GUIDEBOOK ON TECHNOLOGIES
FOR
DISASTER PREPAREDNESS AND MITIGATION
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INTRODUCTION

Natural disasters and calamities throw up major challenges for national governments in many countries of the Asia-Pacific region. Earthquakes, floods, cyclones, epidemics, tsunamis, and landslides have become of common occurrence in the region, repeatedly taking a heavy toll of life and property. In such serious disaster situations, the major challenge for authorities is the protection of life (human and animal), property, and the vital life-supporting infrastructure necessary for disaster mitigation. Any delay or laxity in disaster relief could escalate the magnitude of distress for the victims. Advanced disaster management technology could provide a critical support system for disaster management authorities at times of disaster-related crises. Such a technology also provides important inputs for any disaster management plan of action in modern times.

Natural disasters inflict severe damage on almost the entire spectrum of social and natural habitats, ranging from housing and shelter, water, food, health, sanitation, and waste management to information and communication networks, supply of power and energy, and transportation infrastructure. The major challenges faced in all disasters include pre-disaster early warning infrastructure; the supply of food and clean drinking water; health and sanitation; information and communication; power and energy for lighting and cooking; waste collection and disposal, including rapid disposal of dead bodies of humans and animals; disaster-proof housing and shelter; emergency and post-disaster shelters; rescue and relief operations; and transport infrastructure.

Rapid advancement of technology in all these sectors could be deployed in efficiently tackling the challenges emerging from disasters, minimizing the impact of disasters in terms of reducing the magnitude of death and casualties, improving the health and sanitary conditions of the affected population, rehabilitation of the victims, etc. Specific technological solutions can be utilized in all the phases of disaster management, namely, disaster preparedness, disaster reduction, disaster mitigation, and post-disaster rehabilitation.

Traditionally, disaster management makes use of indigenous and locally developed appropriate technologies to a great extent. People in disaster-prone areas have developed, over generations, traditional technologies as efficient solutions to many of their disaster-related problems. These technologies are considered culturally compatible and inclusive to the indigenous populations. However, many of these technologies and methods have only restricted applicability and possess limited potential to reduce the impact of disasters, considering the severity of natural disasters such as floods, earthquakes, and cyclones. Hence the need arises for the application of modern technologies in disaster management, wherever and whenever possible. Many frontier areas such as space technology, modern information and communication systems, renewable energy, advanced medical diagnostics, and remotely operated robotic systems for rescue and relief operations, find useful applications in disaster management efforts. A number of advanced technologies and equipments that have already entered the marketplace in recent years could provide vital support to disaster management programmes.

It is noteworthy that advanced technologies cannot be considered in isolation whenever any disaster management mission is in operation, as advanced technologies too have their own limitations. For many of the Asia-Pacific countries, these are expensive, inaccessible, and unavailable to a great extent. What is more, the largely uneducated and illiterate population is not usually conversant with the application and utilization of these technologies. On the other hand, indigenous and traditional technologies have many virtues and advantages, and could therefore be suitably integrated with their modern counterparts for maximum benefits at the time of disasters.

This Guidebook is designed to assist disaster management authorities, professionals, and practitioners while seeking for appropriate technological solutions to various problems arising out of natural disasters. The document deals with a broad range of technologies which could have wide-ranging potential applications at
various stages of disaster management. Technologies for the following applications are elaborated in this Guidebook:

- Early warning and disaster preparedness
- Search and rescue of disaster survivors
- Energy and power supply
- Food supply, storage, and safety
- Water supply, purification, and treatment
- Medicine and healthcare for disaster victims
- Sanitation and waste management in disaster mitigation
- Disaster-resistant housing and construction.
CHAPTER 1. EARLY WARNING AND DISASTER PREPAREDNESS

Introduction

In recent years, efforts in disaster management have gained impetus from the unprecedented development in information, communication, and space technologies (ICST), which have wide-ranging applications in disaster preparedness, reduction, mitigation, and management. ICSTs provide vital support for disaster management in many ways: observation, monitoring, data collection, networking, communication, warning dissemination, service delivery mechanisms, GIS databases, expert analysis systems, information resources, etc. ICSTs, especially remote sensing, have successfully been used to minimize the calamitous impact of disasters in all phases of disaster management.

ROLE OF INFORMATION TECHNOLOGY

Effective disaster risk management depends on the informed participation of all stakeholders. The widespread and consistent availability of current and accurate data is fundamental to all aspects of disaster risk reduction. Exchange of information and easily accessible communication practices play key roles in this exercise. Data is also crucial for ongoing research, national planning, monitoring potential hazards, and assessing risks. Neglecting information management and the early warning system in disaster management may augment serious consequences for the victims.

For correct decision-making at any stage of natural disasters – from prediction to reconstruction and rehabilitation – a considerable amount of data and information is necessary. The most important procedures relating to information for disasters are monitoring, recording, processing, sharing, and dissemination. Experience has proved that information technology facilitates the receiving, classifying, analyzing, and dissemination of information for appropriate decision-making.

The main data and information critical for an efficient and robust disaster management system are those made available from:

- observatory stations;
- satellite/s observed;
- centre-to-centre;
- classified experiences;
- research results;
- training contents;
- reports; and
- news.

ROLE OF COMMUNICATION TECHNOLOGY

The available data and information should be effectively transmitted from the supplier to the end user, passing through several stages. The role of communication technology in disaster management is to keep the flow of real-time data and information during all these phases. A dynamic communication system would serve to integrate many different communication categories such as:

- data transfer from observatory stations;
- data exchange among suppliers and users;
- exchange of information and experience;
- training and video conferences; and
- tele-control (commands).
ROLE OF SPACE TECHNOLOGY
Space technology is a crucial component of ICST-enabled disaster management systems because it remains largely unaffected during disasters whereas both information and communication technologies which are based on ground infrastructure are vulnerable to natural disasters.

The scope of space technology in disaster management is as follows:

- A voluminous number of data can be collected.
- Data collection can be conducted across a wide area.
- Data accuracy can conform to the purpose of application.
- A suitable transfer period can be regulated, depending on the type of data.
- Data transfer is more reliable and safe even during disasters.
- Communication is faster in various locations.
- Communication is reliable across a wide area and remote distances.

TECHNOLOGY OPTIONS
The wide spectrum of ICSTs used in disaster preparedness, mitigation, and management include:

- Remote sensing;
- Geographical Information System (GIS);
- Global Positioning System (GPS);
- satellite navigation system;
- satellite communication;
- amateur and community radio;
- television and radio broadcasting;
- telephone and fax;
- cellular phones;
- internet, e-mail; and
- special software packages, on-line management databases, disaster information networks.

Scope of Applications
Disaster management professionals depend on ICSTs for critical solutions during almost all phases of disaster management. These include:

- disaster early warning, dissemination, and evacuation; disaster information, quick processing and analysis;
- database construction;
- information integration and analysis;
- disaster mapping and scenario simulation;
- hazard assessment and monitoring;
- disaster trend forecasting;
- disaster characteristic factor monitoring;
- vulnerability assessment;
- emergency response decision support;
- planning of disaster response, reduction, and relief;
- logistics preparation for disaster relief;
- needs assessment for disaster recovery and reconstruction;
- risk investigation and assessment;
• disaster loss assessment;
• monitoring of recovery and reconstruction; and
• rehabilitation.

Critical applications of ICSTs include the following: 1, 2, 3, 4, 5, 6, 7, 19

• To develop and design early warning systems which include: understanding and mapping the hazard; monitoring and forecasting impending events; processing and disseminating understandable warnings to administrative authorities and the population, and undertaking appropriate and timely actions in response to the warnings. (An early warning system may use more than one of the many available ICST media in parallel, and these may be either traditional [radio, television, telephone] or modern [SMS (Short Message Service), cell broadcasting, internet].)

• To build special software packages for activities such as registering missing persons, administrating on-line request management databases and keeping track of relief organizations or camps of displaced persons, which are particularly useful in the immediate aftermath of natural disasters.

• To facilitate planning, coordination, and implementation of disaster risk-reduction measures.

• To build knowledge warehouses (by using internet and data warehousing techniques) which can facilitate planning and policy decisions for preparedness, response, recovery, and mitigation at all levels.

• To improve the quality of analysis of hazard vulnerability and capacity assessments, guide development planning, and assist planners in the selection of mitigation measures.

• To provide emergency communication and timely relief and response measures.

ICST INFRASTRUCTURE

ICSTs are used mainly for collecting, analyzing, and disseminating disaster data and information for utilization by different stakeholders. This infrastructure broadly consists of the following components:

• adequate number of observatory stations and satellites at suitable places and facilities;
• adequate number of high-tech sensors and measurement instruments which can record, process, judge, and transfer data;
• data centres with very high-tech computer systems for Supervisory Control and Data Acquisition (SCADA) for saving, processing, and monitoring collected data; and
• adequate number of data dissemination equipment and devices.

Remote Sensing 1, 2, 7, 19

Remote sensing is an investigative technique that uses a recording instrument or device to measure or acquire information on a distant object or phenomenon with which it is not in physical or intimate contact. The technique is used for accumulating vital information on the environment. It comprises Aerial Remote Sensing, which is the process of recording information such as photographs and images from sensors on aircrafts; and Satellite Remote Sensing, which consists of several satellite remote sensing systems which can be used to integrate natural hazard assessments into development planning studies.

Remote sensing can collate data much faster than ground-based observation, covering a large spatial area at one time to give a synoptic view. It has the capability of capturing images of distant targets, and in all weather conditions.
Potential Application of Remote Sensing
Remote sensing technology is a powerful tool in disaster preparedness, monitoring, relief, and mitigation. Many types of disasters, such as floods, droughts, cyclones, and volcanic eruptions, have certain precursors that satellites can detect. Potential applications of remote sensing in disaster management (see Figure 1.1) include the following:

- Using remote sensing data, such as satellite imageries and aerial photos, to map the variations in terrain properties, such as vegetation, water, and geology, both in space and time. Satellite images give a synoptic overview and provide practical environmental information, spanning a wide range of scales, from an area of a few metres to entire continents.
- Helping to locate the area of a natural disaster and monitor its growing proportions while the forces of disaster are in full swing, providing information on the disaster rapidly and reliably, and thereby ensuring that the extent of devastation is evaluated precisely.
- Monitoring the disaster event which provides, in turn, a quantitative base for relief operations. Such assessment can be used to map the new scenario and update the database used for the reconstruction of the crisis area, thereby helping to prevent the recurrence of such disasters in the future.

Geographical Information System (GIS)
Geographical Information System (GIS) can be loosely defined as a system of hardware and software used for measuring, storing, retrieving, mapping, monitoring, modeling, and analyzing a variety of data types related to geographic and natural phenomena. In other words, GIS is a computer-based system capable of integrating, storing, editing, analyzing, sharing, and displaying

Figure 1.1 Disaster management based on remote sensing and GIS technology
geographically-referenced information. Spatial features (latitude, longitude, state plane, etc) are stored in a coordinate system (latitude, longitude, state plane, etc) which alludes to a particular place on earth. Descriptive attributes in tabular form are associated with the spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis. The GIS tool aids efficient storage and manipulation of remotely sensed data and other spatial and non-spatial data types for both scientific management and policy-oriented information.

**Potential Application of GIS** 1, 2, 7, 8, 9, 10, 19

GIS is normally used for scientific investigations, resource management, and development planning. The analytical capabilities of GIS support all aspects of disaster management: planning, response and recovery, and records management. The system facilitates the ordering of the voluminous data needed for the assessment of hazard and risk, and uses models to combine different kinds of data. The combination of different kinds of spatial data with non-spatial data and attribute data provides useful information at the various stages of disaster management.

The most common applications of GIS in disaster management are the following:

- GIS provides a versatile platform for **Decision Support** by furnishing multilayer geo-referenced information, which includes hazard zoning, incident mapping, natural resources and critical infrastructure at risk, available resources for response, real-time satellite imagery, etc. Such ready information allows disaster managers to quickly assess the impact of the disaster/emergency on a geographic platform and plan adequate resource mobilization in the most efficient way.
- The specific GIS applications in the field of risk assessment are: **Hazard Mapping** to indicate earthquakes, landslides, floods, and fire hazards across cities, districts, or even the entire country, and tropical cyclones; **Threat Maps**, which are used by meteorological departments to improve the quality of the tropical storm warning services and quickly communicate the risk to potential victims.
- **In the disaster preparedness phase**, GIS is used as a tool for the planning of evacuation routes, for the design of centres for emergency operations, and for integration of satellite data with other relevant data in the design of disaster warning systems.
- **In the disaster relief phase**, GIS is extremely useful, in combination with GPS, in search- and-rescue operations in devastated areas where such operations are difficult.
- **In the disaster rehabilitation phase**, GIS is used to organize the damage information and the post-disaster census information, and in the evaluation of sites for reconstruction.
- GIS facilitates the calculation of emergency response times for emergency planners in the event of a natural disaster. It also allows disaster managers to quickly access and visually present critical information by location. Such information can be shared easily with disaster response personnel to help coordinate and implement emergency efforts.
- **A reliable GIS-based database** will ensure the mobilization of the necessary resources to the right locations within the least response time. Such a database would also play a fundamental role in the planning and implementation of large-scale preparedness and mitigation initiatives.

Some applications of remote sensing and GIS in various disaster situations (see Table 1.1) are as follows:2, 6

**Drought:** Remote sensing and GIS can be used to develop early warnings of drought conditions which would help in planning the strategies for relief work. Satellite data may be used to target potential groundwater sites for well-digging programmes. Satellite data provides valuable tools for evaluating areas prone to desertification. Film transparencies, photographs, and digital data can be used for the purposes of locating, assessing, and monitoring the deterioration of natural conditions in a given area.

**Earthquake:** GIS and remote sensing can be used for preparing seismic hazards maps in order to assess the exact nature of risks.
Floods: Satellite data can be effectively used for mapping and monitoring flood-inundated areas, flood damage assessment, flood hazard zoning, and post-flood survey of rivers configuration and protection works.

Landslide: A landslide zonal map demarcates the stretches or area of varying degree of anticipated slope stability or instability. As the map has an inbuilt element of forecasting, it is of a probabilistic nature. Depending upon the methodology adopted and the comprehensiveness of the input data used, a landslide hazard zonal map is an excellent information aid in respect of location, extent of the slope area likely to be affected, and rate of mass movement of the slope mass.

Search-and-Rescue: GIS can be used in carrying out search-and-rescue operations in a more effective manner by identifying areas that are disaster-prone and zoning them according to risk magnitudes.

| Table 1.1 Applications of space remote sensing in disaster management6 |
|------------------------|------------------------|------------------------|------------------------|
| Disaster               | Prevention              | Preparedness (Warning) | Relief                |
| Earthquakes            | Mapping geological lineaments and land use maps | Geo-dynamic measurements of strain accumulation | Locate stricken areas, map damage |
| Volcanic eruptions     | Topographic and land use maps | Detection/measurement of gaseous emissions | Mapping lava flows, ashfalls and lahars, map damage |
| Landslides             | Topographic and land use maps | Rainfall, slope stability | Mapping slide area |
| Flash floods           | Land use maps           | Local rainfall measurements | Map flood damage |
| Major floods           | Flood plain maps; land use maps | Regional rainfall; evapo-transpiration | Map extent of floods |
| Storm surge            | Land use and land cover maps | Sea state; ocean surface wind velocities | Map extent of damage |
| Hurricanes             |                        | Synoptic weather forecasts | Map extent of damage |
| Tornadoes              | Local weather; local weather observations | Map amount, extent of damage |
| Drought                |                        | Long-range climate models | Monitoring vegetative biomass |

Global Positioning System1, 7, 10
A critical component of any successful rescue operation is time. Prior knowledge of the precise location of landmarks, streets, buildings, emergency service resources, and disaster relief sites saves time – and saves lives. Such information is critical to disaster relief teams and public safety personnel in order to protect life and reduce property loss. The Global Positioning System (GPS) serves as a facilitating technology in addressing these needs by helping the users, at any point on or near the earth’s surface, to obtain instantaneous three-dimensional coordinates of their location.

Global Positioning Systems are very useful in disaster preparedness, reduction, and mitigation efforts. Major applications of GPS include:

- Pinpointing the location of damage sites and floodplains.
• Playing an increasingly prominent role in helping scientists to anticipate earthquakes in earthquake-prone areas. Using the precise position information provided by GPS, scientists can study how pressure slowly builds up over time in an attempt to characterize, and in the future perhaps anticipate, earthquakes.

• Meteorologists responsible for storm tracking and flood prediction also rely on GPS. They can assess water vapour content by analyzing transmissions of GPS data through the atmosphere.

• GPS has become an integral part of modern emergency response systems – whether helping stranded motorists find assistance or guiding emergency vehicles.

• GPS has given managers a quantum leap forward in the efficient operation of their emergency response teams. GPS improves the ability to effectively identify and view the location of police, fire, rescue, and individual vehicles or boats, and examine how their location relates to an entire network of transportation systems in a geographic area. Location information provided by GPS, coupled with automation, reduces delay in the dispatch of emergency services.

• Incorporation of GPS in mobile phones places an emergency location capability in the hands of everyday users. Widespread placement of GPS location systems in passenger cars and rescue vehicles helps in developing a comprehensive safety net. Today, many ground and maritime vehicles are equipped with autonomous crash sensors and GPS. This information, when coupled with automatic communication systems, activates a call for help even when occupants are unable to do call on their own.

**Satellite Navigation and Communication**

A way to improve the chances that an emergency link will remain operational during a disaster is to connect it via satellite. Satellites are the only wireless communications infrastructure that are not susceptible to damage from disasters, because the main equipment sending and receiving signals (the satellite spacecraft) is located outside the earth’s atmosphere. Two kinds of satellite communications networks support disaster management and emergency response activities: geo-stationary satellite systems (GEO) and low-earth orbit satellites (LEO).

*Geo-stationary satellite systems:* GEO satellites are located 36,000 km above the earth in a fixed position, and provide service to a country or a region extending up to one-third of the globe. They are capable of providing a full range of communications services, including voice, video, and broadband data. These satellites operate with ground equipment, ranging from very large, fixed gateway antennas down to mobile terminals the size of a cellular phone. Currently, almost 300 commercial GEO satellites are in orbit, being operated by global, regional, and national satellite carriers.

*Low-Earth Orbit satellites:* LEO satellites operate in orbits between 780 km and 1500 km (depending on the system), and provide voice and low speed data communications. These satellites can operate with hand-held units about the size of a large cellular phone. As with hand-held terminals that rely upon GEO satellites, the highly portable nature of LEO-based units makes them another valuable satellite solution for first responders in the field.

Even before disaster strikes, these networks are used in many countries to provide seismic and flood-sensing data to government agencies, enabling early warning of an impending crisis. Also, they broadcast disaster-warning notices and facilitate general communication and information flow between government agencies, relief organizations, and the public.

Satellite technology can provide narrowband and broadband Internet Protocol (IP) communications (internet, data, video, and voice over IP) with speeds starting at 64 Kbps from hand-held terminals up to 4 Mbps bidirectional from portable VSAT antennas. Fixed installation can bring the bandwidth up to 40 Mbps. The operation of these satellite systems and services follows the general topology depicted in Figure 1.2.
Solutions using this topology can be applied in both advance disaster mitigation services and in supporting relief and recovery efforts under three general categories: 11

1. hand-held mobile satellite communications;
2. portable and transportable mobile satellite communications; and
3. fixed satellite communications.

**Hand-held Mobile Satellite Communications**

Once a disaster has occurred, local infrastructure – including microwave, cellular, and other communication facilities – is often inoperative, either because transmission towers are destroyed, or because of electrical failure. In the immediate aftermath of such a disaster, the only reliable form of communications is the hand-held satellite telephone systems provided by mobile satellite service providers. These systems provide access through very small, cell-phone-sized devices, as well as pagers and in-vehicle units.

**Portable and Transportable Mobile Satellite Communications**

Mobile satellite systems, or terminals used for “communications on the move”, include equipment that can be transported and operated from inside a car, truck, or maritime vessel, as well as in helicopters and other aircraft, including commercial airplanes. This kind of terminal is an asset where data-intensive, high-speed connections are needed on an expedited basis for damage assessment, medical evaluation, or other applications for voice, video, and data. Depending on the satellite system and type of equipment, they can be operational anywhere from 5-30 minutes, usually without expert technical staff, and can be deployed anywhere. As with communication systems in general, higher satellite terminal prices – whether portable, mobile, or fixed – equate to more robust services, higher reliability, faster delivery, and a wide range of other features and options.

**Fixed Satellite Communications**

Fixed satellite communication terminals would typically be installed by a qualified technical team in cases where the equipment is required for longer than a week, in both pre-disaster applications – e.g. environmental monitoring, communications redundancy, etc – and post-disaster recovery operations. Such systems can be configured to all specifications – from low-speed data transmissions up to very broad bandwidth data and full broadcast-quality video –, replacing local and national telecommunications infrastructure. To support the installation and deployment of such systems, satellite companies have developed an industry-standard VSAT Installation & Maintenance Training Certification Program.
Common Satellite Communication Systems

Mobile satellite systems: Currently, the most widely used mobile satellite system is the Inmarsat system. The Inmarsat system is composed of geo-stationary satellites, which connect mobile terminals via Land Earth Stations (LES) to the Public Switched Telephone Network (PSTN) and other networks. A communication link includes at least one LES which is the actual service provider.

Standard M and mini-M terminal for Inmarsat applications: Mini-M terminals are about the size and weight of a laptop computer, and standard M terminals the size of a briefcase. They enable connections with any PSTN subscriber worldwide, including other mobile satellite terminals. They cannot be used when a vehicle is in motion unless equipped with special antennas that compensate for the vehicle’s movement.

Global Mobile Personal Communications by Satellite (GMPCS): The advantage of GMPCS over other mobile satellite systems is that the terminals are very small and lightweight, about the size and weight of a cell phone. Also, the terminals being of dual mode type are able to connect to either satellite or terrestrial service. Normally, users program the terminal to connect to a cellular system when such service is available, but automatically connect to the satellite system when cellular coverage does not exist. During a disaster, the terminal gets directly connected to the satellite. Regional mobile satellite systems have the capacity to restore telecommunication services in disaster-hit areas.

Very Small Aperture Terminal (VSAT) networks; VSAT networks are designed mostly for fixed installation, but “Flyway” systems are available for disaster recovery purposes and disaster communications. For serious reliable long-range communication, VSAT is considered a superior system. The terminal equipment needs to be protected from physical damage. The dish, in particular, should be installed in a strategic position, where it is shielded from exposure to flying debris during storms, while its connectivity with the satellite remains unimpaired. After a storm or an earthquake, the antenna’s position may need to be adjusted, for which special equipment in addition to the actual VSAT terminal is required. VSAT systems connect the Private Branch Exchange (PBX) directly to another location via a satellite link. This means immunity from failure of the ground services as long as the earth station remains operational and has independent power.

The possibility of the use of a VSAT-based Private Automatic Branch Exchange (PABX) in disaster management is also useful as it provides wide connectivity. Land/satellite mobile communication with voice, data, and video facility are best suited for rescue operations. Further restoration work is possible with advanced storage of the required rebuild equipment.

Amateur Radio

Amateur radio has earned its reputation as an instrument best used to communicate during disasters in areas where other means of communication have failed. Amateur radio operators provide vital assistance to their communities and countries during disasters by providing reliable communication on voice mode about the status of survivors as well as information on casualties to disaster relief organizations and friends and relatives.

The amateur radio operator’s licence is also called a ‘Ham’ licence, and the licence holders are referred to as ham operators. ‘Ham’ is the abbreviation of Hertz Armstrong and Marconi, though it is also known as Home Amateur Mechanic. Ham operators use many modes of operation to communicate: Continuous Wave; Frequency Modulation (FM); Amplitude Modulation (AM); Single Side Band; Digital mode which includes radio telephony; Radio TeleType (RTTY), Continuous Wave – CW for Morse Code; Tele-printing Over Radio (TOR); PSK31 – a type of modulation, and packet radio transmission; Fast and Slow Scan Television; and Internet Radio Linking. In an emergency operation, these modes can be used to transmit different information depending upon the urgency of the communication.
Amateur radio is a scientific hobby which can be cultivated by individuals of all age groups and professions. In an emergency such as a natural disaster, two main activities by amateur radio operators can prevent loss of life. The first is to forewarn people about a possible emergency, enabling them to take appropriate preventive measures for saving lives. And the other is to pass messages, images, and other information to aid agencies to help the survivors and injured as soon as possible in an emergency situation. Satellite images or video pictures of the affected area can be transmitted without delay as soon as amateur radio operators reach the disaster site or by those who are already present. This information and knowledge can facilitate speedy decision-making when it comes to providing basic aid to disaster victims.

**Community Radio**

Community radio stations are usually set up “by the community, for the community”. They differ from national and international radio broadcasters in that they feature local news and issues and often include local people in the programmes which are broadcast in the local language. Most community radio stations broadcast on the FM (VHF) waveband, and their coverage varies, depending upon the equipment in use. Some small stations cover areas of a few square kilometres whereas others broadcast across hundreds of kilometres to a large population. The regulations concerning the licensing of radio broadcasters vary from country to country, and should be understood before undertaking radio initiatives.

Community radio has proved to be a key agent in the prevention of natural disasters and in relief operations by allowing access to information and voice at the local level.

*How to Use Community Radio:* Setting up and running a community radio station is a significant undertaking which requires careful planning:

- Secure a licence before broadcasting starts.
- Assess the funds required for equipment, premises, and all running costs.
- Ensure that the necessary technical and broadcasting know-how will be available.
- Decide on the number of broadcasting hours per day and ensure that interesting programme content is collected to fill time ‘on air’. Consider making your own local programmes or sourcing material from other stations. Build up a library of recordings and music, and share this information with others.
- Consider live programming, including interviews, group discussions, and phone-ins.
- Encourage feedback and involvement from the listening audience.

*Advantages of Community Radio*

- Community radio is often greatly appreciated by its audience because of the localized nature of the programming.
- The community feels involved and can contribute directly to the programme content through letters, phone-ins, or by visiting the station.
- Listeners do not require literacy.
- A large audience can be reached.
- For isolated communities without electricity and telephone, it may be the only communication medium.

*Constraints of Community Radio*

- Some countries restrict the issuing of licences or have time-consuming, complicated application processes.
• The necessary technical and broadcasting skills may not be available.
• The radio station owners/managers are in control of a powerful communications medium, and must use it responsibly.

**WLL**

The Wireless Local Loop (WLL) equipment with V5.2 interface, which is connected to the Base Station (BS), is an exchange of approximately 1000 lines. It could be transported in an air-conditioned van which should have built-in power supply, battery, generator, and the WLL antenna installed on the rooftop. The subscribers are given hand-held terminals, and Mobile PCOs could also be set up. The exchange’s junction E1 lines are connected to a nearby working exchange either by a radio system (within 30 km) or by optical fibre cable. If difficulties arise in the installation of a rooftop antenna on a microwave tower, a collapsible/ready-to-assemble on-site microwave tower could be taken to the disaster area to solve this problem.

**GSM/Cellular Mobile Telephone System**

The Global System for Mobile Communications (GSM)/Cellular Mobile Telephone system can be installed on the van with emergency equipment which could be taken as near as possible to the disaster site. If a cellular mobile telephone network is working near the disaster-hit area, the air-conditioned van containing Base Transceiver Station (BTS) equipment, three panel antennas, and a 15 GHz radio system/Optical Line Transmission Multiplexer (OLTE) for an E1 line connection to BSC could be taken to the disaster area. The subscribers are given hand-held terminals. Mobile PCOs could also be set up.

The BTS is connected to a nearby working Base Station Controller (BSC) either by radio system (within 30 km) or pre-terminated optical fibre cable. The air-conditioned van should be equipped for built-in power supply, battery, generator, etc. If installing a rooftop antenna or microwave tower is difficult, a collapsible/ready-to-assemble on-site microwave tower could be taken to the disaster site.

For the provision of 2 Mbps connectivity to WLL-based equipment or a Cellular Mobile Telephone, satellite Intermediate Data Rate (IDR) equipment with a 2.4 m antenna in Ku band, or a 3.8 m antenna in C band, can be used instead of a Microwave Radio or optical fibre. This mobile station should have the capability to uplink audio, data, and video broadcasting information.

**Internet**

In the present era of electronic communication, the internet provides a useful platform for disaster mitigation communication. The internet becomes a valuable asset, provided the rate of illiteracy in the disaster area is insignificant, the residents understand the language in use and are familiar with the computers and the software, and have physical access to both the net and computers, with both clients and servers up and not overloaded. Well-defined websites have been a cost-effective means of rapid, automatic, and global dissemination of disaster-related information. A number of individuals and groups, including several national meteorological services, are experimenting with the internet for real-time dissemination of weather observation, forecasts, satellite, and other data.

The internet provides support for major operations and functions of organizations, irrespective of distances between headquarters and field offices. For disaster relief managers and workers, access to the internet permits continuous updates of disaster information, accounts of human and material resources available for response, and state-of-the-art technical advice.

**TV and Radio Broadcasting**

Television and radio broadcasting are among the most important traditional electronic media used for disaster warning. The effectiveness of these two media is high because, even in developing countries and rural environments where the tele-density is relatively low, they can be used to quickly send out a warning to
a sizeable population. The only possible drawback of these two media is that their effectiveness is significantly reduced at night, when they are normally switched off.

Allocated Frequency Bands
The frequency choice is critical for transmitting the alert. Theoretically, all bands from AM to FM, LM and Band IV and V up to L-Band for satellite can be used. Band IV and V is nowadays used mostly for TV; and the L-Band is used mainly by satellite radio systems such as XM, Sirius, and WorldSpace. The advantages of this technology are the miniscule antennas, the absence of terrestrial transmitters needing power, and a proven technology. Some countries use the L-Band also for terrestrial transmission, but the main problem today is the economics and the scale of a whole network.

Receiving Equipment
For awareness and prevention of disasters, the standard radio and TV receivers are sufficient. The only critical element of these sets is the need for batteries which can be overcome by resorting to a combination of A.C. power and batteries. Radio and TV provide a major broadcast channel for populations at risk. The advent and proliferation of high-bandwidth cable modems, value-added services such as WebTV, and low-cost network computers suggest that this could be a primary information dissemination system of warnings and public information for the foreseeable future.

Satellite Radio
Satellite radio or subscription radio is a digital radio that receives signals broadcast by communications satellite, which covers a much wider geographical range than terrestrial radio signals. Satellite radio functions anywhere, given a line of vision between the antenna and the satellite, and no major obstructions such as towers or buildings. Satellite radio audiences can follow a single channel, regardless of location within a given range.

Satellite radio can play a key role during both disaster warning and disaster recovery phases. Its major advantage is the ability to work even outside of areas not covered by normal radio channels. Satellite radios can also be of help when the transmission towers of the normal radio station are damaged in a disaster.

The International Telecommunication Union (ITU) has identified various radio communication media for disaster-related situations (Table 1.2).
<table>
<thead>
<tr>
<th>Disaster phases</th>
<th>Major radio communication services</th>
<th>Major tasks of radio communication services</th>
</tr>
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<tr>
<td>Prediction and Detection</td>
<td>• Meteorological services (meteorological aids and meteorological-satellite service) • Earth exploration-satellite service</td>
<td>Weather and climate prediction Detection and tracking of earthquakes, tsunamis, hurricanes, typhoons, forest fires, oil leaks, etc Providing warning information</td>
</tr>
<tr>
<td>Alerting</td>
<td>• Amateur services</td>
<td>Receiving and distributing alert messages</td>
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<tr>
<td></td>
<td>• Broadcasting services: terrestrial and satellite (radio, television, etc)</td>
<td>Disseminating alert messages and advice to large sections of the public</td>
</tr>
<tr>
<td></td>
<td>• Fixed services: terrestrial and satellite</td>
<td>Delivering alert messages and instructions to telecommunication centres for further dissemination to the public</td>
</tr>
<tr>
<td></td>
<td>• Mobile services (land, satellite, maritime services, etc)</td>
<td>Distributing alert messages and advice to individuals</td>
</tr>
<tr>
<td>Relief</td>
<td>• Amateur services</td>
<td>Assisting in organizing relief operations in areas (especially when other services are not operational)</td>
</tr>
<tr>
<td></td>
<td>• Broadcasting services: terrestrial and satellite (radio, television, etc)</td>
<td>Coordination of relief activities by disseminating information from relief planning teams to population</td>
</tr>
<tr>
<td></td>
<td>• Earth exploration-satellite service</td>
<td>Assessment of damage and providing information for planning relief activities</td>
</tr>
<tr>
<td></td>
<td>• Fixed services:</td>
<td>Exchange of information between</td>
</tr>
</tbody>
</table>
terrestrial and satellite different teams/groups for planning and coordination of relief activities

- Mobile services (land, satellite, maritime services, etc) Exchange of information between individuals and/or groups of people involved in relief activities

Telephone (fixed and mobile)
Telephones play an important role in warning communities about an impending disaster. For example, simple phone warnings saved many lives in South Asian countries during the 2004 tsunami. In some countries, mechanisms called ‘telephone trees’ are used to warn communities of impending danger: an individual represents a ‘node’ in a telephone tree; when that individual receives a warning message (either by phone or other means), s/he is supposed to make a pre-determined number of phone calls (usually four or five) to others in a pre-prepared list. This arrangement not only ensures the timely delivery of the warning message, but also ensures a minimum duplication of efforts. However, the use of telephones for disaster warning has two drawbacks: telephone penetration in many areas is still unsatisfactory – particularly in rural and coastal areas most at risk; notwithstanding the exponential increase in the number of phones that has occurred in recent years, a telephone is still considered a luxury in many regions in the Asia-Pacific region. The other drawback is the congestion of phone lines that usually occurs immediately before and during a disaster, hindering the users from contacting the disaster management authorities during the emergency situation.

Short Message Service
Short Message Service (SMS) is available on most digital mobile phones that permit the sending of short messages (also known as ‘text messages’, ‘SMSes’, ‘texts’, or ‘txts’) between mobile phones, other handheld devices, and even landline telephones. SMS works on a different band and can be sent or received even when phone lines are congested. SMS also has another advantage over voice calls in that one message can be sent to a group simultaneously.

Cell Broadcasting
Most of today's wireless systems support a feature called cell broadcasting. A public warning message in text can be sent to the screens of all mobile devices with such capability in any group of cells of any size, ranging from a single cell (about 8 km across) to the whole country, if necessary. CDMA, D-AMPS, GSM, and UMTS4 phones have this capability.

Some of the many advantages of using cell broadcasting for emergency purposes are:

- No additional cost is incurred when implementing cell broadcasting as this function is already built into most network infrastructure as also the phones. So there is no need to build any towers, nor lay any cables, nor write any software, nor replace handsets.
- It is not affected by traffic load; therefore it is of use during a disaster, when load spikes tend to crash networks. Also, cell broadcasting does not cause any significant load of its own, so it does not add to congestion.
- It is geo-scalable, allowing a message to reach innumerable people across continents within a minute. It is also geo-specific, enabling government disaster managers to avoid panic and road jamming by sending specific alerts to each neighbourhood on whether they should opt to evacuate or stay put.
The only possible disadvantage of cell broadcasting is that not every user may be able to read a text message when they receive it. In many Asia-Pacific countries, a sizeable number of phone users who have no reading skills cannot understand a message sent in English, making it necessary to send warning messages in the local languages. However, such messages would still be inaccessible to those who cannot read even in their own language!

**Disaster Management Software**

Different types of software tools are being used to gather, store, and analyze data related to disasters, not only in post-disaster conditions, but also as a long-term measure to mitigate the risk of disasters. Some software packages frequently used in disaster management are covered briefly below.

**DesInventar**

DesInventar offers a systematic method for collecting and storing data on the characteristics and effects of different types of disasters, particularly the ones not visible from global and national scales. This allows for the observation and analysis of accumulated data on these ‘invisible’ disasters. The DesInventar system can also be used to simulate disasters and proceed to study their impact. For example, it can trigger an earthquake in the virtual environment and analyze its impact on a geographical area ranging from a municipality to a group of countries. The system forecasts information on the possible loss of human lives, impact on the economy, and damage to infrastructure, etc. DesInventar is also a tool that facilitates the analysis of disaster-related information for applications in planning, risk mitigation, and disaster recovery. It can be used not just by government agencies, but also by NGOs in their disaster management work.

**MANDISA**

The programme for Monitoring, Mapping and Analysis of Disaster Incidents in South Africa (MANDISA) is a core activity for the Disaster Mitigation for Sustainable Livelihoods Programme of the University of Cape Town. MANDISA was initiated as a pilot study in the Cape Town metropolitan area in the Western Province of South Africa from 1990 to 1999. It focuses on hazards relevant to South Africa, including large urban ‘non-drainage’ floods, wildfires, and extreme wind events, and frequent ‘small’ and ‘medium’ fires.

**Groove** ([http://www.groove.net](http://www.groove.net))

Groove was initially developed by a small technology start-up established by Ray Ozzie, creator of Lotus Notes and former CEO of Iris Associates. Groove has recently been acquired by Microsoft. At its most basic level, Groove is desktop software, designed to facilitate collaboration and communication among small groups. A key concept of the Groove paradigm is the shared workspace. A Groove user creates a workspace and then invites other people into it. Each person who responds to an invitation becomes a member of that workspace and is sent a copy of the workspace that is installed on his/her hard drive. All data is encrypted both on disk and over the network, with each workspace having a unique set of cryptographic keys. This local copy avoids the physical distance between the user and his/her data. In other words, a workspace is a private virtual location where members interact and collaborate. Once a workspace is established, Groove keeps all the copies synchronized via the internet or the corporate network. When any one member makes a change to the established space, that change is sent to all copies for update. If that member is offline at the time the change is made, the change is queued and synchronized to other workspace members when the concerned member comes back on-line. Using the shared workspace, one or more members (peers) now have a context for collaboration. Groove is being used widely by disaster management practitioners; for instance, in Iraq, for the Indian Ocean tsunami response, and in other emergencies.

**Voxiva** ([http://www.voxiva.net](http://www.voxiva.net))

Voxiva is another technology start-up with a specific philanthropic intent. It originally provided only reporting services, especially in the health sector, to governments in developing countries. Now, it targets NGOs as well as UN agencies. Voxiva is currently being used by organizations such as the US Department
of Defense, USAID, the Rwanda Ministry of Health, the Ministry of Health of Tamil Nadu (India), the
International Rescue Committee, and the Ministry of Health of Peru.

Voxiva offers an integrated monitoring and reporting function through an on-line platform. Another
application meant to provide programme management in the field is currently being developed. Voxiva’s
Pyramid Platform is designed to bring technology to the so-called ‘bottom of the pyramid’, such as rural and
poor communities. By leveraging phones, mobile phones, personal digital assistants (PDAs), faxes, and
radios as well as the internet, applications built and deployed on Voxiva’s multi-channel Pyramid Platform
have a much broader reach than other technologies. Solutions built on the Pyramid Platform allow
organizations to collect information from and communicate with distributed networks of people in a timely
and systematic way. Voxiva also provides the tools to organize maps, analyze the data collected, and make
the right decisions. Voxiva systems are deployed to track diseases, monitor patients, report crime, and
respond to disasters across Latin America, Africa, Asia, and the USA.

FACTS
The Food and Commodity Tracking System (FACTS) is an easy-to-use, internet-based application that is
capable of managing multiple relief operations simultaneously. Mercy Corps, a humanitarian aid
organization, based in Portland, USA, has worked with Microsoft to develop this tracking system which can
help humanitarian aid agencies deliver supplies in disaster situations.

According to Microsoft, FACTS represents the first significant step towards the creation of a standard
framework for improving humanitarian assistance on a global level. During a crisis, coordinating and
distributing the teeming supplies of food and other commodities from donors is a challenge to even the most
seasoned relief agencies – a challenge that FACTS aims to address. The FACTS design team, which also
includes the American Red Cross, Catholic Relief Services, Food Aid Management, Food for the Hungry
International, Project Concern International, and Save the Children, has worked to standardize logistics
operations and to streamline reporting. This allows material aid programme managers to focus on the actual
delivery of needed supplies while maintaining high standards of commodity tracking. Mercy Corps has
already implemented FACTS pilot programmes in Indonesia and Kyrgyzstan. Three additional agencies are
using FACTS in their Bolivia and Guatemala operations, and one agency soon plans to extend the service to
Ethiopia.

Disaster Information Networks
Many national and regional networks have been useful for effective information sharing and coordination.
Two examples are cited below.

UNDP’s Tsunami Resources and Results Tracking System
The United Nations Development Programme (UNDP) has developed a regional information portal and
customized Development Assistance Database (DAD) to help align aid inflows with priority needs. The
DAD system is used as a resource for coordination at the regional level. This brings together results and
resource allocation data from each country and makes it available at a single site: http://tsunamitracking.org.

By accessing DAD, users can avail of real-time information on who is doing what and where. The portal also
provides access to various maps, reports, charts, documents, and other information which give donors,
implementers, governments, and the general public better insight into funding flows and projects’ progress.
A private sector DAD has also been developed to record private sector flows, particularly those from
transnational firms that may not have reported their assistance to the individual government-owned systems
in the tsunami-affected countries.
India Disaster Resource Network

The India Disaster Resource Network (IDRN) is a web-enabled and GIS-based national database of resources essential for effective emergency response. The project, initiated by the Ministry of Home Affairs and UNDP, collects and stores information such as individual and organizational expertise, and details of equipment and supplies required during emergencies, available at government departments, military units, NGOs, and private companies in different districts. Accessible from http://www.idrn.gov.in, this inventory is being used by disaster managers at the national, state, and district levels to make informed decisions and quickly mobilize resources during emergencies.

RECENT/LATEST TECHNOLOGIES

ICST has been an area of intense research in recent years, resulting in the development of many new and advanced systems which could be helpful in early warning, forecasting, and mitigating the impact of natural disasters. Some of these technologies are briefly presented in the following sections.

Satellite-based Weather Warnings

Disaster preparedness has long been a part of development work, but now World Vision, India, plans to take advantage of new technology in disaster-prone development areas. For the first time, satellite weather warnings will give villagers a chance to react and respond before disaster strikes.

The system works through a simple local computer network connected to television, internet, and the local public address system. During times of alert, all weather reports are aired in the local language through multiple loudspeakers, and the internet is monitored for the latest weather patterns.

As a back-up, WorldSpace Radio connects the early warning centres, submitting messages as well as forwarding computer files. This means warnings can be communicated to many destinations even when internet communication has been suspended.

Once completed, it is hoped the system will cover as many as 5800 villages in several different states of India. In addition, disaster preparedness activities include an introduction to alternative crops and livelihoods; identification and strengthening of roads, riverbanks, and buildings prone to damage; and regularly rehearsed evacuation and response plans with community volunteers.

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Flood Forecasting System

In the summer of 2004, a forecasting system developed by scientists of National Center for Atmospheric Research (NCAR) and Georgia Institute of Technology in USA generated 10-day forecasts which indicated that the Brahmaputra River in Bangladesh would likely exceed the critical flood level (the horizontal dotted line) on two occasions in July. At the time, the forecasts were not fully integrated into the Bangladeshi warning systems, and approximately 500 people in Bangladesh and India died in the floods. In the summer of 2008, for the first time, the forecasts were being distributed directly to more than 100,000 residents in flood-prone areas along the Brahmaputra and Ganges rivers. As catastrophic floods worsen in Bangladesh, a pilot forecasting programme is being used to warn thousands of residents in selected flood-prone regions.

The pilot programme began in the summer of 2008 with the aim of delivering 1- to 10-day forecasts directly to more than 100,000 residents in the floodplains of the Brahmaputra and Ganges rivers, and gradually
expanding the reach to additional residents in the future. It predicted the floods of the year 2008 a few days in advance, alerting a network of volunteers in Bangladesh to notify residents at risk. The volunteers could not confirm the extent to which these efforts helped people prepare for the floods.

The system uses a combination of weather forecast models, satellite observations, river gauges, and new hydrologic modeling techniques. It is part of a larger initiative, known as Climate Forecast Applications in Bangladesh (CFAB), to improve flood and precipitation warnings in the low-lying nation.

The forecasting system emphasizes modeling and satellite data to compensate for a lack of river gauge data upstream of Bangladesh, as well as for a lack of radar data. It is updated daily with new model runs and measurements.

For more information, contact:
National Center for Atmospheric Research (NCAR),
P.O. Box 3000,
Boulder, CO 80307-5000,
USA.
Tel: (303) 497-1000

Tsunami Warning System

Indian scientists have unveiled a tsunami early warning system (National Early Warning System) for tsunami and storm surges in the Indian Ocean. The tsunami warning centre, which has been set up at the Indian National Centre for Ocean Information Services (INCOIS), aims to issue alerts on the killer waves within 30 minutes of an earthquake. The Centre will generate and give timely advisories to the Ministry of Home Affairs (MHA) for dissemination to the public: to accomplish this work, a satellite-based virtual private network for disaster management support has been established. This network enables an early warning centre to disseminate warnings to the MHA as well as to the state emergency operations centres.

Scientists have installed two bottom pressure recorders (BPR), which are key sensors that indicate the generation of tsunami off the Gujarat coast in the Arabian Sea. So too, a set of four BPRs which had been installed in the Bay of Bengal region were put to the test on 12 September 2008 when a massive undersea earthquake hit southern Sumatra. INCOIS, in association with Tata Consultancy Services, has generated simulations of 550 possible scenarios triggering a tsunami after massive earthquakes.

For more information, contact:
Indian National Centre for Ocean Information Services (INCOIS),
"Ocean Valley",P.B No.21,IDA Jeelimetla P.O,
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Tel: +91-40-23895000; +91-40-23895002
Fax: +91-40-23892910
E-mail: webmaster@incois.gov.in

Integrated Public Alert and Warning System

A 'next generation' system will help ensure reliable, efficient communication to citizens in the event of hurricanes and other potentially catastrophic events. In partnership with the Federal Emergency Management Agency (FEMA), Sandia National Laboratories is designing and deploying a pilot alert and warning system which will provide a robust, multi-faceted path to ensure effective public communication during federal, state, and local emergencies.
Known as the Integrated Public Alert and Warning System (IPAWS), the programme, which began piloting on August 1, 2007 in the midst of the hurricane season, is administered by FEMA for the Department of Homeland Security, and is initially supporting several states and local jurisdictions in the Gulf Coast region of USA. IPAWS addresses the mandate and vision of Executive Order 13407 to ensure that the President can rapidly and effectively address and warn the public over a broad range of communication devices and under any conditions.

IPAWS is designed to transform national emergency alerts from audio-only messages, delivered over radios and televisions, into a sophisticated, comprehensive system which can reliably and efficiently send alerts by voice, text, and video to all Americans, including those with disabilities or who cannot understand English. FEMA’s aim is to deliver targeted alerts and warnings via more communication devices to more people, anywhere, and at any time that a disaster strikes.

The new IPAWS system will include the deployment of an enhanced Web Alert and Relay Network (WARN) which provides emergency operations staff with collaboration tools, public access websites, and alert and warning notification facilities. WARN also features an “opt-in” capability which allows citizens to sign up to receive alert messages via pagers, cell phones, e-mail, and other communication devices. The WARN system also includes an Emergency Telephone Notification (ETN) component which provides automated calling of all residents in a selected geographic area, and a Deaf and Hard-of-Hearing Notification System (DHNS) which provides information to the hearing-impaired by using American Sign Language videos on the internet and on personal communication devices.

For more information, contact:
Mike Janes,
Tel: (925) 294-2447; E-mail: mejanes@sandia.gov,
FEMA News Desk,
Tel: (202) 646-4600; E-mail: FEMA-News-Desk@dhs.gov.

Tsunami Disaster Information Alert System
Bangalore-based Geneva Software Technologies Limited (GSTL) has developed a Tsunami Disaster Information Alert System which sends messages on mobile phones in 14 Indian languages to a tsunami-prone area in less than 50 seconds. Designed to reach the maximum people in the minimum time, it is programmed to help especially the rural people and fisherman community to receive messages in their local language. Comprehensible public alert that is on time can save many people who would otherwise be caught unawares in a calamitous situation.

The new system, which is based on the National Disaster Information System (NDIS), works on the following principles:

**LBLMS – Location-Based Language Message Service**
Automatic message translation into 14+ Indian languages.
Dynamic message formatting for SMS, EMS, CBS, etc.
Dynamic location identification based on Area (or BTS).
Automatic tagging of language SMS.

**DVTS – Dynamic Voice Translation System**
Automatic text-to-speech conversion within a few seconds for 14 Indian languages.
Accent matching for Indian dialects.
Speech engine with highest degree of phonetics, specially built for Indian languages.
Audio streaming compatible to all telecom networks.
**WPAS – Wireless Public Address System**
Wireless audio to remote areas.
Automatic activation.
Remote diagnosis and maintenance.
Minimal battery usage, supplemented by solar power.

For more information, contact:
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E-mail: info@genevasoftech.com; Website: www.genevasoftech.com

**Quake Alarm System**
A long-felt need for an alarm system in homes to alert occupants when an earthquake is imminent has at last been fulfilled, thereby saving such home-dwellers from sitting out on the streets on nights of earthquake scares. Dr. Kuldeep Singh Nagla of the Department of Instrumentation and Control Engineering and in charge of the Robotics lab at Dr. B.R. Ambedkar National Institute of Technology, Jalandhar, has made this a reality. He has completed work on an earthquake alarm which allows those precious few seconds to run for safety when an earthquake strikes. The patent for this life-saving invention is ready for a grant.

The alarm, a simple audio-visual device, which is the size of a single phase electric meter, is a reliable, advanced earthquake sensory system fitted inside a box and can be fixed on the wall of a room. It resembles a small box, is currently made of wood, and runs on a rechargeable general-purpose battery. “It is not a prediction device but detects primary waves when they hit your area,” clarifies Dr. K.S. Nagla. It can sense the primary vibrations of an earthquake when the P- (primary) wave strikes, which is before the actual tremors can be felt. In the precious seconds provided by the alarm, those so alerted can run out of the targeted building in case of an earthquake. The alarm gives instant warning of seismic activity by detecting the P-wave, which is weak and starts from the epicentre or the compression wave of an earthquake, traveling 20 times the speed of sound in the air. The P-wave is thus 10 times faster than the more destructive S- (secondary) wave. Simple and low cost, the innovative alarm can be adjusted manually in areas near the railway line or a mining area.

For more information, contact:
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**V-SAT Phone**
A device called S-Band Briefcase Terminal is among the many tools designed for disaster management by Bharat Electronics Ltd (BEL), India. Developed in association with the Defence Research and Development Organisation and DEAL, Dehradun, the lightweight, compact, very small aperture terminal (V-SAT) can be used as a satellite phone in establishing a communication network in inaccessible areas which are totally isolated.
The Mobile Emergency Operation Centre (MEOC) is another offer from BEL. It looks similar to the vans used by the broadcast media. The all-terrain vehicle carries, among other facilities, the V-SAT, video cameras, video phones, and a laptop computer. Communication can be set up within 30 minutes, and links can be established with police stations across the country, using the POLNET facility. This mobile unit can also establish contact with the Prime Minister’s office and many Central Government departments.

For more information, contact:
Bharat Electronics Limited,
Nagavara, Outer Ring Road,
Bangalore - 560 045,
India.
Tel: 080 250 39300; Fax: 080 250 39305

Disaster Management Tool

IBM’s India Research Laboratory has developed the Resiliency Maturity Index (RMI), a framework that quantitatively assesses an organization’s ability to recover from a variety of disasters such as floods, power outages, software glitches, epidemics, and terrorist attacks. Components of the system include the network, the e-mail system, and even the transportation system. The RMI tool is expected to be useful for companies outsourcing work, as they can now use it to assess the resiliency of their service providers. Companies outsourcing work typically worry about the ability of their suppliers to withstand threats and recover from disasters. Service providers can, in turn, use the RMI tool to assess and improve their ability to cope with disasters.

For more information, contact:
IBM India Research Lab,
Embassy Golf Links, Block D,
Domlur Ring Road, Bangalore 560071,
India.
Tel: +91-80-41775027; E-mail: irl@in.ibm.com

Mobile Communication System

In an effort to assist communities and organizations affected by natural disasters or major communications disruptions, Catalyst Telecom, a sales unit of ScanSource, Inc., USA, has set up the Avaya Mobile Communication System (MCS). The MCS is a stand-alone system designed to quickly deploy emergency response communications during relief/recovery operations from disaster, and for temporary operations when communications have been lost or are unavailable.

The pre-configured MCS is readied for connection to a satellite service provider receiver or available terrestrial network facility and consists of two environmentally hardened cases: one containing an uninterruptible power supply (UPS), a configured G350 media gateway, and a S8300 media server, and the other with up to 12 digital handsets.

For more information, contact:
Avaya Inc.,
211 Mt. Airy Road, Basking Ridge, NJ 07920, USA.
Tel: +1 (908) 953-6000
Web: http://www.avaya.com

Multimedia Communication System

Scientists from Asian Institute of Technology, Thailand, have developed an emergency network platform based on a hybrid combination of mobile ad hoc networks (MANET), a satellite IP network operating with
conventional terrestrial internet. It is designed for collaborative simultaneous emergency response operations deployed in a number of disaster-affected areas. The architecture of the network is called DUMBONET.

DUMBONET is effective in real physical disaster-affected fields. Its goal is to provide information to rescue teams who may simultaneously explore physically isolated disaster fields with mobile ad hoc multimedia internet communication among field team members and with a distant command headquarters. Its multimedia internet capabilities allow rescuers to collaborate more effectively by sending and receiving rich and crucial multimedia information. Rescuers may also consult with case experts via the internet for the know-how necessary for the operation.

DUMBONET is a single, mobile, ad hoc network comprising a number of connected sites, each with a variety of mobile nodes, end systems, and link capacities. A node on the net can communicate with any other node belonging to the same site, or with a node at another site a distance away, as well as communicate with a remote headquarters on the internet. Within each site, nodes share relatively similar network conditions, whereas between sites a long-delay satellite link is used to accommodate long distances. The headquarters is considered a special site, with communication access to every site on the net and sometimes broadcast messages to all sites. A normal site of DUMBONET can maintain a communication channel with the headquarters while possibly opening up communication channels with other selected peering sites on the net, based on demand.

In DUMBONET, a virtual private network (VPN) is used to hide network heterogeneity that arises from the use of different networking technologies comprising satellite, MANET, and terrestrial internet. From the perspective of mobile devices, they belong to the same private IPv4 subnet (e.g. 192.168.1.0) that spans all different geographical locations (i.e. the headquarters and disaster-affected sites). At present, only the OLSR protocol is used to route traffic among the devices that may not have direct wireless contact but are located within the same aforesaid private IP subnet. The OLSR protocol also has additional routing capabilities, such as HNA, which we have not used. The entire DUMBONET is a single OLSR-driven network which includes local MANETs, and inter-site links via VPN and satellite.

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Web: http://www.interlab.ait.ac.th/dumbo/DUMBO.
REFERENCES

CATALYST%20TELECOM%20AVAYA%20CREATE%20MOBILE%20COMMUNICATIONS%20SYSTEM%20FOR%20DISASTER%20READINESS.aspx
Introduction

Disaster mitigation requires rapid and efficient search and rescue of survivors. The goal of search and rescue is to locate and access injured or trapped victims, stabilize the emergency situation, and transport the patients to safety. Relief workers need to speedily find the trapped survivors in collapsed buildings and crumbled structures in the aftermath of disasters. Otherwise the likelihood of finding victims alive could be negligible.

The search-and-rescue operations in the aftermath of disasters commonly employ many traditional methods and techniques which have been evolved over a long period of time. Modern technology has also provided vital inputs to their evolution, and these techniques are still being widely used by disaster rescue workers. Newer and advanced technologies and equipment have recently made an impact in search-and-rescue operations, making them easier and quicker, while improving a missing or injured person’s chance of survival.

TECHNOLOGY OPTIONS

The choice of search-and-rescue tools and methods depends on their availability and the needs of the situation. For example, storm and earthquake wreckage may require tools for lifting debris whereas flood damage may require boats and ropes. Different scenarios require differing technology options for disaster search and rescue. These are summarized below: ¹

- Improved real-time data access (data pertaining to site conditions, personnel accountability, medical information, etc).
- The ability to accurately and non-invasively locate survivors following structural collapse – the ability to "see" through walls, smoke, debris, and obstacles.
- The ability to communicate (transmit signals) through/around obstacles.
- Lighter, more efficient power sources (batteries, fuel cells, or other technologies able to power multiple systems for longer periods of time).
- Improved monitoring systems (i.e. atmospheric, biomedical, personnel accountability, etc.) - real-time, portable, multi-function devices that expand on existing detection capabilities.
- Improved personal protective equipment – lightweight, comfortable, and rugged equipment that provides enhanced worker protection against multiple hazards.
- Improved breaching, shoring, and debris removal systems - portable, lightweight, longer life, stronger materials and equipment.
- Reliable non-human, non-canine search-and-rescue systems - robust systems that combine enhanced canine/human search-and-rescue capabilities without existing weaknesses (i.e. robots).

Tools and Equipment

The tools and equipment for disaster search-and-rescue operations include cutting equipment; diving equipment; forcible entry tools; jacks (hydraulic/pneumatic); life rafts; lighting (torch, lamps, searchlights); location beacons; night vision equipment; pneumatic/ hydraulic equipment and tools; rescue equipment; rescue tools; rope rescue systems; rescue belts; safety equipment; search equipment; spreading tools; thermal imaging equipment; water rescue equipment; winches; robotic systems; etc.

Concrete Saw²

A concrete saw (often known as a consaw or road saw) is a power tool used for cutting concrete, masonry, brick, asphalt, and other solid materials. Concrete saws are powered by petrol, hydraulic, pneumatic, or
electrical motors. The significant friction generated in cutting hard substances such as concrete means that the blades need to be cooled to prolong their life and reduce dust. Blades are either abrasive or diamond-tipped.

**Jackhammer**

A pneumatic drill or jackhammer is a portable, percussive drill, powered by compressed air. It is used to drill rock and break up pavement, among other applications. It works in a manner similar to a hammer and chisel: by jabbing with its bit, not rotating it.

**Drill**

A drill (from Dutch drillen) is a tool with a rotating drill bit, used for drilling holes in various materials. Drills are commonly used in woodworking and metalworking. The drill bit is gripped by a chuck at one end of the drill, and is pressed against the target material and rotated. The tip of the drill bit does the work of cutting into the target material, slicing off thin shavings (twist drills or auger bits) or grinding off small particles (oil drilling).

Of the many types of drills, some are powered manually and others use electricity or compressed air as the motive power. Drills with a percussive action (such as hammer drills, jackhammers, and pneumatic drills) are usually used for hard materials such as masonry and rock.

**Air-lifting Bags**

Three types of lifting bags are generally sold and used for rescue or heavy recovery work: high-pressure, medium-pressure, and low-pressure systems.

Low-pressure bag systems are essentially high-lift bags which operate at 7¼ psi maximum working pressure. These low-pressure cushions provide vertical lift over a large surface area and work especially well on thin-skinned, light-walled vehicles such as aluminum truck trailers, tankers, buses, and aircraft. The construction of low-pressure bags utilizes seven-ply strong, reinforced fabric material for the top and bottom surfaces. The internal structure is designed with nylon strapping supports. The cushion itself is constructed of a simple canvas of Kevlar which is impregnated and bonded to neoprene.

Medium-pressure bag systems are designed to operate at 15 psi and are not very common. Most tasks can be accomplished with 8-12 psi. These bags are designed to function at 15 psi, but register bursting pressures between 58 psi and 100 psi, depending on the size and style manufactured. Generally, medium-pressure bags have thicker sidewalls than low-pressure bags.

High-pressure bag systems are the type most commonly found on rigs today. High-pressure air-lifting bags generally operate with inflation pressures of 90 psi-145 psi. With a high-pressure system, a direct relationship is evident between lifting capacity and inflation height.

**Emergency Rescue Shoring**

Emergency shoring operations for urban search-and-rescue incidents are defined as the temporary stabilization or re-support of any part of, or section of, structural element that is physically damaged, missing, or where the structure is partially or totally collapsed or in danger of collapsing. Such an exercise is conducted in order to secure a safe and efficient atmosphere while conducting search-and-rescue operations of trapped victims at a collapse incident where the risk conditions are relatively safe and reduced for the victims as well as the concerned trained rescue team. The work includes the stabilization of any adjacent structure or object that may be affected by the initial incident.

For a shore to work properly and be considered a system, it must generally have four main parts: a header or top plate, one or more posts or struts, a bottom plate or sole plate, and finally, a lateral or diagonal bracing
system. Each of these constituents is important for the success of the shoring system. The key to all the shores is to collect the loads from a damaged area, funnel it through the post system, and redistribute the load to the ground or other suitable structural elements.

**Hydraulic Rescue Tools**

Hydraulic rescue tools are used by emergency rescue personnel to assist vehicle extrication of crash victims, as well as other rescues from small spaces. These tools include cutters, spreaders, and rams. Hydraulic rescue tools are powered by a hydraulic pump, which can be hand-, foot-, or engine-powered, or even built into the tool itself. These tools may be either single-acting, where hydraulic pressure will move the cylinder in only one direction; and the return to starting position is accomplished by using a pressure-relief valve and spring set-up; or it is dual-acting, i.e. hydraulic pressure is used to both open and close the suzzette cylinder.

**Spreader-Cutters:** In operation, the tips of the spreader-cutter's blades are wedged into a seam or gap – for example, around a vehicle door – and the device engaged. The hydraulic pump, attached to the tool or as a separate unit, powers a piston which pushes the blades apart with great force and spreads the seam. Once the seam has been spread, the now-open blades can be repositioned around the metal. The device is engaged in reverse and the blades close, cutting through the metal. Repeating this process allows a rescuer to quickly open a gap wide enough to pull free a trapped victim. The blades can spread or cut with a force of several tons or kilonewtons, with the tips of the blades spreading up to a metre. This operation can also be performed by dedicated spreading and cutting tools, which are designed especially for their own operations and may be required for some rescues.

**Rams:** Rams are used far less than spreader-cutters in auto rescues; nonetheless, they serve an important purpose. There are many types and sizes, including single-piston, dual-piston, and telescopic rams. Sizes commonly vary from 20" to 70" (extended). As rams use more hydraulic fluid during operation than spreader-cutters, it is essential that the pump being used have enough capacity to allow the ram to reach full extension.

**Rescue Craft**

Inflatable life rafts are lowered from small aircraft during marine rescues. Jet rescue boats, and later inflatable jet boats, assisting in close-to-shore rescues, are also widely used. Their advantage is that they can be launched anywhere.

**Planes and Helicopters**

Aircraft help to spot missing people in land searches. Light planes are also used in coastal searches, and have proved even more successful than seaborne craft in finding lost boats. Helicopters have also revolutionized both land and marine search-and-rescue missions, as they can reach people in remote places and take them quickly to safety.

**Communications Equipment**

Communications equipment relays information to and from searchers. Today, HF and VHF radio are used and, where appropriate, satellite phones and cellphones. In cave rescues, Michie phones are useful. An insulated wire is attached to a receiver at the cave entrance and strung into the cave. Underground search teams can puncture the wire to use a handset and talk to those aboveground. Increasingly, emergency beacons are being carried by passenger aircraft and boats, and marine radio has become more sophisticated. Emergency beacons equipped with GPS (global positioning systems) have helped to speed up the rescue of victims. In 2007, analogue beacons were replaced by digital beacons linked to a satellite system, making for quicker and more efficient rescues.
**Laser Light**

Sophisticated laser light signaling instruments may be a promising new option over conventional light systems. Waterproof and simple to use, laser light devices emit light that can be seen for up to 20 miles. They can be used for both sending signals to lost parties and detecting reflective materials to locate a lost person. Laser light is stronger and more directional than conventional light systems and produces an unmistakable brilliant red flash which can be easily seen by the lost party. When the light is reflected by some object on the lost person, the search party will see a bright red flashback.

**Infrared Surveillance**

A new airborne surveillance technology, the Infrared Eye, is a promising viewing system that will enhance airborne spotting-and-searching techniques. The Infrared Eye accomplishes this task by duplicating the mechanics of the human eye and simultaneously using two fields of view. This includes a wide overall field with high sensitivity but low resolution for situation awareness and detection, and a narrow field of view with very high resolution which can be easily directed to objects of interest in the wide field, tracking the operator’s line-of-sight.

**Robots**

Robots can bypass any existing danger and expedite the search for victims immediately after a collapse. For the robots to handle these tasks, appropriate mobile bases need to be developed which can crawl through unstructured terrain, heavy rubble, and confined spaces. Some hardware platforms such as small robots, shape-shifting robots, and flexible snake robots already exist. So, both robot mechanisms and software are the current focus of development for urban search-and-rescue robots.

This technology can assist rescue workers in four ways: (1) reduce the personal risk to workers by entering unstable structures; (2) increase the speed of response by accessing ordinarily inaccessible voids; (3) increase efficiency and reliability by methodically searching areas with multiple sensors, using algorithms guaranteed to provide a complete search in three dimensions; and (4) extend the reach of specialists to go places that were otherwise inaccessible.

**RECENT/LATEST TECHNOLOGIES**

**Wireless Network for Disaster Rescue**

The Asian Institute of Technology in Bangkok, Thailand, has unveiled a state-of-the-art mobile wireless network which can be used to establish communication for emergency workers after a disaster. The network, developed with groups in France, Japan, and other countries, will allow rescue teams at a disaster site to communicate even if conventional forms of communication break down.

The new network allows emergency workers to set up a mobile satellite station which creates a wireless network for laptop computers or personal digital assistants (PDA). Each laptop or PDA is then able to act as a node that can transmit the wireless signal to other devices further out in the field and extend the network into hard-to-reach areas.

The project aims to turn any ordinary device into a wireless node without having to acquire special hardware. Users on the network could use video, SMS, or e-mail to communicate with others on the network or over the internet.

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High-tech Tool for Disaster Rescue

The Responding to Crises and Unexpected Events (RESCUE) project is working to transform how communities and first responders plan for and respond to both natural and man-made disasters by turning new technologies and cutting-edge research into practical tools for emergency planners and responders. Funded by the National Science Foundation (NSF), RESCUE’s goal is to dramatically improve the ability of emergency responders to gather, process, and disseminate information with each other and the general public. Led by the University of California, Irvine, RESCUE brings together researchers from around the country who work in a variety of academic fields, creating a unique perspective to the understanding of disaster responses. Scientists have provided risk communication models and insight into how humans perceive and react to risk communication. Engineers helped the team understand how tools such as early warning systems could impact evacuation routes and other concerns. The result has been new approaches to risk communication which are being put into practice.

Another tool being developed by RESCUE researchers is a complex disaster simulation platform called MetaSim. This computer system allows researchers to merge different types of simulations at once in order to provide planners with a more accurate picture of what conditions may be like during and after a disaster, as also provide researchers with a way to test and validate how new technology concepts could help a response effort.

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Wearable Technology to Aid Disaster Relief

Wearable, interactive 3-D technology being developed by the University of South Australia will be able to transfer people into “mobile augmented reality (AR) systems”. Weighing 7 kg, the technology is composed of a computer which can be carried in a backpack, virtual reality goggles, and an attached video camera which can convey information to a control room via wireless, LAN, and 3-G networks.

Professor Bruce Thomas, director of the wearable computer laboratory at the university, said the technology has the potential to dramatically improve the effectiveness of disaster relief operations. The control centre can also create 3-D maps and images for field personnel to view through their goggles. The project is composed of three components: the indoor visualization control room, the outdoor wearable AR system, and collaboration between the indoor and outdoor systems.

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Canine Search-and-Rescue Technology

Computer Science Associate Professor Dr. Alex Ferworn heads a team of Ryerson researchers who are improving the communication between trained search-and-rescue dogs and their handlers. Equipping man's best friend with top-notch sensory gear can increase the effectiveness of search-and-rescue missions, according to Ryerson University researchers.

Under the leadership of Associate Professor Dr. Alex Ferworn, the team has developed two new products for trained search dogs: Canine Augmentation Technology II (CAT II) and Canine Remote Deployment System (CRDS). Employing existing off-the-shelf components from the realms of wireless communication, canine care, computer science, and search and rescue, the team has created an integrated system that is customized to the needs of the search-and-rescue community.

Dr. Ferworn's research uses custom camera, and audio and communication harnesses which enable wireless transmission of information to a receiver carried by the handler to another responder, or to a receiver located in the site command post. Rescue teams are able to receive real-time video of the disaster site from a dog's-eye view, as well as two-way audio. The new CAT technologies also enable search dogs to deliver equipment or supplies to a trapped victim long before emergency personnel can reach them.

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Mechanical Mole

A digging robot inspired by the mole is being built by UK researchers, who hope it will one day 'swim' through rubble at disaster sites to help find survivors. Robin Scott and Robert Richardson at the University of Manchester, UK, assert that a robot that digs would be most useful in an emergency. The pair has already built a new digging mechanism that can shove aside relatively light objects, such as bricks and furniture.

The digging robot was inspired by the European mole, which uses its spade-like front paws in a digging motion similar to a swimmer's breast-stroke. The first part of the 'stroke' drags earth in front of the animal to the side and pushes it to the rear. The return stroke brings the forelegs to the front again, keeping them close to the mole's body to avoid pushing already-moved earth forward again.

To duplicate the mole’s digging motion, the researchers used a tried-and-tested design called a four-bar mechanism which is similar to the arrangement that drives car windscreen wipers. The new mole-style digging arm links two of these four-bar mechanisms. This arrangement makes it possible to create a mole-like digging motion from two normal rotary electric motors that never need to run in reverse. That should make for low maintenance, according to the researchers. In preliminary tests, the digging arm has successfully moved aside bricks and other debris. The design is now being mounted onto a robot chassis for more comprehensive tests. Richardson estimates that an actual search-and-rescue robot based on the design might be ready in two years.

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REFERENCES

CHAPTER 3. ENERGY AND POWER SUPPLY

Introduction

Power supply is generally the first casualty when a natural disaster strikes an area. Grid failure often follows immediately after major disasters such as earthquakes, cyclones, and floods. The utility grid, a highly centralized and complex system, is inherently vulnerable to disaster-related disruptions.¹ In such an eventuality, lights fail, and furnaces, refrigerators, and other electrical appliances stop working. Further, the drinking water supply, sewage treatment, and conventional communication systems are also disrupted. Emergency response teams therefore need a reliable source of electric power, even to begin to deal with the crisis situation.²

The services needed for disaster relief, particularly in the reconstruction phase, require energy (either heat or electricity). Some of the time, traditional energy systems are appropriate; at other times, renewable energy systems serve the purpose. The potential for renewable energy technologies to support disaster relief is significant. The concept of using on-site renewable energy systems to mitigate the crippling impact of power shortage during disasters has been successfully introduced in many instances.³ Solar, wind, and hydroelectric systems are notable examples, providing enough power to meet the basic needs of the disaster-affected population. Biomass can also be used to generate electricity or as an emergency fuel source for heating and cooking.

Many renewable energy technologies can provide base-load power (landfill gas and other bio-energy technologies, wind power, hydropower, etc), and others are suitable for providing power on a distributed grid basis. This can be either in the form of heat (e.g. solar water heaters and solar stills) or electricity (e.g. solar photovoltaic systems and small wind generators).³

TECHNOLOGY OPTIONS

Depending on the sources of energy, disaster situations require mainly two groups of technologies. These are:

- conventional energy: electrical generators, lighting equipment, fuel for cooking; and
- renewable energy: portable solar PV systems, PV-powered generators, solar water heaters (SWH), solar lanterns, solar cookers, solar stills, solar batteries, and micro wind generators.

Conventional Energy Technologies

Electrical Generators⁴

Emergency generators are very popular after disasters. They can help preserve food in freezers and refrigerators, but they may also be dangerous if not used with due care. Standby generators are powered by tractors or engines and may be either portable or stationary. Engine-driven units may have an automatic or manual start and are powered by gasoline, LP gas (bottled gas), or diesel fuel. The generators must provide the same type of power, at the same voltage and frequency as that supplied by power lines. This is usually 120/240 volt, single phase, 60 cycle alternating current (A.C.).

Size of generators:⁵ A full-load system handles an entire farmstead’s energy needs. An automatic, engine-powered, full-load system begins to furnish power immediately or within 30 seconds after power is off. A smaller, less expensive part-load system may be enough to handle essential equipment during an emergency. Power take-off (PTO) generators cost about half as much as engine-driven units and can be trailer-mounted. A part-load system operates only the most essential equipment at a time.
Simple tips for using generators safely

- As gasoline engines produce carbon monoxide they should not be run in an enclosed area.
- Check the oil level in the engine before use, and on a regular basis (for example, when refueling).
- Let the engine cool off before refueling.
- The generator should be kept a safe distance from structures because of engine heat.
- Place the generator on a level surface to keep oil at the proper level in the engine.
- Water damages generators and produces an electrical hazard, so keep the generator dry.
- A voltage drop may occur if an extra-long extension cord is connected to the appliance or if one with too small a wire size is used. If the extension cord becomes very warm, it is inadequate.
- Connect the generator directly to the appliance. Do not try to hook generators to your home electrical supply box.
- Ground the generator as stated in the instructions. If an extension cord is needed, use one with a ground plug.
- Allow the generator to run before turning on the A.C. circuit on the generator or before the appliance is plugged in.
- An appliance that has a heating element, such as a toaster or hair dryer, consumes considerable current. It’s advisable to avoid using generators for these types of items.
- If an appliance is wet or damaged, it may not be in good working order. The use of such an appliance may damage the generator.
- Some generators have the capacity to produce 115/120 volts and 220 volts. Select the outlet that corresponds to the voltage requirement of the appliance.

Problems with electrical generators: Unfortunately, generators that run on fossil fuels such as gasoline and diesel oil have a number of limitations. These include:

- They can be dangerous in the hands of untrained users. In the wake of a major disaster flood, cyclone, earthquake, or fire - newspapers often report incidences of fires, burns, fuel explosions, and even asphyxiations caused by the improper use of a generator.
- Generators can have very short life spans.
- Noise can pose a big problem. The constant loud noise adds to the trauma experienced by emotionally fragile disaster victims.

A truck-mounted 200 hp diesel genset may provide enough energy for lights and also produce clean drinking water. The flue gases from the genset can be used to power a small desalination plant or boil water to destroy germs. Both these units can also be mounted on the same truck. A simple analysis reveals that about 10,000-15,000 litres/day of excellent drinking water could be produced from a 200 hp diesel genset as a byproduct. Thus, the truck-mounted unit will be a dual-purpose plant for producing electricity and water. This will also help increase its efficiency.

In areas where roads are washed out and cannot be reached by a power truck, improved kerosene lanterns and solar lanterns should be available for providing light. Nimbal Agricultural Research Institute (NARI) has produced an extremely efficient multi-fuel lantern called Noorie, which runs on kerosene and diesel and also doubles up as a small cooking stove. Noorie lanterns provide good light (equivalent to a 100W bulb) and also cook a small quantity of urgent food items.

Fuel for Cooking

In disaster times, major national and international efforts have been focused on the provision of food supplies to disaster-affected persons. However, in the absence of adequate cooking fuel, a substantial amount of these supplies gets spoiled instead of providing nourishment to survivors. Thus, the supply of stoves, which can run on both diesel and kerosene, or solar cookers, may be useful.
Renewable Energy Technologies

The availability of fuel supplies is a constant anxiety to those who rely on fossil-fuel-powered generators during an emergency. Not only do renewable energy systems eliminate that worry, but they also work without producing the overbearing noise and noxious fumes that accompany gasoline and diesel generators. Because they can be designed to continue working even when the utility grid fails, renewable energy systems can actually prevent power outages -- keeping homes and businesses functioning during black-outs, or amid the chaos following natural disasters. A key benefit of renewable energy systems for emergency use is their self-sufficiency. They require no fuel and minimal maintenance, yet provide reliable power for as long as needed.

- Two types of renewable energy systems are generally used for meeting the energy requirements of disaster management: fixed and portable. Fixed systems tap the renewable resource most appropriate for specific locations, be it solar, wind, hydro, or biomass. These systems function constantly, supplementing utility power during normal times and providing back-up power during outages. Portable systems, on the other hand, are deployed following disasters to assist response crews and victims. Solar electricity is the most appropriate renewable energy source for such applications because the systems are relatively easy to transport, and solar energy is plentiful in many regions. Portable photovoltaic (PV) systems are best suited for meeting smaller-scale needs which require only a few kW or less.

The applications for renewable energy equipment for disaster relief, reconstruction, and development are:

- emergency relief;
- lighting (portable lighting, street lighting);
- water supply (water pumping and distribution, water purification);
- healthcare (field hospital, morgues, medical refrigerators);
- refrigeration (individual power kits);
- food preparation (cooking);
- communication (radios, satellite communication systems, laptop and mobile charging systems); and
- security and safety (alarm systems, lighting).

PV-powered Generators

Powered by the sun, the PV-powered gensets make use of a solar electric panel to produce electricity. The electric energy produced by these gensets can be used immediately or stored in batteries for later use. These gensets have many advantages: they are virtually silent, safe to operate, environmentally benign, and seldom a fire hazard; they are also extremely rugged, having been designed to withstand the impact of hailstones; they can be made mobile for transporting from place to place by truck.

Solar Lighting

Solar PV lighting can replace typical flame-based lanterns, providing better quality light with greatly improved safety (reduced fire risk and free from fumes), while also avoiding refueling needs. A solar lantern pack has a small solar PV module for daytime charging to provide three or more hours of light at night. PV modules for solar lanterns may be permanently mounted on a pole or roof of a shelter for convenience.

HEALTH SERVICES

Power requirements for medical services in disaster-affected areas are mainly in the following areas:

- power for medical services (field hospital activities, mobile morgues, shelter for medical staff);
• supply of clean water;
• water heating (sterilization, personal hygiene); and
• cooking.

Power for Medical Services
Maintenance of the cold chain is critical for the preservation of vaccines (i.e. maintaining vaccine temperatures within the range 0-8°C at all stages between their manufacture and use). In the aftermath of a disaster when there is no reliable electricity supply, highly efficient, well-insulated vaccine refrigerators connected to a gas or kerosene-powered system or a battery bank, and a solar PV or small wind energy system are useful. Solar PV-powered vaccine refrigerators are robust and have low maintenance requirements. They do not depend on fossil fuel supplies, and can be designed to provide additional electricity for lighting, minor operations, and health workers’ residences in disaster-affected areas.

Similarly, solar PV, or small wind generators, can support lighting for medical facilities, extending the effective operating hours of hospitals and clinics. The power demands of communication networks and other systems required for effective health centre operations may also be readily achieved with small-scale renewables. Depending on the scale of the operations, a wide range of power needs may be met - from relatively simple, small-scale systems, comprising only a few solar modules and a small battery bank, to power a few lights and a refrigerator, to a fully contained PV/diesel hybrid unit capable of delivering grid-quality power for multiple lights, fans, oxygen concentrators, nebulisers, microscopes, and other vital medical equipment.

Supply of Clean Water
Usually, clean water in tankers and big bottles is moved into immediate and mid-term disaster relief situations. This could often prove to be a costly operation. However, other alternatives, such as solar stills and solar PV-powered water purification systems, can be used to purify contaminated water for safe consumption. Many of these systems are very simple to install and operate.

Solar PV and/or mechanical wind pumps may be very effective for longer term solutions, pumping water from the surface or from relatively deep boreholes. For the treatment of non-saline water, solar PV pumping systems can be readily coupled to suitable membrane filter arrangements (gravity driven), with individual pump and filter units capable of providing up to 10,000 litres of potable water per day – sufficient for 300-500 people. Larger volumes can be delivered by using multiple units.

Solar Water Heating
At its simplest, a solar water heater is a black container, placed in direct sunlight to absorb solar radiation and transfer the sun’s heat directly to the water inside. The hot water requirements of field hospitals in disaster-affected areas can be provided by a number of solar water heating technologies, such as flat-plate collectors, evacuated tube systems, and heat pumps.

In flat-plate collectors, water passes through channels within the absorbers, gaining temperature as it does so. The hot water is stored in an insulated tank for use as required.

Evacuated tube collectors have their heat-absorbing fin shrouded by a vacuum-tube (similar to a thermos flask), which reduces convective and conductive heat losses. Water flows through the collector and is stored in a suitable tank for use on demand. Evacuated tubes are generally more efficient and can produce higher temperatures than flat-plate collectors.

A hot water system that combines a heat pump with a fine coil evaporator is described as a solar heat pump water heater. The system works on the principle of a refrigeration circuit, drawing heat out of one space and...
discharging it into another. In operation, the evaporator absorbs whatever heat energy is available to it from the atmosphere to vaporize the refrigerant. The vapour is then compressed, raising its pressure and temperature. This high-temperature vapour is passed through special pipes which are permanently bonded around the outside of the insulated water storage tank, forming the condenser. As the refrigerant vapour condenses back to its liquid form, it gives off heat to the stored water.

Solar water heating can also be used for food safety, cleaning, and sanitation purposes. As the water temperature in the storage tanks of solar water heaters exceeds 65°C, the process can be used to effectively pasteurize water, removing all of the pathogens that are commonly borne by untreated water. For heating water of a small volume, including pasteurization for personal consumption, solar water heating cookers can be very effective.

**Solar Cookers**[^2][^3]

Pulses, grains, dried legumes, and many root vegetables, which form a significant part of a nutritious diet, may require many hours of cooking. Such ingredients can be effectively used for meals for the disaster-affected population by using solar cookers. Typically, a family or small group of individuals can prepare two cooked meals a day with a single, simple solar cooker. A wide choice of solar cookers is available, from simple box cookers made of cardboard and aluminum foil to large systems for the entire community. Of the wide variety of solar cooking technologies available, the two main categories are the box and the concentrator. The cooker design dictates the temperatures that can be achieved and the rate of cooking.

Box cookers include a simple reflector arrangement which directs solar energy via a transparent cover into the inside of an insulated box. Food (or water) is placed in a black pot within the oven. The pot absorbs solar radiation and transfers the heat to the contents. Box ovens are simple but slow and robust and can be effective for relatively slow cooking purposes. They generally require minimal intervention, enabling users to undertake other activities while meals are being cooked, with little risk of food spoiling.

In the concentrator arrangement, typically the pot or kettle is suspended at the focal point of a reflective dish which is oriented towards the sun, with the sun’s rays focused on the food container. Some concentrators can achieve very high temperatures which are suitable for rapid cooking, including frying. But this method has the drawback of being susceptible to burns and therefore requires frequent intervention to keep the sun’s rays focused on the cooking vessel to prevent food from burning. They also tend to be more affected by intermittent clouds than are box cookers.

The benefits of solar cooking include the following:
- eliminates disease pathogens in a disaster setting;
- reduces the demand for liquid or gas fuels which may be in limited supply;
- reduces the burdensome task of securing scarce fuelwood; and
- does not emit smoke or fumes and is therefore non-polluting.

**PV Cells for Disaster Response Crews**[^2]

Photovoltaic (PV) cells convert radiant energy from the sun into direct current (D.C.) electricity. A standard 12-volt, 3-amp solar module consists of 36 4-inch-diameter cells which are wired together in series to obtain the panel voltage. Though this commonly used module type is referred to as a 12-volt panel, it actually produces about 17 volts of D.C. electricity at around 3 amps. Peak power production per standard panel, therefore, is about 50W. The modules can be wired together in series to further increase the voltage; or they can be wired in parallel to increase amperage. For example, two standard 12-volt, 3-amp modules in series produce 3 amps at 24 volts; in parallel, they produce 6 amps at 12 volts. Besides this standard module type, many other types of panels are designed to meet specific needs.
Since energy is produced only when the sun is shining, it is usually stored in batteries for later use. If the load to be powered requires A.C., an inverter, which converts D.C. power to A.C. power, is part of the system setup. Most standard home and business lights and appliances operate on 110-volt A.C. electricity.

The majority of PV systems operate at remote sites where the power demand is relatively small (less than 1000W), and utility power is unavailable, or unreliable, or cost-prohibitive. Solar power is the most economical and practical option in these cases. The number of viable applications is continually increasing, as panel efficiencies rise and cost decreases.

TRANSPORTATION AIDS AND WARNING SIGNALS

Transportation aids, along with PV-powered emergency telephone call boxes, flashing barricade lights, and other warning signals, are extremely handy not only during times of crisis, but also for day-to-day use. The signs and barricades inform motorists about road construction projects, and highway call boxes play an important safety role. PV cells also power warning signals on Coast Guard buoys and navigational beacons; solar heat energizes railroad signals, aircraft warning lights, and road crossing lights, enabling these public safety systems to continue functioning when a disaster disables the utility grid.

Battery Charging

Another potential use for PV in the disaster response area is for charging batteries. When rechargeable batteries are used to power items such as hand-held radios and cellular phones, they sometimes lose their power before the workers can return to the base camp to recharge them. Work crews are often transported by bus to work sites where they lack the vehicular chargers they can rely on at home. When their battery packs run down, their communication line is cut until someone can bring a charged one or they themselves return to camp.

Another PV-battery charging option would be to equip a mobile unit with PV panels. It could be parked at a remote site to recharge an entire bank of cellular phones, or radio battery packs, simultaneously. Search cameras and high-tech listening devices used to locate trapped victims also operate on DC batteries which could possibly be recharged by using PV panels. However, all of these potential battery-charging applications require field testing to determine their need and feasibility.

Portable PV Power

Portable PV power systems are especially well-suited for meeting long-term emergency power needs at small-scale, isolated sites. These systems could be used to provide electricity for relief operations centres, and to operate vaccine refrigerators, lights, fans, medical equipment, and small radios and televisions. Solar power is especially ideal at clinic locations, because it protects patients from prolonged exposure to the noise and fumes of portable generators. It also aids in the operation of medical instruments (stethoscopes, for example) that require a quiet environment for proper use.

Portable units that arrive on the scene ready to go, with little user interaction, are essential to the expanded use of PV generators in disaster response. During a crisis, there is no time for careful installation of delicate equipment. Rescue workers must also be educated on the proper use of PV before the disaster occurs, as they are not in the proper frame of mind to learn new technologies in the disaster response environment.

At some locations, PV systems eliminate the need for portable generators, and at others, solar power significantly reduces the use of generators. The systems enable workers to turn off the generators at night without having to handle dry ice for the vaccine refrigerators, thereby lessening anxiety in respect of fuel supply.
Outdoor Lighting
PV-powered outdoor security lights are useful for disaster-affected areas. Though they are low-power systems as compared with traditional street lights (30W versus 250W), the light they provide greatly raises the comfort level in times of total darkness. Solar-powered lanterns also help in disaster relief efforts when certain outdoor emergency lighting needs are too large to be met with PV systems.

In less-populated but very dark areas, PV outdoor lights are ideal. They represent yet another PV application that works well not only during emergencies, but also all the time. They can be found illuminating parking lots, highway signs, parks, trails, and bus shelters. In many cases, the use of solar power is more economical and expedient than extending utility service to these locations.

SOLAR HOME SYSTEMS
Solar Home Systems (SHS) are useful for providing sufficient energy for houses of disaster victims in the rehabilitation phase. SHSs often comprise only a single solar PV module, a battery, and a charge regulator.

SMALL-SCALE HYDROPOWER SYSTEMS
Small-scale or ‘family’ hydropower systems are very effective in disaster-affected areas where a river or stream is available. These operate on the flow of the river and do not necessarily require a large ‘head’ differential (available vertical fall in the water, from the upstream level to the downstream level) to generate power. A variety of such systems, such as run-of-the-river systems and feedstock pens, are available, each suiting a particular topography and designed for a minimal impact on the environment.

COMMUNITY POWER SYSTEMS
In the post-disaster rehabilitation phase, energy for business and larger households can be provided by larger solar PV systems (by increasing the number of modules and batteries), or by using larger wind or hydro generators. Beyond meeting simple lighting requirements and power for radio and fans, these systems are likely to incorporate an inverter which will deliver A.C. power equivalent to the grid electricity. For small (typically less than 50 households), dispersed, or mobile communities, or where electrical energy demands are minimal, individual D.C. micro-generators are likely to be appropriate sustainable energy solutions.

FIELD PERSONNEL COMMUNICATION SYSTEMS
Renewable energy power solutions are now mainstream for last-mile telecommunications, for instance, telephone repeater stations in locations without grid electricity. Particularly in less accessible disaster-affected sites, battery banks coupled to solar PV or wind turbine generators could provide high-reliability power without demanding frequent intervention for refueling and maintenance of generators.

Portable Repeaters
Perhaps the best application for solar power by disaster response teams is to use PV panels to power portable repeater stations which extend the range of hand-held radio communications. A typical portable PV-powered repeater station has been developed by Nida Companies in California, USA. It is designed specifically for the urban disaster search-and-rescue environment. The system employs two 3-amp PV panels (about 50W each) wired in parallel to float charge the 12-volt, 100-amp-hour sealed, lead acid battery that powers the repeater signal. The repeater pulls 5 amps when transmitting and 1 amp when receiving information. PV is ideally suited to meet this power need because it can be set up in a remote spot and then left unattended indefinitely. A generator, on the other hand, would be well oversized for such a small load and would need regular refueling.

Amateur Radio Links
Ham radio stations often prove useful channels of communication following disasters when much more sophisticated communications systems fail. These stations are ideal for solar power. Ham radio operators
could use PV modules to replenish the batteries for maintaining vital communication links between police, fire brigades, and hospitals in the aftermath of a disaster.

Computers
The power demand of a typical laptop can be reduced to only a few watts (typically 10-30W), depending on the screen and other hardware configurations, application demands, and power management strategies. Portable plug-in solar PV chargers of 20-30W can power many modern laptops in peak sunshine, and recharge batteries during daylight hours. Foldable and/or flexible solar module solutions, if required, are also available on the market.

Remote Monitoring
Solar power is involved in many emergency situations even before a disaster strikes. Hundreds of remote PV-powered sensors, data loggers, and information transmitters send continuous data to central offices for use in flood, drought, and forest fire forecasting. Information on weather patterns and seismic data, water quality, and highway conditions is transmitted in this manner.

RECENT/LATEST ENERGY SYSTEMS AND EQUIPMENT
Many advanced technologies and equipment which have been recently developed could be utilized at different stages of disaster management. Some of these are briefly described in the following sections.

Portable Power System
A small company in Florida, USA, has introduced a new portable “micro-utility device which combines clean power generation, water purification, and wireless internet access. Ecosphere Technologies' new Ecos LifeLink is a portable, self-contained station which is designed to use the sun’s power and an optional wind turbine to provide clean electricity, convert the most contaminated groundwater to purified drinking water, and deliver wireless internet connectivity. The system is intended to support off-grid needs, including disaster relief and emergency support activity in remote locations.

Deployed as two 20-foot cubes, the Ecos LifeLink incorporates an array of stacked solar panels which, when deployed, provide a photovoltaic surface area of approximately 1000 sq ft, with as much as 16 kW of clean electricity. An optional wind turbine can also be used to generate additional power. It also incorporates a 30 gallon per minute water filtration module capable of removing arsenic, bacteria, and waste from groundwater and a satellite communications and electrical power management system that powers a full range of wireless VSAT, VOIP, and wireless communications. “The system is capable of handling thousands of phone calls and offering wireless connectivity for a range of up to 30 miles,” Ecosphere said.

For more information, contact:
Ecosphere Technologies, Inc.,
3515 S.E.,
Lionel Terrace, Stuart, FL 34997, USA.

Solar-powered Disaster Rescue Kit
The latest piece of disaster recovery equipment is an ingenious feat of engineering from Japan, featuring a most unusual application of solar technology. The Fuji Power Rescue is a portable solar generator, developed by the company PowerBankSystem as an alternative electricity supply in the event of earthquakes or other disasters which disrupt the power grid. Comprised of a flexible solar panel, a battery, and various pieces of cabling, the system fits into a backpack, thanks to the fact that the solar panel is fixed to a sheet that can be rolled up into a tube. On arrival at a disaster site, rescuers can unroll the gear and get to work, generating power (100V/36W) that should be enough for computers, phones, and the like. Of course, this is possible
only when disaster strikes in sunny weather (and therefore not at night), else the panel might serve only as a
cosy blanket!
For more information, contact:
PowerBankSystem Co. Ltd.
Tel:  (096)334-6311; Fax:  (096)334-6312
Web:  http://www.powerbs.co.jp

Solar-powered Flashlight/Radio

The Survival Center’s Emergency Preparedness Division, USA, has released their new solar-powered
disaster preparedness flashlight/radio, the Sunburst Mega. It uses the new "Never Need Batteries Again!"
technology which stores power in an internal non-memory energy cell for immediate or later use. This non-
memory energy cell is unlike regular or rechargeable Ni-Cad batteries (which have a memory) in that it
doesn’t have to be fully discharged before it is recharged, allowing it a much longer life.

It is powered four ways by the sun with the built-in solar panel which, atop the handle, is always charging
(even indoors with only room lights) the built-in hand crank dynamo, A.C./D.C. adapter, or additional “C”
batteries. The curved solar panel charges the internal batteries faster. The Super Bright LED Beam w/Flasher
is a replaceable flashlight bulb. The crystal clear AM/FM radio has a high sensitivity via the built-in FM
antenna. The built-in siren sounds loud and clear to signal for help in an emergency. The Intella-switching
system switches to a charging power source and allows the dynamo to charge while the radio/flashlight, etc.
is in use. The durable acrylic case with a strong handle makes carrying the kit easy.

For more information, contact:
Richard Mankamyer,
Director of Preparedness and Emergency Planning,
Survival Center, POB 234,
McKenna, WA  98558,USA.
Tel: 1-360-458-6778 ext. 2
E-mail: info@survivalcenter.com

Solar- and Wind-powered System for Disaster Sites

Solar Cube, a portable, self-contained system, caters to disaster sites where power has been interrupted, and
clean drinking water and electricity are not readily available. The system provides water and electricity to
remote and rural areas. It runs on a bank of 24-volt batteries, which are charged on-site by photovoltaic solar
panels and a wind generator. Solar Cube purifies water from any source, including sea water, river water,
creek water, well water, and polluted fresh water. It can provide up to 3500 gallons of clean drinking water
per day from polluted water or salt water—enough to sustain hundreds of families during a disaster. The
system generates enough electricity for emergency response crews to power refrigerators for medical
supplies, run a laptop computer online, or ensure that crisis communications equipment remains operational.
To commence operation, the pump (attached to machine) needs to be placed into the polluted water source.
For more information, contact:
Spectra Watermakers,
20 Mariposa Road,
San Rafael, California 94901,
USA.
Tel: 415.526.2780; Fax: 415.526.2787
E-mail: techsupport@SpectraWatermakers.com
Portable Pedal-Power Generator¹²
Great Systems, Inc. (GSI), USA, has a US Patent for the EGAS (Energy Generation And Storage) system. EGAS is the world’s first power generator that is capable of being used in an unventilated home or apartment because it does not use combustible fuels to generate power. EGAS uses body kinetics, or leg muscle power, to charge a unique spring system which slowly unwinds to spin a high-efficiency generator which can deliver up to 1000W of power on demand.

EGAS is designed for use in emergency situations where fuel is scarce and portable power is an immediate need. The EGAS design incorporates an "intelligent battery system" which allows for continuous energy output while the user recharges its spring system. Without the need for fuel, EGAS is infinitely rechargeable in the field, rendering it practical for use in areas of natural disaster (e.g. hurricanes, earthquakes, and tsunami) and war (e.g. Iraq) when the centralized power grid is destroyed and the basic power for households and small businesses may take weeks or months to be re-established.

For more information, contact:
Great Systems, Inc. (GSI),
A division of CyberKnight Intl Corp,
9812 Peoria Ave, Peoria, AZ 85345,
USA.
Tel: 623-972-6322
REFERENCES

http://www.smartcommunities.ncat.org/articles/energsyst.shtml
2. Natural disaster reduction through technology.  
http://www.science.doe.gov/sbir/solicitations/FY%202008/28.OE.Disaster.htm
5. Disaster Relief Standby Electric Generators for Emergency Power.  
11. http://www.spectrawatermakers.com/
CHAPTER 4. FOOD SUPPLY, STORAGE, AND SAFETY

Introduction

In the aftermath of natural disasters, such as earthquakes, floods, cyclones, and tsunamis, food in distress areas may become a scarce commodity. The available food may also become contaminated and consequently lead to outbreaks of food-borne diseases, including diarrhoea, dysentery, cholera, hepatitis A, and typhoid fever. The lack of suitable conditions for preparing food, coupled with poor sanitation, including inadequate safe water and toilet facilities in disaster-affected areas, has led to outbreaks of food-borne diseases. This chapter deals with technologies and best practices for storage, handling, and distribution of food.

TECHNOLOGY KNOW-HOW AND BEST PRACTICES OPTIONS

Storage, safety, and distribution of food in disaster-prone and disaster-affected areas require a package of best practices, technical know-how, technologies, equipment, and devices. Disaster management practitioners could make use of the best possible options that are available at hand;

- preventive food safety measures;
- safe and hygienic warehouse management;
- safe food handling during food distribution and preparation;
- inspecting and salvaging food;
- food storage – refrigerated and frozen foods, canning of food;
- cooking stoves;
- solar cookers; and
- food supply and delivery systems – mobile canteens, mobile kitchens, and mobile feeding units.

Food Safety Measures

While contamination can occur at any point of the food chain, inadequate washing, handling, and cooking of food just before consumption is still a prime cause of food-borne diseases. Many infections are preventable by observing simple, hygienic rules during food preparation whether in family settings or large food-catering facilities.

Under most conditions, the threats posed by polluted water and contaminated food are interrelated and cannot be separated. Therefore, water should be treated as a contaminated food and should be boiled, or otherwise purified, before it is consumed or used as an ingredient in food. The World Health Organization (WHO) has prepared guidelines for public health authorities and other related bodies on the key food safety measures to be observed in disaster situations. This includes a reminder that authorities maintain existing support for food safety and improve their vigilance against new food-borne risks posed by disasters. Basic precautions, such as those specified in the WHO “Five Keys for Safer Food”, should be implemented by all food handlers, especially those involved in mass catering.¹

KEY 1: KEEP CLEAN (prevent growth and spread of dangerous microorganisms)

- Wash your hands with soap and water (or other cleansers such as wood ash, aloe extract, and dilute bleach) after toilet visits, before and after handling raw food, and before eating.
- Avoid preparing food directly in areas flooded with water.
- Wash/sanitize all surfaces and equipment - including hands - used for food preparation.
- Protect kitchen areas and food from insects, pests, and other animals.
- Keep patients with diarrhoea - or other symptoms of disease - away from food-preparation spaces.
- Keep faecal material away from food-preparation zones (separate kitchen and toilet areas).
- Avoid eating raw food if it may have been flooded, e.g. vegetables and fruits (see also Key 5).

**Why?**

Dangerous microorganisms are widely found in the gut of animals and people and therefore also in water and soil in places with poor sanitation as well as in flooded areas. These microorganisms can be transferred to food and can, even in low numbers, cause *food-borne* diseases.

**KEY 2: SEPARATE RAW AND COOKED FOOD (prevent transfer of microorganisms)**

- Separate raw meat, poultry, and seafood from ready-to-eat foods.
- Separate sites for animal slaughter from food-preparation areas.
- Treat utensils and equipment used for raw foods as contaminated - wash and sanitize before any other use.
- Store raw (uncooked) food separate from prepared foods.
- Avoid contamination with unsafe water: ensure water used in food preparation is potable or boiled.
- Peel fresh fruits before eating.

**Why?**

Raw food, especially meat, poultry, and seafood and their fluids, may contain dangerous microorganisms which can be transferred to other foods during food preparation and storage. Prevent the transfer of microorganisms by keeping raw food separate from prepared food. Remember that cooked food can become contaminated through the slightest contact with raw food, unsafe water, or even with surfaces where raw food has been kept.

**KEY 3: COOK THOROUGHLY (kill dangerous microorganisms)**

- Cook food thoroughly, especially meat, poultry, eggs, and seafood until it is steaming hot.
- For cooked meat and poultry to be safe for consumption, their juices must run clear and no part of the meat should be red or pink.
- Bring foods such as soups and stews to boiling point and continue to boil for at least 15 minutes to ensure that every part of the food has reached at least 70°C.
- Cooked food should generally be eaten immediately; when this is not possible, thoroughly reheat the cooked food until it is steaming hot throughout.

**Why?**

Proper cooking kills dangerous microorganisms. The most important microorganisms are eliminated very quickly above 70°C, but some can survive up to 100°C for minutes. Therefore, a basic caution is for all cooked food to generally reach boiling temperatures and continue to be cooked at such temperatures for an extended period while remembering that large pieces of meat heat up slowly. It is also important to remember that in emergency situations, with their potential for significant contamination levels in food, the food should be cooked for longer than is normal.

**KEY 4: KEEP FOOD AT SAFE TEMPERATURES (prevent growth of microorganisms)**

- Eat cooked food immediately and do not leave cooked food at room temperature longer than two hours.
- Cooked food should be steaming hot (more than 60°C) prior to serving.
- Cooked and perishable food that cannot be refrigerated (below 5°C) should be discarded.
Why?

Microorganisms multiply quickly if food is stored at ambient temperature - the rate is maximum when the temperature is around 30-40°C. The higher the number of microorganisms in the food, the greater is the risk of food-borne disease. In general, discard food that cannot be eaten within two hours - or such food should be kept really hot or really cold. Most microorganisms cannot multiply in food that is too hot or too cold (higher than 60°C or lower than 5°C).

**KEY 5: USE SAFE WATER AND RAW MATERIALS (prevent contamination)**

- Use safe water or treat it to make it safe - e.g. through boiling or treatment with chlorine tablets.
- Wash or preferably cook vegetables and peel fruits that are eaten raw.
- Use clean containers to collect and store water, as also to dispense stored water.
- Select fresh and wholesome foods - discard damaged, spoiled, or mouldy food.
- Breast-feed infants and young children at least up to the age of six months.

Why?

Raw materials, including water, may be contaminated with microorganisms and dangerous chemicals, especially in flooded areas. Similarly, the risk of vegetables and fruits being contaminated with water containing sewage is high in flooded conditions. Toxic chemicals may be present in spoiled and mouldy foods. Safe water may be seriously contaminated with dangerous microorganisms through direct contact with hands or unclean surfaces. Breast-feeding protects infants against diarrhoea as breast milk is a rich source of antibodies and oligosaccharides which provide immunity to dangerous food-borne microorganisms.

**Safe Harvesting and Use of Food Crops**

During and after natural disasters, particularly floods and tsunamis, food crops may become contaminated by surface water that has been contaminated by pathogenic bacteria from sewage and wastewaters from sewer systems, septic tanks, and latrines as well as from farms and farm animals. The following practices could be adopted for safe harvesting and handling of food crops:

- While much of the normal agricultural produce may be adversely affected by flooding associated with a tsunami, some select areas may still have food safe for harvesting or food that has been stored safely post-harvesting.
- If agricultural produce is harvested from an area affected by flooding, it may be contaminated with microorganisms (from raw sewage or decaying organisms) and chemicals in the flood waters. While it is possible to reduce the potential hazard associated with microorganisms by thoroughly cooking the produce, such precautionary methods may not remove chemical hazards. Therefore, food from affected areas may be harvested only when no better option is available, and when it is certain that the food has not been contaminated by chemicals. Also ensure that the product is properly identified as being harvested from an affected area.
- Similarly, agricultural produce stored in the affected areas at the time of the disaster may also be contaminated by the flood waters. Such food should be treated as with food harvested from affected areas.
- If crop fields have been contaminated by human excreta, following floods or damage to sewage systems, an assessment should be carried out immediately to assess the contamination of crops and to effect corrective measures, such as delayed harvesting and thorough washing and cooking, to reduce the risk of transmitting faecal pathogens.
- Foods that have remained safe for consumption should be protected against exposure to other sources of contamination and not stored under conditions in which bacterial growth may occur.
Safe and Hygienic Warehouse Management

Large-scale storage and warehousing facilities for food are a necessity in disaster-stricken areas. The warehousing structures and food storage practices are critical to the safety of food that is stored in the aftermath of natural disasters. The practices adopted for safe and hygienic warehouse management in disaster-affected areas include:

- Storage structures should have good roofs and ventilation. Products should be kept away from walls and off the floor. Pallets, boards, heavy branches, bricks, plastic bags, or sheets should be placed underneath them for protection. Bags should be piled two-by-two, cross-wise to permit ventilation.
- Spilled food should be swept up and disposed of promptly to discourage rats.
- Fuel, pesticides, bleach, and other chemical stocks should never be stored together with food.
- If spray operations for pest control are needed, they should be carried out by qualified technical staff, under close supervision of the national authority (Ministry of Health/Ministry of Agriculture). The operators should wear protective gear to reduce their exposure to toxic chemicals in the sprays.

Safe Food Handling

Emergency response operations often include large-scale distribution of imported or locally-purchased food items as well as mass preparation of cooked food. In this context, special attention must be given to the following:

- All foods used in food distribution and mass feeding programmes must be fit for human consumption (in addition to being nutritionally and culturally appropriate). The quality and safety of all items should be controlled before importation or local purchase, and any unfit items should be rejected.
- Stocks should be regularly inspected, and any suspect stocks should be separated from other stocks, and samples be sent to a suitable laboratory for analysis; in the interim they should not be used.
- Kitchen supervisors, cooks, and ancillary personnel should be taught personal hygiene and the principles of safe food preparation (see Annex). Their implementation of these healthy norms should be regularly monitored.
- Kitchen supervisors should be trained to recognize potential hazards and apply appropriate food safety measures.
- Employees and volunteers preparing food should not be suffering from any of the following ailments: jaundice, diarrhoea, vomiting, fever, sore throat (with fever), visibly infected skin lesions (boils, cuts, etc), or discharge from the ears, eyes, or nose.
- Staff should be employed to ensure that the kitchen and surrounding areas are clean; they should be properly trained in this basic exercise and their work supervised.
- Adequate facilities for waste disposal are essential.
- Water and soap must be provided for personal cleanliness, and detergent for cleaning utensils and surfaces which should also be sanitized with boiling water or a sanitizing agent, e.g. bleach solution.
- Foods should be stored in containers that will prevent contamination by rodents, insects, or other animals.
- Hot and/or cold holding of food may have to be improvised.

Inspecting and Salvaging Food

In disaster situations, food items available from the market, storage depots, and warehouses should be of high quality. The available food and its source entities should be under constant inspection and quality surveillance for safe supply and distribution to the affected population. This process should conform to the following norms:

- Food industries, slaughterhouses, markets, and catering establishments should be inspected to ensure their safe operation. Particular attention should be given to those handling perishable products, such as milk. Steps should be taken to bar the marketing of foods that have been adversely affected.
When salvaged foods are fit for consumption and sold, they should be labelled accordingly, and consumers should be clearly informed of measures they need to take to render them safe.

In areas that have been flooded, those foods that have remained intact should be moved to a dry place, preferably away from the walls and off the floor.

Any foodstuff found to be unfit for human consumption must be disposed of, used for animal feed or industrial purposes or destroyed, depending on the assessment of the food safety authorities. Condemned food may be marked with a harmless dye, such as gentian violet, to ensure that the item is not used for human consumption.

When salvaged foods are deemed fit for consumption and sold, they should be labelled accordingly. If necessary, consumers should be clearly informed of measures they need to take to render them safe.

**Assessing and Using Salvaged Pre-packaged Food**

- Discard canned foods with broken seams, dents, or leaks as also jars with cracks.
- Undamaged canned goods and commercial glass jars of food are likely to be safe. However, if possible, containers should be sanitized before being opened. To do this, the jars and cans need to be washed thoroughly. As this may result in the loss of labels, it is advisable to write the contents on the lid of the can/jar with indelible ink before washing. Finally, the containers need to be immersed for 15 minutes in a solution of 2 teaspoons of chlorine bleach per quart of room temperature water and air-dried before opening.

Foods that are exposed to chemicals should be dumped, as the chemicals generally cannot be washed off the food. This includes foods stored in permeable containers such as cardboard and screw-top jars and bottles which are difficult to clean.

**Assessing and Using Salvaged Refrigerated Food**

- Inspect refrigerators to determine if their functioning is affected by the lack of electricity or by flood waters. Where refrigerators and cold food have not been directly affected, they may be a suitable source of safe food.
- Where power is not available, try to use refrigerated food – especially meat, fish, poultry, and milk -- before it is held in the danger zone (5-60°C) for more than two hours.
- To avoid the loss of meat, fish, poultry, and milk, these may be placed in a freezer immediately if they have not reached the danger zone. They may also be cooked and frozen in case they are to be kept longer.
- Some foods normally stored in the refrigerator can be kept in the danger zone for longer than others. Under emergency conditions, it is possible that foods such as butter, margarine, fresh fruits, and vegetables, open jars of concentrates and sauces, and hard and processed cheeses can be kept and used for a longer period; but they should definitely be discarded if they show signs of spoilage (odour, texture, gassiness, mould).
- To prevent warm air from entering the refrigerator, open it only when necessary.

**Assessing and Using Salvaged Dry Stores of Food**

- Check all food for physical hazards (such as glass) that may have been introduced during the earthquake.
- The likelihood of mould growth on stored dried vegetables, fruits, and cereals is greater in a humid environment and where food has become wet. Mould growth can be associated with chemical toxins.
- Intact food should be moved to a dry place, away from the walls and off the floor. Bags must not lie directly on the floor – pallets, boards, heavy branches, bricks, plastic bags, or sheets should be placed underneath them for protection. Bags should be piled two-by-two, cross-wise to permit ventilation.
- Wet bags should be allowed to dry in the sun before storage.
- Damaged bags should be replaced and stored apart from undamaged ones. A reserve of good-quality empty bags should be kept for this purpose.
- Spilled food should be swept up and disposed of promptly to discourage rats.
Food Storage
When disaster strikes, food and water may be inaccessible. Therefore, it is important to have an adequate stock of food and water in case of a disaster. Refrigeration is considered the best available option for the safe storage of food in pre- and post-disaster situations. It is also important to stock food that does not require refrigeration.

Foods Recommended for Storage in case of Emergency
To keep food safe and avoid food-borne illness, people need to know what foods to store before a natural disaster, as well as how to handle food in the aftermath. The foods that are generally recommended for storage in case of emergency situations include:

- ready-to-eat canned foods: vegetables, fruit, beans, meat, fish, poultry, meat mixtures, pasta;
- soups: canned or "dried soups in a cup";
- smoked or dried meats such as beef jerky;
- dried fruit;
- juices (canned or powdered), vegetables, and fruit;
- milk: powdered, canned, or shelf-stable brick pack;
- staples: sugar, salt, pepper, instant potatoes and rice, coffee, tea, cocoa;
- ready-to-eat cereals, instant hot cereals, crackers;
- high-energy foods: peanut butter, jelly, nuts, trail mix, granola bars; and
- cookies, hard candy, chocolate bars, soft drinks, other snacks.

Every six months, these stocks need to be finished and replenished with new items for storage.

Refrigeration of Food
The shelf-life of food depends on the food itself, its packaging, and the temperature and humidity. If the food is not sterilized, it will ultimately spoil due to the growth of microorganisms. Foods such as dairy products, meats, poultry, eggs, fresh fruits, and vegetables will spoil rapidly if not stored at the proper temperatures. Dairy products should be stored at refrigerated temperatures between 34°F and 38°F, meats between 33°F and 36°F, and eggs between 33°F and 37°F. Fresh vegetables and ripe, fresh fruits should be stored between 35°F and 40°F. Refrigerated foods should always be stored at temperatures less than 40°F. A thermometer should be placed in the refrigerator to monitor the temperature often. This is especially important during the hot summer months.

Frozen foods should be stored below 0°F in moisture-proof, gas-impermeable plastic or freezer wrap which should be labelled and dated. Frozen foods may be stored beyond the recommended storage time, but their quality may diminish. Sometimes consumers overload a freezer, blocking the circulation of coolant throughout the freezer compartment and thereby lowering the efficiency of the freezer in keeping the food below 0°F.

Food that is temperature-abused will spoil rapidly, as evidenced by off-odours, off-flavours, off-colour, and/or unduly soft texture. For instance, spoiled milk takes on a fruity off-odour and acid taste, and may curdle, whereas spolit fruits and vegetables may get an off-colour and soft texture. Slime on the surface of meat, poultry, and fish indicates spoilage. As microorganisms grow, they utilize the food as a nutrient source and may produce acids. The consumption of such spoiled food carries an increased risk of food-borne illness.. Food may be spoiled even when an off-odour is not obvious. Therefore, when in doubt, throw it out!

When stocking food storage areas, newly purchased items should be placed behind the existing food items to ensure that food is consumed prior to the expiration date and thereby reduce the amount of food to be
discarded. Leftovers should always be portioned in clean, sanitized, shallow containers which are covered, labelled, and dated. Generally, leftovers should be discarded after 48 hours in the refrigerator.

Dry food staples such as flour, crackers, cake mixes, seasonings, and canned goods should be stored in their original packages or tightly closed airtight containers below 85°F (optimum 50-70°F). Humidity levels greater than 60% may cause dry foods to draw moisture, resulting in caked and stale products. Canned goods stored in high humidity areas may ultimately rust, resulting in leaky cans. Dry, stable foods should be stored in the original containers or, when opened, packaged in plastic bags or in clean, dry, airtight, sealed containers. Pantry foods should be purchased in good condition in their original package; and canned goods that are swollen, badly dented, rusted, and/or leaking should always be discarded.

For safety, food should always be stored separate from non-food items such as paper products, household cleaners, and insecticides. The contamination of food, crockery, and utensils by a household cleaner or insecticide could result in chemical poisoning.

**Recommended Storage of Various Foods**

**Breads, Cereals, Flour, and Rice**

Bread should be stored in its original package at room temperature and used within five to seven days. Bread stored in the refrigerator has a longer shelf-life due to delaying mould growth; in the freezer, bread may be expected to stay fresh for two to three months. Cream-style bakery goods containing eggs, cream cheese, whipped cream, and/or custards may be refrigerated for no longer than three days.

Cereals may be stored at room temperature in tightly closed containers to keep out moisture and insects. Whole wheat flour may be stored in the refrigerator or freezer to retard rancidity of the natural oils. Raw, white rice should be stored in tightly closed containers at room temperature and used within a year. At room temperature, brown and wild rice have a shorter shelf-life (six months) due to the oil turning rancid. The shelf-life of raw white and brown rice may be extended by refrigeration. Cooked rice may be stored in the refrigerator for six to seven days or in the freezer for six months.

**Fresh Vegetables**

Removing air (oxygen) from the package, storing the vegetables at 40°F refrigerated temperatures, and maintaining optimum humidity (95-100%) may extend the shelf-life of fresh vegetables. Most fresh vegetables may be stored up to 5 days in the refrigerator. Fresh, leafy vegetables should always be wrapped or stored in moisture-proof bags to retain product moisture and prevent wilting. Root vegetables (potatoes, sweet potatoes, onions, etc) and squashes, eggplant, and rutabagas should be stored in a cool, well-ventilated place between 50°F and 60°F. Tomatoes continue to ripen after harvesting and should be stored at room temperature. Removing the tops of carrots, radishes, and beets prior to refrigeration will reduce the loss of moisture and extend their shelf-life. Palatability of corn diminishes during cold storage due to the conversion of starch to sugar. Corn and peas should be stored in a ventilated container. Lettuce should be rinsed under cold running water, drained, packaged in plastic bags, and refrigerated. Proper storage of fresh vegetables will maintain their quality and nutritive value.

**Processed Vegetables**

Canned vegetables can be stored in a cool, dry area below 85°F (optimum 50-70°F) for up to a year. After a year, canned vegetables may still be suitable for consumption, but their overall quality and nutritional value may have diminished. Dented, swollen, and/or rusty cans should be discarded. Frozen vegetables may be stored in the freezer for eight months at 0°F, whereas dehydrated vegetables should be stored in a cool, dry
place and used within six months since they have a tendency to lose their flavour and colour. Home-prepared vegetables should be blanched prior to freezing.

**Fresh Fruit**

In general, fresh fruit should be stored in the refrigerator or a cold area to extend their shelf-life. Loss of moisture from fresh fruit may be avoided by using ventilated, covered containers, which should always be placed in a separate storage area in the refrigerator since fresh fruits may contaminate or absorb odours from other foods. Prior to consumption, fresh fruits and vegetables should be rinsed under cold, running water to remove possible pesticide residues, soil, and/or bacteria. Peeling, followed by washing of fresh fruits and vegetables, is also very efficient in removing residues.

Ripe, eating apples should not be washed prior to being stored separately from other foods in the refrigerator and should be eaten within a month. Apples stored at room temperature will soften within a few days. Remember to remove apples that are bruised or decayed prior to storage in the refrigerator.

Green pears and apricots should be ripened at room temperature before being stored in the refrigerator. Expect a five-day refrigerated shelf-life for these fruits.

Unripe peaches may be ripened at room temperature and eaten after two days. Ripe peaches should be stored in the refrigerator and consumed at room temperature.

Grapes and plums should be stored in the refrigerator and eaten fresh within five days of purchase. Store unwashed grapes separately from other foods in the refrigerator and wash them prior to consumption.

Ripe strawberries can be stored in the refrigerator separately from other foods for approximately three days. Strawberries should be washed and hulled prior to consumption.

Citrus fruits, such as lemons, limes, and ripened oranges, can be stored in the refrigerator for two weeks. Grapefruit may be stored at a slightly higher temperature of 50°F.

Melons, such as the honeydew melon, cantaloupe, and watermelon, may be ripened at room temperature for two, three, and seven days, respectively. Ripe melons should be stored in the refrigerator.

Avocados and bananas should be ripened at room temperature for three to five days. Never store unripe bananas in the refrigerator, since cold temperatures will cause the bananas to rapidly darken.

**Processed Fruit**

Canned fruit and fruit juices may be stored in a cool, dry place below 85°F (optimum 50-70°F) for a year. As with canned vegetables, badly dented, bulging, rusty, or leaky cans should be discarded. Dried fruit has a long shelf-life because moisture has been removed from the product. Unopened, dried fruits may be stored for six months at room temperature.

**Dairy Products**

The shelf-life of fluid milk stored in the refrigerator (<40°F) is 8-20 days, depending upon the date of manufacture and the storage conditions of the grocer’s shelf. Milk is a very nutritious and highly perishable food and therefore should never be left at room temperature but rather be always capped or closed during
refrigeration. Freezing milk is not recommended, since thawed milk easily separates and is susceptible to the development of off-flavours.

Dry milk may be stored at cool temperatures (50-60°F) in airtight containers for a year. Open containers of dry milk, especially whole milk products, should be stored at cold temperatures to reduce off-flavours. Reconstituted milk should be handled like fluid milk and refrigerated if not immediately used.

Canned, evaporated milk and sweetened, condensed milk may be stored at room temperature for 12-23 months. Opened, canned milk should be refrigerated and consumed within 8-20 days.

Natural and processed cheese should be kept tightly packaged in moisture-resistant wrappers and stored below 40°F. Surface mould growth on hard, natural cheese may be removed with a clean knife and discarded. Rewrap cheese to prevent moisture loss. The presence of mould growth in processed cheese, semi-soft cheese, and cottage cheese is an indicator of spoilage and such foods should therefore be discarded.

Commercial ice-cream should be stored at temperatures below 0°F. The expected shelf-life of commercial ice-cream is approximately two months before its quality diminishes. Opened ice-cream should be returned to the freezer immediately to prevent loss of moisture and development of ice crystals. Ice-cream should be stored at constant freezer temperatures to slow the growth of ice crystals.

Meats, Poultry, Fish, and Eggs

Meat, poultry, fish, and eggs are highly perishable and potentially hazardous due to their high moisture and high protein content. Generally, fresh cuts of meat contain bacteria on the surface which will grow, produce slime, and cause spoilage after three days of refrigerator storage in oxygen-permeable packaging film. Ground meat products are more susceptible to spoilage due to the manufacturing process and increased surface area of the product. Bacteria in ground meats are distributed throughout, providing rapid growth in the presence of air. Ground meats should be stored on the lower shelf of the refrigerator and used within 24 hours of purchase. Refrigerator storage slows bacterial growth; however, the product will eventually spoil. Optimum storage temperature of refrigerated meats, including ground beef, is 33-36°F.

Freezing inhibits the growth of bacteria. Whole cuts of meat may be stored in the freezer, ranging from 4-12 months, whereas ground meat may be stored for three to four months. For maximum storage, meats should be wrapped in moisture-proof, gas-impermeable packaging to prevent freezer burn.

Cured meats, such as bacon, should be stored in their original packaging in the refrigerator. Cured meats have a tendency to become rancid when exposed to air. Therefore, rewrap cured meats after opening the package. Expect approximately a one-week shelf-life for cured meats. Vacuum-packaging (absence of air) and modified atmospheric packaging (partial removal of air) extends the shelf-life of meats and meat products (i.e. luncheon meats). The shelf-life of vacuum-packaged meats and gas-flushed meats is 14 days and 7-12 days, respectively.

Poultry should be prepared within 24 hours of purchase or stored in the freezer. Poultry may be stored in the freezer (0°F) for 12 months. Thaw poultry from the refrigerator under cold, running water, or in the microwave. Cook poultry to an internal temperature of 180°F. Leftovers stored in the refrigerator should be consumed within three days and reheated to 165°F prior to consumption. Poultry broth and gravy should not be stored more than two days in the refrigerator, and should be reheated to a full boil (212°F) before consuming.
Fresh fish, shrimp, and crab stored in the refrigerator (slightly above 32°F) should be consumed within a couple of days. Fresh fish should never be stored in water due to leaching of nutrients, flavour, and pigments. Frozen fish and seafood (except shrimp) may be stored for three to six months at 0°F. Shrimp may be stored for 12 months at 0°F.

Eggs should be purchased refrigerated and stored in the refrigerator (33-37°F) in their original carton. Storage of eggs in the original carton reduces absorption of odours and flavours from other foods stored in the refrigerator. Eggs should be used within four to five weeks of the pack date listed on the carton (1-365 indicating the pack date within the year). Leftover egg yolks and egg whites may be stored in the refrigerator, covered, for two and four days, respectively. Egg yolks should be covered with water. Hard-boiled eggs may be stored in the refrigerator for 5 days. Pasteurized liquid eggs may be stored in the refrigerator for 12 days. Egg whites and pasteurized eggs may be stored at freezer temperatures for a year. Shell eggs should never be stored in the freezer. Dried eggs may be stored in tightly closed containers in the refrigerator for a year.

**Water**

Commercial, bottled water has an extended shelf-life of one to two years due to extensive water treatment (filtration, demineralization, and ozonation) and strict environmental controls during manufacturing and packaging. Bottled water should be stored in a cool, dry place away from sunlight. Household, tap water has a limited shelf-life of only a few days due to the growth of microorganisms during storage. Therefore, consumers should purchase bottled water if planning to store water for extended periods. The Food and Drug Administration (FDA) regulates commercial, bottled water as a food.

**Handling Frozen Food during Power Failures**

When the power supply fails in the home, minimize opening the refrigerator and freezer as these appliances, being insulated, aid in keeping foods cold. However, if the refrigerator or freezer door is opened often, the cooling efficacy will reduce. Perishable, refrigerated foods (i.e. foods of animal origin) should be discarded after a six-hour power failure. The use of block ice at such times may increase the life of refrigerated foods. Food stored in fully loaded freezers may last for approximately two days, whereas food stored in partially loaded freezers may last for only a day. Freezer foods may be re-frozen if ice crystals are present. If the frozen food has completely thawed but is cold, it must be cooked within 24 hours; or be re-frozen within 24 hours of thawing. However, the quality may diminish. If in doubt about when the food actually thawed in the freezer, discard the thawed food. Discard all frozen foods that may have been at room temperature for more than two hours. Dry ice may be used to maintain the temperature constantly in both the frozen and cold storage procedures. Be careful not to handle dry ice with bare hands or breathe the vapours.

**Canned Food**

Canned foods are most likely to survive the damage of a flood or earthquake and still be usable. Safety of such food will depend on the condition of the can or jar. To evaluate safety, the following could be considered:

**Metal Cans**

- If the seams are still intact, the food is safe to use. Thaw gradually and store at room temperature.
- If the seam has broken and the food has thawed to room temperature, it should be discarded.
- If the seam has broken and the food is still cold (refrigerator temperature or below), it may be safely salvaged. Transfer it to a clean container and either store it in the refrigerator or refreeze for future use.
• All food that has frozen in tin cans should be examined carefully for spoilage before use. For an extra margin of safety, boil low-acid foods (meats, fish, poultry, and vegetables) for 10 minutes before consumption.

**Glass Jars**
• If jars have cracked or broken during freezing, the food should not be used.
• If the seal is still intact, the food is safe to use. Thaw gradually and store at room temperature.
• Re-check seals after thawing.
• If the seal has broken and food has thawed to room temperature, it should be discarded.
• If the seal has broken and the food is still cold (refrigerator temperature or below), it may be safely salvaged. Transfer the food to a clean container and store in the refrigerator or refreeze for future use.
• All food that has frozen in glass jars should be examined carefully for spoilage before use.
• For an extra margin of safety, boil low-acid foods (meats, fish, poultry, and vegetables) for 10 minutes before consumption.

**Disinfection of Commercially Canned Foods**
In the aftermath of disasters, canned foods need to be properly disinfected before consumption. The two best possible options available today include disinfection by chlorine treatment and by boiling. Table 4.1 provides an overview of applications of these methods for disinfection of commercially canned foods in glass or metal food contact surfaces, and utensils.

<table>
<thead>
<tr>
<th>Disinfection Method</th>
<th>Immersion Time for Scrubbed Containers</th>
<th>Water Temperature in Bleach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>15 minutes</td>
<td>Room temperature</td>
</tr>
<tr>
<td>Boiling</td>
<td>10 minutes</td>
<td>Rolling boil household</td>
</tr>
</tbody>
</table>

**Safety Precautions for Canned Food Containers**

*Commercially canned foods in metal containers*

• Commercially canned foods that have not been exposed to flood water can be eaten straight from the can.
• Commercially canned foods that may have been exposed to flood water but have been sealed with airtight, metal lids can be thoroughly cleaned and sanitized and are safe to use after disinfection. Do not use home-canned foods that may have been exposed to flood water.

*Commercially canned and home-canned, frozen foods*

• Commercially canned food that has frozen in sealed, airtight metal cans is safe to eat if the cans are not bulging, swelling, or seeping, and the seal is not damaged.
• Home-canned and commercially canned food in glass jars that have frozen should not be used due to the possibility of glass fragments in the food and broken seals.
Cooking Stoves\textsuperscript{4,5,6}

Cooking of food in disaster-affected areas has always been a challenge for field personnel. In such situations, the cooking should be quick, safe, less energy-intensive, and community-oriented, and the food should be nutritious. A number of cooking stoves and techniques – both conventional and modern – are available for disaster management personnel to tackle the problems of food preparation in disaster-affected areas.

*Wood stoves, fireplaces, Dutch ovens, charcoal briquettes, gas grills, camp stoves;*\textsuperscript{5} Bricks may be used to make a stand for a pot or to hold a grill in an open fireplace. Dutch ovens are also handy for cooking on outdoor fires or in the fireplace. Charcoal briquettes can be used with cast iron skillets, Dutch ovens, and other pots and pans, but such cooking must be done outdoors. Small 1-3 burner propane camp stoves can be used indoors (with adequate ventilation), whereas liquid Coleman/white gas fuel stoves and gas grills must be used outdoors. Most kerosene heaters get heated enough for basic cooking on the top surface.

*Baking on top of a camp stove;*\textsuperscript{5} (1) Place a cast iron skillet or cookie sheet on top of the burner(s). (2) Raise the cooking pan with any suitable item – a cake pan, or an empty tuna can, or the trivet from a gas range - to allow air to circulate underneath. (3) Put the food to be baked in a covered pan on top of the “risers”. (4) Make a tent from several layers of foil over the cake pan, so that air can circulate beneath it, and put a small vent hole in the top of the aluminum foil. Large cans or pot lids also work. Keep an eye on the food while it is baking. Biscuits may need to be flipped so that they brown on top.

*Chafing dish cooking;*\textsuperscript{5} Chafing dishes come in different sizes and use small cans of jelled fuel for heat; some use candles or denatured alcohol burners. A fondue pot is a type of chafing dish. The small stand supporting the chafing dish can be used with a skillet or omelette pan, or a pot for soup or stew. It takes up to a half-hour to warm a can of food with a candle. Buddy burners and candles can be used with chafing dishes.

*Non-electric crock-pot;*\textsuperscript{5} This can be made with a box or bucket big enough to pack four inches of insulating material on all sides, as also the top and bottom. Line the inside with aluminum foil, and place insulating material (such as newspapers, cloth, sawdust, hay) on the bottom. Bring the food to a boil, cover the pot (three to six quarts), and put it in the container. Pack the top and the spaces between the pot and the sides of the box/bucket with insulating material, and cover with the lid. The crock-pot is good for up to four hours cooking.

*Solar Cookers*\textsuperscript{4,5,6,7}

Solar cookers are made with cardboard boxes, aluminum foil, duct tape, and glass. Such ovens can reach 350°F, which is hot enough to bake meats and casseroles. A solar cooker works by reflecting light onto a dark pot through a clear transparent cover such as glass or an oven baking bag, and insulating the pot so that the heat does not radiate outwards but rather cooks the food. Crock-pot recipes are generally suitable for a solar cooker. It is best to use materials at hand to create the insulated container with a transparent top that can reflect the sun’s rays.

The three most common solar cookers are heat-trap boxes, curved (parabolic) concentrators, and panel cookers. Numerous variations are available with a host of manufacturers, and instructions for making them are freely available on the internet.

*Box cookers;* The most common cooker around the world, the box cooker cooks at moderate to high temperatures and can heat several pots at once. Several hundred thousands of such cookers are available in India alone, according to the Solar Cookers International Website.
**Parabolic cookers:** Focusing sunlight on a single point, these cookers cook fast at high temperatures. They need frequent adjustment and supervision for safe operation. Several hundred thousand exist, mainly in China. They are especially useful for large-scale institutional cooking.

**Panel cookers:** These cookers have features of the box and parabolic cookers. They are simple and relatively inexpensive to buy or produce. Solar Cookers International's "CooKit", designed by a physicist, is the most widely used combination cooker. It is a simple, cost-effective solar cooker for refugee situations and other times of shortage as it can be made from cardboard and aluminum foil or similar reflective material and requires only a dark, covered pot and one high-temperature plastic cooking bag per month. Even a few hours of sunshine are enough for the CooKit to cook tasty meals for five to six people at gentle temperatures like a slow cooker, and it is therefore ideal for cooking food and preserving nutrients without burning or drying out. CooKit is a local innovation of the conventional solar cooker that is cheaper than other household box-and-concentrator-type solar cookers. It does not require frequent adjustments to face the sun and is also easier to mass produce in Africa. CooKits for the Iridimi camp in Chad are hand-assembled on-site, providing an income-generating activity for the refugee women.

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To keep food warm or extend cooking time, people can use an **insulated basket.** Solar cookers can also be used to dry foods, heat water, and pasteurize water for drinking.

**Advantages of Solar Cookers**

- Food does not need stirring, and does not stick to the pan. This allows for easier cleaning, saving precious water and lessening stress in emergencies.
- Food does not need to be constantly watched, as food does not usually burn if cooked longer than normal.
- Food tastes better because moisture is retained.
- Food is more nutritious.
- A variety of cooking tasks can be achieved – from baking bread to cooking meats, vegetables, rice, etc for everyday use as also in emergencies.
- Water can be pasteurized in about an hour (instead of boiling for 10 minutes which consumes precious fuel). A simple device called a WAPI (water purification indicator) is normally used.
- Medical instruments can be sterilized in an emergency.
- Minimal smell is produced because moisture is retained in the food.
- As only sunlight is used to cook food; smoke is not a byproduct.
- As the food retains its moisture, it is less likely to burn.

**Commercially Available Solar Cookers**

**Rocket stove:** Recently, the U.S. Environmental Protection Agency’s (EPA) Partnership for Clean Indoor Air has been promoting the scale-up project involving a uniquely designed wood-burning device called a rocket stove which “has been certified to be at least 42 % efficient.” The stove does not pollute the environment, and eliminates about 95 % of all the harmful gas particles from the living space.
**Sun Oven:** Along with a good water filter, food supplies, some clothing, and a bedding, a solar cooker could prove to be invaluable. The Sun Oven is considered a useful item for emergencies, especially in disaster-affected situations.

A Sun Oven weighs only 21 pounds. This light weight makes it handy in emergencies when families have to move quickly. It can then be carried as easily as a suitcase. And it can also accommodate other necessities such as paper towels and light bedding. A great advantage is that it does not require fuel or fire for cooking, thereby erasing the chance of accidental fire. Unfamiliar gasoline or propane camp stoves can be cumbersome to use in emergency situations when people are more easily distracted and therefore more susceptible to fire hazards.

**Low-cost solar cooker:** Solar Cooker Japan (SCJ) has introduced a new solar cooker prototype - an inflatable solar cooker invented by a Japanese industrial designer, Tomohiro Ohmura. SCJ first introduced the cooker in Kenya, demonstrating it at different venues and to Kenyan governmental officials. It is also performing verification tests in cooperation with a local NGO.

The newly developed inflatable solar cooker is made of rubber. When the cooker is inflated with air, low-cost, light reflectors made of aluminum, evaporated film stretch out on its concave orbicular surface. Its performance is highly rated, and it is also portable when deflated. SCJ plans to modify the product to meet local needs, expecting to manufacture the new cooker in Kenya in the future.

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**Portable, foldable oven:** Scientists at the Taiwan Textile Research Institute have recently demonstrated a prototype of a folding oven which is woven out of soft cloth. Thin and flexible conductive elements are woven into the oven's highly heat-resistant fabric. Despite weighing only a few hundred grams, the lightweight electrical oven can be made hot enough to roast chicken, according to the researchers who have developed it.

The oven is designed to be extremely portable. Researchers have suggested a variety of potential applications where a highly portable, durable oven could be useful - whether in military field kitchens, or while camping, or for outdoor catering and disaster relief -, pointing out that, unlike gas-powered portable cooking equipment, it requires little space while being transported, and can be safely and legally carried on aircraft.

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Food Supply and Delivery Systems
An efficient and fast mechanism for the supply and delivery of food to disaster victims is a must. Disaster relief personnel could take crucial support from modern technology for an efficient supply and distribution of food items in an emergency situation. Food supply and delivery systems such as mobile canteens, mobile kitchens, and mobile feeding units could be very useful in the aftermath of a disaster.

Mobile Canteen
A truck, station wagon, or SUV can be converted into a mobile canteen with the addition of portable sections. A simple unit, the mobile canteen is equipped to serve food which has been prepared elsewhere. The food and utensils should be replenished frequently.

Suggested equipment for a mobile canteen
• can opener;
• utensils;
• containers for food and liquids;
• disposable plates, cups;
• garbage cans;
• insulated containers, etc;
• serving utensils;
• sugar and salt shakers;
• pitchers;
• trays;
• a folding table (for serving); and
• a portable stove to keep food hot (above 60°C/140°F).

Mobile Kitchen
A mobile kitchen comprises one or more vehicles equipped to serve but not prepare food. It carries its own water, food supplies, and fuel.

Mobile Feeding Unit
The mobile feeding unit (MFU) can be used to serve simple meals on a continuous basis to 400-600 persons per hour. The unit is packed in 13 wooden boxes; a limited number of units are stockpiled in the provinces and territories. The MFU is equipped as a self-contained emergency feeding unit (exclusive of fuel and food). It is used to prepare and serve the following:
• one-dish meals;
• meals in retort pouches;
• freeze-dried foods;
• hot beverages; and
• canned or dehydrated soup.

The MFU includes equipment and supplies for:
• purifying and carrying water;
• starting fires;
• opening cans;
• preparing, cooking, serving, and eating food; and
• cleaning, sanitizing, and garbage disposal.
REFERENCES

1. Ensuring Food Safety in the Aftermath of Natural Disasters.  
   http://www.searo.who.int/en/section23/section1108/section1835/section1864_8326.htm

2. “Plan an emergency food supply”, Food safety and natural disasters.  
   http://www.cce.cornell.edu/suffolk/Prepared/naturaldisasters.pdf


   http://usinfo.state.gov/xarchives/display.html?p=washfileenglish&y=2007&m=September&x=20070912133645lcnirellep0.8758814


   http://solarforemergencies.com/sfe/solarcooking.html


CHAPTER 5. WATER SUPPLY, PURIFICATION, AND TREATMENT

Introduction

Water is a prime requisite for victims of disasters before, during, and after their distress. Storage of water in hygienic conditions is as essential as the purification and treatment of water in post-disaster situations. Hence, water management is considered a prerequisite at all stages of disaster management: preparedness, reduction, and mitigation. Several conventional techniques and know-how for water storage and purification are already well-researched in technical literature and have been successfully applied to benefit populations in disaster situations. In recent years, a number of advanced technologies and equipments that have entered the market-place could provide vital support to disaster management efforts.

TECHNOLOGY OPTIONS

Several technological options available today for storage, purification, and treatment of water could easily be employed by disaster management practitioners and the affected population in both pre- and post-disaster situations. These include the following:

- **Storage of water**: containers for water storage; disinfection of drinking water containers.
- **Purification and treatment of water**: sedimentation; filtration; heat treatment (boiling); chemical treatment (chlorine, iodine); distillation; activated carbon filter systems; membrane technology for water filtration; solar water disinfection; etc.

Storage of Water

In the event of an earthquake, cyclone, or any other disaster, the affected community might not have access to water for days, or even weeks. As water is essential for many purposes such as drinking, food preparation, and cleaning, an ample supply of clean water is always a top priority, which, in turn, makes the storage of water an urgent need in an emergency. It is always recommended to store at least a two-week supply of water for each family member. The technical know-how for the safe storage of water for meeting requirements in the eventual occurrence of disasters relates primarily to the appropriate usage of storage containers and disinfection of drinking water containers.

Containers for Water Storage

Of the many types of containers available for water storage, the ones most commonly used are made of glass/fibreglass, plastic, or metal. All such containers should be thoroughly washed.

*Glass containers*: Glass is a fairly effective material for water storage, but it breaks easily and is heavier than plastic. Glass is non-permeable to vapours and gases; however, water in glass containers should not be stored near gasoline, kerosene, pesticides, or similar substances.

*Plastic containers*: Plastic jars are frequently used for water storage. These containers are lightweight and quite sturdy. Of the many types of plastic containers available, the polyethylene-type plastics are generally safe for storing water. Plastic jars with secure lids, which have contained milk or other edible substances, are also safe for water storage; however, it is essential that the milk bottles be thoroughly washed to remove the fat traces. Since plastic is permeable to certain vapours, water stored in plastic should not be kept near gasoline, kerosene, pesticides, or similar substances. It is advisable to store plastic water containers away from direct sunlight.

*Metal containers*: Some metals, such as stainless steel, can be successfully used for water storage. A metal water storage container should be resistant to rust as a metallic taste can be picked up by the stored water in
some types of metal containers. Water stored in metal containers should not be treated with chlorine prior to storage as the chlorine compound is corrosive to most metals.

**Disinfection of Water Containers**

Water containers should be disinfected before filling them with purified water the first time and again every time they are refilled. The two main methods of disinfecting water containers are: boiling and chemical disinfection.  

**Disinfection of water containers by boiling:** Glass bottles or jars can be boiled to disinfect them. The glass bottle or jar should be submerged in water in a large container, the water brought to a rolling boil and then allowed to continue to boil the container for another 10 minutes. The glass bottles/jars are then filled with purified water and capped for later use. The stored water should be used within six months. It should be noted that plastic containers cannot be boiled.

**Chemical disinfection of water containers:** Water containers can be purified by using bleach as a chemical disinfectant. Before using this method of disinfection, the container should be washed thoroughly with soap and water, and then rinsed out with clean water. Pour a solution of one tablespoon of liquid household bleach to a gallon of water into the container. Let the solution remain in the container for 10 minutes before pouring it out. Next, rinse the container with purified water. Pour out the rinse water. Fill the container again with purified water and cap the container for later use. Use the stored water within six months.

**Purification and Treatment of Water**

Water gets frequently contaminated in a disaster situation such as floods and earthquakes when sewerage and water lines are damaged. In some emergency situations, the only water available is contaminated by disease-causing microorganisms. Contaminants in water which may cause illness or disease include bacteria such as *E. coli*, protozoan cysts such as *Giardia* and *Cryptosporidium*, and viruses such as Hepatitis A. The presence of viruses should be suspected in any water that may be contaminated with human waste. In addition to having a foul odour and bad taste, the contaminated water can cause many diseases such as dysentery, cholera, typhoid, and hepatitis.

When stored or bottled water supply is unavailable, an alternative water source may be made acceptable for drinking purposes by purifying it. All water of uncertain purity needs to be treated before using it for drinking, food washing or preparation, washing dishes, brushing teeth, or making ice.

Although rescue workers are proficient at quickly mobilizing clean emergency water supplies in distress areas, it may be more efficient in some cases to transport not water supplies but water purification equipment.

Dr. Ashok Gadgil of the Lawrence Berkeley National Laboratory, USA, has developed a highly efficient water purification system which delivers up to four gallons potable water per minute. The water flows by gravity through a trough below an ultraviolet light. The ultraviolet radiation emitted kills most viruses and bacteria present in the water. The lamp used resembles the standard fluorescent tube common in offices, but it's made of a special glass that is transparent to ultraviolet light and it's not coated with phosphor. The system's only power needs are the 40W of electricity required to operate the lamp, rendering it ideal for PV power. Though it was designed to provide clean water to the people of developing countries, it would be ideal for emergency use wherever water supply disruptions occur.

Water may be treated in many ways: heating, chemical disinfection, filtration, or an appropriate combination of these methods. Each method has its own advantages and disadvantages which should be considered for
individual situations. None is perfect. Often, the best solution is a combination of the above-mentioned methods. Water treatment methods such as boiling, chlorination, and water treatment tablets kill microbes but do not remove other contaminants such as heavy metals, salts, most other chemicals, and radioactive fallout. Distillation removes microbes as well as most other contaminants, including radioactive fallout. Details of technological know-how for water purification are described in the following sections.

**Sedimentation**

Water should always be inspected before treatment as microorganisms may be attached to or embedded in soil or other organic particles suspended in the water. The water to be treated should be allowed to stand so that suspended material settles to the bottom of the container. Coarse materials such as sand settle more quickly than finer materials suspended in the water. During and after settling, care should be taken not to agitate the water. Water from the top of the container can be gently poured or drained into a second clean container.

Another option for removing suspended particles is to strain the water through a clean cloth, or layers of paper towels, or paper coffee filters. This is preferable to opting for commercially available portable water filters which tend to get rapidly clogged by the suspended material.

**Filtration**

Commercially available portable filters provide widely varying degrees of protection against disease-causing contaminants. The more sophisticated filters typically operate by a hand pump which draws water into the filter through an intake hose or by slow gravity flow through a filter or series of filters. The filtration process works by physically removing the contaminants from the water and retaining them within the filter medium. The size of contaminants retained depends on the pore size or the space between media fibres or granules. Most filters list an average pore size and are rated by the manufacturer according to the smallest particle they can trap. For example, a one-micron (one thousandth of a millimetre) filter traps contaminants one micron in diameter or larger. The removal percentage of contaminants is affected by the amount of time the water is in contact with the filter media: shorter contact time with filter media generally results in less contaminant removal. Some filters have a chemical treatment component - activated carbon or iodine-impregnated resins - which is effective against bacteria and some viruses. However, the contact time with the iodine in the filter may be too short to kill protozoan cysts.

Portable filters provide immediate access to drinking water without adding unpleasant tastes or odours. Portable filters available for field use with pore sizes of 0.1-0.3 microns may effectively eliminate cysts and bacteria, but such pore sizes are not small enough to reliably kill viruses. While the filters may be reliable in remote areas where human waste contamination is unlikely, in heavily populated areas filtration should be followed by either chemical disinfection with chlorine or boiling.

Proper selection, operation, care, and maintenance of portable water filters are essential for ensuring safe drinking water in emergency situations emerging at the time of disasters. When considering the purchase of a filter, one should assess the filter's rating for pore size, output, pump strokes per litre, and pump force (how much effort is required to operate the pump). If size and speed are not critical factors, a gravity-fed drip filter which lets water slowly drip from a reservoir down through a filter may be a good option. When using a portable water filter, always follow the manufacturer's instructions for use, care, and replacement.
Heat Treatment

Boiling: Heat kills microorganisms and is the oldest effective means of disinfecting drinking water. The process of bringing water to a boil kills virtually any disease-causing organism, including bacteria, cysts such as *Giardia* and *Cryptosporidium*, and viruses. In this method, water should be brought to a rolling boil for 3-5 minutes and allowed to cool. It is important to realize that bringing water to a vigorous boil will adequately disinfect it. If fuel is not limited, however, additional boiling for one minute, or keeping the water covered and hot for several minutes, can provide an additional margin of safety.

Though boiling effectively disinfects water for drinking, it does not provide a residual disinfection (long-term). Therefore, care must be taken not to re-contaminate the water. If the boiled water tastes flat, the taste can be improved by pouring it back and forth between two clean containers to re-oxygenate it or by adding a pinch of salt to each quart after it has cooled.

Solar heating: Solar thermal technology can be used to provide hot water at relief camps. Without hot water to ensure health and safety, emergency kitchens cannot function. The solar units allow kitchens to continue operating over a long period. A typical system is equipped with PV-powered pressure pumps, allowing it to deliver pressurized hot water. It is mounted on a flat-bed trailer for convenient transporting.

Another water-related solar option which offers a practical solution is the "solar shower" devices. These low-tech products generally comprise a simple, black, plastic water-bottle-type bag with a spout attached. The bag is filled with water and then left in the sun to heat, providing warm water for a shower at the end of the day.

Solar Water Disinfection

In this method, water is kept for four to six hours in strong sunlight in a transparent closed container, the dependent part of which can be painted black.

Chemical Treatment (chlorine, iodine)

Chlorine and iodine are the most commonly used chemicals for emergency disinfection of water. Bacteria are very sensitive to chlorine and iodine, whereas viruses, *Cryptosporidia*, and *Giardia* require very high dosages of disinfectant, or longer contact times with the disinfectant, than the standard recommendations. Heat treatment is recommended if the presence of these pathogens is suspected in the water.

Water treatment "purification" tablets which release chlorine or iodine are inexpensive and available at most chemists and drugstores. The effectiveness of the chemical as a disinfectant depends on the concentration of the chemical in the water, the amount of time the available chemical is in contact with the water prior to use (contact time), the water temperature, and the characteristics of the water supply. A decreased concentration of the chemical, or a lower temperature, will require a longer contact time for adequate disinfection. If the water temperature is less than 41ºF (or 5ºC), it should be allowed to warm prior to disinfection, or the chemical dose should be doubled. If the water is cloudy, it is recommended that it be strained through a coffee filter before treatment.

Chlorine: Chlorination uses liquid chlorine bleach to kill microorganisms such as bacteria. Regular household chlorine bleach which contains 5-6% sodium hypochlorite as the only active ingredient can be used for disinfection. A medicine dropper should be used to add 16 drops per gallon (four drops per quart); next, the water needs to be stirred and allowed to stand covered for 30 minutes. For adequate disinfection, the water should have a slight chlorine odour after the 30-minute waiting period. If this odour is not apparent after 30 minutes, repeat the dose and let it stand covered another 15 minutes. If this odour is still not present,
the bleach may have lost its effectiveness due to the product’s age or exposure to light or heat. Use the freshest chlorine bleach available. If the chlorine taste is too strong in the treated water, the taste can be improved by pouring the water from one clean container to another several times.

**Iodine:** Two forms of iodine commonly sold for chemical disinfection of drinking water are tincture of iodine (2%) and tetracycline hydroiodide tablets. Iodine was once widely used for water purification, but is no longer recommended because health research has shown that iodine can adversely affect people with hidden or chronic thyroid, liver, or kidney ailments. Also, iodine should not be ingested by children below the age of 14.

**Distillation**

Distillation entails boiling water and then collecting the vapour that condenses back to water. The condensed vapour will not include salt and other impurities. To distill water, fill a pot halfway with water. Tie a cup to the handle on the pot's lid so that the cup hangs right-side-up when the lid is upside-down (make sure the cup is not dangling in the water) and boil the water for 20 minutes. The water that drips from the lid into the cup is distilled.

**Activated Carbon Systems**

Activated carbon filter systems (ACF) work by passing water through treated carbon. Chemicals, sand, and particles in the water adhere to the surface of the treated carbon. ACF, the most common type of water treatment, is effective against some chemicals, including pesticides, solvents, and chlorine, but does not remove heavy metals. In a shelter application, activated carbon filters should not remain wet or filled with water for extended periods of time. When not in constant use, filters become incubators for bacteria. Also, once a filter becomes saturated with pollutants, it will allow additional pollutants in the water to pass through the filter.

**Hand-powered portable activated carbon water filters:** Many brands of portable filters are available in the market. When selecting an activated carbon filter, a two-stage filter system with 0.1-0.3 micron filtering capacity is adequate. The first filter is a pre-filter which removes suspended particles, sand, rust, and solids. The second filter eliminates bacteria. Water is forced through a filter made of porous material with “pores” that allow only particles of equal or smaller size to pass through. The filter media traps organisms that are bigger than their pore size, such as parasites, *Giardia*, amoebas, *Cryptosporidia*, and organic material. Many filters have pore sizes small enough to eliminate bacteria. The larger pore-sized filters may be effective in mountain streams where *Giardia* is the primary concern, but are not safe for treating water that may have bacterial contamination (for instance, from sewage). However, the pore size of portable hand-operated filters is not small enough to eliminate viruses.

**Gravity-operated activated carbon water filters:** These filter systems, though not portable, are a good household solution and very convenient in that they do not need water pressure to function. The unit is set on a counter, the untreated water is poured in from the top opening and drains down through the filter by gravity.

**WATER PUMPING**

Photovoltaic power could also be used to pump water during emergency situations. Some portable solar pumping systems do not require batteries as they work directly off the power supplied by the array. These systems, which have proven to be cost-effective for pumping water for livestock on remote ranches, may also be suitable for accessing water in isolated, disaster-affected areas. However, most pumps that may be utilized to combat flood waters or restore flooded utility structures have power needs much greater than what could be feasibly supplied by PV. Although conventional gas pumps require more electricity than could practically
be provided by a portable PV system, PV-powered pumps could possibly be used to extract gas from underground storage tanks. As with battery-charging, this potential application requires further study and field-testing.

**RECENT/LATEST TECHNOLOGIES**

Many advanced water purification equipment and devices have been developed and marketed in recent years. These could have potential applications for disaster situations. Some of these are briefly presented below.

**Mobile Units for Drinking Water**

The mobile Disaster Management Unit (DMU) has been developed by Ion Exchange-India to meet the critical need for safe drinking water during disasters such as droughts, cyclones, floods, and earthquakes. During such crises, water supplies get contaminated with suspended solids, dirt, clay, and pathogenic bacteria, spreading disease and epidemics. The DMU is compact, containerized, and skid-proof; it can be mounted on a truck and quickly transported to disaster sites. It is designed to treat any kind and quality of surface, or high salinity groundwater, producing drinking water conforming to international standards; it can also treat chemically contaminated water. Moreover, treatment plants designed specifically for the removal of iron, arsenic, nitrates, and fluoride can be conveniently attached when required.

**Low-cost Disinfecting Unit**

Developed by Ion Exchange-India, the low-cost disinfecting unit does not require piped water or electricity. Based on the principle of siphoning, and designed for easy use, Zero-B Srijal has only to be placed into a container of water, and the outlet hooked onto another empty, clean container. Pumping the pneumatic bellow twice starts the water trickling through the pipe; then, opening the outlet stopper ensures a steady flow into the empty container. Water passing through Srijal undergoes a two-stage purification process: first, a filter pad removes suspended dirt and mud; then the water passes through a Zero-B resin chamber where harmful bacteria and viruses are eliminated.

**Bicycle-powered Water Filter System**

Researchers from the Nanyang Technological University's (NTU) Institute of Environmental Science and Engineering, Singapore, have developed a portable water filtration system for use in disaster zones. Powered by a bicycle, the unit uses a mechanical pump and fine membranes to filter water, rendering it safe for drinking straight from the tap. The pedal-powered unit can be dismantled in just five minutes for transportation to another area.

As an aftermath of the December 26, 2004 tsunami disaster, the Institute had quickly produced the hand-cranked units which were shipped by the Red Cross for emergency relief.

**Membrane Technology for Water Filtration System**

Siemens Water Technologies is working with the SkyJuice Foundation of Sydney, Australia, to provide a reliable source of clean drinking water to communities deprived of a safe water supply. The low maintenance, simple operation and high efficiency SkyHydrant water filtration units convert contaminated water into clean, potable water which exceeds the World Health Organization's (WHO) requirements for potable water. Siemens supplies low-pressure membrane technology for the SkyHydrant water filtration unit. So far, over 300 systems have been installed worldwide, including a recent installation in the rural village of Obambo-Kadenge in Kenya, Africa.

Designed for affordable community water supply and disaster relief applications, the SkyHydrant unit is robust, compact, and portable. The technology is based on chlorine disinfection combined with a self-
contained Memcor low-pressure membrane filtration system from Siemens which operates under minimal feed pressure without the need for power and conditioning chemicals. The SkyHydrant removes particulates, bacteria, protozoa, and other pathogenic substances greater than 0.1 micron, and produces a minimum of 10,000 litres of potable water per day. The self-cleaning unit can be easily transported, installed, and operated with minimal training and operator interface. The treated water should be chlorinated to ensure protection against post-treatment contamination.

**Solar-powered Water Treatment Machine**

If a natural disaster strikes, clean drinking water and emergency electricity can now be made available through the innovative Solar Cube, a cooperative project by Spectra Watermakers, Inc., of San Raphael, California, and Trunz Metallchnik AG of Switzerland. Completely portable and easily assembled on site, the Solar Cube is powered by sunlight and wind, and can provide up to 3500 gallons of clean drinking water per day from polluted water or salt water — enough to sustain hundreds of families during a disaster. It can also provide sufficient energy for emergency disaster officials to power refrigeration for emergency medical supplies, keep a laptop on-line, or ensure that crisis communications equipment remains operational.

The Solar Cube works by placing a pump, which is attached to the machine, into polluted water or a salt water source. The water is pumped through a series of filters to remove large contaminants. At the final stage, the water is filtered through a reverse osmosis membrane, which is so fine that it dispels all bacteria, viruses, salts, and dangerous chemicals. Power for the Solar Cube’s operation is generated by 24-volt batteries which are charged by both the integrated PV solar panels and a wind-powered generator. Once assembled, the system is easy to operate, cleans its own filters, and has a service life of at least seven years.

Recently, the Solar Cube has been introduced in remote areas of Asia and South America. It is also being used in isolated villages in Venezuela, and in Pakistan where it provided drinking water and electrical power to several villages after the major earthquake in 2005.

**Solar-powered Water Purification System**

Using only solar power, a new water-purifying system which is both easy to store and portable has been developed by EnergyQuest, USA. EnergyQuest claims its system is invaluable for use in providing drinking water during disaster relief efforts. The system also has promising applications for agriculture in areas where water is brackish or unsuitable for crop development.

The system purifies water while also reserving any minerals or other usable byproducts collected during the purification process, such as sea salt from an ocean water source, for future use or sale.

**Technique to Purify Water Contaminated by Disaster**

National Science Foundation-funded researchers Vishal Shah and Shreya Shah of Dowling College in Long Island, New York, in collaboration with Boris Dzikovski of Cornell University and Jose Pinto of New York's Polytechnic University in Brooklyn, have developed a technique that makes use of specialized resins, copper, and hydrogen peroxide to purify tainted water. This simple water purification technique can eliminate 100% of the microbes found in water samples from Hurricane Katrina.

The system—safer, cheaper, and simpler to use than many other methods—breaks down a range of toxic chemicals. While the method cleans the water, it doesn't yet make the water safe for drinking. However, the method may eventually prove critical for limiting the spread of disease at disaster sites around the world.

The treatment system that the researchers are developing is simple: a polymer sheet of resins containing copper is immersed in the contaminated flood water. The addition of hydrogen peroxide generates free
radicals on the polymer. The free radicals remain bound to the sheet, where they come in contact with bacteria and kill them.

To develop their process, the researchers built upon a century-old chemical mechanism called the Fenton reaction - a process wherein metal catalysts cause hydrogen peroxide to produce large numbers of free radicals. Free radicals are atoms or molecules that have an extra electron in dire need of a partner (they obtain the partner by stripping it from a nearby atom, damaging the "victim" in the process). In large quantities, the radicals can destroy toxic chemicals and even bombard bacteria to death or irreparably damage a microorganism's cell membrane.

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Hollow Fibre Ultra-Filtration Membrane Technology
A water treatment plant with the unique hollow fibre ultra-filtration membrane technology has been installed in the Curca village in Goa, India, to supply virus-free water to the villagers. M/s Aquaplus Water Purifiers Pvt Ltd, a Pune-based company in India, has developed this latest technology.

The ultra-filtration membrane technology has very tiny pores of 0.01 microns, which restrict the bacteria and virus from passing through the system, thereby generating ultra-pure water. The plant has a capacity to produce 100 m³ of pure water per day. Aquaplus Water Purifiers Pvt Ltd has also developed mobile water-purifying plants to be deployed in disaster areas with drinking water emergencies.

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Ultra-Filtration (UF) Membrane
A water purifier that requires no electricity can be set up in 10 minutes in the remotest areas, and filters out even viruses, has been developed by the polymer division of the National Chemical Laboratory (NCL), Pune, India. The filter has immense potential in rural and disaster-prone areas. A unique aspect of the ultra-filtration (UF) membrane is that not only does it clean water of all suspended particulate matter and bacteria, but it also gets rid of harmful viruses.

High-water permeability, low fouling, and the ability to reject undesirable species in the water (worms, spores, bacteria, viruses, etc) are some of this filter’s noteworthy features. According to scientists, the membrane is so fine that only the tiniest of molecules (water and salt) pass through it. Larger molecules, viruses, and bacteria get trapped on the membrane’s surface.
The technology has thus proven highly appropriate for extreme circumstances, in regions where the quality of potable water is poor and electricity unavailable. The filtration units are portable and can be easily carried to remote areas.

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REFERENCES

1. http://medind.nic.in/iaj/t06/i3/iajt06i3p123.pdf
CHAPTER 6. MEDICINE AND HEALTHCARE FOR DISASTER VICTIMS

Introduction

Medicine and healthcare are critical considerations in disaster preparedness and mitigation of all types of diseases. In the immediate aftermath of disasters, the distraught population is in dire need of medicines and healthcare. This has always been a major challenge for administrative authorities. Any delay or laxity in the supply of medicines and appropriate healthcare aid could multiply the number of casualties among the victims. Hence, providing an adequate supply of disaster medicine and medical relief always remains a top priority for disaster management personnel.

TECHNOLOGY OPTIONS

In preparing for a disaster such as an earthquake, storm, or power outage, people with special medical problems need special attention. Technology plays a crucial role in meeting the many challenges faced in providing the requisite medicine and healthcare in disaster times. Modern healthcare management systems and equipment could provide vital support to the medical personnel engaged in post-disaster areas. The technological solutions considered helpful for disaster healthcare managers would include the following:

- diagnostic equipment;
- equipment for critical care;
- equipment for disaster health kits: basic, first-aid items; intravenous (IV) and feeding tube equipment; oxygen and breathing equipment; electrically-powered medical equipment;
- disaster relief response: robot-assisted medical reachback; telemonitoring; patient tracking systems;
- pre-hospital management systems;
- relief medical equipment vans;
- post-response rehabilitation systems;
- tele-medicine: disease surveillance systems; web-based tele-medicine; personal digital assistants (pocket tele-medicine); wearable computing (personal imaging); advanced sensors and medical monitoring; DICOM network services; and e-Film Video; and
- advanced systems for disaster medicine and medical relief.

The following sections provide an overview of the technological inputs required for disaster medicine and healthcare management.

General Equipment

- Large commercial or general-purpose military canvas tents
- Generators and associated power distribution systems
- Lighting
- Water purification systems
- Water
- Fuel
- Food (normally, ready-to-eat meals)
- Latrines
- Showers and sinks
- Safety, communications, and computer equipment
- Medical equipment
- Monitor defibrillators
- Ventilators
- Portable ECG machines
• Pulse oximeters
• Small point-of-service laboratory analysers
• Minor surgical kits
• Wound and orthopaedic stations
• Intravenous set-ups
• Minor care stations
• Observation unit supplies
• Large cache of medical disposable supplies
• Associated housekeeping equipment

**Diagnostic Equipment**

The diagnostic equipment needed in disaster situations are a small ultrasound device, and point-of-care laboratory testing and portable bronchoscopy. Other useful apparatus includes monitoring devices, infusion pumps, and ventilators.

**Equipment for Critical Care**

Equipment for critical care components, especially retrieval, should include monitoring technologies that overcome the limitations of noise. This includes automated blood pressure monitors, oxygen saturations, end tidal carbon dioxide, limited electrocardiography, and ventilators with variable minute volumes over a wide range of barometric pressures. Infusion devices must be compact and robust with extended battery life. Point-of-care laboratory testing is needed. And the drugs available must include those that can meet the critical needs of analgesia, sedation, vasoconstriction, inotropic support, vasodilation, and neuromuscular blockade.

**Disaster Health Kits**

A well-stocked health kit could be very useful to disaster victims. However, such a kit should be readied well before crisis strikes. Several modern apparatus and devices are included in the disaster health kits which, besides the basic first-aid items, include: medications, intravenous (IV) and feeding tube equipment, oxygen and breathing equipment, and electrically-powered medical equipment.

**Medications**

- At least a three-day supply of all prescribed medications.
- All medications stored in one place in their original containers.
- A complete list of all prescribed medications: name of medication, dose, frequency, and doctor’s name.

**Medical Supplies**

- If medical supplies such as bandages or syringes are being used, an extra three-day supply should be available.

**Intravenous (IV) and Feeding Tube Equipment**

- If an infusion pump is being used, one needs to ascertain that it has battery back-up, and how long it would last in an emergency.
- Instructions from the home-care provider about manual infusion techniques in case of a power outage are often useful.
- Written operating instructions should be attached to all equipment.
**Oxygen and Breathing Equipment**

- If oxygen is being used, an emergency supply (for three days or more) is recommended.
- Oxygen tanks should be securely braced to ensure they do not fall over. The bracing instructions should be checked in advance with the medical supplier.
- If breathing equipment is being used, a three-day supply or more of tubing, solutions, medications, etc is advisable.

**Electrically- powered Medical Equipment**

- For all medical equipment requiring electrical power – for instance, beds, breathing equipment, infusion pumps -, one needs to check with the medical supplier for details on a back-up power source, e.g. a battery or a generator.
- A helpful precaution is to check in advance with one’s local utility company to ascertain that back-up equipment is properly installed.

**Emergency Bag**

In the event one needs to leave home at short notice, an emergency bag should always be packed with:

- a medication list;
- medical supplies for three days;
- copies of vital medical papers such as insurance cards, Advanced Directive, Power of Attorney, etc;
- refrigerated medications and solutions.

**Medical Relief**

In disaster-affected areas, medical relief requires a wide range of technological back-up and support systems for meeting the complex challenges. The requirements vary at different stages of the disaster management process, namely, relief response, pre-hospital management, and post- disaster response; rehabilitation.

**Relief Response**

- **Robot-assisted medical reach-back**
  - Access to the victim during the 4-10 hrs of extrication.
  - All functions below depths of 10-30 metres in rubble.
- **Tele-monitoring**
  - Critically ill patient – sensors nodes.
  - During triage.
- **Patient tracking systems**
  - Bar coding and mobile wireless data acquisition to individually identify and track victims of disasters.
  - Bar coding has been piloted and tested in Europe.

**Pre-hospital Management**

- **Mobile technology in pre-hospital management**
  - Tele-diagnosis and tele-consultation, crucial signals.
  - Fixed or portable, wired or wireless, TCP/IP.
- **Miniaturization technology; PDAs**
- Support keyboard, pen, touch, and voice inputs.
- Information management, portability, and connectivity.
- E-mail, fax, graphics, digital photography, and voice recording capabilities.

- **Personnel status monitor (PSM)**
- **Mobile ICU**
- **Tele-diagnosis**
  - Tele-radiology: the term covers x-rays, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound.
  - Tele-pathology.
- **Tele-consultation**
  - During surgery; reduce number of inessential amputations.
  - Ambulatory patients.

**Relief Medical Equipment Vans**

In India, Accident Relief Medical Equipment (ARME) vans and Accident Relief Trains (ART), including a few self-propelled vehicles, are positioned at strategic locations for rushing to an accident site on top priority, along with doctors, paramedical staff, rescue workers, and engineers. The medical team attends to injured passengers, and the seriously wounded are transported to nearby hospitals. ARME vans are equipped with medicines, resuscitation machines, dressings, disposables, etc for use in emergencies and also have an operation theatre with facilities for conducting minor surgeries. These vans are so located as to cover an area within a distance of 150-200 km, normally in two-to-three hours. ARME vans may take up to four hours to reach a remote accident site.

**Post-disaster Response: Rehabilitation**

- Tele-psychiatric interventions
- Tele-rehabilitation
- Clinical decision support system for ambulatory patients.
- Public health issues:
  - Disease Early Warning System
  - Disaster Medicine
  - Epidemiology

**Tele-medicine**

Tele-medicine refers to the utilization of telecommunication technology for medical diagnosis, treatment, and patient care. A tele-medicine system is composed of customized medical software integrated with computer hardware, along with medical diagnostic instruments connected to the commercial VSAT (Very Small Aperture Terminal) at each location on fiber optics.

Tele-medicine enables a physician or specialist at one site to provide healthcare, diagnose patients, treat and monitor them, give intra-operative assistance, administer therapy, and consult with another physician or paramedical personnel at a remote site, thereby ensuring convenient, site-independent access to expert advice and patient information. Transmission modalities include direct hard-wired connections over standard phone lines and specialized data lines (single/twisted pairs of metallic wires, coaxial lines, fiber optic cable) and “wireless” communications, using infrared, radio, television, microwave, and satellite-based linkages. Improved space- and ground-based technologies now form a communications infrastructure well suited to addressing ongoing disaster management needs.
**Disease Surveillance Systems**

Some of the existing (or in the process of being developed) disease surveillance systems are as follows:

- Electronic Disease Reporting and Management System (EDRMS)
- Real-time Outbreak and Disease Surveillance (RODS)
- Lightweight Epidemiological Advanced Detection and Emergency Response system (LEADERS)

**Web-based Tele-medicine**

The Web provides an efficient platform for medical education, access to medical knowledge, and tele-medicine consultations. An ideal Web-based tele-medicine system would integrate existing technologies, providing access to diverse application programs and utilizing multimedia modalities. It would also deliver information to a single access point, independent of hardware platform (e.g. desktop PC, portable laptop computer, or pocket-sized computer), and be protocol-driven, with store-and-forward or real-time tele-consultancy capability. The system would promote cost-efficient transfer and sharing of clinical information throughout the world, even in remote areas.

**Personal Digital Assistants (pocket tele-medicine)**

Recent computer miniaturization has produced pocket-sized personal digital assistants (PDAs) with personalized interfaces. These small computers can support keyboard, pen, touch, and voice inputs and provide information management, portability, connectivity (via phone modem, wired or radio-frequency LAN [local area network], and diffuse infrared transmission) and, to varying degrees, e-mail, fax, graphics, digital photography, and voice recording capabilities. The ability to use a single small communicator to transmit different types of information anywhere in the world would be ideal for the disaster field worker. A small “pocket tele-medicine” unit, equipped with Web-browsing capability, a digital camera, telephone, and computer, could be used to conduct on-site, real-time consultations whenever necessary.

**Wearable Computing (personal imaging)**

Miniaturization of components has enabled the development of personal computer systems that are lightweight, unobtrusive, and wearable. Both the military and civilian sectors are investigating such systems which allow hands-free operation, enhanced mobility, access to information, and shared visual experiences. Early prototypes for wearable wireless computers utilized video images sent to a remote supercomputing facility over a high-quality microwave communication link. The computing facility sent back the processed image over ultra-high frequency communication links. Newer versions incorporate commercial head-mounted displays and cellular communications.

Wearable computing will, in the future, incorporate the advantages of a PDA but in a more compact, hands-free form which allows the worker to communicate while helping disaster victims. This will become the ultimate wireless-communication support system for the disaster responder.

**Advanced Sensors and Medical Monitoring**

Innovative applications for advanced sensors and smart materials currently being developed for combat soldiers in the USA could act as potential tele-medicine devices. The Personnel Status Monitor (PSM), a miniaturized device resembling a wristwatch, is being designed to be worn by the soldiers. It combines advanced environmental sensors and non-intrusive physiologic sensors with a CPU, geo-positioning receiver (interacting with global positioning satellites), and low-power wireless radio. The PSM will monitor the
soldier's vital signs (pulse rate, temperature, respiration, and blood pressure) continuously. The monitor is programmed to remain passive until queried, when it replies with the soldier's geographic location and vital signs. However, if the soldier's vital signs alter significantly from established norms, the PSM would promptly transmit the location and vital signs until it is shut down by a medic.

**DICOM Network Services**

The DICOM network services are based on the client/server concept. Before two DICOM applications can exchange information, they must establish a connection and agree on the following parameters: (a) Who is the client and who is the server? (b) Which DICOM services are to be used? (c) Which format is to be used for data transmission (i.e. compressed or uncompressed)?

**e-Film**

Organizations often have equipment that does not support the DICOM standard or provide the means of outputting digital images. e-Film Video is a system that captures still images and video streams from analog medical image acquisition devices (with analog outputs) and converts them to the industry standard DICOM 3.0 format. Promoting integrated digital medical imaging, e-Film Video images and video loops can be sent to DICOM-compliant devices for display and processing. Unlike many similar applications, video offers modality work-list capability, thereby eliminating redundant patient data entry.

**RECENT/LATEST TECHNOLOGIES**

**LSTAT (Life Support for Trauma and Transport)**

The LSTAT is the result of a joint effort of Northrop Grumman Corp (Los Angeles, California) and various military medical services in the USA. The LSTAT is a self-contained, stretcher-type platform designed to aid in field stabilization and transport of severely injured patients. It incorporates a number of on-board devices for ongoing treatment, which include monitors for basic vital signs and blood chemistry; mechanical ventilation and oxygen supplementation for patients requiring endo-tracheal intubation; a self-contained, battery-powered infusion pump to deliver intravenous fluids; and a self-contained, battery-powered suction pump. An automated external defibrillator is also built into each of the LSTAT units. All patient medical data that is monitored by the on-board devices of the LSTAT can be data-linked to the receiving medical facility while the patient is being transported by air or ground ambulance.

**Mobile Medical Communication Technology**

Telemedicus owns the exclusive rights to an innovative breakthrough in rapid medical emergency response and communications technology called "Disaster Relief and Emergency Medical Services (DREAMSTM)", jointly developed by the University of Texas Health Science Center in Houston, led by Dr. Red Duke, and the Texas A&M University, led by Dr. Richard Ewing.

DREAMSTM is the latest generation of mobile medical communication technology that allows a doctor to be “virtually on board” the ambulance or medi-flight as the patient is transported to the hospital or at the scene of an accident or at a remote location where traditional medical treatment is impractical.

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New Technology for Hospital Readiness for Disasters

In the USA emergency medicine specialists from Johns Hopkins have developed a tool to help hospitals prepare for disasters with the potential to overwhelm services. The Electronic Mass Casualty Assessment & Planning Scenarios (EMCAPS) computer program calculates the impact of such crises as a flu epidemic, bioterrorist attack, flood, and plane crash, accounting for such elements as the number of victims, wind direction, available medical resources, bacterial incubation periods, and bomb size. Written by members of the Johns Hopkins Critical Event Preparedness and Response (CEPAR) office and the Johns Hopkins University Applied Physics Laboratory (APL), the program depends heavily on population density estimates to derive 'plausible estimates' of what hospitals may expect in the initial minutes or hours of a disaster.

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Deployable Tele-medicine Kit

AMD Telemedicine, the world leader in developing, marketing, and providing training for tele-medicine equipment, has created a Deployable Tele-medicine Kit and is working to identify disaster organizations, first-responder teams, and medical facilities around the world that would be able to deploy and/or utilize this type of medical equipment in the event of a disaster. With this kit, healthcare providers in the field would have the ability to send photo images of the inner ear/nose/throat; of any trauma to extremities; of soft tissue injuries; of captured ultrasound scans; and of digital 12-lead electrocardiograms, digital lung capacity reports, and heart or lung sounds. The specialist in the field would then send this data to a medical specialist via satellite, internet, or Integrated Services Digital Networks (ISDN), providing an evaluation and/or consultation for these remote victims by using live videoconferencing or store-and-forward applications.

The new transportable, tele-medicine kit includes:

- AMD-2500s General Examination Camera, a powerful general examination camera, which is the first analog camera to combine power zoom, auto focus, freeze frame capture, and electronic image polarization in one diagnostic device.

- AMD-3550 SmartSteth Digital Electronic Stethoscope, permitting the recording, analysis, and transmission of high quality lung and heart sounds.

- AMD-2015 ENT/Otoscope for comprehensive ear, nose, and throat (ENT) examinations, combining the functionality of a high performance otoscope, a short sinus scope, and an oral exam scope in a single diagnostic device.

- AMD-3920 Digital Spirometer for PC, the PC-based digital spirometer that supports a full range of diagnostic cardiac and pulmonary applications, including expiratory reserve volume (REV), relaxed vital capacity (VC), forced vital capacity (FVC), forced expiratory volume (FEV), peak expiratory flow (PEF), and maximal voluntary ventilation (MVV). Fully compliant with the strict requirements of the American Thoracic Society (ATS).
• AMD-2020 Direct Ophthalmoscope, the video version of a diagnostic direct ophthalmoscope which enables viewing and illumination of retina, head of optic nerve, retinal arteries, vitreous humor, through an undilated pupil. Images can be captured in freeze frame for extended review.

• AMD-5500 SmartProbeTM Ultrasound,- the system on a chip provides true 128 channel resolution in a laptop PC, with all the functionality of the most expensive ultrasound systems.

• AMD-3875 12 Lead Interpretive ECG for PC, when connected to the serial port of a PC, converts any Windows® 98/NT platform to a real-time 12 Lead ECG machine with Interpretation.

• The AMD Image Management System - a quick and efficient software program to organize individual patients, conditions, and screenshots while at the emergency scene.

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Communication System for Emergency Tele-medicine
The Disaster Emergency Logistics Tele-medicine Advanced Satellites System (DELTASS) has been developed by CNES for the European Space Agency (ESA). DELTASS uses both geo-stationary and low-earth orbit communication satellites, enabling `top-down` management of emergency workers dispersed across a disaster zone, as well as letting medical experts located hundreds of miles away carry out on-the-spot diagnoses of casualties.

Such a sure-safe communication system for emergency tele-medicine greatly enhances the effectiveness of rescue workers within the affected area, especially as existing communication networks might have broken down. Using DELTASS, search-and-rescue workers entering a disaster area to identify casualties carry PDAs and satellite phones to transmit details of the victims, opening `electronic patient forms` that remain with casualties throughout their treatment process and can therefore be continuously updated.

First-aid and ambulance teams are equipped with Portable Tele-medicine Workstations for two-way communication with medical experts at a nearby Medical Field Hospital. Patient data, such as ECGs and vital signs, can be transmitted along with still images of injuries. And at the hub of the DELTASS system is this Medical Field Hospital, set up within the disaster area. It is from here that mobile teams’ activities are coordinated, patients are identified, treated, and their data tracked, and decisions are made about their transfer to safer locations.

Broadband communication links enhance patient treatment, enabling videoconferencing with hospital staff in another country as well as tele-diagnosis techniques such as ultrasound.

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REFERENCES


CHAPTER 7. SANITATION AND WASTE MANAGEMENT IN DISASTER MITIGATION

Introduction

In the aftermath of disasters, sanitation and waste management are placed next only to food and medical supplies in the list of priorities for the authorities in charge. The maintenance of appropriate sanitary conditions and hygienic waste disposal are critical because these efforts have a direct bearing on the health of disaster victims. If the sanitation and waste management systems and practices are below par, the survivors could be exposed to the danger of infections and diseases. Hence, these concerns have become important components of any disaster management plan of action in modern times.

TECHNOLOGY OPTIONS

Technologies and methodologies are a critical part of the response strategy that local governments need to have in place for disaster situations. They help to maintain optimum sanitary conditions and to handle large amounts of different kinds of wastes (including hazardous wastes) in an environmentally sound manner. Response strategies of the local governments include:

- incorporating disaster wastes into the waste management and planning at the national and local levels;
- maintaining close links with disaster management agencies;
- ensuring that waste management is incorporated into emergency plans;
- nominating 'stand-by' waste personnel and equipment; and
- incorporating training and practice in disaster waste management as a part of the usual emergency management procedures.

Strategies to resolve a wide range of problems relating to sanitation and waste management in post-disaster situations include:

- best sanitation practices: defecation, disinfection, drainage;
- disposal of corpses and carcasses;
- disposal of excreta: shallow trench latrines, deep trench latrines, simple pit latrines, ventilated improved pit (VIP) latrines, double-pit latrines, composting latrines, water-seal latrines;
- disposal of sewage and wastewater (sullage): disposal into water courses, infiltration techniques, evaporation and evapo-transpiration techniques, grease traps;
- treatment and disposal of household refuse and solid waste: burial, sanitary landfill, incineration, waste recycling; and
- disposal of rubble: Construction & Demolition (C&D) waste.

Sanitation Practices

Defecation

The lack of a viable sanitation system makes the disaster-affected area a virtual sitting duck for diseases. The simplest and quickest sanitation facilities are shallow trench latrines, collective latrines, and defecation areas or fields. The most suitable facility depends upon the water table level, soil, locally available materials, and people’s habits and customs. Basic education in the advantages of healthy sanitation practices may be required before the local people agree to follow new norms. Further, at least one latrine, which is regularly cleaned and disinfected, should be made available to every 15-20 persons.

Defecation fields should be at least 15 m away from the water source, but near enough to be conveniently reached by children and the elderly. Hygienic cleaning of these fields has to be ensured with a sufficient
supply of lime and bleaching powder to prevent the breeding of flies. The excreta should be disposed of in 
prepared pits which are later covered with at least 25 cm of soil.

**Disinfection**

The most commonly used and least expensive disinfectant is probably liquid chlorine bleach. A 5.25% 
solution of sodium hypochlorite is required for a liquid chlorine bleach to function effectively as a 
disinfectant. A common recommendation for the final disinfecting rinse after a flood clean-up of most hard 
surfaces is ½ cup per gallon of water. The dilution recommended for laundering clothing is one cup per 
wash-load for top-loading washers. Bleach should not be added directly to the clothes.

**Drainage**

Storm water and wastewater can pollute drinking water sources because of poor drainage. Drainage trenches 
need to be built, and stagnation in the pools should be avoided.

**Disposal of Corpses and Carcasses**

Quick disposal of corpses and carcasses is a must for maintaining a healthy environment for the survivors of 
disasters. While cultural factors play a major role in the disposal of human corpses, animal carcasses would 
need to be disposed of by any one of the following five methods, according to the availability of time and 
resources; burial, incineration (burning), composting, rendering, and alkaline hydrolysis.

**Burial**

The burial of human corpses and animal carcasses is generally recognized as the preferred choice of disposal 
when infectious agents are involved, but it can also be the routine choice in times of natural disasters. It is the 
preferred choice because it is generally quicker, cheaper, environmentally cleaner, simple to organize, and 
often the most convenient means of disposing of large numbers of livestock. There are two common methods 
of burial, namely, open pit disposal and closed pits.

*Open pits:* Historically, open pit disposal has been the most common method used for disposing of dead 
animals. This practice however has several disadvantages. The burial in disposal pits could pose a threat to 
groundwater quality as the carcasses could leach contaminants for an undetermined length of time if they do 
not decompose properly. Ambient temperature and moisture conditions can slow or speed up the degradation 
process, thus endangering the environment with contamination possibilities. Open pits are also susceptible to 
scavenger intrusions which are highly undesirable in disease-related disasters.

*Closed pits:* Freshly closed pits have become the method of choice for the most current disaster situations. 
By heaping soil on top of the pit, the soil’s weight acts to stop carcasses from rising out of the pit due to gas 
entrapment, prevents scavengers from digging up carcasses, helps filter out odours, and assists in absorbing 
the fluid from decomposition. A major wasted effort in the recent tsunami tragedy has been the digging of 
huge pits for burying bodies. A more viable solution is to opt for a small earthmover to dig a trench 3 m x 1.5 
m wide and 1 m deep for burying a single body. These shallow trenches which can be dug quite rapidly serve 
the purpose for burials in disaster times.

**Incineration**

Incineration is a desirable method for disposal of carcasses in many situations, because burning of animal 
carcasses produces a solid waste by-product (bone and ash) that is essentially free of pathogens. There are 
however limiting factors such as location of site, access to site, type of animal carcass, fuel availability, size 
of carcass, and environmental considerations. Incinerations are of three types: open-air burning, biological 
icineration, and controlled burning.

*Open-air burning:* This method requires the addition of combustible material, such as timbers and straw as 
fuel additives, to achieve adequate temperature for completely consuming the carcasses. Smoke from such
Fires can be high in particulates and/or produce offensive odours if the burning process is incomplete. The type of animal to be disposed of also plays a critical role in the success of open-air burning. Animals with a high fat content burn much faster and with less fuel than those with less fat content.

**Biological incineration:** Biological incineration is an efficient disposal method, as it creates almost no pollution or particulates, and achieves virtually complete oxidation of the carcasses. However, the choice of this method is limited by considerations of the costs incurred, lack of portability, location of existing incinerators, and capacity restraints.

**Controlled burning:** Controlled burning is usually carried out in an open pit, or by air curtain incineration. Air curtain incinerators (also called trench burners) are a relatively new technology which is now used in many large-scale natural disasters to burn combustible waste. The incinerators have large-capacity fans driven by diesel engines connected to ducting, which delivers the high velocity air down into a long, narrow pit or trench. A commonly recommended dimension for the trench is 8’ x 8’ x 35’, but the size can be altered according to the number of carcasses or the amount of debris to be consumed. The system delivers the air stream at approximately 165 mph down into the pit at an angle, creating a “mini-cyclone” within the pit. The continual downward pressure by the incoming air forces the complete destruction (burn) of all material, producing minimal smoke at temperatures of up to 2000°F.

The advantages of air curtain incinerators are that they are portable, environmentally friendly (minimal ash or particulates produced), and can incinerate vegetative debris from natural disasters (as a fuel source) at the same time as animal carcasses need to be burned. Some disadvantages are that the incinerators are expensive to operate, are not available in all locations, and may require excessive fuel, depending on the material to be incinerated.

**Composting**

Composting is defined as the controlled decomposition of organic materials. Decomposition occurs when organic materials go through a “slow cooking” process as heat and microorganisms consume the organic material. Composting consists of two stages: a primary, high-temperature, active stage; and a secondary lower-temperature “curing” or stabilization stage. The primary phase of composting takes two-to-three months, and the secondary phase another two-to-three months. The end result of the process is the production of carbon dioxide, water vapour, heat, and compost. Composting of animal carcasses can occur in either bins or wind-rows (deposited in a straight line within a field or pasture).

Composting is rated as one of the most environmentally friendly forms of carcass disposal, because it is, in effect, a form of recycling. It could be conveniently used in many natural disaster situations and has become an accepted form of disposal today. The advantages of composting are that initial start-up costs are minimal, and the end product can be utilized as a fertilizer material or a soil additive. The disadvantages of composting are that it is a slow process (months) which requires frequent monitoring.

**Rendering**

Rendering is a process of separating animal fats and proteins, usually by cooking. The process can be carried out by either of two primary methods: the older method uses steam under pressure (with a grinding process) in large closed tanks; and a second, newer method, called dry rendering, uses dry heat to cook the material in its own fat in open steam-jacketed drums. The recovered proteins are used almost exclusively as animal foodstuff, whereas the recovered fats are used both industrially and in animal feeds.

Rendering is considered an environmentally friendly method of disposal because it recycles the animal protein from the carcasses back into a usable form as meat or bone meal. The disadvantage is that rendering might not be an economically feasible option.
Alkaline Hydrolysis

Alkaline hydrolysis or tissue digestion is a relatively new technique for carcass disposal. The process uses alkali at elevated temperature to convert the animal carcasses to a sterile, aqueous solution of amino acids, sugars, and soaps. The only byproduct of the process is the mineral constituents of the carcasses’ bone and teeth, which are soft enough, after the organic matter is degraded, to be easily crushed by hand. The bone remnants can be captured and reused as calcium phosphate powder (sterile bone meal). The advantages of the process are that it sterilizes and digests in one operation, is more economical than some other forms of disposal, and is environmentally responsible. The disadvantages are the likelihood of capacity constraints, which preclude its effective use in large-scale digesters; and its restricted availability in current times.

Disposal of Excreta

The techniques in this section are described in order of increasing permanency and complexity. In some emergency situations, several of these options are used at different stages of the response as the situation develops. The techniques such as defecation fields, shallow trench latrines, and deep trench latrines have mostly been used in displacement emergencies, but may be useful in any situation where temporary toilets are needed at short notice. The other techniques are widely used in stable situations, but can be adapted to any long-term emergency settlement. The needs of small children should be given special attention.

Portable Toilets

If approved flush toilets and sanitary sewage disposal facilities are inoperable, unavailable, or insufficient in number at the temporary housing or shelter area, other methods of approved excreta and sewage disposal become necessary. Portable toilets provide an immediate solution to this problem, and a shelter manager is assigned the responsibility of ensuring that the prescribed toilet fixtures and facilities are provided and maintained in a sanitary condition. The following practices could be followed in maintaining portable toilets in disaster-affected areas:

- Portable toilets are to be furnished at the ratio of one toilet per 75 shelter occupants.
- Portable toilets are to be serviced daily.
- Hand-washing facilities are to be provided in close proximity to the toilets. If running water is not available, individual packets of hand cleanser must be provided by the shelter manager.
- In the event that an approved sanitary sewer system is not available, wastewater from hand washing, bathing, and the food service operations may be disposed of in properly constructed soakage pits or soakage trenches. These are to be used only for a week at the most.

Shallow Trench Latrines

Shallow trench latrines allow faeces to be buried and far better contained than in a defecation field. The basic requirement is one shallow trench, measuring approximately three-to-five metres in length, for every 100 people, and it is preferable to opt for a number of shorter, shallow trenches. Trenches should never be used for more than a week before they are completely filled, compacted, and replaced by new trenches. Shallow trench latrines should be sited in the same way as defecation fields. Consultation with the camp health committee usually establishes whether it is better to arrange for each family in a tent or shelter to dig and use its own shallow trench. For this purpose a stock of shovels should be provided to the residents.

After each visit, the user should shovel into the trench sufficient soil to cover the excreta. Boards placed along the edges of the trench provide stable footing and prevent the sides from caving in. When the trench is filled to within 30 cm of the top, or after a week’s use (whichever is earlier), it should be completely filled, compacted, and marked for future identification, and a new trench should be dug for use.

Deep Trench Latrines

An improvement on the shallow trench latrine is the deep trench latrine, which is deeper, longer, and wider. It can last one-to-three months and can be constructed from a variety of materials, including wooden planks.
and plastic squatting plates for the floor, and plastic sheeting and wooden planks or metal sheets for the superstructure. The latrines are normally 10 m long, each provided with 10 plastic squatting plates, and superstructures with wooden frames and either metal or plastic sheeting.

Each deep trench can accommodate up to six cubicles, which should be screened for privacy. Each cubicle measures 90 cm x 80 cm. At peak usage, a reasonable estimate is 50 users per day per cubicle, or 240 users each day for each deep trench. Soil is piled up and used to cover excrement, as in a shallow trench system. The simple arrangement of using boards across the trench as footrests can easily be improved on as time and materials allow. Eventually, however, a wooden cover with either squatting plates or seats can be constructed. Volunteers should be mobilized to help with such improvements - some residents may have experience in carpentry -, and the use of ashes and soil to cover excreta can help to control flies and curtail odours.

A new improvement is the use of plastic latrine slabs placed in line over a deep trench to form a row of toilets which are quick to construct and easy to keep clean.

**Simple Pit Latrines**

Individual, simple pit latrines, either hand-dug or drilled, may be an option in lower-density, longer-term emergency settlements. Family latrines are normally preferred as they are more hygienic than public facilities, and allow long-term benefits in terms of maintenance. A family can dig its own latrine, if given clear instructions and provided with tools. Initial, simple screening which provides privacy can later be improved to give protection from the weather, as needed. A basic essential is that squatting holes are attached with tight-fitting lids which are always closed by users after every visit to the latrine as a deterrent to flies, mosquitoes, and odours.

The latrine slab can be of sawn timber, logs (with or without an earth covering), concrete, plastic, or a combination of two or more of these. The latrine superstructure may be a wooden framework covered with plastic sheeting, grass, or other local materials. Temporary superstructures may be replaced by the users with more permanent materials after the emergency phase. The choice of materials for slabs and superstructures will depend on considerations such as cost, local availability, environmental impact, and ease of use for families constructing their own latrines.

Normally, the pit should be designed to last at least a year, and its volume should be calculated on the basis of about 0.07 m per user per year. In unstable soils, the top 50 cm. of the pit, or the whole depth of the pit, may need to be lined to prevent collapse. Pit linings may be made of many different materials, including brick, concrete, old oil drums, or bamboo, and normally should not be watertight below a depth of 50 cm.

**Other Types of Latrine**

The simple pit latrine is the basis for the design of a number of other types of latrine, described below. Some may be appropriate for specific soil or site conditions. Most require more time, materials, and specialist knowledge for their construction.

**Ventilated Improved Pit (VIP) Latrine**

The VIP latrine incorporates one-way ventilation through the pit to reduce odours and insect breeding. While non-ventilated latrines should have lids to reduce these problems, the VIP latrine does not require a cover over the defecation hole if there is sufficient wind to create an air flow up the pipe. The extremity of the ventilation pipe should be covered with mosquito netting, hindering flies that breed in the pit from leaving the latrine when they fly up the pipe towards the daylight while, at the same time, impeding the entrance of flies on the outside that are attracted by the smell from the top of the pipe. The pit design is the same as that for the simple pit latrine.
**Double-pit Latrine**
Double-pit latrines (Figure 8.6C) are useful where room is limited for new pits. The filled side can be emptied via an access hatch while the other side is being used. If the filling of one side takes sufficient time (from a minimum of six months to, perhaps, two years), emptying can be delayed until anaerobic decomposition has killed the pathogens. Double-pit latrines may be ventilated or non-ventilated.

A variation of the double-pit latrine is the twin-pit latrine that uses water-seal toilets. Two separate pits are joined to a water-seal toilet with a pipe that has a Y-junction in an access chamber. Each separate pit is used in turn, as with the double-pit system, switching between pits being achieved by blocking one-half of the Y-junction. Raised or mound latrines can be used where the water table is high.

**Composting Latrine**
The composting latrine is suited to lower-density, longer-term settlements, where the compost produced can be used in food production. It may take 12–24 months for the compost to become safe to handle, depending on the climate.

**Water-seal Latrine**
Water-seal (or pour-flush) latrines are similar to simple pit latrines but, instead of a squatting hole in the cover slab, they have a shallow toilet pan with a water seal. In the simplest type, excreta falls directly into the latrine pit when the pan is flushed with a small quantity of water. Pour-flush latrines can be connected, at a later stage, with either a septic tank - from which the effluent can be disposed of by means of subsurface-soil absorption - or a small-bore sewer system. It may be possible to install such latrines, depending on the lead time in the setting-up of an emergency settlement; the length of its life (hence the time available for incremental improvements); its location; and the availability of pour-flush pans.

**Disposal of Sewage and Wastewater (sullage)**

*Assessment and Design of the Response*
The scale and nature of the wastewater problem should first be assessed. Important information includes: the amount of wastewater produced, and the variations in its production during the day and over longer periods; the nature of the wastewater, including whether it is likely to be contaminated with faeces, and the characteristics pertinent to the disposal method to be used; the source of the wastewater; the location of risks or nuisances it may cause; and soil, topography, climate, and other factors that may determine the choice of possible disposal options. In many emergency situations, it may be judged that the quantity and the nature of the wastewater produced do not present a health risk sufficient to justify control activity. In others, efforts to limit the production of wastewater may be sufficient to keep the problem under control. In many situations, however, specific measures are needed to dispose of wastewater, and these are described below. The response chosen should take the above-mentioned factors into account, and be carried out in a way that complements concurrent activities in water supply and excreta disposal.

The main options for the disposal of wastewater are: discharging it into water courses, with or without treatment; or infiltrating it into the soil; or using it for irrigation (in which case most of the water is disposed of by infiltration, evaporation, and evapo-transpiration).

*Discharge into Water Courses*
If nearby water courses suitable for accepting the type and quantity of wastewater produced are available, the best disposal method may be to direct the wastewater to them via pipes or open channels. It may be possible to make a connection to an existing drainage network and thereby to treatment and discharge installations. It is important for staff to investigate the drainage system as far as the final discharge point, to avoid creating or contributing to environmental pollution and contamination of water supplies. But where relatively small quantities of slightly contaminated wastewater are produced (for instance, the water spilled at a water collection point), discharge into a water course may have no significant environmental impact.
**Infiltration Techniques**

Infiltration into the soil should be facilitated where large quantities of spilled or used water will accumulate, e.g. under water distribution tanks and taps, outside bathing rooms and laundries, and near communal kitchens. The simplest technique is to construct a soak-away (or soakage pit). This is an excavation at least 1.25 m deep and 1.25 m wide, filled with stones and allowing water to seep into the surrounding ground. It is sealed from above by an impermeable layer (oiled sacking, plastic, or metal) to discourage insect breeding. Wastewater is fed by a pipe into the centre of the pit.

In emergencies, soak-aways may consist simply of pits filled with small stones or gravel into which wastewater is directed. As long as the water level in the pit does not rise above the top of the ground, insect breeding is minimal. Soak-aways can dispose of only a limited amount of water because they provide a relatively small area of soil surface for infiltration. Infiltration trenches, which are commonly used for the disposal of the effluent from septic tanks, overcome this problem through a series of parallel trenches in which perforated pipes are laid in a bed of gravel.

**Evaporation and Evapo-transpiration Techniques**

Where infiltration methods do not work effectively because of low soil permeability, wastewater may be disposed of by using it for irrigation. Even when infiltration methods are possible, it may be appropriate to use wastewater for vegetable gardening when water for irrigation is scarce. Such a system might be considered for longer-term use, for instance, adjacent to a nutrition rehabilitation centre, health centre, or school. Water is directed into garden plots by simple flood irrigation, or by allowing it to collect in basins from where it is carried to plots. Care must be taken to allow flood-irrigated beds and storage basins to dry out regularly to avoid mosquito breeding.

A simpler system that does not involve irrigation is to allow water to flow into shallow pans, where it simply evaporates. Alternatively, soap-free wastewater from spillage at water collection points may be used for watering livestock, but care should be taken not to create muddy and contaminated areas near water points.

**Grease Traps**

Irrespective of which disposal method is chosen, wastewater from the kitchen and laundry areas should first be put through a grease trap. If hot water containing fat is run into an adequate supply of cold water, the fat solidifies and rises to the surface, where it can be skimmed off. A strainer is fitted to the inlet to catch any large particles that might pass through the trap and choke the inlet to the soakage pit. The first baffle prevents the incoming water from disturbing the layer of grease, the second keeps the effluent from carrying it off. Grease traps are also effective in reducing the amount of sand and soap in wastewater.

**Disposal of Household Refuse and Solid Waste**

This section deals with the disposal of household refuse and market waste.

**Burial**

In low-density settlements where relatively small quantities of refuse are produced, small refuse pits may be dug by each family. Alternatively, a communal trench 1.5 m wide and 2 m deep can be excavated by hand for the refuse. Each day, refuse should be covered with 20–30 cm of earth. When the level in the trench is 40 cm below ground level, the trench should be filled with earth and compacted, and a new trench dug. If time and available labour permit, refuse should be separated into material that is biodegradable (vegetable matter), which should be dumped in one trench, and other material (bottles, cans, plastic, etc.), which should be dumped in another. The biodegradable refuse can be unearthed after six months and used as compost. Bottles and cans may be cleaned and recycled, but care should be taken to segregate all containers used for dangerous chemicals such as pesticides. Containers that have held pesticides should be crushed so that they cannot be reused, and should be buried far from any water source.
Sanitary Landfill
In most cases, the use of sanitary landfills is the best option for final disposal. When existing landfills are inoperative or inaccessible, the construction of new landfills becomes necessary. The landfill site should be:
- located away from the settlement;
- easily accessible;
- situated on vacant/uncultivated land;
- located in natural depressions with slight slopes;
- facing downwind from the settlement;
- organized to avoid surface water and groundwater pollution; and
- sited in an area that is not exposed to landslides or earthquakes.

The site must be carefully selected, as it may be used as a permanent place for final disposal. Earthmoving equipment may be needed to modify the site and to manage the landfill operation.

Incineration
Incineration is a third possibility, but it is not usually suitable for the volume of domestic refuse produced by the general population, because it requires large incinerators and considerable amounts of fuel, and inevitably causes air pollution. Incinerators should be located away from the settlement, on the opposite side from the direction of the prevailing wind. They should be built on an impervious base of concrete or hardened earth. Ash and any unburned refuse should be buried and covered with 40 cm of soil. In many countries, waste is partially burned at landfill sites. This has the advantage of reducing the volume of waste to be buried, but the smoke created is a nuisance and a health hazard.

Waste Recycling
It may be appropriate to encourage and facilitate the recycling of refuse after its collection and transport. Refuse can be sorted as an income-generating activity, producing separate lots of paper, glass, metals, and plastics for recycling, where these materials are present in significant quantities in the common refuse heap. Measures should be taken to ensure that people sorting refuse for recycling are protected from health hazards such as exposure to harmful chemicals and cuts from sharp-edged substances.

Composting is a practical way to treat the residue of organic waste after sorting. Simple methods produce good-quality compost for use in gardens. It may be possible to co-compost refuse and sludge by emptying latrines and septic tanks. In this case, special attention is required to ensure compost heaps attain and maintain adequate temperatures to kill pathogens. If there is any doubt on this, the compost should be stored for at least a year before use.

Disposal of C&D Waste
As a result of a natural disaster, large quantities of building stock and infrastructure are often damaged beyond economic repair and require demolition with subsequent removal of debris. Management of these waste streams can prove a considerable challenge for national and local authorities during rehabilitation and reconstruction. If such construction and demolition (C&D) wastes are not properly managed, they may subsequently impose serious environmental and economical burdens in the reconstruction phase. This also includes the negative effect that debris can have on the general municipal waste collection-and-handling operations, which is a major challenge following disasters.

It is understood that during site clearing and reconstruction work, numerous opportunities arise for the reuse and recycling of the demolition debris, with subsequent provision of building materials for the ensuing reconstruction work, thereby reducing the quantities of waste directed to the often limited disposal sites. It should be noted that the construction and demolition waste stream does not include solely the demolition rubble, but also the construction waste generated during the ensuing rehabilitation and reconstruction work.
Debris management entails debris collection, transportation, and disposal. It must take into account the special treatment of hazardous waste, as well as the environmental implications of such risk-related work. The various components of rubble should be separated to facilitate recycling. Metals, mainly iron and steel, can be smelted for reuse. Concrete can be crushed for road building, land reclamation, etc. Wood can be used as fuel. In many cases, the local population will spontaneously recover useful materials. This activity may need monitoring to reduce the risks of accidents and avoid legal problems. The final disposal may be in landfill sites.

**Types of Debris**

Three types of debris are associated with a disaster:

- debris generated *directly* by the disaster, e.g. rubble, roofing, insulation;
- debris generated *indirectly* by the disaster, e.g. spoiled food due to power failure or excessive donations; and
- debris generated by *abnormal patterns of life*, e.g. greatly increased consumption of bottled water and canned food.

To facilitate decision-making in respect of debris collection and disposal priorities, it is important to classify and group debris into categories. The criteria used to establish debris categories will depend on local variables, for example:

- amount of debris generated;
- type of region, e.g. urban, rural, coastal;
- land use, e.g. agricultural, residential, industrial;
- types of wastes, e.g. non-hazardous, special; and
- recycling infrastructure and programs.

Examples of debris that might be generated by a disposal include the following:

**Debris subject to putrefaction**

- animal carcasses: cattle, pets, and wild animals; and
- food remnants: meal leftovers or food spoiled as a result of power failure.

**Vegetation**

- leaves;
- branches; and
- uprooted shrubs and trees.

**Inert environmental debris**

- dirt;
- mud;
- rocks; and
- sand.

**Construction debris**

- acrylic;
- asphalt;
- blinds;
- brick;
- carpet;
- concrete;
- drywall;
• electrical wires, lamps, bulbs;
• glass and mirror;
• insulation materials (fibreglass, Styrofoam, etc);
• masonry;
• metals (steel, iron, aluminum, copper, brass, etc);
• tiles;
• pipes;
• plastic;
• rubble;
• vinyl; and
• wood.

*Appliances, household equipment, and furniture*
• beds and mattresses;
• upholstered furniture;
• computer equipment, telephones, typewriters;
• desks, chairs, chests;
• lamps;
• sofas; and
• washing and drying machines, refrigerators, dishwashers, stoves, hot water tanks, furnaces.

*Personal items and objects*
• art work;
• books and papers;
• clothing; and
• cooking utensils, china, glassware.

*Hazardous wastes*
• asbestos;
• biomedical wastes;
• cleaning agents;
• combustibles;
• explosives;
• fertilizers;
• oils;
• paints;
• pesticides;
• radioactive substances;
• solvents; and
• other toxic substances or materials.

*Debris Risk Estimation*
Reasonable estimates of the amount of debris by type will improve the overall clearance efficiency, for example:
• define resource needs;
• allocate adequate resources;
• evaluate disposal capacity of existing sites; and
• estimate hauling time.
The level and variety of methods and technologies required to estimate the amount of debris generated will depend on the type, magnitude, and extent of the disaster, for example:

*Visual inspection*
- aquatic;
- terrestrial: vehicular and pedestrian; and
- aerial: aircraft and helicopters.

*Photography*
- common;
- aerial: aircraft and helicopters with photo/video capability; and
- satellite.

**Collection**
The choice of a debris collection method will depend on the following criteria:
- amount of debris generated;
- type of debris;
- urgency of site clearance;
- disaster site characteristics;
- debris recycling possibilities; and
- geographic complications.

Tools and equipment for debris collection are mainly for collecting, separating, and lifting. The same equipment is used by the construction and heavy duty industry, e.g. bulldozers, front-end loaders, cables, cranes, cutting torches, hand tools (shovels, picks, hammers, handcarts, etc), mechanical shovels, saws, and vacuum equipment. Debris collection equipment should also include protective clothing and apparatus for workers.

**Transportation**
The efficiency of debris transportation depends on the hauling time, i.e. the time spent in travelling between the debris clearance areas and the disposal sites. Some strategies to increase the transportation efficiency include:
- First consolidate a transportation network and then clear whole sectors. Transportation corridors progress from primary routes to secondary feeder roads to residential streets.
- Establish a transportation network with well-defined uses. Classify roads according to their use (general public, debris transportation), the vehicle speed (emergency vehicles), and the destination linkage (highways, disposal sites).

**Disposal**
Debris disposal could be a major challenge of the overall debris management during a disaster, not only because the volumes generated could be overwhelming, but also due to potential hazards to the environment. In major disasters, the total clearance may take months or even years.

Some strategies that could be used when faced with debris disposal problems include:
- Increase the number of disposal sites, e.g. gullies, natural or artificial cavities, etc.
- Increase disposal methods, e.g. incineration, composting, etc.
- Reduce debris volume, e.g. grinding, chipping, crushing, granulating, mulching, etc.

**Sorting of C&D Wastes**
A pre-condition for recycling C&D wastes is that the waste stream is sorted into recyclables and non-recyclables. This is optimally performed at the site of waste generation, i.e. at the site of demolition or construction. It is thus important for demolition contractors to sort their wastes and transport the recyclables
to recycling depots. The non-recyclables then need to be disposed of at authorized landfills. Building owners are also responsible for ensuring that the contractors are obligated, through the construction and/or demolition contract, to sort their wastes.

**Plant and Equipment**

The design of the plant and equipment required for processing the C&D wastes need to be based on the strategy’s overall ambitions, taking into account the sustainability and capacity-building factors. This machinery is typically robust and simple, resembling the types of machinery used in the quarry industry. However, certain modifications of the quarry machinery are required, as for the separation of the reinforcement bars and other contaminants. The recycling machinery is available worldwide on the construction market and can be delivered within 4–8 weeks of placing an order.

An important aspect of machinery procurement is the after-sales servicing of the machinery with a ready supply of spare parts and support. Thus, the make and model of the plant and equipment chosen must be appropriate to local conditions, taking into account the locality of service workshops, climate, and power supply. Furthermore, the plant and equipment procured can also be designed to fulfil other functions, for example, the processing of quarry materials. This will ensure that the machinery is utilized throughout its operational lifetime.

**Logistics**

The haulage and handling of the C&D wastes is an important environmental and economic parameter in the preparation of the strategy. Haulage costs can be prohibitive, and efforts should be made to minimize them, especially where trucks are not easily available and/or the disaster has damaged road infrastructures. Such drawbacks can be dealt with by either selecting decentralized depots for the storage of C&D wastes with processing by a mobile recycling plant, or utilizing a central depot with a stationary recycling plant. The quantities and sources of C&D wastes, with a cost-benefit analysis of the haulage costs versus prices for natural raw materials, will help in indicating the most environmentally and economically optimal solution.
REFERENCES

2. Ellis, Dee B., D.V.M. Carcass disposal issues in recent disasters, accepted methods, and suggested plans to mitigate future events, Public Administration Program, Texas State University, USA. http://ecommons.txstate.edu/cgi/viewcontent.cgi?article=1068&context=arp.
CHAPTER 8. DISASTER-RESISTANT HOUSING AND CONSTRUCTION

Introduction
Earthquakes, cyclones, and floods cause extensive damage to buildings, resulting in an overwhelming loss of life and property. Buildings prone to such disasters are the single most important cause of such loss. Therefore, vulnerable houses and other structures made of mud or stone or brick, which are common among the developing countries, must be adequately strengthened to withstand such disasters; and, even more important, existing buildings need to be strengthened or retrofitted to ensure that they are relatively safe. Mitigation measures in the form of retrofitting could significantly reduce the chances of structural damage and casualty.

TECHNOLOGY OPTIONS
Disaster-resistant construction and retrofitting technologies are already available in the public and private domains. The technologies range from simple techniques for retrofitting non-engineered buildings to modern and complex civil engineering solutions for constructing engineered building structures and bridges. The technology selected must suit the type of structure, extent of damage, and availability of materials, manpower, funds, etc.

Objectives of Retrofitting
Retrofitting is the modification of existing structures to make them more resistant to seismic activity due to earthquakes, tropical cyclones, thunderstorms, floods, etc. Strengthening of a building entails either enhancement of its component strength or modification of its structural system or both. Such retrofitting is expected to improve the structure’s overall strength in the following ways:

- Increasing the lateral load resistance by reinforcement or by adding new walls and columns.
- Introducing continuity between the structure’s components to achieve ductile performance. This will include connection of wall with roof, including bands and ties between walls, and introducing connections between walls as also between roof and walls.
- Eliminating prevalent weakness in an existing building by introducing symmetry in plan, changing location of mass, reducing large openings, etc.
- Avoiding brittle modes of failure which includes improving anchorage and providing bracings in walls.

Steps in Retrofitting
The process of retrofitting involves several steps. These are:

- Understand the existing construction in depth, especially its “what’s” and “whys”, and the stress path caused by seismic forces.
- Assess the structure’s weakness, and the repercussions of an earthquake of an expected intensity.
- Identify the measures to counter the weaknesses.
- Estimate the cost of application of each measure.
- Calculate the budget.
- Decide on the sequence and mix (all v/s a few) of measures and their extent (whole house versus portions of it) at the given time, based on the budget as well as the house owner’s convenience.

Retrofitting of Engineered Buildings

Hybrid solution: This technique involves structural methods suitable for ductile reinforcement and the joining of rigid concrete plates and beam structures. As these systems comprise both post-tensioning and external energy dissipation, they are called hybrid solutions. Fibre-reinforced concrete is an essential element.
in such structures as it allows the creation of structural regions capable of "plastic hinging", a feature that promotes progressive flexible joint failure without catastrophic dismantling.

**Isolation:** Generally required for large masonry buildings, excavations are made around the the building’s foundations, and the building is separated (in piecemeal fashion) from the foundations. Steel or reinforced concrete beams replace the connections to the foundations while, under these, layered rubber and metal isolating pads replace the material removed; these, in turn, are attached below to new or existing foundations. The pads absorb energy, transforming the relative motion between the ground and the structure into heat.

**Dampers:** Dampers absorb the energy of motion and convert it to heat, thus "damping" resonant effects in structures that are rigidly attached to the ground. In such cases, the threat of damage does not come from the initial shock itself, but rather from the structure’s periodic resonant motion which is induced by repeated ground motion.

**Shock absorbers:** Shock absorbers, similar to those used in automotive suspensions, may be used to connect portions of a structure that are free to move relative to each other and that may collide during an earthquake.

**Tuned mass dampers:** Tuned mass dampers employ movable weights with dampers. These are typically used to reduce wind sway in very tall, light buildings. Similar designs may be selected for earthquake resistance in 8-10 storey buildings that are prone to destructive earthquake-induced resonances.

**Active damping with fallback:** Very tall buildings ("skyscrapers"), when built with modern lightweight materials, might sway uncomfortably (but not dangerously) in certain wind conditions. A solution to this problem is to include, at some upper storey, a large mass that is constrained yet free to move within a limited range, and moving on some sort of bearing system such as an air cushion or hydraulic film. Hydraulic pistons, powered by electric pumps and accumulators, are actively driven to counter the wind forces and natural resonances.

**Reinforcement:** The most common form of seismic retrofit to lower buildings is adding strength to the existing structure for resistance to seismic forces. The strengthening may be limited to connections between existing building elements, or it may involve adding primary resisting elements such as walls and frames, particularly in the lower storeys.

**Multiple piers in shallow pits:** Some older, low-cost structures are elevated on tapered, concrete pylons set into shallow pits - a method frequently used to attach outdoor decks to existing buildings. During an earthquake, the pylons may tip, knocking down the building to the ground. Such a catastrophe can be overcome by using deep-bored holes to contain cast-in-place reinforced pylons, which are then secured to the floor panel at the corners of the building. Another technique is to add sufficient diagonal bracing or sections of concrete shear wall between pylons.

**Reinforced concrete column burst:** Reinforced concrete columns typically contain large diameter vertical rebar arranged in a ring, surrounded by lighter-gauge hoops of rebar. A simple retrofit is to surround the column with a jacket of steel plates formed and welded into a single cylinder. The space between the jacket and the column is then filled with concrete - a process called grouting.
**Brick wall resin and glass fibre reinforcement:** Brick buildings are securely reinforced with coatings of glass fibre and appropriate resin (epoxy or polyester). In lower floors these may be applied over entire exposed surfaces, whereas in upper floors such reinforcement may be confined to narrow areas around openings of windows and doors. This coating provides tensile strength which stiffens the wall against bending away from the side with the application.

**Reinforced concrete wall burst:** Concrete walls are often used at the transition between elevated road fill and overpass structures. One form of retrofit entails drilling numerous holes into the wall’s surface, and securing short, L-shaped sections of rebar to the surface of each hole with epoxy adhesive. Additional vertical and horizontal rebar is then secured to the new elements, a form is erected, and an additional layer of concrete is poured. This modification may be combined with additional footings in excavated trenches and additional support ledgers and tie-backs to retain the span on the bounding walls.

**Reinforced concrete post to beam connections:** An examination of unsound structures often reveals weakness at the corners, where vertical posts join horizontal beams. These corners can be reinforced with external steel plates, which must be secured by through bolts and which may also offer an anchor point for strong rods. The horizontal rods pass across the beam to a similar structure on the opposite side, while the vertical rods are anchored after passing through a grouted anti-burst jacket.

**Retrofitting of Non-engineered Buildings**

Many buildings are informally constructed, conforming to traditional practices rather than any formal design by qualified engineers or architects. Such buildings are composed of stone, brick, concrete blocks, rammed earth, wood posts, and thatch roof or a combination of some or all of the foregoing materials. They are built with mud, lime, or cement mortar. The safety of these non-engineered buildings against earthquakes is of great concern, especially because most of the fatalities during past earthquakes have occurred in such buildings. The retrofitting of such buildings requires different materials, methods, and technologies, which are briefly described below.

**Repairing materials:** Cement and steel are commonly used for repair work. Various types of cement with properties such as shrinkage compensation, low heat, and sulphate resistance are preferred for specific repair applications. Steel in the form of bolts, threaded rods, angles, and channels, and high strength pre-stressed steel are also useful. Wood, bamboo, and casuarinas are often used for temporary supports. The commonly used binding and repairing materials include: shotcrete; epoxy resins; epoxy mortar; gypsum cement mortar; quick-setting cement mortar; micro-concrete; fibre-reinforced concrete; mechanical anchors; fibre or reinforced polymer (FRP and CFRP materials); metal plates; steel and aluminum; ferro cement; etc.

**Repairing cracks:** Cracks of width smaller than 0.75 mm can be effectively repaired by pressure injection of epoxy. For cracks wider than 6 mm and where brickwork or concrete is crushed, steel and polymer mortar are effective.

**Local modifications:** Local modifications entail the strengthening of structural components such as walls, locally. This can be achieved by local modification, such as either closing the opening or providing reinforcement around it.

**Global modification:** Global modification includes the insertion of walls with the intension changing the building’s lateral load performance. This reinforces overloaded members and ensures better seismic strength. Such an exercise is also undertaken to change the building’s centre of mass or centre of stiffness to avoid torsion due to asymmetry.
**FRP retrofit:** FRP composites are tailorable, flexible, and easy to apply. Hence they can be used in a retrofit operation. As their profile is thin, they can be made architecturally pleasing. They don’t reduce the usable floor space.

**Stress-relieving techniques:** This technique involves the insertion of a new structural member in order to relieve an overloaded or damaged component.

**Bracing:** Most non-engineering constructions do not have lateral load resistance. Fixing bracing in a rural hut stabilizes the structural system. The provision of opening for doors can be accommodated by providing bracing on either side of the door. This is achieved by nailing or tying bamboo or casuarina to vertical and horizontal framing members.

**Infilling:** Weak R.C. frames can be stabilized by providing brick infilling at a chosen location and thereby increasing the later load capacity. The infilling will also affect the building’s centre of stiffness. Hence, the choice of infilling should be made with care so that the increase in stiffness and strength of the frame that is infilled does not make other frames or members vulnerable.

**Strengthening roof:** The roof has to be water-proof, distributing the lateral load to the walls. Hence it should act as a horizontal diaphragm. Of the innumerable varieties of non-engineered roofs, some are timber roof truss, light roofing sheets, and thatch roof.

**Modification/strengthening of wall:** In most traditional buildings, masonry walls are used to support the roof. They also provide lateral load resistance. If they are not integrated with the structure, they are sure to crumble in a brittle manner. The various methods of retrofitting such walls by strengthening and integrating with the rest of the structure include:
- inserting new walls;
- strengthening existing walls (a) by grouting, (b) by confining by using more ductile R.C, ferro-cement, or FRP lining, and (c) by inserting pre-stressing bars in pairs on opposite sides of a wall to prevent out-of-plane bending;
- strengthening wall-to-wall connection through “T”- and “L”-junctions in masonry building;
- installing connections in stone walls by using the stitching technique; and
- ensuring external binding and keying (splint and bandage strengthening technique).

**Flood-resistant Housing**
Practical Action has worked with communities to develop simple and affordable flood-resistant housing. Some of the techniques being used include the following:
- **Jute panels** make resilient walls which are of negligible cost yet are quick and easy to replace. Treated bamboo poles on concrete bases are strengthened with metal tie rods to hold the wall firm and safe.
- **A plinth** raises a house. Made from soil, a little cement, and some pieces of stone and brick, a plinth keeps a structure strong and high enough to withstand repeated floods, unlike the traditional earthen floors which simply wash away.
- **Bracings and fastenings** bind the walls firmly to the house ‘skeleton’ through a network of holes and notches – locally called a ‘clam system’ –, and the whole building can stand firm through the strongest of winds and rain.

**Strengthening Timber Structures**
Many methods are available for the reinforcement of weak timber structures. Technologies focused on strengthening structures are constantly developing, adhering closely to a building’s historic character.
Strapping of a Building
Earthquakes, which are essentially the shifting of the earth’s crust, hit a building first at its foundations. For this reason, an analysis of the soil at the building site and the foundation system are important. The structure can be bolted to its foundation, or the timber frame can be strapped together. Strapping provides for the building to perform structurally as a whole.

Infill Openings
Another method of providing structural continuity is to fill in openings. As this affects the appearance of a historical building, it is not a preferred option. Masonry or timber framing, which are very expensive, are used to infill the openings. This method also provides for the building to move as a single unit.

Bracing Existing Members
An interior bracing system is always preferable to exterior ones as it does not mar the building’s original appearance. Bracing systems aim to provide emergency consolidation after a disaster and must be integrated with the building’s existing structural system. Reinforced bracing, which strengthens weakened wooden structural systems, has minimal impact.

The joints of timber buildings between floor, wall, and roof connections, and column and beam ties can be reinforced by using mechanical fasteners such as anchor ties or bolts, metal straps, dowels or pegs of wood, metal or glass, fibre-reinforced plastic, etc.

Retrofitting of Bridges
The disaster caused by earthquakes can be greatly minimized by retrofitting of vulnerable bridges. Two situations that necessitate retrofitting are (i) seismically deficient existing bridges which have not yet experienced any earthquakes and do not meet the current code requirements and (ii) bridges that are damaged in earthquakes. In the latter case, both repair and retrofitting are required.

The need for seismic retrofitting in existing bridges can arise due to any of the following reasons:

- Upgrading of seismic coefficients as a result of revision in the seismic zone.
- Updating design criteria due to revision of the code requirements.
- Bridges not designed to cope with the seismic force.
- Bridges that are damaged in earthquakes.
- Deterioration and aging.

The retrofitting techniques for various portions of bridges are described below.

Superstructure: In superstructures designed for dead load and traffic load with a large safety factor, direct damage resulting from seismic effects is limited. The common retrofit techniques for superstructures are:

- Installation of unseating prevention devices called restrainers which are add-on structural devices that participate in resistance of only seismic force effects.
- Replacement of steel bearings by base isolation bearings.
- Extension of bearing seats.
- Provision of stoppers and devices to prevent jumping of girders.

Substructure: The deficiencies encountered in bridge piers/columns are flexural deficiencies, shear deficiencies, ductility, and lap-spliced deficiencies. These deficiencies could be due to the lack of transverse reinforcement in the plastic hinge region which results in inadequate confinement. Retrofitting techniques for columns are steel jacketing, reinforced concrete jacketing, and FRP jacketing. The use of Advanced Composite Materials is becoming popular in retrofitting because it involves less effort in construction, has favourable mechanical properties, and is lightweight and extremely strong. The procedure involves wrapping
layers of thin, flexible straps or sheets of fibre composites around the column in the plastic hinge zone or along the entire height of the column.

**Foundation:** A structure’s foundation is normally not retrofitted as such work is very costly. The rocking and uplift of the foundation, though undesirable, is often considered a form of isolation and may reduce seismic forces in the bridge superstructure and substructure. The retrofitting option available for footing is the enlargement of the footing size. The retrofitting option for a pile foundation may consist in the addition of piles and then integrating these with existing piles by extending pile caps. The outline of seismic retrofitting techniques for existing foundations are: micro pile methods, the screen pipe drain method, and the super strengthening pile bents method.

**Abutments:** Abutments are subjected to soil pressure from the back-fill side to the front side. Of the two types of abutment movement, one is the movement of an abutment at the top, thus resulting in a tilt on the front side. The other is the movement of an abutment under the footing which results in a tilt of the abutment to the back-fill side. A unique retrofit for the tilt of abutments in the front direction is to replace some part of the back-fills with expanded polystyrene (EPS).
REFERENCES

4. Flood-resistant housing: Adapting to climate change in Bangladesh. http://practicalaction.org/?id=flood-resistant_housing#more