damage

- Keeping roofs waterproof
- Ensuring quick and free drainage of rainwater from the building and the site
- Keeping installations waterproof
- Checking foundations, floors, walls, ceilings regularly for cracks
- Securing foundations against erosion
- Investigating cracks to identify the causes; the causes of the cracks should be addressed and the more serious cracks repaired by skilled masons
- Undertaking regular rat, bat, insect and micro-organism (fungus) control.

Further reading

Quality Assurance Checklist (3) – House Maintenance in Resettlements for House Owners and Occupants, Practical Action – Sri Lanka

Annex I: Case studies

Pakistan

Pakistan Straw Bale and Appropriate Building (PAKSBAB)

PAKSBAB offers creative green building solutions using local labour and renewable materials, such as straw, to provide affordable permanent housing especially suited for seismic and severe temperature regions of developing countries, such as Pakistan. The building methods used are about two times more energy efficient and almost one-half the cost of modern low-income housing.

Displaced families from Alai work with PAKSBAB on their straw-bale homes

Bamboo pins provide out-of-plane support for straw-bale walls

Since 2005, over 400,000 people have tragically died in devastating earthquakes in developing countries, mostly due to building collapse. Experts predict that a million people will die in a single earthquake in this century. In post-disaster reconstruction programmes and in building codes, there is an emphasis on conventional building materials and methods such as concrete and masonry construction. These methods are deadly when improperly constructed and require the use of high-cost, energy-intensive materials and skilled labour, usually unaffordable for the poor. Following an extensive natural disaster the demand for these materials further increases the cost. Concrete and masonry construction also perform poorly in hot and cold climates, and their production, transportation and use are harmful to the environment.

Straw-bale construction uses straw, an agricultural by-product, compressed and tied into bales, as building blocks for walls. As currently practised in many developed countries, straw-bale construction offers numerous benefits, including energy efficiency, the use of natural non-toxic materials, and resistance to earthquakes, fires and pests. Straw-bale buildings have proven to be durable, some lasting more than 100 years.

The challenge is that the cost of typical straw-bale construction is as high as conventional standard construction, as it utilises many similar components and materials. In response, PAKSBAB has developed unique straw-bale building methods providing exceptional structural capacities at about one-half the cost of modern low-income housing in Pakistan. We are able to accomplish this with simple load-bearing designs, in which the straw-bale walls support the roof load and resist earthquake and wind loads. We also utilise renewable and locally available materials such as straw, bamboo, wood, clay soil, sand, gravel and rock, as well as local labour. The site-fabricated bales are smaller than those used in typical straw-bale buildings, with reductions in foundation footprint and cost. Other unique features include the use of stone foundations encased in soil cement, and nylon fishing net that provides plaster reinforcement and ties the foundation, straw-bale walls and roof together.

Fabricating straw bales on site

Fishing net is wrapped underneath stone foundation

Additional appropriate building methods that PAKSBAB is promoting include passive solar, rainwater catchment, solar lamps, high-efficiency cooking and heating, and the use of natural building materials such as light straw-clay, wattle and daub, and cob.

As of March 2012, PAKSBAB has trained about 60 people and has built 26 straw-bale houses in northern Pakistan, 25 of which are in Khyber Pakhtunkhwa and one in district Jhelum, Punjab. During this time, building materials and methods were refined in order to decrease material and labour costs as well as meet homeowner needs. The houses are one storey and range in size from one room with veranda (340 sq ft) to four rooms plus bath, kitchen and veranda (1,024 sq ft).

Placing first layer of straw bales

One-roomed straw-bale house under construction

Straw bales suitable for building are not currently available in Pakistan; therefore, PAKSBAB has developed a system for manufacturing straw bales from manually operated farm jacks and locally fabricated compression moulds. PAKSBAB works to establish viable independent local enterprises to supply building materials for straw-bale construction projects.

In 2007, a rural Community Development Programme (CDP) was initiated, designed to engage severely disadvantaged families in the construction of their own straw-bale houses. The standard CDP home is 24ft x 24ft (576 sq ft), comprised of two rooms and a veranda, with an optional kitchen. Each family contributes labour and some building materials, if possible. With local community input, PAKSBAB selects project beneficiaries based on their need, vulnerability and willingness to participate in the home-building process. Preference is given to victims of the recent floods or 2005 earthquake, widows with small children, and people with disabilities. PAKSBAB has also been partnering with the organisation Spinal Cord Injury Project for Pakistan Earthquake Rehabilitation (SCIPPER) to build homes for people paralysed in the earthquake and in vulnerable situations.

To date, the homes PAKSBAB has built have been extremely well received. Interviews and a survey of PAKSBAB's low-income home-owners have shown improvements in security (30% felt secure before/100% after), comfort (40%/100%), health (30%/80%), school attendance (20%/80%), employment (60%/100%), economic collateral (50%/100%) and social status (50%/80%). Most of their employees come from the micro- to small-income bracket and many now live in straw-bale homes. They are good ambassadors for the building method as they have first-hand knowledge regarding the construction, operation and performance of their homes.

Standard 24ft x 24ft straw-bale house

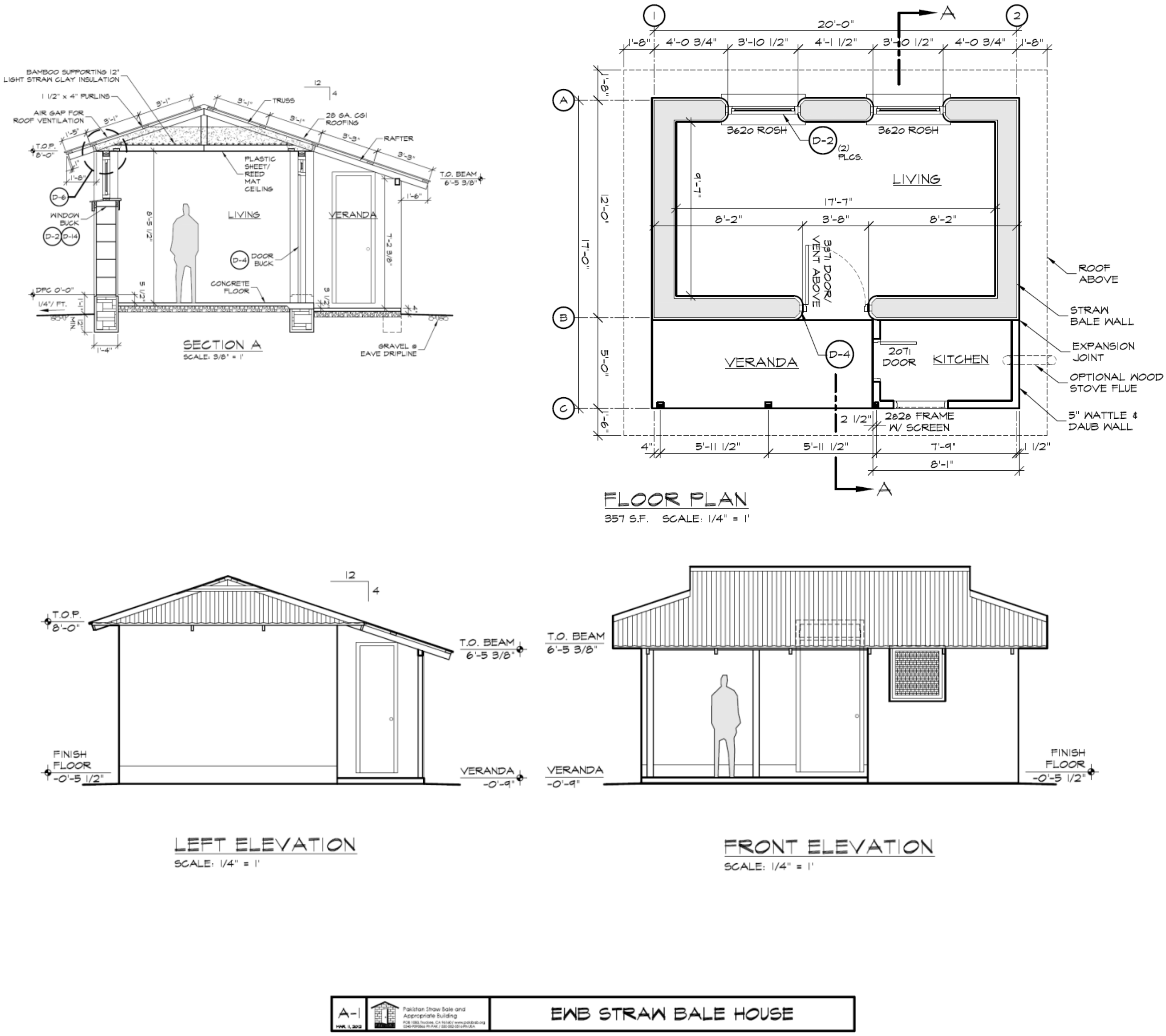
Straw-bale house earthquake simulation at the University of Nevada, Reno, US

In March 2009, PAKSBAB conducted successful shake table tests of a 14ft x 14ft x 10ft full-scale straw-bale house in order to determine its seismic response. The test was conducted at the Network for Earthquake Engineering Simulation (NEES) facility at the University of Nevada, Reno, US. The Earthquake Engineering Research Institute helped to fund the project and the NEES Consortium provided shared-use access to the laboratory. The house, representative of those currently being built in Pakistan, was subjected to a series of eight simulated earthquakes of increasing intensity. It survived accelerations of 0.8g, larger than the 0.3 to 0.6g estimates of the Kashmir Earthquake accelerations (Geological Survey of Pakistan). These were the first shake table earthquake simulations conducted on a straw-bale house and have provided solid evidence that PAKSBAB's straw-bale construction system is indeed earthquake resistant. The results will be used to obtain official approval from building authorities and have provided valuable baseline data, from which we can further improve performance and optimisation of the design and cost.

Over 6.6 million micro- to small-income families are currently in need of decent housing in Pakistan as they lack land, financing, and construction skills. PAKSBAB offers affordable housing solutions at a construction cost (materials and labour) of about 550 rupees per sq ft (6 US dollars per sq ft) as compared to conventional developers' estimates of 1,000 rupees per sq ft (11 US dollars per sq ft) for low-cost housing.

Compared to conventional building methods, PAKSBAB's approach is unique in that the primary materials of straw, timber and bamboo used in our home-building process sequester CO_2. Straw-bale construction is extremely energy efficient and comfortable, with an excellent balance of insulation and mass, reducing the amount of fuel required for heating and cooling. Our construction methods significantly also reduce the use of building materials with high-embodied energy such as cement and steel, as well as the fossil fuels required for their manufacture and transportation.

Further information: www.paksbab.org



Cambodia

Ketsana Relief and Rehabilitation in Kampong Thom and Ratanakiri

Typhoon Ketsana made landfall in Cambodia on 29 September 2009. At its peak intensity it reached wind speeds of up to 165km/h. The weakening typhoon struck north-eastern Cambodia as one of the most severe storms ever to lash the country, with the worst damage in the provinces of Kampong Thom, Preah Vihear, Siem Reap and Oddor Meanchey, Mondulkiri and Ratanakiri. The death toll was 43 people. More than 66,000 families were forced from their homes by flood waters. This is an area where, even before the disaster, most communities lived below the poverty line.

The Cambodian Red Cross (CRC) requested the Swiss Red Cross (SRC) to support their reconstruction initiatives in Ketsana-affected villages. SRC decided to assist in the rehabilitation of housing in Kampong Thom and Ratanakiri. This decision was made following first-relief activities carried out by the CRC and an inter-agency assessment led by the Government of Cambodia and the official request for assistance of the CRC. The project aimed at reconstructing 111 family homes in the above-mentioned provinces with local constructors' labour and active follow-up and monitoring by CRC and SRC.

The overall goal of the project was to reinstall or improve the living conditions and reduce vulnerability of the Ketsana-affected families. The specific focus was directed on the provision of affordable, cyclone-resistant, sustainable, social and environmentally-friendly habitat for 67 families in Kampong Thom Province and 44 families in Ratanakiri Province. Water supplies and separate toilets were provided by partner NGOs. The beneficiaries were carefully selected with a clear criteria and an endorsement of local governmental authority in regard to their land titles and their status to poverty as they could hardly generate sufficient income to rebuild their dwellings.

Vernacular architecture was not seen as a style, but as a system of knowledge. The lessons learnt from it are based on the sophisticated structural frame of the traditional wooden houses in rural Cambodia. Due attention was given by the architect to design housing units that are suitable for the climate, social and cultural aspects and the sustainability of the environment. Design and planning consider safety (cyclone-proof structure), sustainability (environmentally friendly), and social responsibility (saving the community) as inseparable. This incorporates the construction of autonomous and appropriate houses built with locally available materials which can be easily replicated.

Each housing unit is provided with access to drinking-water supply and a toilet, thus creating a complete habitat. Most of the beneficiaries had no experience of a hygienic sanitation system. The provision of WatSan infrastructure goes simultaneously with knowledge dissemination to the villagers with respect to maintenance, healthcare and disaster-mitigation programmes to enhance ownership. The funding for these WASH components was provided by partner organisations facilitated through the CRC.

The operational management was done by the CRC, closely monitored by the SRC. Technical support was provided by Skat through regular monitoring visits before, during and after the construction. For the construction implementation a mixed owner/contractor-built approach was applied. The structural frame including roof was built by a contractor, while the doors, windows, etc. were done by the beneficiaries. The key cornerstones of this mixed approach comprise people's participation in the construction process, customisation of houses to accommodate beneficiary aspirations, meeting stringent technical safety standards, beneficiary satisfaction and ownership.

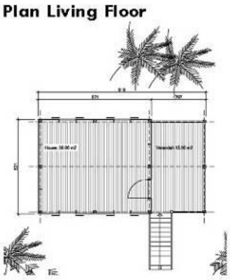
Access to the remote villages was often difficult and therefore increased construction costs. In response, well-known, field-proven technologies with low maintenance requirements are applied. The expected lifespan of the buildings is 30 years. The new houses fit very well into the existing village architecture. Beneficiary satisfaction is very high. Also, local authorities are very pleased with the support given to the most vulnerable population. Against this background the provision of cyclone-proof houses at around 2,000 US dollars per unit is seen as exceptional compared with common reconstruction projects.

Financed by:	Swiss Solidarity and Swiss Red Cross
Overall Responsibility:	Swiss Red Cross
Implementation:	Cambodian Red Cross
Technical Backstopping:	Skat Consulting Ltd, Switzerland

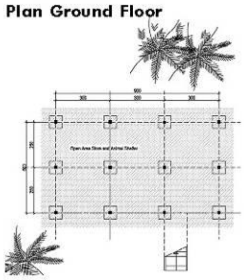
PROJECT DATA

Function:	Post Disaster Reconstruction
Location:	Provinces of Kampong Thom and Ratanakiri
Funding:	Swiss Solidarity and Swiss Red Cross
Project implementation:	Cambodian and Swiss Red Cross
Architects/Engineers:	Skat, Switzerland
Construction implementation:	Contractor built
Water / Sanitation:	Owner built
Years of construction:	2010 / 2011

Plan Living Floor

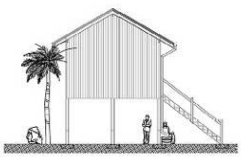


Plan Ground Floor

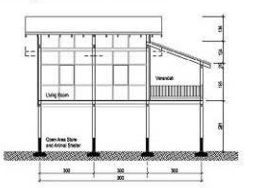


Longitudinal Elevation

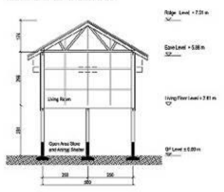
Cross Elevation



Longitudinal Section



Cross Section

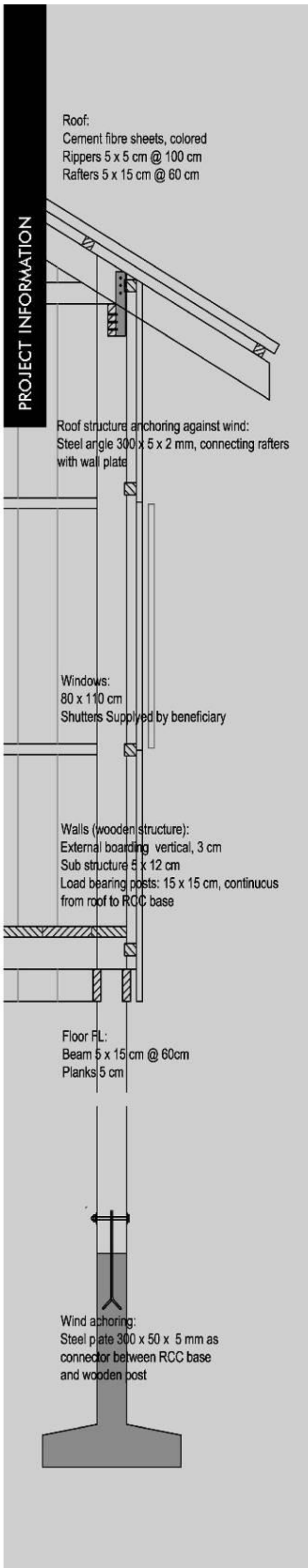


PROJECT SCOPE

Number of houses built:	114
Number of villages served:	5
Built-up house area, incl. veranda (in m^2):	47.8

BUILDING COST AND MATERIALS USED

Cost / house, incl. veranda, toilet, excl. window shutters:	US $	1'900
Cost / m^2, incl. veranda, toilet:	US $	40
Structural frame:		local hardwood
Foundations:		reinforced concrete
Walls / Floors:		local hardwood
Roof:		cement fibre sheets



Skat

Disaster risk reduction through improved vernacular construction methods

UNIQUE FEATURES

Traditional way of construction	Improved cyclon proof solution


The stilts of traditional houses often lack solid cyclone and flood proof foundations. The improved solution includes wooden stilts fixed in a wind resistant manner on solid pre-fabricated footings made of reinforced concrete.


Often the corner joints of traditional houses are poorly done. As a result the structural frame cannot resist strong winds.
Much higher resistance can be achieved by introducing simple corner joints with grooved beams


In traditionally made joints single floor beams are penetrating the columns resulting in a low load bearing capacity. The improved solution shows twin floor beams grooved into the column without weakeing it


King posts with simple jointed roof beams as introduced in the improved solution increase resistance against wind forces. At the same time they reduce wood consumption.


Rafters of traditional roofs are often not properly fixed to the roof structure. By adding simple steel angles the roof becomes cyclone proof.

Skat

Haiti (I)

Ti Kay Pay - A Straw-bale Rebuilding Solution for Haiti[43]

The earthquake on 12 January 2010 that devastated Haiti, causing the deaths of 230,000 and leaving 1.4 million homeless, was an enormous tragedy for the people of Haiti. But it has also yielded an enormous opportunity for Haiti to rebuild, restore and revitalise itself in ways not possible before. In the building realm, there is the opportunity, and truly the necessity, to rebuild in ways that are appropriate and sustainable – culturally, economically and environmentally.

Straw-bale construction uses straw, compressed and tied into bales, as stackable blocks for wall systems. The stacked bales are usually covered with plaster – made from sand and a clay, lime or cement binder, and often reinforced with fibres, mesh or internal or external 'pins' – to create a composite wall system. Originating in the state of Nebraska (US) in the 1890s, this construction method remained localised with sporadic use into the 1930s. Some of these early buildings are still in use. Rediscovered in the 1980s, and further investigated and developed, modern straw-bale construction has been practised for 25 years, and is now found in 49 of the 50 states of the US, and in over 45 countries and in every climate across the globe, including in areas of high seismic risk, such as California, China and Pakistan.

Straw-bale construction has been used primarily for residences, but also for offices, schools, environmental centres and retail stores. Straw-bale buildings have ranged from the very small and simple, to the very large and elaborate. Although usually single storeyed, two and even three-storeyed buildings have been constructed.

Why Straw-bale Construction in Haiti?

Straw-bale construction offers many significant advantages as a semi-urban and rural building system in Haiti.

- Low cost: The estimated cost of materials and labour for the Ti Kay Pay, with an interior dimension of 3m x 5m plus a front Galri (veranda), is between 1,500 and 3,000 US dollars.
- Earthquake resistant: In laboratory tests, straw-bale buildings have proven remarkably resistant to seismic forces. The most notable tests include:
  - 2002 – monotonic and reverse in-plane cyclic tests of 8ft wall specimens at the University of Illinois, US
  - 2004 – in-plane cyclic test of 4ft wall specimen at California Polytechnic State University, US
  - 2009 – monotonic tests of 4ft and 8ft wall specimens, and a shake table test of full-scale house specimen of the PAKSBAB system at the University of Nevada, US. The house specimen withstood 1.4 times the ground-force acceleration of the 2005 Kashmir earthquake. See the video of this successful test at http://nees.unr.edu/projects/straw_bale_house.html

[43] Project proposal by a team of building professionals expert in straw-bale construction and other appropriate and sustainable building practices; under the auspices of Builders Without Borders: Martin Hammer – Architect, Builders Without Borders; Regine Laroche – Architect, Port-au-Prince, Haiti; Henri Mannik – P.E., Principal, Azure Engineering; Andy Mueller – Principal, Green Space Collaborative; Kevin Rowell – Director, Kleiwerks International; Dan Smith – Architect, Principal, DSA Architects.


Crushing rubble into usable aggregate


Tarpaulins into gravel bags


Straw bale being tied off in a steel compression mould

- Local materials/resource efficient: Virtually all materials in the Ti Kay Pay are available in country, and most are available locally. The design minimises use of materials that are scarce, expensive, environmentally harmful, or imported, such as wood, steel and cement. The Ti Kay Pay utilises a seasonally renewable agricultural waste product, rice straw, as the core of its composite wall system. Rice straw is plentiful in the Artibonite Valley and near Les Cayes. Annually renewable bamboo is used as external, wall-stiffening pins. The finish plaster consists of readily available clay (the binder), sand or other fine aggregate, and natural tensile fibre such as straw. The primary plaster reinforcing is either nylon fishing net, or a natural-fibre mesh. The foundation system uses a rubble trench footing as well as crushed rubble, gravel or earth in coursed geo-textile bags for the stem wall. The top plate of the wall uses wood, but shorter lengths can be spliced together, and bamboo is a possible non-wood option. The roof structure is shown as bamboo trusses, although options include 'pallet trusses' made from wooden pallets or other short lengths of wood or light-gauge steel trusses.


Disassembling pallets

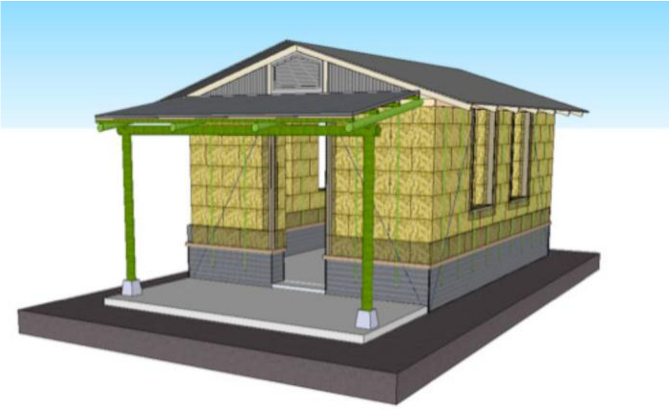

Preparations for wall construction

- Market for straw/job creation: Substantial use of straw and straw bales as building materials would create a market for rice straw (rarely utilised in Haiti, and worse, sometimes burned), and develop an industry for the manufacture of straw bales (currently unavailable in Haiti). Bales are made manually using a steel compression mould and farm jack.
- Culturally appropriate forms: Straw-bale construction is easily adapted to architectural forms that are culturally appropriate in Haiti. The bales can be thought of as large, fuzzy, masonry units, which are stacked and plastered. The design form is that of the Ti Kay, the archetypical small rural cottage, but other rectilinear designs, and even curved forms, are possible. The design shown allows for expansion to the rear with an extended gabled roof, and to either side with shed roofs. Structurally, the design is single-storeyed load-bearing, but two-storeyed buildings can be constructed with a post-and-beam structure and straw-bale infill shear walls.
- Thermal comfort: Plastered straw-bale walls offer an optimal balance of thermal mass and thermal insulation. Although the tropical climate of Haiti requires little if any need for insulation against heat loss, the plaster on the walls provides sufficient mass to temper the day-night temperature swings, and the straw insulation helps keep the daytime exterior heat away from the interior. Also, a mixture of light straw-clay above the ceiling provides an insulating barrier against radiant heat from the steel roof. Ample eave, ridge and gable ventilation flushes the attic of hot air build-up.
- Fire resistant: Plastered straw-bale walls are remarkably resistant to fire. In 2006, clay and cement-plastered walls withstood one-hour and two-hour ASTM E-199-05a fire tests respectively. Test results are available at www.ecobuildnetwork.org/what-we-do/straw-bale-test-program.
- Acoustic insulation: Straw-bale walls are excellent acoustic insulators, offering acoustic privacy unmatched by conventional wall systems. This is especially advantageous in semi-urban locations, or if housing units are clustered or share walls.

About moisture: Ambient humidity, into the 80 per cent range, is in itself not enough to cause moisture-related problems in straw-bale walls (Haiti's highest daily average Relative Humidity is 56 per cent). However, significant water intrusion without the ability to dry within a reasonable time-frame can create rot or mould in straw-bale walls. The building design minimises this risk by use of moderate roof overhangs and by keeping the bales well off the ground (0.5m). Inherently, the clay plaster wall finish is hydrophilic (readily absorbs moisture), thus helping to keep any moisture that may reach the plaster/straw interface, away from the straw. Also, of all the cereal grains, rice straw (the type of straw available in Haiti) is the most resistant to decay. Straw-bale buildings have been successfully in service for many years in tropical climates such as Hawaii, Nicaragua and Sri Lanka, and in regions of seasonal high rainfall such as the American northwest.

About insects: With minor exception, insects have not caused problems in straw-bale buildings throughout the world. This includes termites, which have shown little or no interest in straw. Rice straw, in particular, with its high silica content, is especially resistant to consumption by termites or other insects.

Structural system: The building type is typically called a 'straw-bale building', but from an engineering perspective a plastered straw-bale wall is a composite system in which the straw bales are only one component. The inner straw-bale core, the outer stiff plaster with reinforcing, and wall ties all work together as a structural assembly – one that yields impressive results as a gravity load-bearing and lateral load-resisting system, all from simple and accessible materials such as earth, straw, twine and wire. In engineering terms, a plastered straw-bale wall functions as a stressed-skin panel. It can be thought of as a 'natural structural insulated panel' or a 'natural SIP'.



The Ti Kay Pay unplastered, showing mesh over gravel bags, bamboo stiffeners over straw bales, and diagonal wire bracing (drawing by Ng T. and Smith D.)

Construction of straw-bale walls

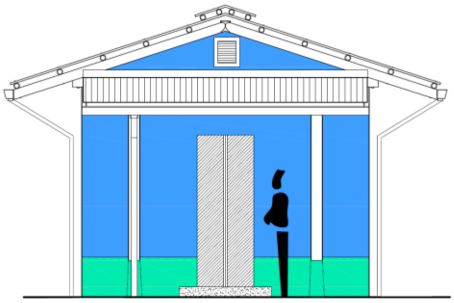
The proposed building uses its composite straw-bale walls as both the gravity load-bearing structure and the lateral earthquake and wind-resisting structure. Seismic testing (see links above) has shown that the capacity, toughness (ductility) and energy absorption of straw-bale walls can equal or exceed the capacity of wood-framed plywood walls commonly utilised in high seismic regions of the US.

The design maintains a minimum of a 4ft (1.3m) shear panel at all four corners. This provides strong and balanced resistance to wind and seismic lateral loads. Under extremely high loads, even if the stiffer plaster skins disintegrate, the highly resilient straw-bale core remains as a secondary load-resisting and dissipating system. In all cases, the opposing and through-tied bamboo pins, which capture both the stem wall and the top plate, provide excellent resistance to out-of-plane lateral loads. The top plate and the steel-roof diaphragm complete the structural tie of the building at its top, with proper connections of all structural elements.

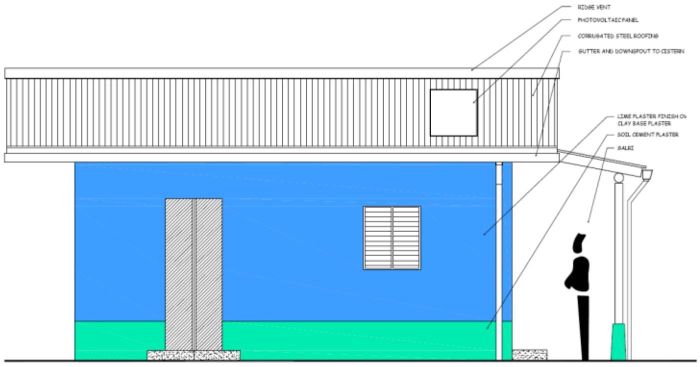
To address high wind forces from hurricanes, tensioned vertical strapping extends from the top plate to the underside of the gravel-bag stem wall, and the roof structure is strapped to the top plate. The foundation stem wall extends 0.5m above the ground to help separate the straw bales from water at the ground and to provide significant mass low to the ground. This stabilises the wall and resists uplift from hurricanes or seismic overturning.

Associated Systems

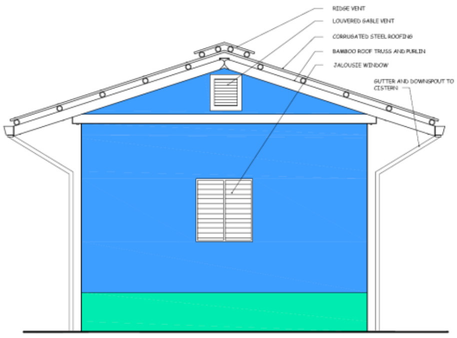
- Electrical: Although not indicated on the floor plan, lights, switches and outlets are included in the house, all powered by a modestly sized, 12V, direct-current, photovoltaic system. The photovoltaic panels' location is dependent on the solar orientation of the building.
- Rainwater catchment: Gutters and downspouts direct rainwater to an above or below ground-level cistern.
- Sanitation: A small detached building, housing a composting or dehydrating toilet (such as those promoted by the organisation SOIL), is suggested for a building of this small size. Such a facility might be initially shared among households, and, although important, is not currently included in this proposal. The safe use of human waste as an agricultural fertiliser is strongly encouraged. This has been practised successfully in many regions of the world including Sweden, China and in parts of Africa.
- Cooking: A cooking facility is not currently integrated into the Ti Kay Pay. Cooking would generally occur immediately outside the home under cover of a roof overhang. Roofs could be extended or added to provide greater protection from rain or sun. A detached kitchen or a kitchen addition could be constructed by the owner. The use of 'rocket stoves' or other highly efficient stoves is strongly recommended.



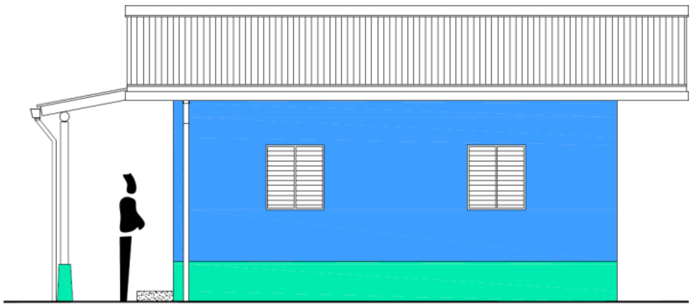
ELEVATION-FRONT



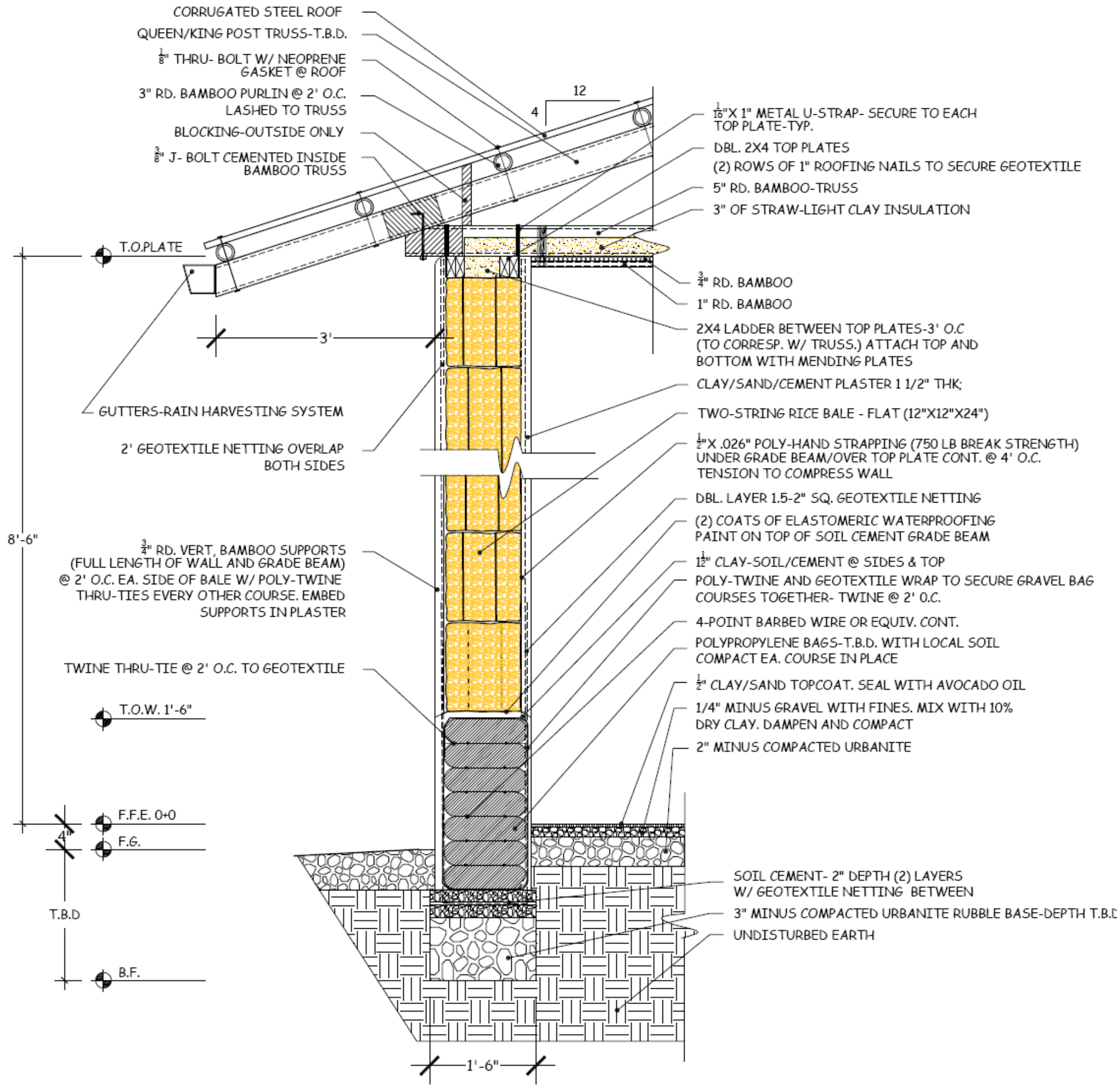
ELEVATION-LEFT SIDE



ELEVATION-REAR



ELEVATION-RIGHT SIDE



LOAD-BEARING WALL SECTION

El Salvador

Improved Adobe Mudbrick in Application – Child-care Centre Construction in El Salvador[44]

Background

Two major earthquakes shook the small Central American country of El Salvador in early 2001. The two quakes (registering Mw7.7 and Mw6.6) devastated the social and physical infrastructure of the small nation. These disasters claimed almost 1,200 lives and affected over 1.6 million people. The housing sector was particularly hard-hit, with over 166,000 houses destroyed and 110,000 houses damaged. In some regions, up to 85 per cent of the houses were destroyed. The vulnerability of traditional adobe (mudbrick) houses was clearly demonstrated, with 113,000 adobe houses destroyed and 43,000 adobe houses damaged. Overall, 44 per cent of the pre-earthquake adobe housing stock was affected (damaged and destroyed), and adobe houses accounted for 57 per cent of the total number of affected houses.

Destroyed adobe houses, El Salvador (López, M.)

There are two main reasons why adobe houses performed so poorly in the earthquakes. Firstly, adobe is a low-strength, brittle material, which yields under much lower stresses than ‘modern’ materials, such as steel, concrete and conventional masonry. Secondly, traditional adobe houses are often poorly constructed and/or maintained due mainly to resource and skill limitations. These features mean that, in general, adobe structures are more vulnerable to damage during seismic events.

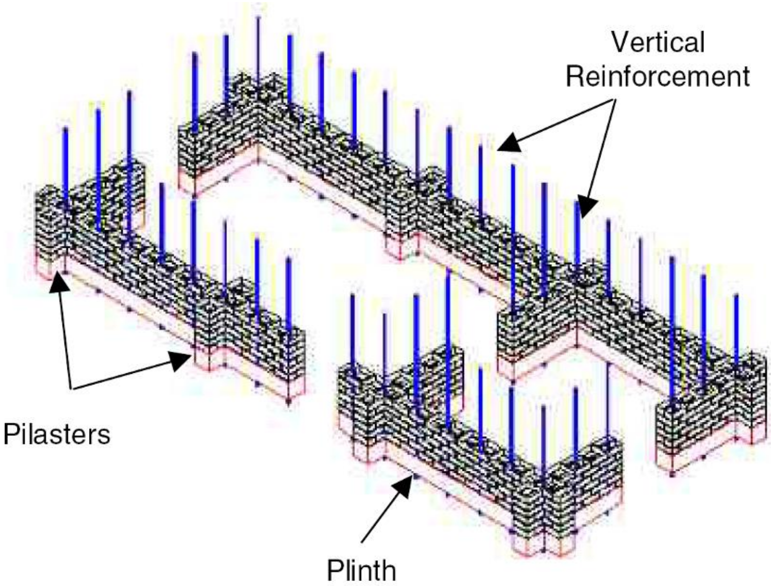
[44] Adapted from: Dowling, D., University of Technology, Sydney, Australia, 2004, *Improved Adobe Mudbrick in Application – Child-Care Centre Construction in El Salvador*, Paper No. 705 for 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, 1-6 August 2004:
www.sheltercentre.org/library/improved-adobe-mudbrick-application-child-care-centre-construction-el-salvador

The Project

The Expedition El Salvador project involved the construction of a small child-care centre in the rural community of El Condadillo, in the Municipality of Estanzuelas, Department of Usulután, in El Salvador. The project was a collaborative venture involving individuals, groups and institutions in El Salvador, the UK and Australia. The main driving force for the project came from a group of enthusiastic students and staff from Imperial College, London, who desired to develop and participate in a practical project to support the reconstruction efforts in post-earthquake El Salvador. The project had the following key objectives:

- provision of an important community facility (child-care centre)
- a hands-on community training programme in improved adobe construction
- promotion of improved adobe as a viable and safe construction system
- introduction to international and community development for engineering students from Imperial College, London
- practical application and assessment of adobe improvement techniques for further research considerations.

The total project time-frame was 12 months (January to December 2002), which included a five-month construction phase (August to December 2002). The direct construction costs were approximately 5,000 US dollars, which covered materials, tools, transport and the services of a master builder. Other in-kind donations included labour, supervision and additional materials, tools and transport. The project was coordinated by an engineer (Dominic Dowling) and a master builder (foreman), with labour provided by local community members and nine student volunteers from Imperial College, London. The child-care centre consisted of one room (9.3 x 3.6m) and a covered veranda area (12.0 x 3.8m), creating an internal area of about 33.5m^2 and a total covered area of approximately 105m^2.



Preliminary design of child-care centre showing plinth, pilasters, door openings and vertical reinforcement (the internal wall was removed in subsequent versions)

Design

The design of the building combined a variety of existing improved adobe construction systems with some new initiatives. The design satisfied the relevant seismic design criteria outlined in the adobe supplement of the El Salvador building code, and the International Association of Earthquake Engineering's *Guidelines for Earthquake-Resistant Non-Engineered Construction*.

Site Constraints

The site for the child-care centre was donated by a local family. The site possessed a number of constraints which represented a significant challenge for the preparation and execution of the project. These site limitations included:

- small site (10 x 15m)
- sloped site (with a height difference of 2.38m between the highest and lowest points, and a maximum slope of 36 per cent in the south-west corner)
- the presence of a large tree trunk with an extensive root system in the middle of the site
- no direct access to potable water. The nearest tap stand was approximately 300 to 400m away
- the only established and safe access was through the property of a local landowner.

These site constraints necessitated considerable changes to the original design and construction plans. Additional time and resources were required for clearing and excavation (building on fill material is not advised in seismic zones), and a deeper foundation was needed on the lower side (with resulting increased costs).

Brick Fabrication

An assessment of locally available soil was undertaken prior to the fabrication of the blocks. The available soil was found to have a very high clay content, which necessitated blending with other existing soils to obtain adequate strength blocks, with minimal cracking. The decided mix was a 1:2:2 soil-sand *tierra blanca* mix. (*Tierra blanca* is a pyroclastic ash deposit.) The blending of more than one type of soil presents significant challenges in the brick fabrication process. The process is slower and more resource intensive (sourcing, transporting and mixing) than using a single source of soil. Firstly, all components were thoroughly dry-mixed in measured batches on a concrete mixing platform, water was then added and the soils were then wet-mixed (tools and 'feet').

Timber and steel moulds were used to fabricate full-sized bricks (300 x 300 x 100mm), half-sized bricks (300 x 140 x 100mm) and channel bricks (for use in the ring beam, as described below). Voids for vertical reinforcement were included in the moulds. The bricks were made on a bare soil or sand ground surface and covered immediately with opaque plastic sheeting to prevent cracking due to the differential drying of the bricks in the hot sun. After two to three days the bricks were turned on edge and allowed to dry in direct sunlight. Bricks were rotated every few days to ensure thorough baking throughout. After a period of two to three weeks the bricks were stacked ready for transportation to the construction site (500m away). The bricks were dried for a minimum of four weeks prior to use. Over 2,000 bricks were required for the fabrication of the child-care centre.

Drying bricks (Note: Drainage ditches and plastic covers)

Foundations

The foundations were 400mm wide and varied between 250 and 750mm deep depending on the slope and underlying rock depth. The foundations were made of river rocks held in a sand-cement mortar. The foundation reinforcement consisted of three 1/2-inch steel bars in a triangular prism configuration, with 1/4-inch stirrups every 250mm. L-shaped 3/8-inch steel bars were tied to the apex horizontal reinforcement bar every 640mm to provide attachment between the continuous horizontal foundation reinforcement and the vertical bamboo reinforcement.

Vertical Reinforcement

Local cane/bamboo was used as internal (within the wall) vertical reinforcement, placed every 640mm. It was attached to the foundation via L-shaped steel bars (tied with wire prior to pouring the plinth/'top foundation') and connected to the ring beam at the top of the wall, thus creating a continuous matrix of reinforcement, tying the structure together. The placement of the vertical reinforcement presented substantial problems. Firstly, during the pouring of the foundations a number of the L-shaped steel bars were knocked slightly out of alignment. This misalignment, combined with the natural and unavoidable curvature of the bamboo meant that the reinforcement was not in the precise location according to the design. As each course of the wall was laid, certain bricks needed to be trimmed and cut to fit. This created delays and frustrations during the construction of the wall, and highlights the need to ensure accurate alignment of the vertical reinforcement.

Location of vertical reinforcement and preparation of plinth formwork

Plinth/‘Top Foundation’

The plinth/‘top foundation’ was 300mm wide and 300mm high and consisted of river rocks in a sand-cement mortar. The plinth serves to raise the adobe wall above the ground level, thus reducing the entry of ground moisture and erosion due to run-off. The plinth was formed using plywood, which must be adequately braced to prevent buckling of the form. The top surface of the concrete plinth was roughened to increase the bond between the plinth and the adobe wall. A layer of plastic sheeting was placed between the plinth and the first layer of adobe bricks to act as a damp proof course.

Adobe Walls

The load-bearing walls were 300mm wide and 2.24m high, consisting of the plinth layer, 15 courses of adobe bricks and a ring beam. The mortar joints were approximately 20 to 25mm wide and were made of the same material (mud) as the adobe bricks. String-lines were used to maintain alignment and plumb of the walls.

Adobe walls under construction, including plinth, pilasters, vertical reinforcement and plastic rain-covers.

Pilasters

Pilasters were constructed externally at each corner of the building and both internally and externally along the long wall. The pilasters were 320mm deep (equal to one block plus one mortar joint) and extended to the top of the wall (2.24m).

Horizontal Reinforcement

Two strands of galvanised barbed wire were placed in the horizontal mortar joints every three courses. The barbed wire strands were weaved between and tied to the vertical bamboo reinforcement to promote continuity. The strands of barbed wire were extended into the pilasters, with U-shaped nails/staples used to connect the wire to the bricks. In some cases, this caused cracking of the bricks, and should be undertaken with caution. In the upper part of the wall (between courses 11-12 and 14-15) a strip of chicken wire mesh was placed horizontally in the mortar joints to complement the barbed wire in this critical section.


Adobe walls under construction, including plinth, pilasters, vertical and horizontal reinforcement and plastic rain-covers

Openings

The building included three doors and three windows (prefabricated, steel, and lockable). During construction of the walls, 1/4-inch steel pins were looped around the adjoining vertical bamboo reinforcement and placed in the horizontal mortar bed joints to provide a connection with the frames for the doors and windows. Timber lintels were placed above the door and window frames and extended approximately 900mm along the wall. The timber was treated with burnt oil to reduce insect and fungus attack. Holes were bored in the timber at the location of the vertical bamboo reinforcement, thus increasing the connectivity with the matrix of reinforcement. A strip of chicken wire mesh was nailed on to the upper face of each lintel to increase the bonding capacity with the adjoining mortar layer.

Ring Beam

'Channel' blocks were formed with special moulds, using a soil-cement mix of 7:1. The channel blocks were wet cured for a minimum of seven days. The ring beam channel blocks were placed on the top course of adobe bricks, using a soil-cement mortar (7:1). Where necessary, holes were bored in the channel blocks to accommodate the vertical bamboo reinforcement. A horizontal reinforcing mesh consisting of two 1/2-inch-steel reinforcing bars with 1/4-inch stirrups every 250mm was placed in the channel. This reinforcement was tied to the vertical bamboo reinforcement and roof anchors. Finally, the channel was filled with a 5:1 sand-cement mix. At the places where the vertical strands of wire passed through the ring beam, it was difficult to level off the cement mix evenly. This created elevated points, which become points of concentrated load where the timber wall plate rests on the ring beam. One option to prevent this occurring would be to place the timber wall plates whilst the cement mix is still fresh enough to be manipulated, to create an even contact surface with the wall plates.


Ring beam channel blocks and reinforcement (Note: Steel pins and wire straps for roof attachment)

Wall – Lintel – Ring Beam – Roof Attachments

Effective attachment between these elements poses a significant challenge because the elements are made of different materials. Two 1/4-inch steel rods were looped through the timber lintels, then tied to the ring beam reinforcement and left protruding for attachment to the timber wall plates of the roof structure. The vertical bamboo reinforcement was tied to the ring beam reinforcement to resist horizontal shear movement and provide continuity between the vertical and horizontal reinforcement. Two strands of heavy-gauge galvanised wire were placed in the horizontal mortar bed (between courses 11-12) then run up with the vertical bamboo reinforcement, attached to the ring beam reinforcement and left protruding for attachment to the timber wall plates of the roof structure. These wire elements formed large U-shaped straps, utilising the mass of the wall to tie the roof down and restrain vertical uplift.

Roof

The roof consisted of a double-pitch timber roof structure with a zinc-aluminium-sheeting cover. The structure comprised of timber wall plates supporting a timber lattice beam, trusses, purlins and diagonal bracing. Connections were bolted, nailed and/or strapped, as appropriate. The wall plate was tied to the ring beam and walls using heavy-gauge wire and steel rods, as described above. A minimum overhang of 600mm was maintained around the building to protect from water damage due to rain. One pitch of the roof covered the veranda area, which was supported by timber columns in concrete footings. The gables were closed with welded mesh and screen mesh to allow the free flow of air, whilst ensuring a secure and safe building.

Roof under construction

Wall Finish

The walls were wetted and rubbed down with a sack cloth. This is a slow and meticulous task, but results in a smooth and attractive surface, which retains the natural appearance of the adobe. The external walls were then coated with a mixture of linseed oil and mineral turpentine (1:1), which acts as a waterproofing agent whilst still allowing the walls to 'breathe'. Further research could be conducted on the effectiveness of more widely available and cheaper local alternatives, such as cottonseed oil and corn oil. The internal walls were coated with wallpaper paste, which acts as an anti-dusting agent. The selected wall finishes had a mixed response from local collaborators; some felt that a concrete render provides a sense of modernity and solidity, whereas others appreciated the natural aesthetic of the adobe wall and the ease of application of the finishes.

Floor

The internal floor consisted of a concrete slab approximately 75mm thick, without reinforcement. The external, veranda floor was made up of a concrete slab about 75mm with mesh reinforcement. Prior to laying the concrete the ground was compacted and levelled.

Additional Infrastructure

A kitchen, including sink, benches and cooking platform, was built in the lower section of the veranda area and a latrine was constructed nearby. Extensive drainage and landscape works were undertaken to expedite storm-water removal and reduce erosion. The local municipality committed to providing future connection to electricity and water.

Weather

Wet weather caused considerable problems during the project. In each phase of preparation and construction, mitigation measures where required to reduce the impact of frequent and intense rainfall periods. Drainage ditches and tent-like structures were built to protect the bricks during the fabrication process, and plastic covers were required to protect the walls throughout the construction. Additionally, stockpiled soil and bricks had to be covered. Despite these measures, several hundred bricks were lost due to water damage during serious storms. The wet weather also made the manual excavation of the site even more laborious because of the difficulty of working with wet and cohesive soil.

Hot weather during the day took its toll on the workers, with job rotation required for the heaviest tasks. The newly formed bricks needed to be covered immediately to prevent excessive cracking in direct sunlight. On the positive side, the hot weather ensured that the bricks dried quickly and thoroughly when protected from the wet.

Training Manual and Workshops

The training was undertaken in an informal manner, with new systems and techniques described as they were encountered during the construction process. In some cases, diagrams were drawn and simple models were made to further explain various concepts. Overall, however, the training component of the project would have been more effective and sustainable if a simple construction manual was provided to each participant and some theory sessions undertaken in a less distracting and intense learning environment than at an active building site.

Community Perceptions

In general, the local community were interested in the new construction systems presented. However, it was also acknowledged that the building, as constructed, was too expensive, too complicated and too labour-intensive to be widely adopted. There were a number of factors which contributed to the high cost and complexity of this particular building, which would be reduced in size for the construction of a family dwelling. Firstly, the function of the building (child-care centre) necessitated the use of a higher level of safety in the design. Secondly, there were a number of specific site constraints which added to the complexity and cost of construction (small, sloped site, unsuitable unblended soil material for bricks, etc.). Thirdly, there was some uncertainty relating to the characteristics of various materials used, so principles of over-design were utilised. Finally, the project was designed to demonstrate a best-practice example of improved adobe construction, with participants encouraged to utilise the systems which matched their personal resource and skill levels.

Notwithstanding these limitations, there was a positive community response to the design and construction techniques presented. In general, the local community were impressed with the solidity of the building and quality of the construction and many workers commented that they would use some of the ideas in future adobe buildings.

Conclusions

Overall, the majority of the project objectives were met: a safe and secure child-care centre was constructed, the local community became engaged in an effective, hands-on introduction to improved adobe construction, the Imperial College students gained invaluable firsthand exposure to international and community development, and a number of practical lessons have been learned about improved adobe design and construction, as described above.

In light of the key lessons learned during the execution and review of the Expedition El Salvador project, it is fitting to suggest that future assessments of the seismic performance of new systems should also include some evaluation or discussion of the skill/experience level (complexity) and resources (costs) required to implement a proposed system.

Haiti (II)

Senp Kay – Simple House (Prototype)

The Senp Kay[45] is the first structure in Haiti constructed from prefabricated, tilt-up, plastic-bottle-filled panels and light straw-clay walls. It was designed and constructed as an innovative solution for low-tech, sustainable housing for low-income communities in developing nations.

Affordable housing is an issue of huge social relevance in Haiti, and indeed globally. Two years have passed since the earthquake in 2010 and thousands of Haitians continue to be without permanent shelter. There are over 800 camp settlements with an estimated 0.5 million people still homeless. Inadequate standards of construction and poor-quality materials were the root causes of many of the collapsed buildings and loss of life. It is extremely important that reconstruction addresses these issues, and ensures that new buildings are earthquake resistant and provide protection in the face of future seismic events as well as hurricanes. The need for permanent, affordable, safe housing is now urgent.

There is an abundance of precedents and inspiration using plastic bottles, tilt-up panels and straw-clay infill as wall systems; the World Earthship Biotecture movement utilises plastic bottles as non-structural filler in walls. The tilt-up method of wall construction (typically concrete) has been practised since the early 1900s, and variations of the straw-clay walls have been adopted for over 700 years in many parts of the world. All three methods have successfully evolved independently in their respective applications, and here they are joined as a hybrid solution for the conditions in Haiti.

The **Senp Kay** uses a modular wall design which incorporates the structural integrity of the tilt-up panel, the creative repurposing of the bottle wall system and the simplicity of light straw-clay infill. It is simple to mass-produce on site and to assemble and customise to one's particular needs. The use of repurposed materials is a positive response to one of many environmental problems in Port-au-Prince. Haiti currently has no successfully operational recycling facilities and there are many refuse dumps where piles of waste lie as a potential source for innovative construction material use. Rice straw is plentiful in both the Artibonite and Les Cayes valleys. Straw is a rapidly renewable resource and 80 per cent of the rice straw goes to waste, usually burned after harvest adding to Haiti's already serious air pollution problem.

[45] Introduced by Andy Mueller of GreenSpace Collaborative and Builders Without Borders: www.greenspacecollaborative.com; www.builderswithoutborders.org

The **Senp Kay** explores the use of local and repurposed materials as a substitute to the widely accepted concrete block method of construction. It offers unprecedented, appropriate solutions to long-standing problems associated with the building of shelters in Haiti; solutions that are not merely handed to the local population, but owned and built by them. This project will take more than a single demonstration, but the idea is to captivate the imagination of the Haitians who have contributed to the scheme so far and of those who follow.

Project Features

Repurposed local materials: The prototype utilises many in-country materials – common plastic bottles, plastic bags, crushed rubble, clay soil, bamboo, sand and rice straw.

Flexible design: Prefabricated panels allow for expansion in either two or four-foot increments. Each wall can contain up to one-third door or window openings. Shed, gabled or hipped roofs can be used. In addition, the shed roof can extend from the rear of the house to accommodate an outdoor kitchen and a semi-enclosed shower with access to the habitable space.

Earthquake and hurricane resistant: The construction of this prototype demonstrates these wall systems have excellent resistance to earthquake and hurricane forces, both in-plane and out-of-plane. It utilises a light and resilient structural system compared to the heavy and brittle concrete and block systems typically used in Haiti. They can be part of a well-engineered structure capable of withstanding forces of a 7.0 or greater earthquake and 140mph hurricane winds.

Comfort: Solutions include building orientation, door and window location, shading, wall and ceiling insulation, and generous ventilation.

Low cost: The Senp Kay is more sustainable and less carbon-consuming than the typical concrete-block building in Haiti. The cost per square foot is 35 US dollars. In this project, the main goals were to reduce the time and cost of the building process, and to allow community involvement.

Fast construction: Low-tech, easy-to-assemble structure, requiring only two skilled trades. The structural system is produced locally, is suited for mass production and provides job opportunities and skills development for the community.

Efficient use of wood: Haiti urgently needs a long-term plan for reforestation and sustainably harvested timber. The Senp Kay currently utilises imported wood for its lightweight wall and roof frame; however, it uses this wood very efficiently compared to other wood-frame systems. It is expected that in-country wood could be used in the future.

Materials

- 179 x 20-oz plastic bottles per 4ft x 8ft prefabricated panel
- 20-gauge x 1-inch galvanised mesh
- Internal bamboo reinforcement in the straw-clay infill walls
- Clay, soil-cement and cement plaster
- Repurposed gutter rain-catchment system

- Roof and wall tie-downs to resist earthquake and hurricane forces
- Straw-clay wall infill
- 2x4 and 1x4 timber
- Corrugated steel roofing
- Concrete footing and stem wall

Contributors

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Funding

GreenSpace Collaborative
Builders Without Borders

In-Country Resource

Haiti Communitere

Construction

Jean Louis Elie
Annio Baptise
Andy Mueller, GreenSpace Collaborative
Chad McLean
Tina Therrien, CamelBack Construction

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Annex III: Further reading and links

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Assessment

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Environmental Stewardship Review for Humanitarian Aid (ESR) www.worldwildlife.org

Guidelines for Rapid Environmental Impact Assessment in Disasters (REA)

Flash Environmental Assessment Tool (FEAT)

Environmental Needs Assessment in Post-Disaster Situation: A Practical Guide for Implementation (ENA) www.oneresponse.info

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Contingency planning

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Links

General
www.sheltercentre.org
www.recoveryplatform.org
www.alnap.org

Community action planning
www.communityplanning.net

Earthquake-resistant construction
www.confinedmasonry.org
www.structureparasismic.com/MaMaisonParasismique.html
www.safestronghome.com
www.strongtie.com

Intergovernmental coordination in Latin America/Caribbean
www.minurvi.org

Land issues
www.gltn.net

Mapping
www.openstreetmap.org
www.esri.com
www.hazards.fema.gov/femaportal/wps/portal

Water supply, sanitation, solid-waste management
www.sandec.ch
www.cwgnet.net
www.waste.nl

Annex IV: Details and checklists

Project environmental review record

1.	PROPOSAL/PROJECT DETAILS – Project Manager to complete						
1a)	Proposal/Project Title:						
1b)	Implementing Agency:			Cluster Group:			
1c)	Work Stage	Proposal		Approved Project		Project No.	
1d)	Cluster Manager:			Cluster Manager Contact: Email Cluster Manager Contact: Phone No.			
1e)	Project Manager:			Project Manager Contact: Email Project Manager Contact: Phone No.			
1f)	Proposal/Project Summary (brief description of activities)						

2.	PROPOSAL/PROJECT STAGE – Project Manager to complete			
				Action
2a)	Will the project result in physical, environmental or site disturbance ?	**YES**		Complete 2d).
		NO		You are proposing a project such as software development, routine inspection, non-intrusive monitoring, and training or the procurement of goods/equipment, complete 2b)
2b)	Will the project result in the procurement of goods/equipment to be delivered to impacted country ?	**YES**		Complete Section 7
		NO		Complete 2c)
2c)	Will the project involve training and capacity building in impacted country ?	**YES**		Complete Section 8
		NO		You are proposing a project with no potential environmental impacts, complete Section 9
2d)	Does the project comply with the Agencies own environmental policies and procedures ?	**YES**		Complete 2e).
		NO		Amend proposal to ensure compliance
2e)	Does the national government require an environmental impact assessment (EIA), review or equivalent document (e.g. an Env. Statement)?	**YES**		Complete Section 3 below.
		NO		Clarify environmental and planning responsibilities with the national government

3.	ENVIRONMENTAL LAW			
3a)	Is it likely that a statutory EIA will be required for the project (major infrastructure development including: thermal/ hydropower stations, industrial plants, water supply, sewage treatment, solid waste management, airports, roads, ports and harbours) ?			**Action**
		YES		Undertake EIA (or budget for completion of EIA at post-approval stage)
		NO		Complete 3b.)
		NOT KNOWN		
3b)	Is planning permission or environmental permit required from the municipality/ government ?	**YES**		Complete application (or budget for completion of application at post-approval stage)
		NO		Jump to Section 4.
		NOT KNOWN		

4.	PROJECT LOCATION			
4a)	Is the project location known ?			
	If **NO**, indicate here [ ] And jump to Section 5			
	If **YES**, provide project location description: town, region and continue to 4b)	**Project Location**		
4b)	Will protected or sensitive areas possibly be affected by the project?	**Mark those issues applicable to this project**		**Remarks/Mitigation Measures**
	If **NO**, indicate here [ ] and jump to Section 5 below.			
	If **YES**, record relevant issues in this section, then continue at Section 5.			
Issue No.		**Yes**	**No**	
1	Sensitive human receptors (residents, schools, hospitals)			
2	Groundwater or Surfacewater Vulnerable Areas			
3	Wetland			
4	Cultural heritage			
5	Coral reef			
6	Mangroves			
7	Coastal fringe (harbours, beach, dune)			
8	Estuary			
9	Forest			
10	Nature reserve			
11	World Heritage Site			

5.	CONSTRUCTION/REHABILITATION ACTIVITIES			
5a)	Does the project result in an above ground construction or installation?	Mark those issues applicable to this project		Remarks/Mitigation Measures
	If **NO**, indicate here [ ] And jump to Section 6 below			
	If **YES**, record relevant issues in this section, then continue to Section 7			
	Will the work result in the generation of the following:			
Issue No.		**Yes**	**No**	
12	Noise (construction/operations)			
13	Odour			
14	Vibration			
15	Air emissions (dust, smoke, etc.)			
16	Traffic (construction and operation)			
17	Fuel and chemical storage (potential for spillage)			
18	Engineering works (infilling, diversion, culverting)			
19	Water (run-off, abstraction and/or discharge, soil erosion)			
20	Marine construction (including dredging and disposal at sea)			
21	Wastes (inert, mining, construction/demolition, clinical, municipal, industrial, hazardous)			

6.	HAZARDOUS LOCATIONS			
6a)	Will the project be undertaken in hazardous area (locations in which humans maybe exposed to fire or explosion hazard, chemical risks, physical hazards)	Mark those issues applicable to this project		Remarks/Mitigation Measures
	If **NO**, indicate here [ ] And jump to Section 7 below			
	If **YES**, record relevant issues in this section, then continue to Section 7			
	Will the work be undertaken in areas subject to the following:			
Issue No.		Yes	No	
22	Ground contamination (previous industrial sites, landfill, buried livestock)			
23	Areas subject to natural hazards (flooding, earthquakes, landslides)			
24	Past mining and quarrying operations (presence of shafts/spoil heaps)?			
25	Hazardous industrial installations (chemical plants, refineries)			

7.	PROCUREMENT ACTIVITIES					
7a)	Does the project result in procurement of goods and services ?			Mark those issues applicable to this project		Remarks/Mitigation Measures
	If **NO**, indicate here		And jump to Section 8 below			
	If **YES**, record relevant issues in this section, then continue to Section 6					
Issue No.				Yes	No	
26	Products that contain ***harmful substances*** or are ***unsafe*** (asbestos, PCB's, ozone-depleting substances, oils, solvents, chemicals, pesticides) are avoided					
27	Products selected rated as having ***high energy efficieny*** of the type of items needed and available ?					
28	Products contain ***recycled*** materials ?					
29	Products (including packaging) can be ***re-used*** or ***re-cycled*** ?					
30	The products include ***environmental control technologies*** (low air emissions/odour/noise, waste minimization),					
31	Products are to be ***transported*** in bulk and distributed efficiently to minimize fuel use, road damage, air pollution, noise, desertification, etc. ?					
32	Products will not include the ***agricultural introduction*** of invasive plant and animal species or Genetically Modified Organisms (GMOs) ?					
33	Project will not include the exploitation of ***local natural resources*** (timber, minerals, water)					

8.	TRAINING AND CAPACITY BUILDING (CB) ACTIVITIES					
8a)	Does the project involve training and capacity building in impacted country ?			Mark those issues applicable to this project		Remarks/Mitigation Measures
	If **NO**, indicate here		And jump to Section 9 below			
	If **YES**, record relevant issues in this section, then continue to Section 9					
Issue No.				Yes	No	
32	The training/CB minimises travel by use of conference calls, video links, etc.					
33	The training/CB minimises the use of paper use (double-sided printing, use of emails for report review)					

9. PROJECT ENVIRONMENTAL REVIEW RECORD APPROVAL			
Proposal Manager: Name		Cluster Manager: Name	
Proposal Manager: Signature		Cluster Manager: Signature	
Proposal Manager: Date		Cluster Manager: Date	

	If there are any other issues or the above issues require additional description use the space below.
Issue No	NOTES (space for additional notes if thought necessary)

Remote sensing and photogrammetric mapping

Remote sensing and photogrammetric mapping technologies and sensor platforms are available that deliver data derived from various altitudes, at different resolutions, and cater for a range of atmospheric conditions, such as cloud cover, etc.

Sensor platforms are broadly classified into active and passive systems. Active sensor systems carry a transmitting source and a receiver (such as airborne LiDAR or imaging radar sensors); passive systems only record electromagnetic energy that is reflected off the surface (e.g., optical space-borne platforms such as Landsat TM and other airborne imaging sensors).

As each system has its own characteristics and produces sensor-specific data, the user has considerable choices to select the correct sensor/data for the required application. Whilst traditionally space-borne platforms would cover wider areas at a lower-ground resolution, geospatial data from airborne sensor platforms usually provide higher resolution but at a more local level.

Advances made in remote-sensing technologies in recent years have created more overlap and several new satellite platforms can produce tasked data sets more frequently at higher resolutions. At the same time, the latest airborne digital cameras are producing even higher-resolution imagery at ground resolutions of 5cm and higher over larger areas in close to real-time.

Looking at the variety of sensor technologies available, LiDAR sensors, for instance, generate point clouds that provide digital elevation models, intensity and wave-form data. Being an active system, LiDAR data can also be acquired at night and can penetrate through vegetation cover, producing so-called bare earth models. Many of these airborne LiDAR platforms are now been integrated with airborne digital cameras to produce both LiDAR data and optical imagery from one flight. On the other hand, new software tools developed specifically for image processing of data acquired with airborne digital cameras are now allowing the user to not only produce high-resolution multispectral imagery in RGB (Red-Green-Blue) and Near-Infrared, but at the same time produce high-resolution digital surface models at much higher point densities from imagery than is possible with current airborne LiDAR systems.

Because the surface data is generated from multispectral imagery, there is software that combines surface generation from imagery with basic classification techniques and thus produces so-called info-clouds which are attributed point clouds with x, y, z as well as spectral, time and classification information for each point of the data set.

Whilst the processing of such data to some degree requires trained operators, sophisticated technical equipment and special software, in recent years dedicated workflows have been developed that simplify and automate the process of extracting information from imagery, thus creating easier and faster access to geospatial data sets. In addition, both space-borne and airborne sensor platforms have been developed to support rapid usage over affected areas.

Whilst the tasking of data acquisition and rapid deployment today is an essential element of post-disaster damage assessment and the coordination of emergency response, several data providers have created a more open access to existing archives and image databases, which can be used for assessments during the planning stages (for instance, NASA Landsat archives, etc.).

When part of a Geographical Information System (GIS), geospatial data from remotely sensed images contributes to better decision-making and to faster solutions, it will be very interesting to see what role the above-described info-clouds or attributed point clouds will play in GIS and particularly in disaster management and emergency response in the future. As in most such cases, time is of the essence: the simultaneous extraction of multispectral information, digital surface models as well as basic classifications of affected housing areas, for instance, to produce an info-cloud or attributed point-cloud seems particularly promising for disaster-management applications.

Example of a simplified bar chart[46]

		Week number																			
	Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Clearing site																				
2	Excavate topsoil																				
3	Excavate foundation																				
4	Steel of foundations																				
5	Formwork to foundations																				
6	Concrete to foundations																				
7	Steel to columns																				
8	Formwork to columns																				
9	Concrete to columns																				
10	Masonry to groundfloor																				
11	Formwork of plinth beam																				
12	Steel to plinth beam																				
13	Concrete to plinth beam																				
14	Return fill																				
15	Ceiling above ground floor																				
16	Curing																				
17	Masonry first floor																				
18	Formwork to ring beam																				
19	Steel to ring beam																				
20	Concrete to ring beam																				
21	Produce roof trusses																				
22	Fix roof trusses																				
23	Install roof timber																				

[46] Adapted from: Process guideline – Quality Assurance Checklist (2), Practical Action – Sri Lanka

	frame																				
24	Place roof covering																				
25	Timber to gable ends																				
26	Form eaves																				
27	Install ceiling boards																				
28	Floor finish																				
29	Install door frames																				
30	Install window frames																				
31	Fix doors																				
32	Fix windows and doors																				
33	Paint exterior walls																				
34	Install all plumbing and sanitary items																				
35	Install all wiring																				
36	Paint interior walls																				
37	Paint ceiling																				
38	Spread topsoil																				
39	Fence/ division walls																				

Assessment of strength of natural soils[47]

The tables below provide guidance on how to assess the strength of natural clay or sand soils.

Also included is an assessment of the allowable load-bearing pressures for shallow foundations on natural clay or sand. These are approximate values and will need to be determined by a site survey in order to design the foundation. A site engineer should always provide advice on allowable foundation pressures.
Rock soil is generally acceptable for foundations of houses that are up to two storeys high.

Cohesive soils (clay)		
Consistency	**Field assessment of soil strength**	**Typical values of allowable bearing pressure (kN/m^2)**
Very stiff	Indented by thumbnail; brittle or very tough	> 300
Stiff	Indented by thumb pressure; cannot be moulded in fingers	150 - 300
Firm	Moulded by strong finger pressure	75 - 150
Soft	Moulded by light finger pressure	35 - 75

Soils that are not cohesive (sand and/or gravel)		
Consistency	**Field assessment of soil strength**	**Typical values of allowable bearing pressure (kN/m^2)**
Dense	High resistance to penetration by hand bar or pick axe	> 350
Medium dense	Difficult to excavate by shovel	100 - 350
Loose	Easily excavated by shovel; only small resistance to penetration by handle bar	40 - 100

[47] Patel, D. et al., 2001, *Repair and strengthening guide for earthquake-damaged low-rise domestic buildings in Gujarat, India*, Gujarat Relief Engineering Advice Team (GREAT) Publication, Gujarat, India

Basics on material testing

Most countries have established quality standards for building materials, and in some cases producers of materials are required to provide certificates confirming that the standards are met.
Unfortunately it is quite common that such certificates lack verification or even are falsified (as is often the case of, for example, certified timber).
It is recommended that the quality of construction materials be assessed whenever its origin and quality are in doubt. Below are a few tips about how to assess materials when testing facilities are not available.
The recycling of materials can be a cheap and easy way of finding construction materials, and also generally a good environmental practice. The quality of recycled materials, however, should always be verified, as even high-quality construction materials may be damaged in disaster situations.

Cement

- When cement is rubbed between fingers and thumb, it should feel like a smooth powder such as flour.
- Check the cement for any lumps and remove them.
- Never use cement that has been stored for more than six months.

Concrete blocks

- Good-quality concrete blocks are produced and stored under a sunshade and have a cement to aggregate mix ratio of 1:6-8, with clean raw materials (sand, gravel, drinking-quality water) and fresh cement.
- Blocks should be properly cured for 21 days and handled with care until used for masonry work.

Fired bricks

- The quality of a brick is good if there is a clear ringing sound when two bricks are struck together.
- A brick should not break when dropped flat on hard ground from a height of one metre.
- A good burned brick has a surface so hard that a fingernail cannot scratch it.

Sand and aggregates

- Dirty sand should never be used in masonry work because it will reduce the mortar's adhesive quality considerably.
- To check whether sand is suitably clean, use the hand test: rub a sand sample between damp hands. Clean sand will leave the hands only slightly stained.

- Or use the bottle test: Fill a bottle halfway with sand. Add clean water until the bottle is three-quarters full. Shake the bottle properly and leave it for one hour. Clean sand will settle immediately. Silt and clay will settle slowly on top of the sand. The clay and silt layers' thickness should not equal more than 10 per cent of the sand layer's thickness.
- Sand from the sea is unsuitable for mortar as it contains salts, which negatively influence the mortar's moisture and overall quality.

Water

- Water should be of drinking-water quality and have no pronounced taste or smell. Seawater should not be used.
- Rainwater collected from roofs can be used for mixing mortar or concrete.
- Water mixed with any kind of oil should not be used for mixing mortar or concrete.
- Water should be stored to prevent it from becoming contaminated.

Overview of the roles in the site selection and planning process[48]

Who Is Involved?	What Do They Do?
Architect	Designs site and buildings
Engineer	Does technical calculations and designs structural elements
Construction	Designs buildings and oversees construction
Sanitation	Designs sanitation systems and oversees construction
Water	Designs water systems and oversees construction
Infrastructure, e.g. roads	Designs other infrastructure and oversees construction
Electrical	Designs electrical systems (e.g., electrical power supply) and oversees construction
Survey	Ensures construction work meets specifications and other contract terms
Spatial Planner	Creates spatial plan for site
GIS Specialist	Creates maps if a site; may collect data at the site
Surveyor	Surveys site
Community Mobiliser	Works with community who will move to site
Construction Company	Constructs buildings, roads and other infrastructure
	Reshapes landscape to fit construction plan (e.g., levels site, removes vegetation)
Transport Company	Brings materials to the site and removes construction waste
Environment Expert	Collects information on the environmental conditions at the site
	Assess environmental impact of development of site
	Prepares EIA for development of the site
Environmental NGO staff	Raise questions about the environmental impact of site development
Local Government Officer	Recommends or selects site
National Level Authority (Minister, President, Government Committee)	Decides on need for resettlement and authorises the creation and development of new sites
	Approves applicable standards and best practice to speed up implementation
Government Environment Department	Reviews EIA or environmental impact of development of the site (in the absence of an EIA)
Development Agency	Oversees spending on site
	Ensures site work meets applicable international standards and best practices (including environmental and social standards)
Site Management Committee	Oversees the construction of the site to ensure work takes place correctly, on time and at agreed costs
Neighbouring Communities	Provide labour for construction
	Provide natural resources (e.g., water, sand, wood, etc.) for construction
	Raise concerns about environmental and social issues
New Site Residents	Provide labour
	Modify building and site plans to meet their own needs
	Raise concerns about environmental and social issues

[48] Adapted from Module 4 in: World Wildlife Fund, American Red Cross, 2010, *Toolkit Guide – Green Recovery and Reconstruction: Training Toolkit for Humanitarian Aid*, Creative Commons, San Francisco, USA: www.green-recovery.org/

Who Is Involved?	What Do They Do?
Donor – Project funder(s)	Sets standards and cost limits for site development
	Establishes applicable standards and practice, including environmental standards and practices
	Supports applicable standards and best practice to speed up implementation

Summary of design principles for safety (for small buildings only)[49]

Designing for earthquake resistance	Designing for wind resistance
■ Select a solid site. Avoid landfills, flood plains and steep slopes. ■ Make buildings light to reduce the horizontal forces caused by earthquakes. ■ Make roofs light to avoid them pushing walls sideways and falling in on people. ■ Design compact buildings with a symmetrical shape and closely spaced walls in both directions. If that cannot be done, design them in separate blocks. ■ Separate adjacent small buildings by at least 7.5 centimetres. ■ Avoid gables as they may fall inwards. ■ If buildings have more than one floor, opt for similar floor shapes and designs. ■ Position the foundations on rock or firm soil. Avoid stepped foundations. ■ Provide strong joints between structural components. Use a ring beam and a plinth beam where possible; use bracing at corners. ■ If masonry walls are used, create good bond especially at corners and intersections. ■ If concrete pillars are used, lap vertical reinforcements mid-way between floors and not just above floors. ■ Keep openings to a minimum, well distributed over the building and within walls. Keep them centrally positioned, at least 60 centimetres away from the inside of corners and intersections and from the nearest other opening.	■ Select a sheltered site. ■ Avoid long and narrow (<6 metres) streets. ■ Position houses in a staggered way rather than in rows. Create wind-breaks by planting trees, hedges, etc. ■ Make buildings heavy (so it is more difficult for the wind to blow them away). ■ Use a compact shape, with low walls, to present minimum obstruction to winds. ■ Use a hipped roof, pitched at 30 to 45 degrees, with small eaves to prevent uplift. Avoid gables, as they may be pushed inwards. ■ If a veranda is required, separate veranda frame and covering from the main roof. ■ Tie roofing sheets well to the roof frame; flying sheets can be lethal. In the case of galvanised corrugated iron (GCI) sheet roofing, provide overlaps of 2.5 corrugations, and more-closely spaced 'U' bolts along ridges and external walls. ■ Reinforce structural connections with 'hurricane straps'. ■ Make solid foundations, well anchored to the ground. ■ Provide strong structural joints and fixings, especially between walls and foundations, and walls and roof. Use diagonal bracing. ■ Give walls a rough finish to reduce wind suction. ■ Position openings centrally and away from corners and intersections. Provide openings on both sides of rooms, so that the wind can eventually pass through, rather than lift the roof. ■ Ensure all windows can be closed. Avoid louvres – if they are essential, provide storm shutters or board them up before storms.

[49] Adapted from: IFRC – International Federation of Red Cross and Red Crescent Societies/Practical Action, 2010, PCR Tool 8 – Participatory Design

Checklist for monitoring and evaluation of sustainable reconstruction[50]

1. Programme Design

General

- To what extent are the beneficiaries actively included in the programme designing process?
- To what extent are women/men's needs addressed in the programme design?
- How useful are Implementation Guidelines? Who does use them?
- How useful are Financial Guidelines? Who does use them?
- How are disaster-risk-reduction measures considered?
- Environmental impact: Does the programme include measures to mitigate any negative environmental impact of the settlement and its development? Is there a special focus on implemented sanitation solution?
- To what extent are biodiversity assessments undertaken for the concerned sites?
- How far is the baseline data/information adequate to design the livelihood/income-generation programme?

Settlement and housing

- Assessment and site preparation: Are the construction site's topographic and physical features and potential risks properly analysed prior to reconstruction?
- Is the site resistant to natural hazards? How?
- Is the settlement situated in a safe area protected from natural hazards (floods, cyclones, etc.)?
- Does the settlement design take the surrounding built-up area into account?
- How does the site design match with the wishes of the users?
- How can national standards, rules and regulations best be addressed by the planned intervention?
- Embeddedness and settlement planning: To what degree is the new settlement embedded in its immediate surrounding and its related services (transportation, education, health, markets and employment opportunities)?
- Does the site allow a connection with future settlement planning in the area?
- Potential for development: Does the settlement design enable the inhabitants to develop social and economic activities within its boundaries?
- Does the design allow house extensions?
- Does the plan offer new opportunities for the population of adjacent settlements?
- How does the house design fit to users' needs?
- Is the house design sound from an engineering/technical point of view?

[50] Checklist developed by Skat

Structural design aspects

- Is the foundation type selected correct and in accordance to soil conditions?
- Is the foundation type appropriate to bear the load of structure, and a foreseen extension with a second floor, if applicable?
- Quality control of foundations, plinth and ring beam: Is an efficient quality control being planned and conducted during construction?
- Appropriate design: Is the structural design of the houses generally appropriate to withstand natural hazards (existence of plinth and ring beam; appropriate proportions of walls; correct distances between doors, windows and corners; appropriate fixation of roof; strength of corners)?

Water supply and sanitation

- How useful/necessary is a KAP (Knowledge – Attitude – Practices) survey before designing the hygiene campaign?
- General physical condition of the technical infrastructure: Can the pipes, tubes, connection elements, access, water wells, pumps, latrines, water tanks, water filters, septic tanks, pits, etc. be considered in good physical condition?
- How does the water and sanitation system fit to users' needs (service levels, willingness to pay for operation and maintenance, etc.)?
- How is the hygiene awareness campaign designed?
- How are risky behaviours identified/prioritised?

Community development

- How is the community mobilisation process planned? What structures, such as committees, Community Development Council (CDC), etc., are planned to be established?

Socio-economic/livelihood/income generation

- Has the programme followed a meaningful 'Back to Business' component in its design for providing hands-on services to micro and small businesses that were 'washed off'?
- Inclusiveness and empowerment (considering the local context): Does the programme foresee proactive measures to favour inclusiveness in terms of gender, social status and religion or to empower marginalised populations?
- Livelihood activities: Has the programme foreseen any complementary livelihood activities for the residents (women and men) with immediate and/or long-term effects?

2. Outputs

General

- What are the most positive results?
- How do you evaluate the success of the overall performance of the programme?
- To what extent are women/men's needs realised after programme implementation?

Housing and settlement

- Beneficiary satisfaction: Are the families (women and men) satisfied with the houses and the settlement design?
- General physical condition of the building: Can the building be considered in good physical condition – in particular, the roof (leaking? enough slopes?), wall plaster (cracks? dampness?), doors (good fixation? closing?), windows (good fixation? shutters closing?), floors (level? easy to clean?).
- Installations: Are the electric, sanitary and kitchen installations properly installed and functioning?
- Ventilation and protection: Is there enough cross-ventilation and protection from rain and sun to ensure comfortable conditions?
- To what extent do programme sites include renewable energy and/or energy-efficient measures?
- To what extent do construction sites include hazardous building materials (such as asbestos cement sheets)?
- Percentage of programme locations that use recycled materials (timber, brick, concrete) including temporary shelters.
- Percentage of sites that use timber from a certified sustainable source.

Water supply and sanitation/hygiene

- Beneficiary satisfaction: Are the families (women and men) satisfied with the water supply/sanitation including latrines?
- Suitability of latrines: Do constructed latrines pay the necessary attention to cultural and gender characteristics?
- Are latrines used by the female and male family members?
- What incentives enhance the use of latrines by women and men i.e., disposal of baby's faeces, hand-washing facilities?
- Are the design and the finalised latrine, including septic tank, sound from an engineering/technical point of view?
- To what extent are national norms and standards met?
- How is the quality control organised?
- How frequently is quality control/monitoring undertaken?

Community development

- To what extent is the community mobilisation process useful (i.e., establishing structures such as committees, CDC, expressing needs of the communities and adjusting interventions accordingly)?
- Are board members of community committees elected in a secret ballot?
- Are at least 50 per cent of the board members women?
- What kind of Community Action Planning (CAP) workshops are prepared to identify the needs of the communities?

Socio-economic/livelihood/income generation

- In what way are the livelihoods/income-generating activities that are supported by the programme more effective (traditional as against modern) to the beneficiaries?
- On what data does the programme choose the activities carried out?
- To what degree are these complementary activities coordinated with the main activities?
- Does the programme address new activities in income generation for the target population (for women and men)? To what degree?
- What has been their success in terms of employment and income?
- How is micro-finance managed through community organisations (CDCs)?

3. Outcomes

General

- Major changes: What are the major changes the programme brought about to the daily lives of the resident families?

Housing and settlement

- Legal status: Do beneficiaries own their new houses and land? Who has the property rights?
- What are the good construction practices in the programme design and implementation?
- Phasing out and maintenance: Do the programme's activities contribute to the maintenance of the newly constructed private and collective infrastructure?
- Do the beneficiaries know how to maintain their houses?

Water supply and sanitation/hygiene

- Impact: Has the programme have any positive influence on the hygienic and sanitary conditions of the population?
- Do beneficiaries know how to maintain their latrines, septic tanks, sanitary facilities, etc.?

Community development

- Sustainability of community organisations (CDCs) and their activities: What are the current activities of community organisations? Who is in charge of them? How often?

Socio-economic/livelihood/income generation

- What are the most significant changes in the lives of the beneficiaries that are linked directly (or indirectly) through the programme?
- What are the major social and socio-economic changes of the programme for affected people?
- Does the programme generate economic benefits (immediate and long term) to the resident families (for women and men)?
- Does the programme generate economic benefits for other people?
- Opportunities: What kind of opportunities has the programme created for the target population to gain knowledge or skills?

- What percentage of the families has increased their income levels compared to their pre-tsunami situation, as a result of the intervention?
- Continuity of former activities: To what extent does the programme enable the residents to pursue their former livelihood activities?
- Possibility for alternative livelihood activities: To what extent does the programme enable the residents to pursue new livelihood activities?
- Has the programme had any empowering effects on marginalised people?
- How do beneficiaries finance the maintenance of their houses including latrines/sanitary facilities? Can they afford it?
- To what extent do beneficiaries have access to credits?
- To what extent do beneficiaries have access to other livelihood support agencies?

4. Programme Management

- Coordination: How has the programme coordinated its activities with the official and traditional authorities and other relevant actors (the partners) in the field to ensure the acceptance by local leaders and politicians?
- Was the overall coordination mechanism adopted at all operational levels sufficient to achieve the programme’s objectives?
- Was the coordination mechanism followed to link the programme activities with other similar programmes satisfactory?
- What are the main hindrances in the programme management? How do responsible managers overcome them?
- Are there any delays in producing the outputs? If yes, how are they managed?
- How do programme managers handle any risks?
- How useful/efficient are the financial procedures?
- Human resources (considering the given context of the labour market): Does the programme have an operational team of sufficient size and quality to assure a proper monitoring of the activities?
- Monitoring and evaluation (M&E): What should be improved regarding monitoring?
- Has the M&E system been effective/efficient? In what way? What are the hindrances or challenges?
- Which M&E tools have been useful?
- To what extent have the stakeholders been satisfied with the information received?
- Concerning participation, to what extent did the programme foster beneficiaries’ participation in project design, implementation and monitoring?
- Are responsibilities of programme management clearly defined and executed?
- Concerning partnerships: Are roles clearly defined and understood amongst partnership members?
- What are the main hindrances to good partnership? How do you overcome them?
- To what extent is there personal protective equipment provided to construction workers at no charge?

Sanitation

Selecting the sanitation method

When selecting a sanitation method the following considerations should be kept in mind:

Need:

- What systems still exist from before the tsunami disaster happened?
- Can these still be used?

Social acceptability:

- Will the proposed method of disposal violate local customs, taboos or preferences?
- Is the method likely to be properly maintained?
- Have residents indicated that they prefer this system or, at least, are willing to try it?

Resources:

- Is the desired method practical considering available money, materials and workers?
- Is the regional or national government likely to provide monetary or other assistance?

Geography:

- Are soil conditions and groundwater levels acceptable for the desired method?

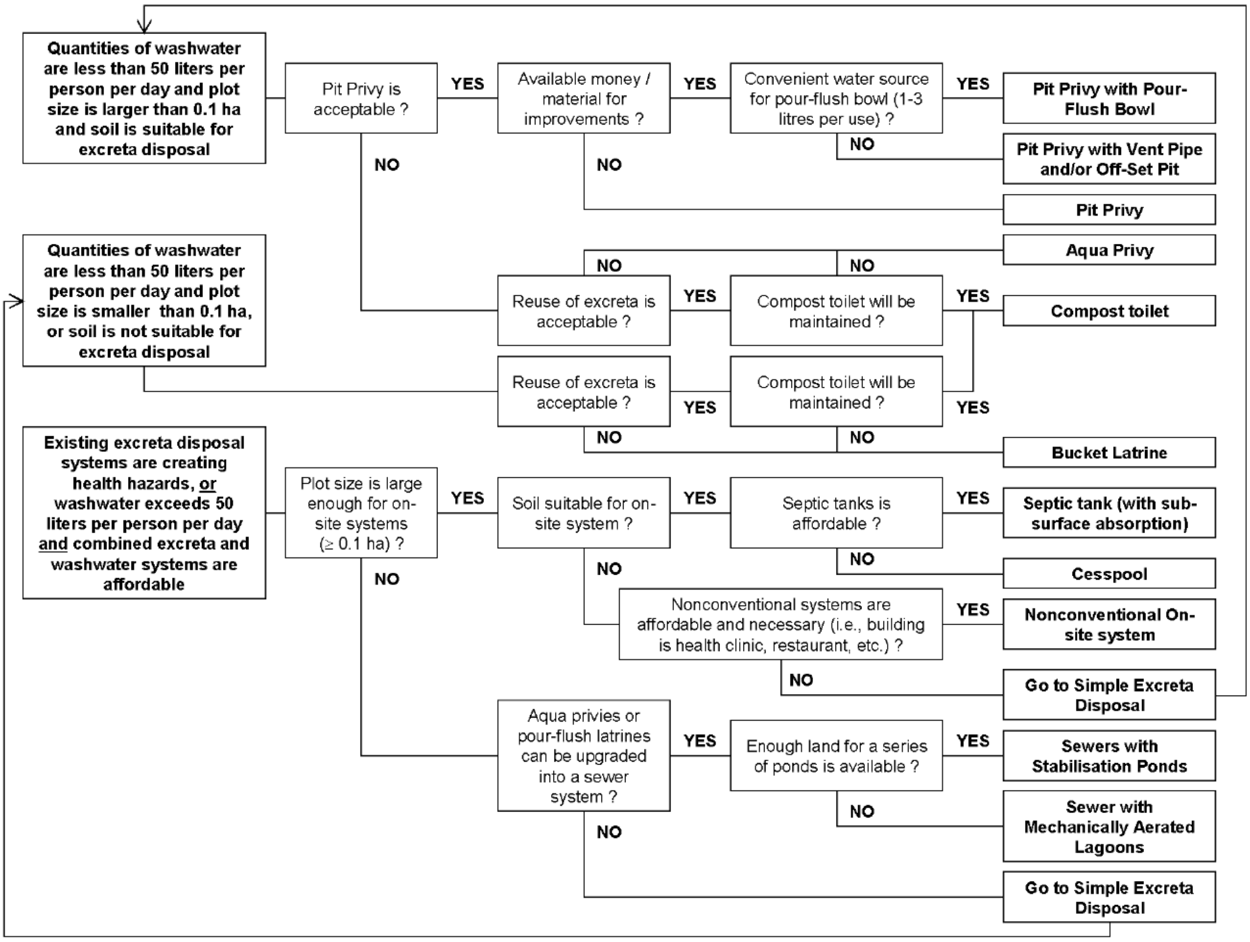
Plot size:

- Is the plot large enough to support an on-site system (at least 0.1 hectares)?

Wash water:

- Is the quantity of wash water generated less or more than 50 litres per person per day?

The diagram below helps in selecting an appropriate sanitation method[51]:



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51 Diagram developed by Skat

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