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## *Global Emergency Response to Disasters for a Harmonious World*

## *Part 1: Papers reviewed by TIEMS International Scientific Committee*

**Editors**:
***Snjezana Knezic***
University of Split, Faculty of Civil Engineering and Architecture, Split, Croatia
***Nils Rosmuller***
TNO, Industrial and external safety, Utrecht, The Netherlands

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# 第 17 届国际应急管理大会论文集

## *“全球灾害应对 共建和谐社会”*

## 第一部分：TIEMS 国际科学委员会评审的论文

**编　辑**
***Snjezana Knezic***
克罗地亚斯普利特大学土木工程学院
***Nils Rosmuller***
荷兰乌得勒支市工业安全应用科学研究组织

**2010 年 6 月 8-11 日**
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# SESSION 1: Global Earthquake Catastrophe Emergency Response, Rescue and Recovery

# 议程一:全球地震巨灾的应急响应、救援与恢复重建

# 为受灾地区提供微波传输电量的光伏太阳能虚拟卫星高压电力系统

**Arie Lavie**

*Professor NYIT-New York Institute of Technology and President CTI-Creative Technologies Israel*

E-mail: arlavie@zahav.net.il

**【摘要】**无线电在电信业中的应用是贯穿 20 世纪的一个主要技术。当然，无线电也可以用于其它用途。大家都知道，下五十年的地球能源会非常缺乏，而空间太阳能发电系统恰恰可以帮助人们解决这一问题。微波无线电力传输为受到空间限制安装输电线路困难的地区（也包括受灾地区）提供了一个解决长时间的电力供应问题的技术方案。本文论述了一个光伏太阳能虚拟卫星发电系统可能的发展，作为一个论据论证了通过在天空吸收光电能力，再通过微波无线传输输送给终端用户，包括给受灾地区提供用电的可能性。光电微辐射的概念将超越世界现有的技术发展水平。这项技术的商业应用潜力很广阔，通过光伏太阳能传输给受灾地区电力是非常有创意的的积极探索，并且这个系统的好处还很多，其中也包括成本效益（在天上直接吸取能力）。

**【关键词】**微波辐射；光电；无线能力传输；空间太阳能发电系统

# PV SOLAR PSEUDO-SATELLITE HIGH POWER SYSTEM FOR ELECTRICITY GENERATION BY MICROWAVE-BEAMING TRANSMISSION IN DISASTER AREAS

**Arie Lavie**

*Professor NYIT-New York Institute of Technology and President CTI-Creative Technologies Israel*

E-mail: arlavie@zahav.net.il

## Keywords

Microwave-beaming, Photovoltaics, Wireless-Power-Transmission, Space-Solar-Power-Station

## Abstract

One of the key technologies throughout the 20th century was the application of radio for telecommunications. However, radio can be also used for other purposes such as human welfare. Due to a lack of energy supply

during the next fifty years, Space Solar Power Station (SPS) could help solve the problem. Microwave wireless power transmission (MPT) is a promising technique for the long term power supply for places where it is difficult to install power transmission lines, including disaster areas This article deals with a "PV Solar Pseudo-Satellite Power Station" concept to be developed, validated and demonstrated as a "predominant demonstration component" by transferring the absorbed in the sky PV (Photovoltaic) power to a terrestrial end-user by microwave beaming wireless transmission, including electricity supply to end-users in disaster areas. The PV MICROBEAMING concept is going beyond existing state-of-the-art at world level. It has potential for wider commercial and urgency exploitation by using solar PV energy transmission to disaster areas and innovative elements to utilize the "multiple benefits of PV system" that adds an extra cost-effective use of available PV power absorbed in the sky.

## 1. Introduction

### M ICROWAVE WIRELESS POWER TRANSMISSION - ACTIVITIES IN THE WORLD

Over the last two decades, there has been a substantial amount of work around the world, in the USA, Japan, Russia, Canada, Germany, and France on microwave wireless power transmission.

### US Activities

In the United States an important milestone in the history of microwave power transmission was the three-year study program called the NASA/DOE Satellite Power System Concept Development and Evaluation Program or NASA/DOE reference model, started in 1978. The next program was published in 1997 as an improved SPS reference system, called the Fresh-Look-SPS concepts as the Sun Tower SPS concept which was one of their new models. In 1998 SSP Concept Def. Study was examined. The SSP Exploratory Research and Technology (SERT) program was examined in 2000, and in 2004 SSP Concept & Technology Maturation (SCTM) program has been pursued by NASA.

### European Activities

A Sail Tower SPS was proposed by Europeans in 2001 The characteristics of the European Sail Tower SPS are shown in the following table. In 2005 a point to point wireless power transmission system was examined to deliver 10 kW of electricity power to a small isolated village in Reunion Island, France

CHARACTERISTICS OF THE EUROPEAN SAIL TOWER SPS

| | |
|---|---|
| Frequency | 2.45 GHz |
| SPS Tx Power | 400 MW |
| SPS Tx Antenna (radius) | 510 m |
| Orbit | GEO |
| Final number of SPS | 1870 |
| Receiving antenna site:<br>Final number<br>Antenna size<br>Site including safety zone | <br>103<br>11 x 14<br>27 x 30 km |

| | |
|---|---|
| Power delivered per SPS | 275 MW |
| SPS tower<br>Length:<br>Electricity prod. | <br>15 km<br>450 MW |

The largest application of the WPT via microwave is a Space Solar Power Satellite (SPS). The typical parameters of retro directive space and ground SPS system are shown in the following tables respectively.

TYPICAL PARAMETERS FOR RETRODIRECTIVE SPS SYSTEM

| | |
|---|---|
| SPS orbit | GEO (36,000 km) |
| Frequency | 5.8 GHz |
| Antenna diameter | 2.580 m |
| Power transmitted to earth Total/one element | 1340 MW/0.175 W |

TYPICAL PARAMETERS FOR RETRODIRECTIVE GROUND STATION SYSTEM

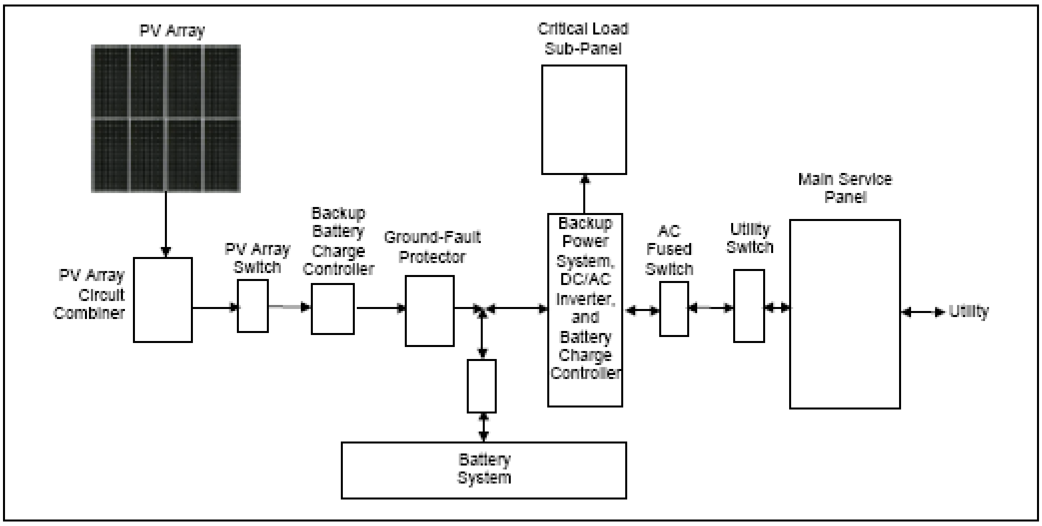
| | |
|---|---|
| Signal power (Pt) | 1 KW (60 dBm) |
| EIRP<br>Free space loss (36,000 km) | 114 dBm<br>199 dB |
| Antenna gain Gt (D=10m, η=0.7) | 54 dBi |
| SPS transmitter antennaelement received power (Pr) | -80 dBm |
| SPS transmitter antenna element gain Gr (circular microstrip antenna) | 6 dBi |
| Atmospheric loss | 1 dB |

## PV MICROBEAMING

### State of the art

The great advantage of a photovoltaic (PV) system is to be able to supply electrical energy to isolated and inaccessible areas with low resources and also as a business opportunity as a small scale energy supplier.

Normally they are composed by photovoltaic modules, inverters, charge regulators, energy storage system and all the necessary electrical (fuses, breakers, plugs, switches), the power surplus is stores and can be sold to the local energy supplier if the installation fits the legal standards.




**Photovoltaic system**

A few advantages and disadvantages of solar power:

Advantages

* The 89 petawatts of sunlight reaching the earth's surface is plentiful - almost 6,000 times more - compared to the 15 terawatts of average power consumed by humans. Additionally, solar electric generation has the highest power density (global mean of 170 $W/m^2$) among renewable energies.

* Solar power is pollution free during use.

* Facilities can operate with little maintenance or intervention after initial setup.

* Solar electric generation is economically superior where grid connection or fuel transport

is difficult, costly or impossible.

* Once the initial capital cost of building a solar power plant has been spent, operating

costs are extremely low compared to existing power technologies.

Disadvantages

* Solar electricity is often more expensive than electricity generated by other sources.

* Solar electricity is not available at night and is less available in cloudy weather conditions.

* Limited power density

* Solar cells produce DC which must be converted to AC

The article objectives are:

1.Analyse and define PV MICROBEAMING operational and performance specifications.

2.Analyse and define technical specifications to demonstrate new PV Solar Pseudo-Satellite Power Station, based on long endurance High Altitude Platform (HAP) absorbing PV energy in the sky.

3.Analyse and define technical specifications for developing wireless energy transmission of a PV Solar Power Ground Station, including PV concentrated solar power, to be transmitted through smart microwave beaming energy networks based on HAPs, to places where it is difficult to install power transmission lines.

4.Analyse an alternative SATCOM application during night time for the pseudo-satellite power station, and a hybrid electricity generation application in night time for the PV solar ground station.

5.Conclude and propose feasibility of PV MICROBEAMING technology by conducting field-tests with test-benches to microwave beaming transmission of PV solar power to airship, and vice versa, propose a test of microwave beaming transmission of PV solar power from airship to ground customer as following described.

## 2. Scientific and technical quality

### 2.1 Concept and objectives

### Proposed objectives

This article tends to provide major scientific breakthrough for high risky/high impact long term emerging concept to analyse and to determine the feasibility terms and conditions for new technology field of an efficient wireless transmission of improved PV energies by a high power Microwave-Beaming technology, from the level of today state-of-the-art of few Kilowatts to the level of Megawatts in the future. Applications of high power transmission could be in the field of electricity generating system by PV and other alternative energies produced in an optimal improved way at specific sites (Solar energy, Hydrogen energy, Wind energy, etc.) to power plant allocated at long distances. Such applications would provide better exploitation of improved alternative energies and impose societal economic impact. Today only a small fraction of PV Solar/Alternative energy sources are exploited due to lack of useful wireless power transmission from the site where energy is optimally generated to specific user and customer. Other uses of this high power PV technology are in PV MICROBEAMING power transmissions to charge energy accumulating devices placed in areas nearby ground PV power stations to provide electricity demands during night in absence of solar radiation. Such combination of using in parallel the PV power absorbed in sky may lead to a dramatic reduction of PV electricity generated cost, even below the today lowest cost of EUR 0.25/ kwh provided to customers.

### Corresponding objectives

In this article the concept of microwave beaming transmission of PV high power generated by an improved ground (possibly regenerative fuel cell) solar station to HAP1 (High Altitude Platform1), and then to a very long distance hovering HAP2 (High Altitude Platform2) at thousands km from HAP1, and then to ground power distribution station to various customers, is investigated and demonstrated. Such way of transmission of PV/alternative energies to isolated or to regions absent of electricity generation infrastructure, would provide abundant, clean, secure and affordable energy to any customer achieving substantial reduction of green house gas emissions too. In the following figures an illustrative description of the concept is presented.

Recently, research works being conducted in NYIT New York Institute of Technology (Final report Nr 993/41349-01 December 2007,new US DOE PEO EIS contract W157-D-E407/0009-0005,2008) in co-operation with Japanese Research Institute show significant progress in the development of “High Power Microwave-Beaming Technology” including new high power source in the GHz range and new transmit antennas design. In this article a scientific challenge justification will be given for long term PV MICROBEAMING research of foundational nature based on laboratory experiments and on field-air-field-tests of proposed test-bench operating at 94 GHz frequency and transmitting 20W/ 20KW power to measure an overall PV transmit/absorbed energy significantly improved efficiency to order of 25%-30%. The proposed tests to be conducted will approve the feasibility and effectiveness of the PV MICROBEAMING concept/technology in the new field of wireless point-to-point power transmission of improved PV/alternative energies generated in an optimal way.

### 2.2 Relevance to the objectives of the article

### RENEWABLE ELECTRICITY GENERATION

Research into, development and demonstration of integrated technologies for electricity production from renewables, suited to different regional conditions where sufficient economic and technical potential can be identified, in order to provide the means to raise substantially the share of renewable electricity production in the EU. Research should increase overall conversion efficiency, cost efficiency, significantly drive down the cost of electricity production from indigenous renewable energy resources including biodegradable fraction of waste, enhance process reliability and further reduce the environmental impact and eliminate existing obstacles. Emphasis will be on photovoltaics, wind and biomass including CHP. Furthermore, research will aim at realizing the full potential of other proposed sources of renewable electricity: geothermal, solar thermal power (i.e. Concentrating Solar Power or CSP), ocean (e.g. wave, tidal power) and hydropower. Policy context: this activity would facilitate the actual implementation of the “Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market (2001/77/EC, O.J. L283, 2./10.2001)” as well as its revision and medium-term application.

### CONTRIBUTION TO THE ENERGY POLICY OBJECTIVES

Research into, development and demonstration of integrated technologies for electricity production from renewables, suited to different regional conditions where sufficient economic and technical potential can be identified, in order to provide the means to raise substantially the share of renewable electricity production in EU. Research should increase overall conversion efficiency, cost efficiency, significantly drive down the cost. Emphasis will be on photovoltaics and other sources of renewable electricity including geothermal, solar thermal power (i.e. Concentrating Solar Power or CSP), etc.

### PV MICROBEAMING photovoltaic solar cell integration

Currently the PV solar cell market is manly dependent on large area polycrystalline silicon solar cells built on top a typical glass substrate with an epoxy resin protection covering/coating, making the technology and the solar cell panels very expensive and, in some cases, impracticable for integration onto/into smaller and flexible structures. Recently, with the development brought by amorphous silicon solar cell technology, flexible solar cells built on top polymeric substrates are becoming a viable option for integrating solar cells onto/into structures that require light-weight and flexibility. However, amorphous silicon solar cells still need to overcome some difficulties, such as the efficiency, durability and unit cost in order to become a viable option.Several research works are focusing on achieving an upgrade in durability and efficiency by introducing new protective and anti-reflective coatings atop the solar cell structure. New technologies are proving that new materials, new multi-layer structures and surface treatments may be the answer to increase both durability and efficiency.Multi-layer anti-reflective coatings of metallic oxides (5),alloys (2), DLC coatings (7,8)&polymeric (9,10) coatings are proving to be the most promising approaches; results show clear improvements in efficiency (up to 40% improvement) and in durability of the solar cell.

## PV MICROBEAMING transmission of photovoltaic generated power

Regarding the microwave-beaming transmission of PV generated power and based on previous research applications, a scope of work, budget and preliminary schedule is presented in this article for an experimental demonstration and assessment of the possibility of using electromagnetic (EM) beamed power for wireless efficient power transmission applications of PV alternative energies for civilian needs, but also for security need to defeat objects of threat that are located at large distance from the emitter/transmitter antenna. Such system could basically be researched to impair transfer of PV power to be absorbed at the receiver/RECTENNA and used by an absorbing device as self generated energy, but to not permanently harm human beings, and that are classified as non-lethal wireless transmission (NLWT) devices.The use of focused electromagnetic beams for the efficient,wireless transmission of PV energy from one point to another is an important area of fundamental research challenge aiming to solve hard problems beyond the present state-of-the-art technology in the sector. The frequency of operation for such systems (including development of power source for given frequency and development of efficient antenna/RECTENNA array) is a crucial research choice:

1. In order to avoid the effects of atmospheric attenuation, frequencies below approximately 6 GHz must be used. For example, at the ISM frequencies 2.45 GHz, the atmosphere is practically transparent even under conditions of high humidity and rain. However at this frequency, the dimensions for the required transmit and receive antennas would be in the range of 50 meters. Antennas dimensions as such would be prohibitively expensive if constructed as continuous rigid structure. It is proposed to research the use of arrays of non-uniformly spaced, relatively small antenna elements to achieve the required electromagnetic focusing, refs. (6, 7). Such antenna arrays would be lighter, mobile and far less expensive to build than a single large, continuous, rigid antenna structure.

2. At altitudes above the earth’s atmosphere, and beyond to outer Space, electromagnetic frequencies of 10 GHz and higher can propagate without experiencing atmospheric absorption. Also, for short distances of 1 to 2 km or less, the effects of atmospheric absorption are not excessive. For example, at 94 GHz, the attenuation through dry air for a distance of 1 km is approximately 0.1 dB. (The attenuation at this frequency would increase sharply under conditions of high humidity and rain.) The diameter and weight of antenna structures required for efficient beam focusing is inversely proportional to the frequency of operation. At 94 GHZ a transmit antenna diameter of 2.5 m would have electromagnetic focusing properties equivalent to that of a transmit antenna diameter of 100 m at 2.5 GHz. At frequencies in the range of 94 GHz, called the millimeter range, development of a rectenna, the integrated receive antenna, and power rectification system

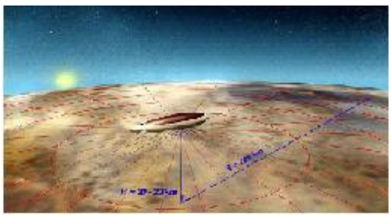
presents a very difficult challenge. The rectenna must provide efficient conversion of the incident high frequency electromagnetic energy to a usable DC power source. Efficient rectenna performance has been achieved at microwave frequencies (e.g. 2.45 GHz) but not yet in the high millimeter range (e.g. 94 GHz). It is proposed to demonstrate the use of specialized array synthesis algorithm, ref.(11, 12),to achieve efficiently performing rectenna at 94 GHz.

In many cases, the terms microwaves are used interchangeably with the term EM waves. Three important factors to be characterized in these research systems: a) Their power levels, b) The spectrum of frequencies used and c) The waveform time dependence of the emissions. With respect to power, levels < 2 kW are generally classified as low power electromagnetics (LPEM) with levels up to tens of megawatts (MW) designated as high power electromagnetics (HPEM). The spectrum emitted can range from single frequency operations, all the way to ultra wide band (UWB) operations in which energy is emitted with a spectrum ranging from hundreds of MHz to 4-5 GHz (see ref. 7). The goals of this article in general will be:a) Analyze NLWT technologies in accord with the definition of mission requirements.b) Develop specialized simulation software for NLWT computer experimentation and performance evaluation. c) Research, develop and construct an experimental proof-of-concept NLWT system.With respect to goal a, our effort will focus on the various levels of system output to assure that the system researched will meet the requirements of the mission. With regard to goal b, a NLWT simulation software will be based on development of specialized EM computational software packages. With regard to the main implementation goal c, it is proposed to research full-scale system operating at 94GHz/20kW (average)-100kW (peak) starting with a scaled experiment at 94GHz/20W that will be used to evaluate key parameters of the full-sized system, to achieve an overall transmitted/absorbed power efficiency of 25%-30% with compare to hardly acceptable few percent efficiency of the today state-of-the-art technology. The concept for such test arises from the need to assess feasibility of using micro-wave beaming system to wireless power transmission of alternative energy. To do so one of the key metrics is to measure the power density at the receiving antenna, rectenna instrumented to determine, among other variables, both the average and peak power densities. Preliminary estimates indicate that for the full scale 20 KW beamed power case, with the target allocated at about 200m from beaming source, the values are approximately 100 KW/m$^2$ (average) and 500 KW/m$^2$ (peak). Scaling the beamed power to 20W (which is the case in this project) indicates that in the proposed test we may see about 50 W/m$^2$ (5mW/cm$^2$).

## 3. PV MICROBEAMING Pseudo-Satellite Platforms

### 3.1 Description of Platforms

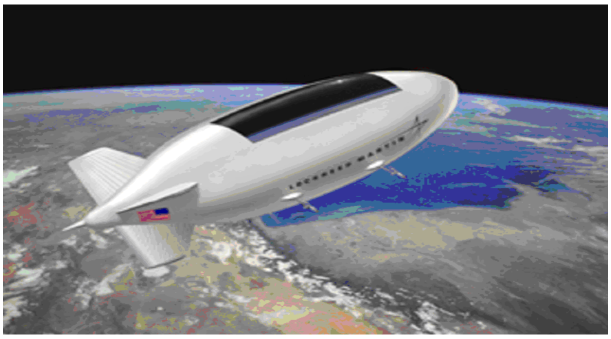
**HAA BERKUT**



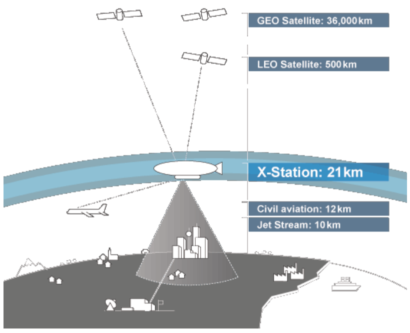
**GLOBAL HAWK HALE UAV**

**Global Observer HALE UAV**

**Lockheed-Martin HAA**



**X - STATION**




a) The **HAA Berkut** is a solar powered airship capable to keep its position over a certain place on a 20 - 23 km altitude. The Berkut can carry up to 1200 kg of various communication and surveillance equipment and supply it with electrical power. Geostationary performance (station keeping) enables to provide various communications, broadcasting and observation services to the territory of more than one million square kilometers.

b) The **Global Observer** USA NASA/AeroVironment stratospheric UAV, presented in the picture below flies today for one week endurance at altitude of 20 km (with liquid Hydrogen), carrying payloads of 35-100 kg mainly for telecom and remote sensing. By year 2008 **Global Observer** will fly for one month with solar/regenerative fuel cell propulsion and payloads of 400 kg.

c) The **Lockheed-Martin** stratospheric airship, presented in the picture below, will be available by year 2009 for 1 month endurance to fly in a quasi-geo stationary position for persistent on station-keeping as a telecommunications relay, a weather observer, or surveillance platform, and will be able to carry payloads of 1000 kg upon customer requirements.

d) The ATG **StratSat** stratospheric airship, similar to the Lockheed-Martin one developed mainly for communications applications to be available by year 2010.ATG claims to negotiate with the Malaysia Government to deliver **5 StratSat** airships above the country, including islands in the Indian Ocean, and to deploy “Telecommunication Backhaul in the Sky” to compensate with the luck of terrestrial infrastructure.

e) The **GLOBAL HAWK,**RQ-4A is high altitude, long endurance unmanned aerial reconnaissance system designed to provide high resolution, near- real-time imagery of large geographical areas. Advanced technology sensors, a range greater than halfway around the world and the ability to remain in flight for long periods of time, enables the Global Hawk to provide surveillance and intelligence data. The new version of the Global Hawk will perform more than 50 hours endurance flight, 65,000 ft altitude and 16,000 nautical miles range.

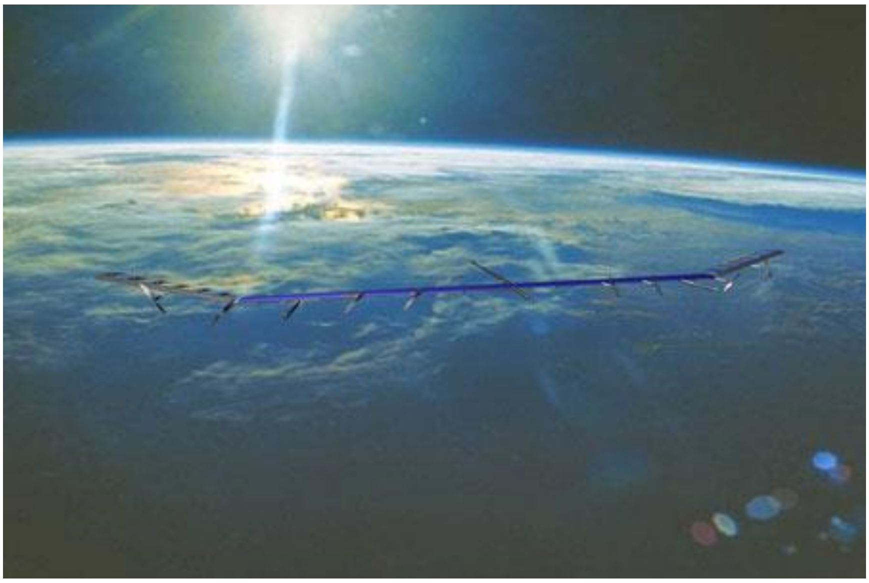
f) The **StratXX LTA Platforms**

**The X-Station (from StratXX AG)** is a LTA platform, developed in Switzerland by the company StratXX AG. Such platform has several unique innovative aspects, leading to high competitiveness in terms of mission profile, payload transportation, system safety, low cost for production ad operation. The

X-Station 100 concept shows an ultralight lifting body, resistant to the harsh thermal environment of the lower stratosphere, and a so-called Payload Plane, being connected underneath the LB, and containing all the electronics, propulsive system, Electric Power System, etc.

**The PhoeniXX(from StratXX AG)** is a LTA all weather platform, developed in Switzerland by the company StratXX AG. Such platform has several unique innovative aspects, leading to high competitiveness in terms of mission profile, payload transportation, system safety, low cost for production ad operation.

g) The **BOEING VULTURE Ultra-Long-Endurance Aircraft**



Boeing has received a $3.8 million Defense Advanced Research Projects Agency contract for Phase 1 of the Vulture program. Vulture is an ultra-long-endurance aircraft that could stay aloft for several years and serve as a pseudo-satellite system. The yearlong Phase 1 covers conceptual system definition, and formal reliability and mission success analysis, concluding with a System Requirements Review. It also requires conceptual designs for sub- and full-scale demonstrators.

### 3.2 Progress beyond the State-of-the-Art

The DoubleSun ® technology, developed by the R&D group at WS Energia, combines the benefits of solar concentration, provided through flat metallic mirros, with the benefits of solar tracking systems, provided by state of the art solar trackers.

The HELIOTS® products (series based on the DoubleSun tech platform) includes, mirrors, solar tracking system, linear motor and electronic system control. The elements are all produced using fisrt-class material: galvanized steel, zn-coated - UV and outdoor resistant aluminium for the mirrors, polycarbonate " bullet proof" panels for the mirrors support and stainless steel for the modules clips. The tracking elctronics uses sensors to detect the inclination of the trackers and to automaticly adjust it to the best angle.

HELIOTS® system with DoubleSun® technology, increase up to 160% the energy produced by photovoltaic solar modules. The high efficiency Si-mono cristalline panels have 20 years warranty over the power levels.

### 3.3 Applications of PV solar power by energy wireless transmission

**Photovoltaic system – Solar energy generation**

Solar cells that are resistant to environment at those altitudes must be thin, flexible and light and can be easily fixed to the surface of the aircraft wingspan. Of course these solar cells must be coupled with another power system for night operations: this could be with fuel cells or batteries.

The traditional solar cell is a single crystal semi-conductor deposited onto glass, which is efficient but heavy and expensive.At 22 km altitude, the solar power is over 1 kW/$m^2$. With a 8% efficiency for the solar array, that is translated into 80 W electricity per $m^2$. For an airship with total surface that could reach 25-30.000 $m^2$, only a small percentage of the surface needs to be covered with solar cells as the required daytime required power should be something like 400 kW (of which 15 for the payload). For aircraft applications a different consideration should be assumed as explained later.

The lenticular shape offers for the solar cells some advantages. Even if using solar energy as the primary source of power is accepted as a reasonable approach,several aspects have to be kept in mind looking in some more level of detail.

## Alternative solutions for use of solar energy

What is sometimes referred as the "Regenerative Fuel Cell (RFC)" for use at night is certainly an attractive future solution. In the day, the airship drives its propellers and the payload with the solar arrays and uses the surplus power to electrolyse at-night-fuel-cell-produced water into hydrogen and oxygen. At night, the RFCs generate power through the reaction of these gases.

## Plataforma Solar de Almeria

In the province of Almeria in southeast Spain, on the edge of Tabernas Desert, lies the Plataforma Solar de Almeria (PSA). On this over-250-acre site, the full force of the Andalusian sun has been exploited since 1980 for the testing and optimisation of a variety of high-temperature solar technologies under nearly practicable conditions. More than 20,000 square metres of mirrors of various shapes in different test facilities concentrate the direct solar radiation to generate high and extremely high temperatures. These facilities in the middle of a barren landscape, some of which seem to have come from the future, make up the largest test centre in Europe for concentrating high-temperature solar technologies - and one which leads the world in its variety.

Plataforma Solar de Almeria

## 4. PV solar pseudo-satellite for renewable electricity generation

### 4.1 High Altitude Airship " Berkut "

Application of the High Altitude Airship Berkut Our High Altitude Airship (HAA) Berkut is a unique combination of lighter - than - air and space technologies, a cost effective alternative communication and earth observation.The HAA Berkut is a solar powered airship capable to keep its position over a certain place on a 20 - 23 km altitude. The Berkut can carry up to 1200 kg of various communication and surveillance equipment and supply it with electrical power. Geostationary performance (station keeping) enables to provide various communications, broadcasting and observation services to the territory of more than one million square kilometers. It covers any large metropolitan areas and such countries as France or United Kingdom! Unlike geostationary satellites, the HAA allows to repair, upgrade or replace the equipment every 3 - 4 months while the airship perform service landing. This stratospheric platform is expected to generate new earth observations at the local area (highly important for anti terrorism and anti smuggling missions).

### 4.2 Microwave beamed energy for solar power wireless transmission

This article tends to provide major scientific breakthrough for risky long term research aiming to determine feasibility conditions for new emerging field of efficient wireless high power transmission by Microwave-Beaming (MICROBIMING) technology, from a level of today few Watts to a level of MWatts. Applications of high power transmission could be in the generation of Alternative Energies produced in optimal way at specific site (Solar energy, Wind energy, etc) to power plant allocated at long distance. Such applications would provide better exploitation of alternative energies and provide societal impacts. Today only small fraction of the Alternative energy sources are exploited due to lack of useful transmission from site where energy could be optimally generated to specific user.Other uses of PV MICROBIMING technology are in the power transmissions to charge battery placed in remote site or in airborne platform. Recently research work conducted in Canada Japan and NASA (NYIT FR No 993/41349-01) show a big progress in the development of PV MICROBIMING technology including new high power sources and new transmit antennas. In this article scientific justification will be given for long term PV MICROBIMING research of foundational nature based on laboratory and proposed field-test-bench tests to be done, operating at 94GHz frequency and transmitting 20W/ 20KW power to measure overall transmit/ absorbed improved 25%-30% efficiency.

### MICROWAVE POWER TRANSMISSION AND ITS APPLICATION

A block diagram of the microwave wireless power transmission demonstration components is shown in Fig. 3. The primary components include a microwave source, a transmitting antenna, and a receiving rectenna. A combination of an antenna and a rectifying circuit is a rectenna. The antenna receives electromagnetic power and the rectifying circuit converts it to electric power. The microwave source consists of a electron tubes (klystron, TWT or microwave oven magnetron) or solid state devices (GaAs MESFET, GaN pHEMT, SiC MESFET, AlGaN/GaN HFET, and InGaAs) with electronics to control the output power. A coax-towaveguide adapter is connected to a waveguide ferrite circulator which protects the microwave source from reflected power. In order to match the waveguide impedance to the antenna input impedance the circulator is connected to a tuning waveguide section. The slotted waveguide antenna, parabolic dish, and microstrip patch are most popular type of tx antennas. Due to high aperture efficiency (95%) and high power handling capability, the slotted waveguide antenna is an ideal antenna for power transmission.

The typical parameters of the transmitting antenna for the SPS are shown in Table II. A rectenna which was invented by W. C. Brown in 1960's (21) is composed of a rectifying circuit and antenna. A rectenna is passive element with a rectifying diode (Si or GaAs Schottky barrier, SiC and GaN) and low pass filter between the antenna (dipole, YagiUda, microstrip or parabolic dish) and the rectifying diode to suppress re-radiation of higher harmonics for absorbing transmitted microwave energy from a transmitter and converting it into direct current (DC) power. The first rectenna was composed of 28 half-wave dipoles terminated in a bridge rectifier using point-contact semiconductor diodes. Later, the point contact semiconductor diodes were replaced by silicon Schottky-barrier diodes which raised the microwave-to-DC conversion efficiency from 40 % to 84 %, the efficiency being defined as the ratio of DC output to microwave power absorbed by the rectenna. In the demonstration of microwave power transmission at the Jet Propulsion Laboratory (JPL) Goldstone Facility in 1975, an efficiency of 84 % was obtained and power of 30 kW was successfully transferred from the transmitting large parabolic antenna dish to the distant rectenna site over a distance of 1.6 km at the 2.5 GHz band.

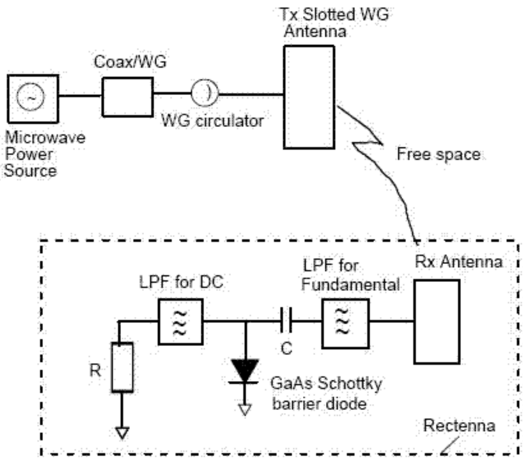



Fig. 3. Block diagram of the microwave wireless power transmission system

## PV MICROBEAMING PSEUDO-SATELLITE PLATFORM TECHNOLOGY

Until the moment most of the similar airships only have a type of renewable energy, in most cases solar power connected to a battery system that feeds the systems during the night, but these batteries groups are very heavy and don't have a very high life span

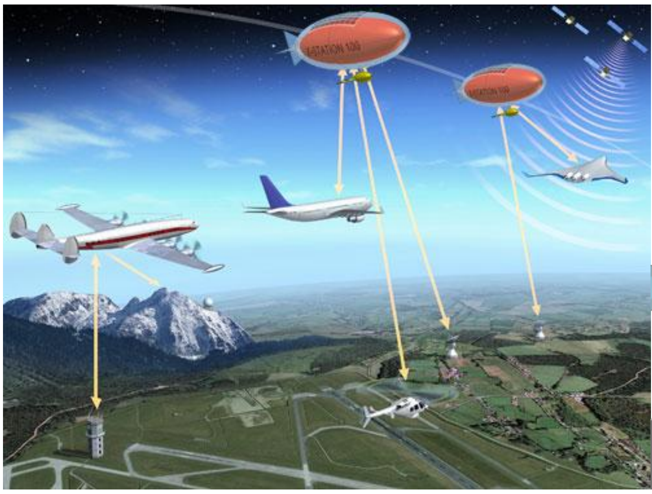
There are other models that use solar and wind power, but still require the batteries groups. But some more recently developed models already have two locomotion systems, and electrical engine that runs with the solar power and a hydrogen engine as a backup system, but this vessels have no hydrogen production capabilities. These type of vehicles are being used mainly for communication and observation missions, a much more limited vision and usefulness.

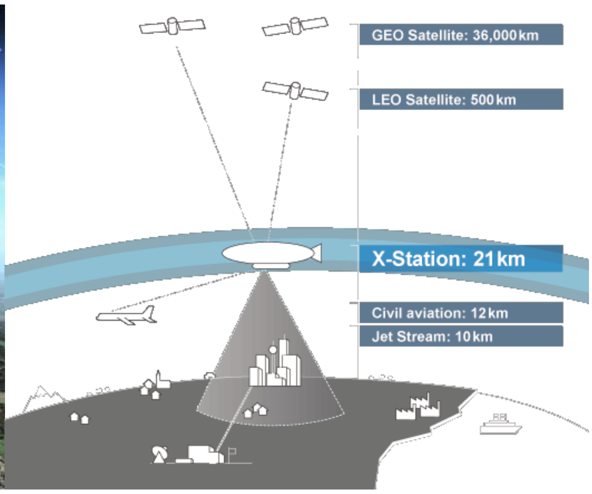
When there is a MICROBEAMING station in a functional range the airship can feed and/or receive power to\from the station thru the Antennas\Rectennas. During this micro wave docking, the ship can restore the power to the backup batteries and produce hydrogen until the tank is full. But the Station can be installed in a remote location in order to supply energy to specific clients (populations, remote observatory, other vessels) and also communications services; the station in this case must have the capability to distribute the electrical energy to the clients. When a station supplies energy it should have a power station attached, for example a

PV system similar to the one installed on the airship, but with more capability if necessary. The ship must have also a system the converts the micro wave into electrical power, and the other way around also.

### 4.3 High Altitude Platform Stations

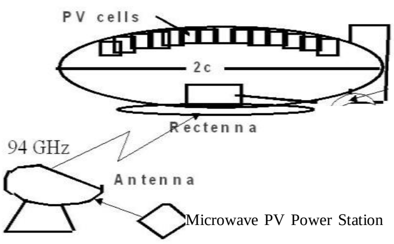
StratXX's 'High Altitude Platform Station (HAPS) technology allows payload equipment to be lifted and maintained in the environment prevailing at high altitudes (low temperature, low air density, high radiation). The concept combines modules that are relatively inexpensive to produce, assemble and operate. The X-Station is unique due to its innovative design, rapid deployment-redeployment characteristics, upgradeability and modular design. The technology is packaged in a simple, modular and upgradeable product range. The X-Station will be made from super-strength and super-light materials. With this novel technology developed by StratXX, our clients can communicate with a fixed "on station" platform 21 kilometers above the Earth.

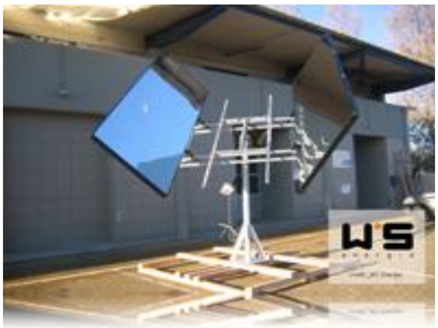





**Possible Applications:** Communications; Crisis and disaster management; Security and border control; Monitoring / protection of critical infrastructures; Laser detection technology

**HAP 1 Schematic**



Receiver

### PV MICROBEAMING SYSTEM BASED ON MICROWAVE BEAMED ENERGY

Based on international power beaming experiences like the Canadian "SHARP" and the Japanese "MILAX" projects, the NASA survey to transmit energy from a satellite to a rectenna on land, a scope of work for the proposed entirely innovative basic research project is presented for experimental assessment of possibility of using at European scale an Electro Magnetic (EM) beamed power for efficient high Wireless Power Transmission (WPT) for civilian needs at European level, but also for security needs to defeat objects of threat located at large distances. PV MICROBIMING system could be basically researched to impair transfer of power to be absorbed at the receiver/rectenna and used by the absorber as self generated energy (or to defeat electronic equipment), but to not harm human beings, and that are classified as Non-Lethal Wireless Transmission (NLWT) devices.

The use of focused EM beams for the efficient, wireless transmission of energy from one point to another is an important area of fundamental research challenge aiming to solve hard problems beyond the present state-of-the-art technology in the sector. Frequency of operation for such systems (including development of power source for given frequency and of an efficient antenna /rectenna array) is a crucial research topic in this article:

1. In order to avoid effects of atmospheric attenuation, frequencies below approximately 6 GHz are desirable to be used. At 2.45 GHz, the atmosphere is practically transparent even under conditions of high humidity and rain. However at this frequency, the dimensions for the required transmit and receive antennas would be 100 meters or greater, and prohibitively expensive if constructed as continuous rigid structure.

2.At altitudes above the earth's atmosphere EM frequencies of 10 GHz and higher can propagate without experiencing atmospheric absorption. For short distances of 1-2 km or less, the effects of atmospheric absorption are not excessive. At 94 GHz the attenuation through dry air for distance of 1 km is approximately 0.1dB.The size/weight of antenna structures required for efficient beam focusing is inversely proportional to the frequency of operation. At 94 GHZ a transmit antenna of 2.5 m diameter would have EM focusing properties equivalent to that of transmit antenna of 100 m diameter at 2.5 GHz. At frequencies in the range of 94 GHz, called the millimeter range, the development of integrated receive antenna, and power rectification system to be done in this project presents a very difficult challenge.

In this article 3 important factors should be characterized regarding WPT systems: a) their power levels; b) the spectrum of frequencies used and c) the waveform time dependence of the emissions. The goals in this article in general will be: a) Analyse NLWT technology in accord with use requirements; b) Analyse specialized simulation software for NLWT computer tests and performance evaluation; c) Research, develop and construct an experimental proof-of-concept NLWT system. With respect to goal a, our effort will focus on the various levels of system output to assure that the system researched will meet user requirements. With regard to goal b, a NLWT simulation software will be based on development of specialized EM computational software packages. With regard to the main implementation goal c, it is proposed to research full-scale system operating at 94GHz/20kW(average)-100kW (peak) starting with a scaled experiment at 94GHz/20W that will be used to evaluate key parameters of the full-sized system, to achieve an overall transmitted/absorbed power efficiency of 25%-30% with compare to hardly acceptable few percent efficiency of the today state-of-the-art technology. The research will be based on novel approach by utilizing laboratory developed components of power source and the emitter/ receiver in order to achieve required performance and efficiency at minimum project cost. The concept for such test arises from the need to assess feasibility of using micro-wave beaming system to WPT. To do so one of the key metrics is to measure the power density at the receiving antenna, rectenna instrumented to determine, among other variables, both the average and peak power densities. Preliminary estimates for full scale 20Kw beamed power case, with the target allocated at about 200m from beaming source, the values are 100KW/m$^2$ (average) and 500 KW /m$^2$ (peak). Scaling the beamed power to 20W that is in the proposed test we may see 50W/m$^2$.

The PV MICROBIMING foundational research challenge is to account for the matrix of design parameters performance indexes and cost factors in order to determine in long run development of optimum European WHT system. The article attempts to establish: 1) Recommended operational frequency; 2) Transmitting antenna size and design concept; 3) Rectenna specifications and design concept; 4) Power conditioning and charging circuit design concept; 5) Microwave sources suitable for WPT; 6) Radiation hazard protection subsystem; 6) Conduct a proof-of-concept laboratory experiments and field tests using microwave beams at 94GHz frequency to wirelessly supply power to potential user's absorbing device.

This article suggests a development and an operation of a scaled low power laboratory experiment and field-tests of a set-up at 94GHz that will be used to evaluate key parameters of a potential high WPT system. Beam power density is an important factor in terms of rectenna efficiency and radiation hazard. Assuming that the transmitter antenna has the proper beam pointing angle and range focusing, the power density incident at the rectenna is a function of transmitter power, transmitter antenna aperture size and range. In this project a transmitting power of 20W will be experimented in the laboratory at 10 m distanced rectenna, and field tests of a test-bench set-up will be conducted at 1 km distance of the rectenna, to measure its power density (predicted to be 37 W/m$^2$ with 20W transmitted power), and perform a measurable extrapolation to1 KW transmitted power (rectenna power density of 1.6 KW/m$^2$), and to 20 KW transmitted power as well. An important measuring will be done to estimate the overall WPT system efficiency transmitted/ absorbed power hopefully to show a significant improvement of reaching 25%-30% efficiency. This aerticle is challenging and entails issues of basic science and technology. But there are also scientific and technological risks due to many uncertainties suggesting that the article may not achieve the goals set this effort. These resides in the nature of microwave power beaming itself and the selected frequency for the proposed experiments, including: 1) Efficiency dependence on temperature and rectenna size; 2) Scaling problems and low efficiency of process; 3) Complexity of working at desired frequency; 4) Electromagnetic compatibility and thermal balance (heat accumulation and dissipation); 5) Beam pattern control, focus and shape.

## Description of potential applications: Wireless Power Transmission ground to aircraft

As an example of prospective scientific challenging application of PV MICROBIMING is the following high power PV MICROBIMING transmission ground to high altitude (10-20 km) long endurance (month) aircraft or airship propelled during day time by using absorbed sun light power and during night time by using PV MICROBEAMING received power. Such HAP-High Altitude Platform hovering at altitude of 10-20 km above clouds and absorbing during day Sun Light Power by efficient photovoltaic cells, and during night absorbing power transmitted from ground through a microwave beaming system allowing its narrow beam to penetrate clouds and fogs at certain frequencies, to rectenna of the HAP. At the present state-of-the-art, the proposed research project will concentrate on the specifications required for the efficient microwave-beaming transmission of absorbed energy (see following scheme). Preliminary PV MICROBEAMING feasibility work carried out so far suggest that if specially designed ground antenna of

50m in diameter attached to 1MW power source then the absorbed rectenna power Pr having diameter Dr and absorbed power density Sr at frequencies f will (without atmospheric attenuation) be as follows:

| f(GHz) | Dr(m) | Sr($W/m^2$) | Pr(KW) |
|---|---|---|---|
| 2.45 | 147.0 | 17 | 288.4 |
| 5.80 | 62.1 | 95 | 287.6 |
| 35.0 | 10.3 | 3,435 | 286.1 |
| 94.0 | 2.5 | | 285.6 |

The smaller antenna would have advantages that might outweigh atmospheric losses. Such important figures should be covered and tested at 94 GHz by a Test-Bench prototype as described later in the article. Such an application of power transmission to HAP is a real airborne issue hindering deployment of a HAP.

## 5. References

1)Douyere,A.,et al,2006,“Modeling and Simulation of a Complete System of Energy Transmission” Digest/IEEE Antennas and Propagation Society. International Symposium, July 9-14.

2)Y.Pinhassi, A.Yahalom, O. Harpaz, G.Vilner,2004,“ Study of ultra wideband transmission in the extremely high frequency (EHF) band”, IEEE Trans. On Antennas and Propagation, 52 (2004), 2833-2842

3)D.Budimir, A.Marincic,2006,“Research Activities and Future Trends of Microwaves Wireless Power Transmission”, Sixth International Symposium Nikola Tesla, 18-20 October, SASA Serbia.

4) S. Lien, D. Wuu, W. Yeh, J. Liu, Solar Energy Materials and Solar CellsVolume 90 , Issue 16, 16 October 2006, Pages 2710-2719

5) K.P. Bhuvana, J. Elanchezhiyan, N. Gopalakrishnan, T. Balasubramanian, Journal of Alloys and Compounds, article in press, 2008

6) Won Seok Choi, Kyunghae Kim, Junsin Yi, Byungyou Hong, Materials Letters,Volumes 62, Issues 4-5, 29 February 2008, Pages 577-580

7) V. Bursikova, P. Sladek, P. St’ahel, L. Zajicjova, Journal of Non-Crystalline Solids, 2099-302, (2002), 1147-1151

8) Pallavi Madakasira, Kanzan Inoue, Ross Ulbricht, Sergey B. Lee, M. Zhou, John P. Ferraris, Anvar A. Zakhidov, Synthetic Metals Volume 155, Issue 2, 15 November 2005, Pages 332-335

9) V. Agarwal, S. Buckner, Solar Energy Materials Volume 12, Issue 2, June 1985, Pages 131-136

10) S. Blank,“An Algorithm for the Empirical Optimization of Antenna Arrays”, IEEE Trans. AP, vol. AP-31, No. 4, pp.685-689, July 1999.

11) S.J. Blank and M.F. Hutt, “On the Empirical Optimization of Antenna Arrays”, IEEE Antennas & Propagation Magazine, April, 2005.

12) Celeste, A., 2004, “Case study in Reunion Island”, Acta Astronautica, Feb. 2006

13) S. Lien, D. Wuu, W. Yeh, J. Liu, Solar Energy Materials and Solar Cells Volume 90, Issue 16,

14) Won Seok Choi, Kyunghae Kim, Junsin Yi, Byungyou Hong, Materials Letters Volume 62, Issue 4-5, 29 February 2008, Pages 577-580

15) V.Bursikova, P.Sladek, P.St’ahel, L.Zajicjova, Journal of Non-Crystalline Solids,2099-302, (2002), 1147-1151

16) Pallavi Madakasira, Kanzan Inoue, Ross Ulbricht, Sergey B. Lee, M. Zhou, John P. Ferraris, Anvar A. Zakhidov, Synthetic Metals Volume 155, Issue 2, 15 November 2005, Pages 332-335

17) V. Agarwal, S. Buckner, Solar Energy Materials Volume 12, Issue 2, June 1985, Pages 131-136

18) R. J. Martín-Palma, L. Vázquez, P. Herrerp, J. M. Martínez-Duarte, M. Schnell, S. Schaefer, Optical Materials Volume 17, Issues 1-2, June-July 2001, Pages 75-78

19) Mao-Jung Huang, Chii-Rong Yang, Yuang-Cherng Chiou, Rong-Tsong Lee, Solar Energy Materials and Solar Cells, In Press, Corrected Proof, Available online 1 July 2008

# 罗马尼亚的地震灾害减灾策略

**Stela Petrescu**
项目管理组，区域发展和旅游部，罗马尼亚

**【摘要】**罗马尼亚是欧洲地震活动最活跃的国家之一，在弗朗恰（Vrancea）地震带上每个世纪都要发生 2-3 次 7.0 级以上的地震，影响着罗马尼亚境内约 2/3 的区域，其中包括首都布加勒斯特（Bucharest），该城市被认为是欧洲最容易遭受地震破坏的首都。

本文介绍了区域发展和旅游部（负责地震减灾活动发展的中央研究机构）采取的一些策略，包括法律体制的改进、建筑物抗震能力和有效的加固措施等，主要通过以下计划和项目来实现：

（1）减灾与应急准备项目（HRMEPP）—B 部分：基于国际支持的地震减灾发展——世界银行资助加固改造重要公共建筑物。该项目的总体目标是通过对关键的公共设施和生命线工程进行结构加固，降低优先级较高的技术和社会基础设施的地震易损性，这点在应急响应和准备系统中非常重要，对强烈地震发生后整个国家的社会功能运转也至关重要。

（2）国家资金支持的加固多层居民住宅的行动计划：这是一项根据技术专家报告制定的年度行动计划——对处于 I 类风险（即存在公共危险）的多层房屋建筑进行加固设计和施工。在罗马尼亚，政府利用国家财政预算中分配的用于设计和施工的经费确保老旧住宅的安全性。

（3）针对存在公共危险建筑物的紧急干预计划：该计划的主要目标是降低那些具有高优先级别，可作为历史古迹的公共设施发生结构倒塌的危险性。

**【关键词】**国家策略；地震危险性；减灾

# ROMANIAN STRATEGY ON MITIGATION OF SEISMIC HAZARDS

**Stela Petrescu**

*Project Management Unit, Ministry of Regional Development and Tourism, Romania1*

## Keywords

National strategy, seismic risk, mitigation

## Abstract

Romania is regarded as one of the most seismically active countries in Europe; in the Vrancea seismic zone are occurring 2-3 earthquakes of magnitude M> 7.0 per century, affecting about 2/3 of the Romanian territory. This area includes the city of Bucharest, considered the most quake vulnerable capital of Europe.

The paper presents the strategy of Ministry of Regional Development and Tourism as responsible central institution for the development of the seismic risk reduction activity, with reference to the legal framework improvement, capacity building and effective retrofitting measures through projects and programs, such as:

- Hazard Risk Mitigation and Emergency Preparation Project (HRMEPP) - Component B: Seismic Risk Reduction Project developed with International support – World Bank financing – for retrofitting of essential public buildings, the overall objective being to reduce the seismic vulnerability of high priority technical and social infrastructure through structural strengthening of critical public facilities and lifelines, which have a paramount role in the emergency response and preparedness system, and those that are essential for the country's social functioning during and after a strong quake.
- National Program of Action developed with national funds for retrofitting multistory residential buildings, an annual program of actions for designing and executing retrofitting works on multi-storey housing buildings assigned to class I of seismic risk by technical expert's report and which are a public danger. In Romania the state is involved to ensure the safety of the old housing stock, by allocating funds from the state budget for design and works.

1 Project Management Unit for the Hazard Risk Mitigation and Emergency Preparedness Project, Ministry of Regional Development and Tourism, 38 Dinicu Golescu Boulevard, 010873, Bucharest, Romania, Stela.Petrescu@mdrl.ro

- First-emergency intervention program for vulnerable buildings representing a public danger, the main objective of this program being mitigation of the danger of immediate collapse of buildings' elements, for public facilities or historical monuments.

## Introduction

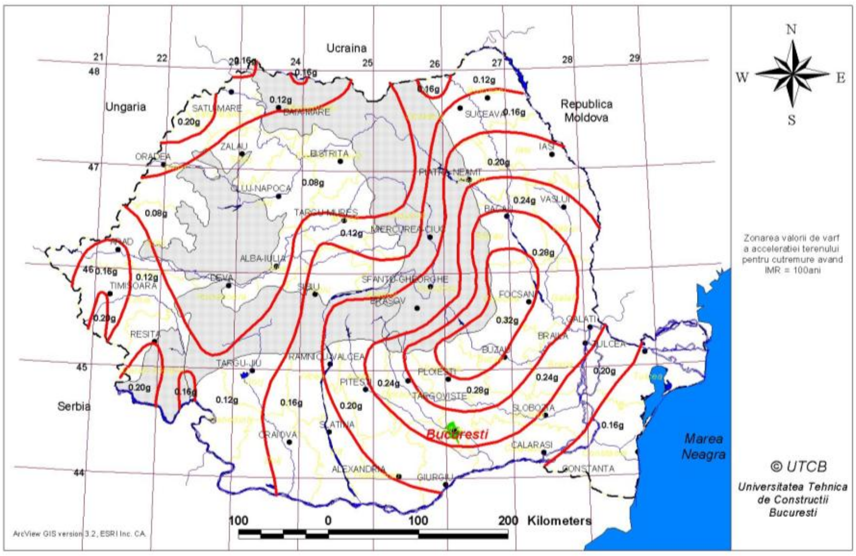
Romania's hazards portfolio consists of earthquakes, landslides, floods and other meteorological phenomena as well as various technological hazards. Romania is regarded as one of the most seismically active countries in Europe. Vulnerability to the seismic risk is due to Romania's geographical location on the Vrancea zone, situated along the south-eastern Carpathian arch, which form an ellipse stretching from the North East to the South West of Romanian territory, including the capital city of Bucharest.

In the Vrancea seismic zone are occurring 2-3 earthquakes of magnitude M> 7.0 per century, affecting about 2/3 of the Romanian territory. Proximity to the Vrancea zone (100-120 km) and poor soils make Bucharest the Europe's highest risk capital city and one of the 10 most vulnerable cities in the world.

The vulnerability of the Romanian economy to earthquakes is further exemplified by the following facts:

- over 35 percent of Romanians and 65 percent of all urban population is exposed to seismic hazard;
- 60-75 percent of fixed assets are located in seismic zones;
- 70-80 percent of GDP is produced in highly seismically prone areas;
- Romanian economic activities are concentrated in and around Bucharest;
- 26% of the buildings were constructed before 1944, and are extremely vulnerable to an earthquake.

Fig. 1 Seismic zoning of Romania's territory



Since 1908, 14 earthquakes of magnitude 7 or greater were recorded affecting almost 2 million people and causing massive economic loss.

The 4 March 1977 earthquake incurred significant losses:

- Human lives:
    - 1578 fatalities of which: 1424 in Bucharest and 154 in other areas;
    - Injuries: over 11000;
- Damages/ collapsed buildings:
    - 33000 housing units destroyed or seriously damaged with 200000 residents homeless;
    - 400 schools destroyed and 2000 seriously damaged;
    - 11 hospitals destroyed;
    - 448 hospitals and health care clinics damaged;
    - 29 tall buildings, over 4 stories, built previous to 1940, collapsed in the centre of Bucharest;
- Economical losses: over US$2 Billion direct losses.

## Thesis – Strategy of Ministry of Regional Development and Tourism

The 1977 earthquake served as a catalyst for Romania to begin implementation of seismic risk reduction measures. Ministry of Regional Development and Tourism (MRDT) is the main authority in the seismic risk reduction field, and coordinates major actions and measures associated with this field. An important development of seismic risk reduction measures were motivated by the consequences of the 1977 earthquake:

- Strengthening of the existing vulnerable buildings;
- Improving the legal framework in seismic risk reduction domain;
- Development of engineering studies and revision of several norms and regulations (including harmonization with Euro codes);
- Permanent upgrading of the seismic monitoring system and increasing the number of stations and sensors;
- Sustained professional training in the risk reduction field.

As a part of the country's overall effort to diminish the effects of a major seismic event, the Ministry of Regional Development and Tourism focus its strategy in two main directions:

- Capacity building;
- Implementation of projects/programs.

Capacity Building

The main capacity building measures currently enforced by the MRDT are:

- Permanent upgrading and improving of the legal framework and government support;
- Elaboration and enforcement of new Building Codes;
- Professional training in cost-effective retrofitting methods;
- Educational programs for protection in case of earthquake.

Two building codes were harmonized following the EUROCODE format:

- P 100-1: Code for Seismic Design with elaboration period between 2002 and 2006 which is in force since January 1st, 2007, for new buildings;
- P100-3: Code for Assessment and Design of Retrofitting Works for existing buildings, vulnerable to earthquakes with elaboration period between: 2004 and 2009, in force since January 1st, 2010.

On the capacity building area two normative acts are important as impact on the earthquake risk mitigation:
A. The Government Ordinance No. 20/1994, with its subsequent completions and amendments and the Methodological Norms, stipulate mainly that: the activity aiming to reduce the seismic risk of constructions is coordinated, from technical viewpoint, by the MRDT by:

- Promoting the relevant technical regulations;
- Advising form the part of the Specialized Technical Commission within MRDT the technical intervention solutions for buildings having a vital importance for the society, the integral operation of which must be secured during and immediately after an earthquake;
- The Technical Commission within MRDT reviews the proposed intervention solutions for the vital importance buildings;
- The *owners liability* - to allow the assessment of design and execution of retrofitting works, in order to increase the seismic safety of the building that they own or manage; such actions are compulsory for buildings ranked by their assessment report in Class I of seismic risk.

B. The Law No. 460/2001 stipulate exceptional financing facilities regarding the promotion of retrofitting the multi-storied residential buildings, ranked in first class seismic risk, presenting public danger, by :

- Providing the necessary funds from the MRDT budget in order to reimburse the owners' expenses;
- The owners have the facility to return the loan advanced from the state budget for the execution of the retrofitting works in equal monthly installments, without any interest, in a period of up to 25 years from the reception of the retrofitting works date;
- The owners having a monthly income per family member under the average monthly salary per economy are exempted from this payment.

Implementation of projects/programs

MRDT has an extensive strategy for seismic hazard prevention which covers all types of public / private constructions and facilities. Currently three programs for buildings retrofitting are under execution:

1. Hazard Risk Mitigation and Emergency Preparation Project (HRMEPP) - Component B: Seismic Risk Reduction developed with International support – World Bank financing for retrofitting essential public buildings;
2. National Program of Action for Retrofitting of Multi-storied Residential Buildings;
3. First-emergency intervention program at vulnerable buildings representing a public danger, the main objective of this program being mitigation of the collapsing danger of constructions such as high priority public facilities, considered as historical monuments.

Financing for the three retrofitting and capacity building programs is assured from various financial resources: International financing (IBRD loan), Government through state (MRDT) budget, local authorities' budget and funds of private owners. Prioritization of the buildings subject to retrofitting works was realized and by the nature of their use is considered as priority:

- Important public buildings (emergency hospitals, educational facilities, universities, emergency and disaster response facilities, administrative buildings);
- Private buildings (multi-storey residential buildings).

General Presentation of Hazard Risk Mitigation and Emergency Preparedness Project

For preventing the consequences of occurring disasters, the Government of Romania sought for assistance at the World Bank for the preparation of a comprehensive hazard risk management project on an ex-ante basis, to be implemented in 5 years.

The preparation of the present project started in September 2004 and was finalized in January 2004; the Loan Agreement was approved and signed by the parties in May 2004. Romania was the first country in Europe-Central Asia region requesting WB assistance in preparation of a multi-sector hazard risk mitigation project on an ex-ante basis.

The overall objective of the Project is to assist the Government of Romania in reducing the financial, social, environmental and economic vulnerability to natural disasters and water pollution accidents from mining activities. The Project has 4 Components:

Component A - Strengthening of Emergency Management and Risk Financing Capacity. The objective of Component A is to enhance the capacity of Romanian authorities to better prepare for, respond to and recover from natural or man-made disasters, through modernization of information technology and communication systems, activities which would increase the planning and training efforts of all levels of government, public awareness and preparedness, and complete technical feasibility work and institutional framework for launching of the Romanian Catastrophe Insurance Program..

Component B - Earthquake Risk Reduction. The objective of Component B is to reduce the seismic vulnerability of priority technical and social infrastructure through the retrofitting of key structures and institutional strengthening.

Component C - Flood and Landslide Risk Reduction. The objective of Component C is to reduce flood risk and vulnerability in critical areas in Romania, to improve safety of large and small dams so that these structures can function as designed, and to map and model the risk of landslides in order to reduce loses and better land use planning.

Component D - Mining Accident Risk Reduction in the Tisza Basin. The objective of Component B is to reduce the risk of water and soil contamination and loss of human and aquatic life from catastrophic mining accidental spills or pollutants.

## 1. HRMEP Project Component B - Earthquake Risk Reduction

Objective: Reducing the seismic vulnerability of priority technical and social infrastructure through the retrofitting of key structures and institutional strengthening.

The objective of Component B, to assist the Romanian Government in reducing the seismic vulnerability of priority technical and social infrastructure was achieved through two directions (5 Sub-components):

A. Capacity Building:
- Sub-component B4: Building Code Review
- Sub-component B5: Professional Training in Cost-effective Retrofitting Methods
- Sub-component B3: Energy Sector Risk Assessment

B. Implementation - Strengthening of High Priority Public Facilities:
- Sub-component B1: Retrofitting Works for High Priority Public Facilities
- Sub-component B2: Design and Supervision

Financial support was assured as follows:
- World Bank Loan:    $ 56.928 million US$;
- Government of Romania Co-financing: $ 16.830 million US$
- Total Component B - Earthquake Risk Reduction 73.758 million US$;
- Beneficiary Contribution: over $ 100 million US$.

The Beneficiary contribution was necessary for assuring total modernization and upgrading of the functionality of the objectives, complementary to the retrofitting works.

A. Capacity Building

1. Building Code Review
The process was finalized and was ensured:
- A comprehensive review focusing on applicable EQ design requirements for the P100-3 / Code for Assessment and Design of Retrofitting Works for Existing Buildings, Vulnerable to Earthquakes;
- Development of a new chapter to introduce innovative retrofitting techniques in the Romanian engineering practice.

2. Professional training in cost-effective retrofitting methods: this process will be integrated with the implementation of the P100-3 Code as a related component to support the engineering training. The training and accreditation program is aimed to assist the design community and their clients (Governmental or private organizations) in better understanding and applying of the concepts of risk management and cost benefit analysis.

3. Energy Sector Risk Assessment

The function of energy systems is essential after major earthquake; while considerable effort has been expended to make an inventory and assess buildings in the Vrancea earthquake zone, no comparable assessment for critical facilities and equipment in the energy sector production and distribution has been made. The assessment will be integrated in the overall regional earthquake scenario and will lay the foundation for follow-up work on promoting the investments needed to address the vulnerabilities in the energy sector.

B. Implementation - Strengthening of High Priority Public Facilities

The high priority public facilities are grouped by their type, as shown in Table 1.

Table 1 Type of facilities under Component B

| No. | TYPE OF FACILITIES | No. of facilities: |
|---|---|---|
| 1 | EMERGENCY AND DISASTER RESPONSE FACILITIES | 22 |
| 2 | EMERGENCY HEALTH FACILITIES | 17 |
| 3 | EDUCATIONAL FACILITIES | 10 |
| 4 | ESSENTIAL PUBLIC BUILDINGS | 4 |
| TOTAL | | 53 |

Implementation Status of Component B:

- During 2005 – 2008 by implementing Component B it was envisaged, mainly, a number of approximately 80 important public facilities and the institutional awareness regarding mitigation of earthquake risk.
- In 2008, due to the Project's re-structuring, operated by the World Bank's Supervising Mission, as the available funds are enough for cover the accomplishment of only 46 investment objects, for which the works can be finished till the Project's ending, the PMU – MDPWH took the necessary steps to ensure the needed funds for the total implementation of Component B.
- During the Government's Session of June 18, 2008, the Memo for an increase of funds for the Project's Component B implementation was approved, by these funds being ensured the retrofitting of 68 buildings.
- In August 2008 it was established, together with the Ministry of Economy and Finance, the conditions for the funds increase from the State Budget. The negotiations with the World Bank were continued in September. 53 important public facilities were approved; the implementation will be finalized by December 2011.
- On these lines, the promotion of the investment objects within the Project is conditioned by the amendment of Law no.389 dated September 2004 for the Loan Agreement's ratification regarding the Project's financing, in order to increase the funds allocated from the State Budget for Component B and the implementation period's expansion by 2 years.
- On December 21, 2009 was issued the Government Decision no. 1515 for approval of the extension of the HRMEP Project, until December 20, 2011. All 53 important public facilities included under Component B will be finalized by December 20, 2011.

Current status for retrofitting works: 12 buildings are finalized; 21 buildings under execution, 7 under bidding process and 13 under designing. Retrofitting works are on-going for 21 objectives, as follows: 9 emergency and disaster response facilities (county administration offices - town halls), 8 healthcare facilities (emergency hospitals), 3 educational facilities (universities) and 1 high priority public building.

The strengthening methods used in HRMEP project are:

- Conventional strengthening:
  - Introduction of reinforced concrete beams, pillars, shear walls;
  - Jacketing of existing foundation and walls;
  - Coating with metal elements;
  - Replacing the existing wood floor with reinforced concrete or composite floor (concrete fill over metal deck and steel beams);
  - Introduction of the steel frames on the facades (bracing) etc.
- Modern methods:
  - Base isolation;
  - Energy dissipation system (viscous dampers).

For each facility was assessed the retrofitting solutions, in order to determine the most cost-effective method. Design and execution engineers benefit from assistance and monitoring of an international consultant, and a core of Romanian engineers benefit from the transfer of knowledge, mainly for the application of the modern innovative seismic retrofitting methods.

## 2. National Program of Action – Multi-storey Residential Buildings

The objective of the National Program of Action developed with national funds for retrofitting multi-storey residential buildings is to reduce the seismic risk to multi-storey residential buildings, ranked in I seismic risk class, representing a public danger, state owned or private. The program started in 2001, until now 3600 were subject to seismic assessments and technical expertise, out of which 2636 in Bucharest. Based on the technical expertise, in the 1$^{st}$ seismic risk class were included 630 buildings, out of which 392 in Bucharest. The buildings subject to retrofitting works were prioritized and 127 building were established by the Technical Committee for Seismic Risk Reduction as first emergency for retrofitting, all of them being constructed before 1940.

The latest improvements of the legal framework:

Government Ordinance No.20/1994 regarding steps to be taken to mitigate the seismic risk for the existing buildings was completed and amended by Law No.195/2007 and republished in the Official Monitory no.837/2007.

The law includes actions and sanctions against the owners and local authority representatives in order to speed up the technical survey work and to continue the designing and the retrofitting works of the multi-storey residential buildings listed in 1 seismic risk class, classified as public hazard:

- Identification and inventory, by the local administration authority, of the buildings having more than ground floor + 3 stories, erected prior to year 1978, housing public spaces at the ground floor or at other levels of the building.
- The requirement of elaborating a technical survey of the resisting structure for the respective buildings.
- Population living in seismic risk areas will be warned by warning boards placed next to the entrance of the technically surveyed buildings listed in 1$^{st}$ seismic risk class.

- The intervention works design must be terminated within 2 years from receipt of notice regarding the building's listing on 1st seismic risk class list.
- Termination of retrofitting works within 2 years from the retrofitting design's finishing.
- Local public administration authority will penalize the owners with fines from 1,000 to 3,000 lei in case of not complying with the obligation to allow the building's technical survey, the designing and the execution of retrofitting works at the deadlines established by the law.
- Local public administration authorities will be granted the power to enter into the respective residence in order to carry out the necessary technical survey, design and execution works even against the owners' refusal.
- Local public administration authorities have the right to refund the owner, at his request, with the residence's value, thus the owner becoming a tenant of the respective residence for the cases of insolvency regarding reimbursement of the retrofitting works cost.
- Financial incentives consist in:
    - Total financing from budgetary allocations of the actions for which the owners, physical entities are liable, regarding designing and execution of retrofitting works.
    - Reimbursement to the owners – physical entities – in monthly installments, without interest, divided equally along 25 years, of the retrofitting works cost, financed from budgetary allocation; all owners – physical entities, are exempted from reimbursing the monthly installments if they have net monthly incomes per family member under the net average salary in Romania.
    - Exemption from paying the authorization tax for retrofitting the residential buildings as well as the architecture works stamp duty.

Current status: as a result of the National Program of Action promoted by the MRDT, implemented through annual programs approved by the Romanian Government:

- The retrofitting works were finalized for 15 residential buildings;
- There are ongoing retrofitting works for 9 residential buildings;
- Retrofitting design is under preparation for 37 buildings, contracts for works will be soon tendered.

## 3. First-Emergency Intervention Program in Vulnerable Buildings Representing a Public Danger

The First-Emergency Intervention Program in Vulnerable Buildings Representing a Public Danger is dedicated to limit the effects of landslides or remove the danger of immediate collapse of buildings' elements. Different types of buildings and facilities are included in this program: social buildings, cultural centers, housing for low-income people, hospitals, theaters, university, city halls, administrative public buildings, churches, cathedrals, chapels etc. The program is financed from the MRDT budget, for 2009 was 2.45 million euro.

Current status: 51 buildings were finalized, 2 buildings in execution phase, 5 buildings under bidding process, 2 buildings with the design finalized and under the process of financing and 3 buildings under designing process.

## Findings and Discussion

The most important findings that can be drawn from Romanian experience:

A. The responsible authorities (in case of Romania is MRDT) have a global approach:

- Promotes a set of comprehensive and high priority measures (revision of the Building Codes, fiscal deductions for owners, promoting of investment projects and programs for prevention);
- Ensure close coordination between responsible authorities (central and local authorities, contractors and employers associations, design institutions, universities, law-makers etc.);
- Strengthen the institutional capacity of existing entities (enforcement of the legal framework and harmonization with EU regulations and standards);
- Closely coordinates the ongoing investment programs to reduce the seismic vulnerability of infrastructure (ensure the approval and monitoring of all investments in the seismic rehabilitation area provided by the central and local authorities).

B. The responsible authority (MRDT) has as primary priority to diminish the seismic vulnerability of public and private buildings. In addition to improving the legislation and the institutional framework which enhanced the emergency response system, the retrofitting of high priority public facilities and private residential buildings lead to diminished post earthquake recovery efforts and allows for properly functioning of Government organizations after an earthquake of high magnitude.

C. The structural retrofitting of public facilities and residential buildings is a key component of the seismic risk reduction and intense measures are taken to finalize the structural retrofitting to safely protect all vulnerable buildings and prevent human and economical losses. Structural retrofitting of public buildings is backed by measures to facilitate and enforce the retrofitting private residential buildings. The private owners are supported through various measures: providing free of charge structural surveys, penalties for the owners that do not allow their building to be surveyed, exemption from tax paying for retrofitting works authorization, financial support for retrofitting works with reimbursement from owners in 25 years of exemption for reimbursements for low-class income. In this respect, Romania is the only country in the world that provides the private owners with a great scale package of fiscal facilities for structural retrofitting of the residential buildings.

D. To prevent is more cost efficient comparing to recovery measures therefore the main focus of MDRT is to ensure the highest technical and institutional level for the prevention measures. All type of existing buildings, both public and private, are addressed by the three programs for seismic rehabilitation under execution.

## References

1. Romania, Government Ordinance No.20/1994 regarding Steps to be taken to mitigate the Seismic Risk for the Existing Buildings, Completed and Amended by Law No.195/2007, 2007, Bucharest: Official Journal No.837/2007.
2. Code for Seismic Design of Buildings P100-1/2006, Bucharest: Official Journal No.803/2006.
3. Code for Assessment and Design of Retrofitting Works for Existing Buildings, Vulnerable to Earthquakes P100-3/2008, Bucharest: Official Journal No.647/2009.
4. Loan Agreement to Government of Romania for Hazard Risk Mitigation and Emergency Preparedness Project, 26 May 2004, enforced by Law 389/2004, Bucharest: Official Journal No.934/2004.
5. Project Appraisal Document on a Proposed Loan in the Amount of US$150 Million and a Grant from the Global Environment Facility in the Amount of UD$7 Million of Government of Romania for a Hazard Risk Mitigation and Emergency Preparedness Project, April 19, 2004, WB.

## Author Biography

Mrs. Stela Petrescu is General Director of Project Management Unit for the Hazard Risk Mitigation and Emergency Preparedness Project in the Ministry of Regional Development and Tourism of Romania since April 2004.

Previous to leading the MRDT PMU for Component B of HRMEP Project, Mrs. Petrescu was Chief of Department regarding Projects for seismic risk and landslides mitigation in the General Technical Directorate of MDRT. She had the responsibility of coordinating the proper implementation, of the ongoing national/international projects in the field of seismic risk and landslides mitigation and to propose and prepare new projects to be financed by international organisms/donors. The most significant projects she was working on were:

- Project on the Reduction of Seismic Risk for Buildings and Structures, a technical cooperation program organized by the Japan International Cooperation Agency;
- EUR-OPA Major Hazards Agreement, Euro-Mediterranean partnership coordinated by the Council of Europe, to prevent, mitigate and solve crises situation generated by natural and/or technological disasters;
- Creating a nation-wide, unitary Geographical Information System (GIS) through a Pilot Assistance Project for Pan–European transportation priority investment, included in the High Technology and Cross Border Operations Working Groups of the “Action Commission for an Enlarged Euro-Atlantic Community” under the authority of Center for Strategic and International Studies, Washington D.C.

Mrs. Petrescu was the Chief of Technical Department in the Project Management Unit for School Rehabilitation Project, Project co-financed by The World Bank, the European Council Development Bank and the Government of Romania. The Project financed civil works/building constructions (retrofitting existing schools and erecting new ones), professional architectural and engineering services to complete technical survey and design, school mapping, preparation of detailed building plans, specifications and bidding documents.

Mrs. Petrescu is member of the National Technical Committee for Seismic Risk Reduction of Buildings, National Union of Romanian Architects and of the Professional Association of Romanian Architects.

# 极值系统在全球尺度地震损失评估中的发展应用

**Valery Akimov and Sergey Kachanov**
全俄民防和紧急形势研究所，俄罗斯联邦紧急情况部（EMERCOM）

**Nina Frolova**
IGE 地震中心，俄罗斯科学院，俄罗斯

**Sergey Suschev and Valery Larionov**
极端形势研究中心，俄罗斯

**【摘要】**本文讨论了应用极值系统进行强震损失评估的程序，期望损失评估结果能为强震后开展有效的应急响应和救灾措施提供信息。文中给出了系统应用的实例，并对系统输出的可靠性进行了分析，还对如何提高可靠性进行了讨论；同时强调了全球尺度损失评估中协调需求和针对使用的不同数据库进行研究的重要性。

**【关键词】**强震；应急模式下的损失评估；救灾力量和资源的估计；风险数据库；影响数据库；全球尺度；国际合作

# EXTREMUM SYSTEM FURTHER DEVELOPMENT FOR ERTHQUAKE LOSS ASSESSMENT AT GLOBAL SCALE

**Valery Akimov and Sergey Kachanov** [2]

[1] *All-Russian Research Institute on Civil Defence and Emergency Situations, EMERCOM of Russia Russian Federation*

**Nina Frolova**[3]

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***1*** All-Russian Research Institute on Civil Defence and Emergency Situations, EMERCOM of Russia, Davydkovskaya str. 14, Moscow, Russian Federation, Email: vniigochs@ampe.ru

***2*** Seismological Center of IGE, Russian Academy of Sciences, Nikoloyamskaya str. 51, 109004 Moscow, Russian Federation

Email : frolova@comail.ru

[2] *Seismological Center of IGE, Russian Academy of Sciences, Russian Federation*

**Sergey Suschev and Valery Larionov，[4]**

[3] *Extreme Situations Research Center, Russian Federation*

## Keywords

Strong earthquakes, loss estimations in “emergency” mode, estimations of forces and resources for rescue and relief operations, data bases on elements at risk, impact data bases, global scale, international collaboration

## Abstract

This paper addresses the procedure of strong earthquakes loss assessment following strong earthquakes with worldwide Extremum system application. The expected loss estimations are accompanied with information about the effective response and relief measures for strong earthquakes. The examples of the system application are given. The issues of output reliability are analyzed and ways to increase it are discussed. The need for coordinated efforts and research on different data bases used for loss estimations at international level is stressed.

## Introduction

Increase in the social losses due to earthquakes is not random phenomenon and mainly dealt with growth of population, industry, infrastructure in urban and rural areas, which are prone to strong events. The number of fatalities and injuries may be significantly reduced at the expense of effective response measures just after the event. In this case the right information about expected damage extant and casualties should be provided to the right persons in order to make the right decision in time. Such information may be obtained by simulation the strong earthquake consequences with near real time systems application.

The Extremum system is one of such systems which may be applied at global scale. The first version of the system assigned for loss assessment due to earthquakes was developed more than 10 years ago by joint efforts of Civil Defense and Disaster Management Research Institute, Emercom of Russia (VNII GOChS), Extreme Situation Research Center and Seismological Center of IGE, Russian Academy of Sciences. Long time experience of its operation within the Council of Europe Partial Agreement on Major Hazards Programs showed that the reliability of loss estimations strongly depends on accuracy of event parameters determination by Seismological Surveys, on reliability of the system databases and parameters of simulation models.

The paper addresses the further development of the Extremum system in order to increase the reliability of expected damage and casualty assessment due to strong earthquakes in “emergency” mode. The following

[3] Extreme Situations Research Center, Yunykh Lenintsev str. 121/5-72, 109439 Moscow, Russian Federation
Email: lar@esrc.ru

actions are foreseen: to verify the system data bases on population and building stock distribution, to verify the impact knowledgebase about well documented past events, which will allow to verify the regional parameters of simulation models used in the system at all stages from estimating shaking intensity to assessing the damage to different elements at risk. It is also proposed to create the special Web site in Internet where the weighted alert information from different seismological surveys, which influence greatly on loss estimations, will be displayed; to make accessible the national seismological survey web sites in the case of strong events in their countries, as well as to organize the special Web site with information about thoroughly documented events which may be used for verification Systems for real time damage and losses assessment.

## Short history

The Extremum System and its different versions are assigned for expected damage and loss assessment due to natural and technological disasters, as well as for identification of effective response measures in the case of emergency. The first System version was developed as a local one more than 15 years ago by joint efforts of the Extreme Situations Research Center (ESRC), the Seismological Center of IGE, Russian Academy of Sciences and organizations belonging to Russian Ministry of Emergency Situations (EMERCOM) within Russian Federal Programs aimed at safety of population and other elements at risk against natural and technological disasters. The System has been used for loss assessment due to natural and technological emergencies, as well as integrated risk estimation and zoning for the Russian Federation territory at different levels: local, urban, regional, national ones. In 1995 the system was applied for the first estimations of expected damage and loss in “emergency” mode due to May 28, 1995 Neftegorsk, Russia earthquake.

In 1998 – 2002 the EXTREMUM System was advanced within the framework of the EDRIM Program (“Electronic Discussions in Risk Managements) of the Open Partial Agreement on the Prevention of, Protection Against and Organisation of Relief in Major Natural and Technological Disasters, Council of Europe (EUR-OPA Major Hazards Agreement).

According to the Recommendations of Moscow Seminar on the Contribution to the Decision-Making Process in Seismic Risk Management: Models for Earthquake Damage Assessment, held in on 29 June – 1 July, 2000, within the framework of the EUR-OPA Major Hazards Agreement since August, 2000 the System version is used by EMERCOM of Russia in order to provide quick information on expected damage and casualties assessment of strong earthquakes all over the world.

Since October, 2002 WAPMERR uses another system version, which is called Quakeloss. The Agency was given by the light and blocked System version as a contribution of ESRC to WAPMERR membership for the purpose of testing. The Agency issues a loss estimate in collaboration with the Swiss Seismological Service to the Swiss Corps for Humanitarian Help and OCHA approximately 2 hours after an earthquake occurs.

Since May, 2004 the Geophysical Survey of Russian Academy of Sciences uses the system version for estimation of expected intensity distribution in “emergency” mode.

In 2000 – 2003 Extremum family systems’ versions were developed for the Ministries of Emergency Situations of Armenia and Tajikistan.

In 2004 the new web version of the System, which is called WebLAT, was developed. After this system version testing any registered end-users may work on a remote computer in order to estimate the expected impact in near real time and scenario earthquake consequences using the System default data bases about population and existing building stock distribution as well their own more detailed data bases.

In 2005-2009 several System version were developed for large industrial cities and administrative regions of the Russian Federation. These System's versions are used by the Regional EMERCOM Departments for loss assessment due to natural and technological emergencies, as well as for integrated risk assessment and mapping.

Within the framework of the Russian Federal Program "Natural and Technological Risk Reduction and Management in the Russian Federation up to 2010" the future improvement of the Extremum System mathematical models and databases is under way for application at different level in the Russian Federation, as well as the system version assigned for near real time loss assessment due to earthquakes at global scale.

## The procedure of Extremum global system implementation and experience

The procedure (Larionov et al., 2003a; Larionov et al., 2003b) of expected damage and loss assessment in "emergency mode", using the different system versions, includes:

1. information about the earthquake parameters (origin time, epicenter coordinates, depth, magnitude) is taken automatically from web-sites of seismological surveys, or received by e-mail messages;
2. computation of expected damage extent, social and economic losses (and, eventually, identification of the effective response measures);
3. expert review of the results obtained with the help of a knowledgebase about past events;
4. validation of expected consequences estimation;
5. dissemination of messages about expected damage and losses.

The results of computations are usually presented as maps and tables, where estimates of expected number of fatalities, injuries and homeless are given for the whole stricken area and for each settlement. The estimations are also given about the requirements in forces and resources needed for rescue and relief operations. Figures 1 and 2 shows maps with the results of expected damage and loss computations for the earthquake occurred on 11 October 2008 in Russian Federation. Dots of different size and color show the settlements in the stricken area; the dot size stands for the number of inhabitants; the dot color tells the expected "averaged" damage state of the buildings. The maps are of different scale: map on the fig. 1 gives the general idea about the area where the earthquake was felt. In principal, there was no damage in the settlements shown by blue color on the map. In the settlements shown by green and yellow colors the average damage state was "light" ($d$=1) and "moderate"($d$=2), but some buildings survived damage states "heavy" ($d$=3) and few even damage states "partial and total collapse" ($d$=4 and 5). The expected distribution of building stock, which survived various damage states, for definite settlements are usually given in the tables (Table 1). The reliability of loss computations in emergency mode depends on many factors (Bonnin et al., 2002; Bonnin et al., 2004; Frolova et al., 2003a; Frolova et al., 2003b; Frolova et al, 2007; Frolova et al., 2009). First of all, it is influenced by error the earthquake parameters determination by Seismological Surveys. The other factors that contribute to the reliability of output results are databases on elements at risk and parameters of simulation models used in the Extremum System.

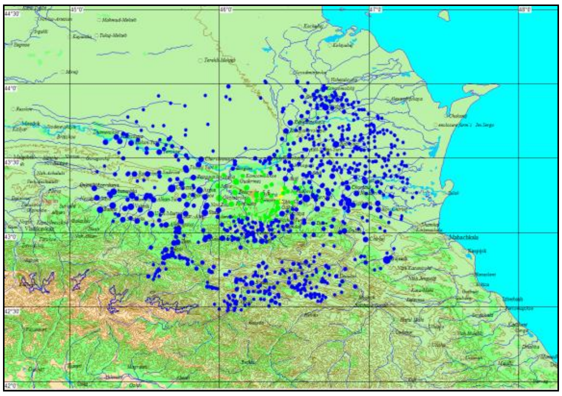


**Figure 1.** Results of possible loss assessment caused by October 11, 2008 earthquake in Russia: dots are settlements in the stricken area; colour of dots shows the average damage state of building stock (yellow : *d*=2, green : *d*=1, blue : no damage)

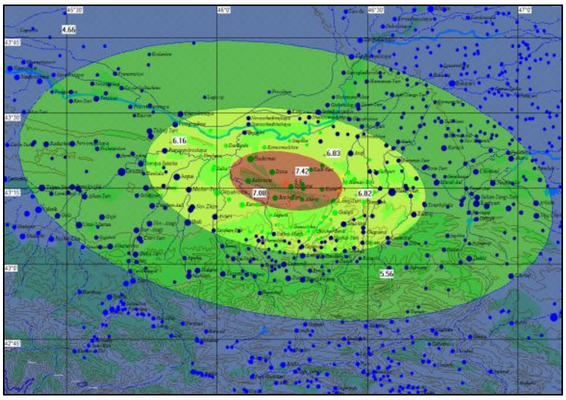



**Figure 2.** Results of possible loss assessment caused by October 11, 2008 earthquake in Russia: figures show the values of expected shaking intensities

At the first stage of loss computations the shaking intensity is simulated (Fig.2). In order to take in to account the regional peculiarities of attenuation laws the computations are made with usage of various parameters of macroseismic field obtained by different researcher for the area under study. This information is accumulated in the knowledgebase of the Extemum system.

***Table 1.*** List of the settlements in the affected area (fragment)

| Settlement name | | $I_{exp}$ | Expected Fatalities | Expected injured | Portion of buildings survived different damage states | | | | | Relative economic losses |
|---|---|---|---|---|---|---|---|---|---|---|
| English | Russian | | | | *d*=1 | *d*=2 | *d*=3 | *d*=4 | *d*=5 | |
| Gudermes | Гудермес | 6.90 | 2-15 | 6-70 | 0.21 | 0.16 | 0.09 | 0.02 | 0.00 | 0.09 |
| Istisu | Истису | 7.19 | 1-11 | 5-41 | 0.21 | 0.16 | 0.10 | 0.04 | 0.01 | 0.12 |
| Suvirov-Yurt | Суворов-Юрт | 7.22 | 2-11 | 5-40 | 0.22 | 0.17 | 0.12 | 0.05 | 0.01 | 0.14 |
| Bachi-Yurt | Бачи-Юрт | 7.07 | 1-8 | 2-35 | 0.19 | 0.15 | 0.09 | 0.03 | 0.00 | 0.10 |
| Beloreche | Белоречье | 7.04 | 1-8 | 2-35 | 0.19 | 0.15 | 0.09 | 0.03 | 0.00 | 0.10 |
| Hasavyurt | Хасавюрт | 6.25 | 0-2 | 0-23 | 0.13 | 0.05 | 0.01 | 0.00 | 0.00 | 0.01 |
| Centoroj | Центорой | 7.12 | 1-5 | 2-19 | 0.21 | 0.16 | 0.10 | 0.04 | 0.01 | 0.12 |
| Ishhoj-Yurt | Ишхой-Юрт | 6.85 | 0-3 | 2-15 | 0.18 | 0.13 | 0.06 | 0.01 | 0.00 | 0.06 |
| Kurchaloj | Курчалой | 6.67 | 0-2 | 0-15 | 0.16 | 0.10 | 0.04 | 0.01 | 0.00 | 0.04 |
| Koshkeldi | Кошкельды | 7.05 | 1-4 | 3-12 | 0.19 | 0.15 | 0.09 | 0.03 | 0.00 | 0.10 |

The simulated estimations of expected shaking intensities and losses are usually compared with observed macroseismic effect and reported damage. Figure 3 shows the comparison of observed values of intensities and the results of computations with usage of different values of regional coefficients of macroseismic field: variant 1 – proposed by Shebalin (Kondorskaya &Shebalin 1977) for Dagestan, variant 4 - proposed by Shebalin (Kondorskaya & Shebalin, 1977) for the Northern Caucasus, variant 5 - proposed by Shebalin (Kondorskaya and Shebalin 1977) for the Caucasian States; variant 6 – proposed by Bystritskaya (Bystistkaya, 1978); variant 7 – proposed by Lutikov (Aver'yanova et al., 1996) for the Chechen Republic; variant 12 - proposed by Shebalin (Shebalin, 2003). The input parameters for computations according different variants are presented in Table 2. The circular isoseists obtained with Shebalin equation application are stretched along the active tectonic faults in order to take into account anisotropy of the medium and source line extension. Expected shaking intensity maps are computed taking into account various regional coefficient of macroseismic field, different orientation of ellipse axis (along the faults or they may be oriented at the angle according to the source mechanism solution) , as well as empirical data about ratio *k* of ellipse major and minor semi-axis (for different value of *k*).

**Figure 3.** Comparison of simulated shaking intensities with application of different attenuation law parameters and observed values

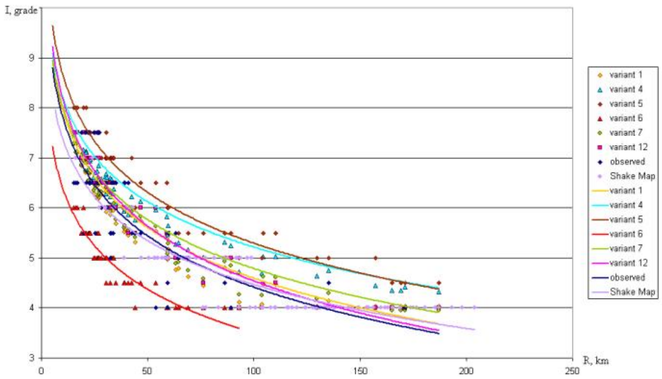



***Table 2.*** Input data for simulation of the Kurchaloj event consequences with the Extremum system application

| No | Event parameters | Regional coefficients in macroseismic field equation | Ratio *k* of ellipse semi-axis | Orientation of ellipse axis |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |
| 1 | 43.276; 46.229<br>M=5.6; h=15<br>instrumental source, GS RAS | *b*=1,5; *ν*=3,6; *c*=3,1<br>for Dagestan<br>(Shebalin, 1977) | k=1.5 | Along faults |
| 2 | 43.276; 46.229<br>M=5.6; h=15<br>instrumental source, GS RAS | *b*=1,5; *ν*=3,6; *c*=3,1<br>for Dagestan<br>(Shebalin, 1977) | k=2 | Along faults |
| 3 | 43.276; 46.229<br>M=5.6; h=15<br>instrumental source, GS RAS | *b*=1,5; *ν*=3,6; *c*=3,1<br>for Dagestan<br>(Shebalin, 1977) | k=4 | Along faults |
| 4 | 43.276; 46.229 | *b*=1,6; *ν*=3,1; *c*=2,2 | k=1.5 | Along faults |

| | | | | |
|---|---|---|---|---|
| | M=5.6; h=15<br>instrumental source, GS RAS | for NorthernCaucasus<br>(Shebalin, 1977) | | |
| 5 | 43.276; 46.229<br>M=5.6; h=15<br>instrumental source, GS RAS | $b$=1,4; $\nu$=3,5; $c$=4,2<br>for Caucasus<br>(Shebalin, 1977) | k=1.5 | Along faults |
| 6 | 43.276; 46.229<br>M=5.6; h=15<br>instrumental source, GS RAS | $b$=1.52; $\nu$=3.6; $c$=1.6<br>for Dagestan<br>(Bystristkaya, 1978) | k=1.5 | Along faults |
| 7 | 43.276; 46.229<br>M=5.6; h=15<br>instrumental source, GS RAS | $b$=1.593; $\nu$=3.41; $c$ = 2.44<br>for Groznyj City<br>(Aver'yanova et al., 1996) | k=1.5 | Along faults |
| 8 | 43.3; 46.3<br>M=5.9; h=10<br>NEIC | $b$=1,5; $\nu$=3,6; $c$=3,1<br>for Dagestan<br>(Shebalin, 1977) | k=1.5 | Along faults |
| 9 | 43.47; 46.34<br>M=5.9; h=15<br>CSEM | $b$=1,5; $\nu$=3,6; $c$=3,1<br>for Dagestan<br>(Shebalin, 1977) | k=1.5 | Along faults |
| 10 | 43.37; 46.35<br>M=5.6; h=10<br>Verified, GS RAS | $b$=1,5; $\nu$=3,6; $c$=3,1<br>for Dagestan<br>(Shebalin, 1977) | k=1.5 | Along faults |
| **1** | **2** | **3** | **4** | **5** |
| 11 | 43.15; 46.10<br>M=5.6; h=15<br>macroseismic source, GS RAS | $b$=1,5; $\nu$=3,6; $c$=3,1<br>for Dagestan<br>(Shebalin, 1977) | k=1.5 | Along faults |
| 12 | 43.276; 46.229<br>M=5.6; h=15<br>instrumental source, GS RAS | $b$=1,5; $\nu$=4; $c$=3,8<br>(Shebalin, 2003) | k=1.5 | Along faults |

In the case of the 2008 Kurchaloj earthquake more general parameters of macroseismic field equation (variant 12), which was proposed by Shebalin V.N., allowed to simulate shaking intensity which proved to be close to observed values of shaking intensities (Fig. 3).

In addition to estimations of expected shaking intensities, expected number of casualties (fatalities, injuries of different level, homeless), engineering situation (percent of buildings survived various damage states, length of blocked transportation systems, number of accidents at lifeline systems and so on) the Extremum system provides optionally information about the effective response measures for strong earthquakes. The estimations are given about the forces rescue operations (rescue mechanized teams, that of hand-operated debris disassembling, medical teams), that for urgent operations (fireman brigades, crash crew, policemen and so on), as well as about engineering devices needed for rescue and relief measures. The estimations are also made about the life-support for the people in the affected area: expected number of temporal shelters, heating devices in winter time and field kitchens; supply with water and food during the first days after the disaster. The estimations are made on the basis of empirical data about past events. The debris volumes and numbers of injured and homeless are used to assess the requirements in forces and resources. At present the relationship are reviewed in order to take into account new modern equipment used for rescue operations.

For the L'Aquila, Italy Earthquake of 6 April 2009 the expected loss computations in emergency mode were made with Extremum System application using the event parameters determined by three Seismological Surveys: NEIC, EMSC and GS RAS. Table 3 shows the input data and the results of expected fatalities simulation.

***Table 3.*** Expected consequences assessment due to the L'Aquila earthquake in Italy

| *Survey* | *Event parameters* | | | | *Expected fatalities, persons* |
|---|---|---|---|---|---|
| | *Longitude* | *Latitude* | *M* | *h, km* | |
| NEIC | 13.334 | 42.334 | 6.3 | 8.8 | 280-1,400 |
| EMSC | 13.32 | 42.38 | 6.3 | 2 | 1,600-6,000 |
| GS RAS | 13.4 | 42.51 | 6.4 | 10 | 180-750 |

When the data on source mechanism, reported macroseismic effect and damage become available the computations were repeated for different variants of input information (Table 4) in order to find the better agreement between simulated and observed effect.

***Table 4.*** Input data for simulation of the L'Aquila event consequences with the Extremum system application

| **No** | **Event parameters** | **Regional coefficients of macroseismic field** | **Ratio *k* of ellipse semi-axis** | **Orientation of ellipse axis** |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |
| 1 | 43.334N; 13.334E<br>M=6.3; h=8.8<br>NEIC | *b*=1,5; *ν*=3,5; *c*=3,0<br>(Shebalin, 1977) | k=1.5 | Along faults |
| 2 | 43.334N; 13.334E<br>M=6.3; h=8.8<br>NEIC | *b*=1,5; *ν*=4,0; *c*=3,8<br>(Shebalin, 2003) | k=1.5 | Along faults |
| 3 | 43.334N; 13.334E<br>M=6.3; h=8.8<br>NEIC | *b*=1,5; *ν*=4,0; *c*=3,8<br>(Shebalin, 2003) | k=3 | Along faults |
| **1** | **2** | **3** | **4** | **5** |
| 4 | 43.334N; 13.334E<br>M=6.3; h=8.8<br>NEIC | *b*=1,5; *ν*=3,5; *c*=3,0<br>(Shebalin, 1977) | k=3 | Along faults |
| 5 | 43.334N; 13.334E<br>M=6.3; h=8.8<br>NEIC | *b*=1,5; *ν*=3,5; *c*=3,0<br>(Shebalin, 1977) | k=3 | Angle 127° |
| 6 | 43.334N; 13.334E | *b*=1,5; *ν*=3,5; *c*=3,0 | k=3 | Angle 156° |

| | | | | |
|---|---|---|---|---|
| | M=6.3; h=8.8<br>NEIC | (Shebalin, 1977) | | |
| 7 | 43.334N; 13.334E<br>M=5.8; h=8.8<br>INGV | *b*=1,5; *ν*=3,5; *c*=3,0<br>(Shebalin, 1977) | k=3 | Angle 156° |
| 8 | 43.334N; 13.334E<br>M=5.8; h=8.8<br>INGV | *b*=1,5; *ν*=4; *c*=3,8<br>(Shebalin, 2003) | k=3 | Angle 156° |

Figure 4 shows the results of computation of expected intensity *I* for the earthquake parameters determined by INGV: φ=43.334N; λ=13.334E; M=5.8; h=8.8 km (variants 7 and 8). Simulation is made for different coefficients of macroseismic field according to (Shebalin, 1977) and (Shebalin, 2003); and for macroseismic field orientation at the angle of 156° in accordance with source mechanism solution of GS RAS.

***Figure 4***. Influence of macroseismic field regional coefficients on simulated values of shaking intensities; INGV event parameters

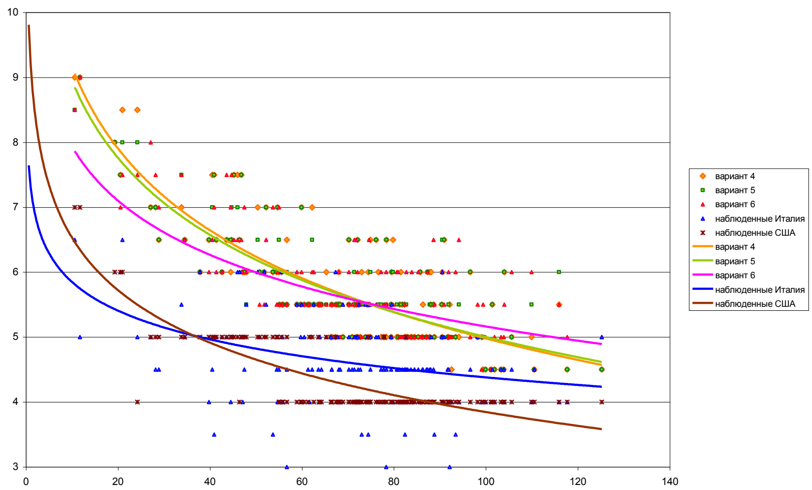
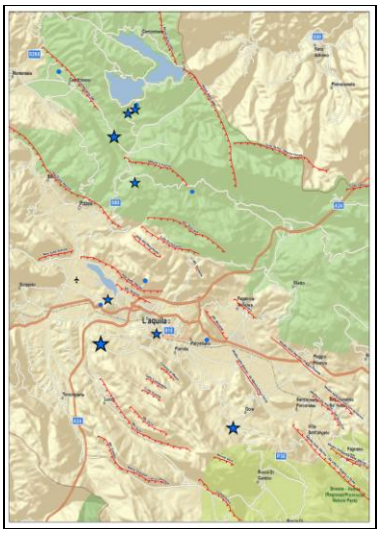
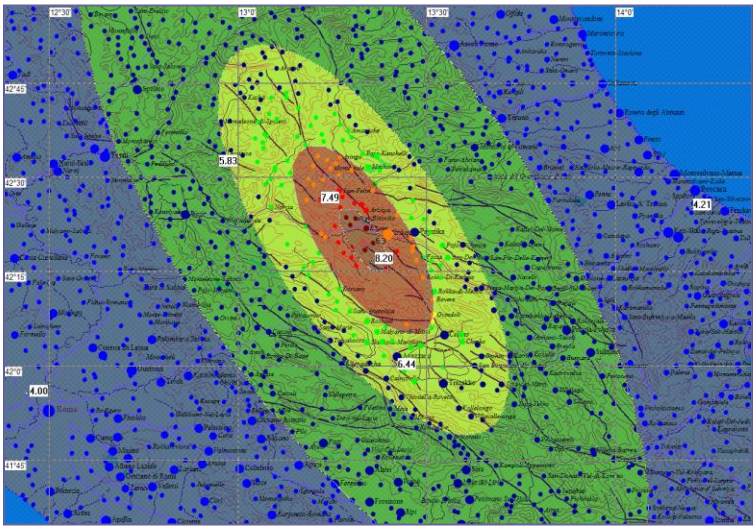



Figure 5 shows active faults of the area under study, figure 6 shows the results of simulation of the L'Aquila earthquake consequences with the Extremum System application; input data are taken according to variant 7 (Table 4). The values of simulated intensities (pink, green and yellow curves in Fig. 5) obtained with the Shebalin macroseismic field equation application (Shebalin, 1968) are higher than the observed values (blue curve in Fig. 5), which were displayed at the INGV website and were based on response of people who feel the earthquake. It was so called Internet intensities. The highest values of *I* were equal to 7 by EMS-98 scale for four settlements. It is possible to suggest that inhabitants whose buildings were severely damages or totally collapsed did not put their information about feelings at the INGV web site. According to the Preliminary Field Report (Rossetto et al., 2009) by the UK Earthquake Engineering Field Investigation Team (EEFIT) at least in 2 settlements Onna and San Gregorio the engineering consequences for existing building stock were estimated as *I*=9 by EMS-98 scale, for other two settlements Malepasso and Paganica the effect was estimated as *I*=8, for L'Aquiala if was estimated between 7 and 8 on EMS-98 scale (Fig. 7).

**Figure 5.** Map of active faults according to INGV (http://cnt.rm.ingv.it)

**Figure 6.** Results of possible loss assessment caused by April 6, 2009 earthquake in Italy; dots are settlements in the stricken area; colour of dots shows the average damage state (brown : *d*=4, red : *d*=3, yellow : *d*=2, green : *d*=1, blue : no damage); figures show the values of *I*






The information about buildings and structures behavior, about response measures published in the Preliminary Field Report by EEFIT (Rossetto et al., 2009) and other similar publications will allow to verify data bases on elements at risk and impact knowledgebase of the Extremum System in order to determine more precisely the regional parameters of the simulation models for the area under consideration.

**Figure 7.** The results of EEFIT team survey of the L'Aquila event affected area (Rossetto et al., 2009): dots with two colours indicate the intensity lies between two values

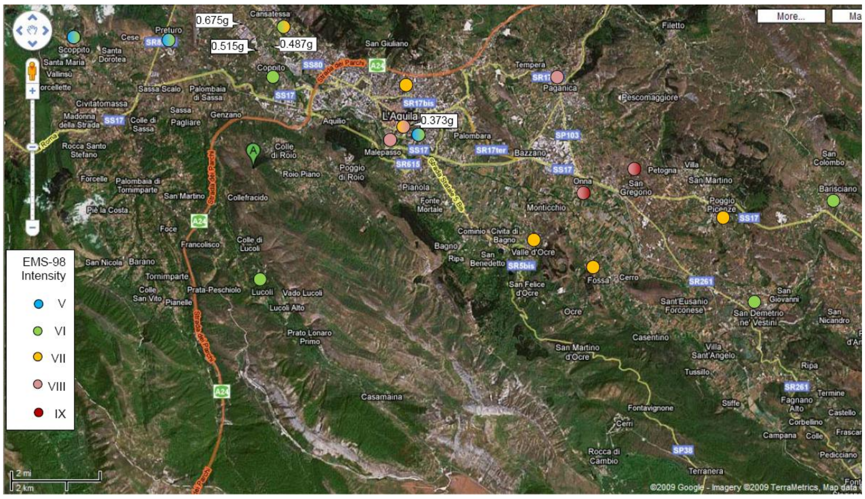
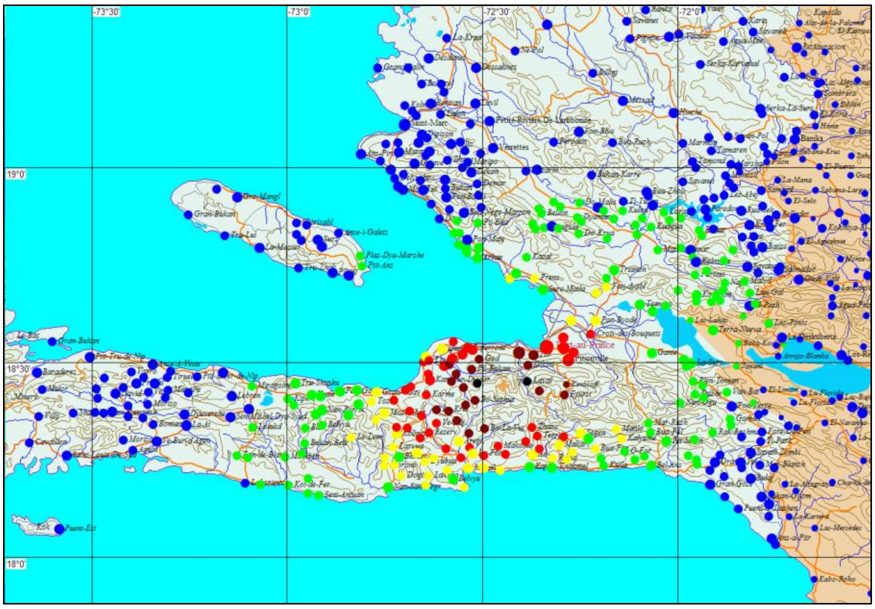



Figure 8 shows one more example of expected loss estimations due to the 12 January 2010 earthquake in Haiti. The computations were made for different input information about event parameters determined by GS RAS, EMSC and NEIC and two orientation macrosismic field according to the source mechanism solution.

**Figure 8.** Results of possible loss assessment caused by January 12, 2010 earthquake in Haiti; dots are

settlements in the stricken area; colour of dots shows the average damage state (black: d=5; brown : *d*=4, red : *d*=3, yellow : *d*=2, green : *d*=1, blue : no damage)




The loss estimations obtained with NEIC parameters usage proved to be the closest to reported one, but the reported casualties will be changed by accumulation new information.

The 10 years experience of the Extremum system application for expected loss assessment due to strong earthquakes worldwide showed the merits and demerits of the System current version. Besides the error of Seismological Survey in event parameters determination in emergency mode there are other factors that contribute to uncertainties in results of computations. First of all, the data bases on elements at risk, impact data bases on past events should be verified and constantly maintained. It will allow to construct more accurate the regional attenuation laws and regional vulnerability functions for various elements at risk, as well to verify models for identification response measures taking into account new technological achievements in the filed.

## Conclusions

The present paper gives a brief description of the Extremum system used worldwide in emergency mode during the last 10 years. The analysis of simulation outputs and used input data allows to draw the conclusion that priority should be given to verification and standardization of data bases on elements at risk and impact data bases about past strong earthquakes, including information about the response measures, in order to increase the reliability of the results.

The experience of System many years application also showed that there is a wide range for verification of simulation models used in the System at all stages from estimating shaking intensity to assessing the damage to different elements at risk and identification the effective response and relief measures. It is definite that the task is huge and hardly can be succefully solved in the nearest future without international efforts.

## References

Aver'yanova V, Baulin Yu, Koff G, Lutikov A, Mindel I, Nesmeyanov S, Sevost'yanov V (1996), Complex estimation of seismic hazard for the Grozny city territory. Moscow: 48-51. (in Russian)

Bonnin J., Frolova N., Kozlov M., Larionov V., Sushchev S., Ugarov A. (2002 ), Experience of "Extremum" System Application for Operative Earthquake Loss Assessment. *Proc. 28th General ESC Assembly*, Genoa, Italy.

Bonnin J., Frolova N. (2004), Near Real-Time Loss Assessment Due To Strong Earthquakes: The State of The Art. *Proc. XXIXth General Assembly of European Seismological Commission (ESC2004),* Potsdam, Germany.

Bystristkaya Yu (1978) Comparison of macroseismic and instrumental data (Dagestan earthquake): Seismicity and hydrogasgeochemistry for the Dagestan territory №2(17): 78-84

Frolova N.I., Larionov V.I., Nikolaev A.V., Kozlov M.A., Ugarov A.N. (2003a), Analysis of Real Time Earthquake Information Applied For Possible Loss Assessment, *Proc. TIEMS2003 Conference*, Sofia Antipolis, France.

Frolova N., Kozlov M., Larionov V., Sushchev S., Ugarov A. (2003b), Extremum System for Earthquake Risk And Loss Assessment, *Proc. of SE-40EEE,* Skopje-Ohrid, Macedonia.

Frolova N., Larionov V., Bonnin J. (2007), Simulation-based information systems for multi-hazard risk and near real time loss estimations due to strong earthquakes, *Proc. TIEMS2007 Conference*, Trogir, Croatia.

Frolova N., Larionov V., Bonnin J. (2009), Challenges Of Global Earthquake Loss Estimation In Emergency Mode, *Proc. TIEMS2009 Conference*, Istanbul, Turkey.

Larionov V., Frolova N. (2003a), Peculiarities of seismic vulnerability estimations. *In* : Natural Hazards in Russia, volume 6: Natural Risks Assessment and Management, *Publishing House "Kruk"*, Moscow, pp.120-131. (in Russian).

Larionov V., Sushchev S., Ugarov A., Frolova N. (2003b), Seismic risk assessment with GIS-technology application. *In* : Natural Hazards in Russia, volume 6: Natural Risks Assessment and Management, *Publishing House "Kruk"*, Moscow, pp. 209-231. (in Russian).

Rossetto T., Peiris N., Alarcon J., So E., Sargeant S., Sword-Daniels V., Verrucci E., Del Re D., Free M. (2009). The L'aquila, Italy Earthquake of 6 April 2009 A Preliminary Field Report By Eefit, 53 P.

Shebalin N.V. (1968), Procedures of engineering seismological data application for seismic zoning. In: Seismic zoning of the USSR, Nauka, Moscow, pp.95-121 (in Russian).

Shebalin N.V. (1977). Reference earthquakes and macroseismic field equations// New catalogue of strong earthquakes for the USSR territory. Nauka, Moscow, pp.20-30 (in Russian).

Shebalin N (2003) Macroseismic Problems. In: Computational Seismology, issue 34: 55-200 (in Russian)

## Author Biographies:

Dr. Valery Akimov is Director, Institute on Civil Defense and Emergency Situations, Emercom of Russia. He is Vice President of Russian Scientific Society on Risk Analysis. He contributed to research and research application in the field of population and territory protection against emergencies of natural and technological character. He is the author of more than 20 monographs devoted to risk assessment and management with special attention to strategic risks.

Dr. Sergey Kachanov is Vice-Director, Institute on Civil Defense and Emergency Situations, Emercom of Russia. He has contributed to research and research application in the field of population and territory protection against emergencies of natural and technological character since 1993. He participated in Council of Europe Partial Agreement Programs aimed at risk reduction with special attention to seismic risk management at global scale.

Dr. Nina Frolova is a senior scientific researcher with Seismological Center of IGE, Russian Academy of Sciences. She has contributed to studies on earthquake hazards and risk reduction and activities of UNDRO, UNESCO, IDNDR on earthquake preparedness since 1985. The Soviet of Ministries awarded Dr. Nina Frolova, along with others, the USSR prize in 1984 for her work on the seismic load assessment and earthquake resistance of high dams. In 2005 she was awarded by UNESCO, the GARD Medal for distinguished professional leadership and personal commitment to ongoing programs on disaster reduction. Dr. Nina Frolova is a responsible scientist for the ESC WG "Earthquake Preparedness and Civil Defence". She is a TIEMS Directors' Board Member and GARD Vice-President for the Asian Region.

Dr. Sergej P. Suchshev is General Director, Extreme Situation Research Center. He is an electronic engineer, has contributed to research and research application in the field of automatic systems for monitoring and forecast of emergency situations of natural and technological types.

Dr. Valeri Larionov is Vice-General Director of Extreme Situations Research Center. He has contributed to research on emergency response since 1972. He is an expert in assessment and management of natural and technological risk; organization of management and response to emergency situations; industrial safety, assessment and management of seismic risk. At present he has conducted researches on expected loss assessment due to natural and technological hazards and emergency management with GIS technology application. The Russian Federation government awarded Dr. Valeri Larionov, along with others, the prizes in 1999 and 2001 for the work on development of the Russian federal system for monitoring and forecast emergency situations.

# 学术项目中灾后重建和可持续发展的集成整合

**James C. Hagen, Ph.D.**

*MPH, MBA, MEP*

*Saint Xavier University, U.S.A.1*

**Susan M. Smith EdD, MSPH**

*Indiana University, U.S.A.2*

**【摘要】**近几年来，灾害管理的恢复阶段和社区恢复之间的关系日益受到关注和考虑。然而直到最近这个关系才扩展到包括可持续整合重要性，当围绕美国强调可持续性和环境责任问题商业项目迅速发展时，他们理解并教育学生知道可持续性、适应力和灾害恢复之间的密切关系是很关键的，如果我们准备让我们的学生理解并将恢复适应能力转向到绿色环境和可持续企业责任，那么必须强调灾害管理，从商业角度考虑，如果要进行灾害准备和灾后恢复和重建，管理项目必须整合企业责任和适应力为一个可持续性企业，

本文将阐述定义可持续企业的主要因素，包括环境保护、经济发展、社会发展等关键测评参数等灾后恢复能力，本文中，对可持续发展企业的项目检查了他们的灾后恢复和可持续发展应用状况，在已有项目中对这两个方面密切关系的认知以及灾后恢复的关注很少甚至没有，

本文研究了如何这些议题合并入未毕业和毕业生课程中的方法，以及如何将这些方法应用于课题和实习中。

创建/发展一个可持续的、有适应力的城市是减少风险、增强灾后恢复能力的方法，无论这个灾害是自然灾害还是人为造成的。本文结果可以用于可持续企业商业项目课程的设置或修订，这将有助于把灾害管理概念整合到已有的知识技能中。

**【关键词】**应急管理；可持续性；恢复；教育

# THE INTEGRATION OF DISASTER RECOVERY AND SUSTAINABILITY

# IN ACADEMIC PROGRAMS

**James C. Hagen, Ph.D.**

*MPH, MBA, MEP*

*Saint Xavier University, U.S.A.1*

**Susan M. Smith EdD, MSPH**

*Indiana University, U.S.A.2*

## Keywords

Emergency Management, Sustainability, Recovery, Education

## Abstract

In recent years, there has been an increased attention to, and consideration of, the relationship between the recovery phase of disaster management and the resilience of communities. However, only recently has this relationship been extended to include the integral importance of sustainability. As business programs spring up around the United States addressing sustainability and environmental responsibility, it is critical that students in the program understand the intimate relationship between sustainability, resilience, and disaster recovery. Disaster management must be addressed if we are to prepare our business students to understand and translate resilience into green environments, sustainable enterprise and corporate responsibility. From a business perspective, management programs must integrate corporate responsibility and resilience into sustainable enterprise if they are to be prepared for disaster and challenges of recovery and rebuilding after disaster.

This paper will address major factors defining a sustainable enterprise that also affect its ability to recover from disasters, including environmental protection, economic development, and social development as critical measurable parameters. In this work, programs on sustainable enterprise are examined for their application of sustainability to resilience and recovery after disaster. There has been little recognition of the intimate relationship of these two concepts, and little attention paid to disaster recovery in existing programs. Strategies by which to incorporate these issues into the undergraduate and graduate business curricula will be provided, and methodologies for translating these strategies into projects and internships will be explored.

Creating/developing a sustainable, resilient city is a means of reducing risk, and enhancing

the likelihood of recovery from disasters, whether natural or man-made. The results of this work will be used to modify/create curricula for sustainable enterprise business programs that will incorporate disaster management concepts into the skill sets learned.

## Introduction

In the early days of disaster management, the emphasis of almost all agencies was on the preparedness phase. This was due to the realization of our lack of preparedness in the United States to identify and thwart terrorist threats or in understanding the nature of asymmetrical warfare better know outside of our own shores. A massive program was begun to identify major gaps and begin the education and training necessary to prepare the various sectors of our society, beginning with the first responders. With the advent of the National Response Plan (now the National Response Framework or NRP), the National Incident Management System (NIMS), and Incident Command System (ICS), the nation began its long road to a more unified view and ability to respond to threats both natural and man-made.

Vast strides have been made, while much remains yet to be done. In those initial stages, little attention was paid to aspects of response and recovery, or to mitigation that would have such a major impact on the recovery and resilience of communities. It is only in recent years that there has been an increased attention and research on the importance of and practical aspects of resilience. There are now many books (International Institute of

Rural Reconstruction and the Catholic Organization for Relief and Development Aid, 2007; Pelling, 2003; Vale and Campanella, 2005) and continuous publications to assist governments and communities in better understanding this area of study. Cities and urban areas are begin carefully examined in respect to their resilience and ability to recover from disaster as a means to not only predict but mitigate for future events. Most attention has been paid to the urban environment due to the level of damage and life lost that could potentially occur from natural or man-made disasters. We were given clear messages in recent disasters, including the Haiti earthquake, Hurricane Katrina, the Indian Ocean Tsunami, Chinese earthquakes, several tornados in the US, and the 9/11 terrorist attack on New York City and the Pentagon.

## Background and Thesis

It has become axiomatic that due to issues of global climate change, urbanization, alteration of fertile land to desert, population growth, and environmental degradation, frequency and severity of natural disasters are on the increase. Natural disasters are increasing in both magnitude and number (Hoyois et al., 2006). The United Nations projects that by 2030, 60% of the world’s population will reside in cities (United Nations Department of Economic and Social Affairs, 2005). It is these urban areas that will be sites for greatest destruction and life lost. Globalization and other factors, combined with global political instability and poverty, create an environment that is exceedingly fragile, and populations that are increasingly vulnerable. The effects of urbanization and poor economic conditions have resulted in developing countries accounting for 96% of natural disaster-related deaths (Natural Hazards Observer, 2000) and the number of affected survivors in developing countries being 40 times higher (Department of Humanitarian Affairs, 1993). As a foreshadowing of the devastation in Haiti, a study of Guatemala City 20 years after the massive death and destruction of the 1976 earthquake affecting primarily the poor (poor-quake) identified 589,900 inhabitants still living around the city that were living in areas “considered highly susceptible to earthquakes, floods, and landslides” (IDNDR, 1996). There must be an effort made to “ensure harmonious interactions between natural and human systems” to minimize vulnerability (El-Masri and Tipple, 2002)

## Mitigation and Resilience

Mitigation has long been established as the cornerstone for community resilience, although only more recently has the emphasis of emergency management shifted from preparedness and response to recovery and mitigation (LeDuc, 2006). In the past decade, new approaches for understanding the concept of community vulnerability and resilience have been proposed. These new approaches to reduce community risk and increase resilience at the local level support the integration of those individuals with backgrounds in social psychology, community economics, environmental management and community development into strategic planning processes to increase community along with groups more traditionally associated with emergency management. This includes those with experience working in human services, non-governmental organizations, and community organizations, as well as individuals associated with agencies more typically identified with emergency response such as fire services, police and emergency services. These sectors can also broaden and strengthen planning efforts to strengthen resilience (Buckle P., Mars G., and Smale S., 2000).

This new emphasis on resilience to reduce the impact of disasters still recognizes the importance of planning and designing community infrastructure including water systems, roads and bridges to withstand a major disaster but further supports the concept that just "the absence of vulnerability," is not enough to maintain the resilience of a community following a crisis such as a disaster (Buckle P.. Mars G., and Smale S., 2000). To strengthen resilience within a community, the capacity must exist in the first place to not only mitigate the losses or damage that might occur from a disaster but when possible prevent the damage. The objective of programs focused on strengthening the capacity of a community to be resilience and prevent damage can be measured by tracking the ability of the community to maintain living conditions for residents as close to normal during the disaster event and documenting that a rapid recovery was achieved. To be successful in achieving resilience a community must provide support for residents at the individual, family, and organizational level. Buckle, Mars and Simale (2000) reported the following elements should be present in a community to support resilience: shared goals within the community- similar values, and aspirations, having established social infrastructure, positive and economic trends exist within a community or region, evidence of sustainability of social and economic life, existing successful partnerships, communitity members share a common interest, individuals and groups use established networks, and adequate resources and skills are available locally to support emergency management related planning.

Jacobs (2004) maintained that communities must be viewed holistically if we are to recognize and react to the interconnectedness of the 5 pillars of society. These include community and family, higher education, effective practice of science and science-based technology, taxes and governmental powers, and self-policing by learned professionals. Through this understanding these pillars that efforts towards a more sustainable community can be a means of risk reduction and disaster resiliency. Resilience comes from the community as a whole, not merely from one agency or unit of government.

Resilience is an important aspect of emergency management, especially when considering the vulnerability of complex physical and social system in our urban environments (Godschalk, 2003). Two cities in the United States, Berkeley in California, and Tulsa in Oklahoma were cited as examples of great progress toward resiliency. These cities have made strides in long-term persistence and innovative risk-reduction policies, in part by the presence of strong champions leading community efforts. Novel is their concept that urban resilience was net necessarily typical to a specific pattern of urban form or development. One possibility was to use communications technology as a substitute for urban density. This aspect of risk reduction may create issues when faced with urban-specific goals of sustainable development.

Resilience has as a goal restoring socioeconomic vitality to a community following disaster. Tobin (1999) proposed a combination of three models in order to attain both resilience and sustainability – a mitigation model, a recovery model, and a structural-cognitive model. Characteristics of the resulting framework included the following:

- Lowered levels of risk by decreasing exposure to geophysical events
- Reduced levels of vulnerability by helping those marginalized and/or vulnerable
- Long-term sustainable goals in all planning efforts
- High level leader/agency support
- Partnerships and coordination at all levels
- Strengthened networks for both independent and inter-dependent segments
- A balancing of practical sustainable goals with economic stability

However, the point is made that current mitigation strategies sustain communities as they are, perpetuating the damage-disaster cycle. At best, we can learn to live with hazards, since it is not feasible in the current socio-political economic environment the change where people live and work. This would be necessary in order to teach people how to work with the environment instead of just working in it.

Chakos (2008) also works with the concept of co-existing with hazards and associated risks faced by contemporary communities. He stressed the importance of complex urban communities to improve built environments as well as adopt sustainable development practices. Paton (2009) proposed a model that recognized the necessity of citizens to co-exist with hazards and discussed issues of how to define and predict resilience by integrating person, community, and society level factors.

## Sustainability

A parallel thread in our global consciousness has been the increasing awareness, and acknowledged responsibility, of every nation for sustaining our planet and its resources (Bell and Morse, 2008; Edwards, 2005; Epstein, 2008; Werbach, 2009. The term sustainability implies that without considering how our actions affect the environment, both as a global society and in respect to corporate culpability, our way of life and ultimate existence can be threatened. Once primarily the realm of environmentalists and those proselytizing for corporate responsibility, this effort has become a multinational cry to action.

However, it is only recently that we have come to acknowledge, study, and respect the relationship of how <u>sustainability</u> can actually create or promote <u>resilience and recovery</u> from all types of disasters or emergencies, and the potential importance of indigenous/traditional knowledge and wisdom. The purpose of this work is to more clearly establish that link, and define some of the aspects of sustainability that need to be enhanced in order to increase resilience. In doing so, we accomplish the dual imperative of increasing both our ability to survive and recover from disasters, as well increasing our respect for the planet to act as better stewards of our planets resources.

The educational offerings and degree programs on emergency management, with an increasing emphasis on resilience and recovery phases, are continuing to increase in number and quality. In the United States, there are a growing number of programs at all levels of education involving the "greening" of America, respect for our planet, sustainability, green buildings and sustainable aspects of the "built" environment.

Increasing programs on sustainability and sustainable enterprise are being developed around the country, as well as an increasing number of certifications (such as the certificate in Leadership in Energy and Environmental Design - LEED) that provide business advantages to those who adhere to certain standards.

## Findings and Discussion

It is illustrative to view the educational programs that are now being offered in the area of disaster management (DHS, 2010). They are found as certificates, as well as Bachelor's, Master's and Doctoral degree programs. However, rarely does the description of the program emphasize the relationship of sustainability to emergency management. Likewise, higher education programs in the area of sustainability (Association for the Advancement of Sustainability in Higher Education - AASHE, 2010), programs traditionally address issues of environmental impact, corporate responsibility, and the need for global partnerships and action. Little is apparent in terms of recognizing the connections between the worlds of emergency management and sustainability.

It is advised that graduate programs in emergency management recognize and make clear the impact that sustainable building, environmental consciousness, and corporate responsibility can have on response and recovery activities in the realm of emergency management. Special courses might be developed to take advantage of, and further, the research that has only begun to verify the important relationship that exists between the two areas.

As environmental science and natural resource management have become both complex and more recognized as vital areas of study in respect to sustainability of our planet, we have concommitantly come to understand that approaches to the problems must be transdisciplinary (Allen, Ataria, Apgar, Harmsworth, and Tremblay, 2009; Kates, Clark, Corell, Hall, Jaeger, Lowe, McCarthy, Schellnhuber, Bolin, Dickson, Faucheux, Gallopin, Grubler, Huntley, Jager, Jodha, Kasperson, Mabogunje, Matson, Mooney, 2001). It is unfortunate that indigenous knowledge systems pertaining to natural disasters, or Traditional Ecological Knowledge (TEK) (Stephenson and Moller, 2009) are most often viewed as stagnant and static, or even as an impediment to socioeconomic progress ( Robson et al., 2009). This is opposite to the reality of the knowledge system as dynamic and adaptive. Robson, et al, (2009) demonstrates the advantage of creating communities of learning as a means to access the depth of knowledge possessed by each community, whether that knowledge be TEK or modern scientific inquiry. Hagen (2008), highlighted the invaluable information possessed by indigenous cultures pertaining to emergency management. It is, in fact, these cultures that have learned to predict, prepare, respond, and recover to disasters of all types. We must take advantage of communities of learning involving the indigenous peoples to help us understand how preparedness and emergency management need to be inter-linked with environmental respect and sustainability if we are to mitigate for, and survive, the disasters that lie ahead.

One of the best and most established examples of the relationship between the sustainable "built" environment and recovery is found in research on impact of the built environment on flood damage ( Brody, Zahran, Highfield, Grover, and Vedlitz, 2007; Zahren, Brody, Peacock, Vedlitz, and Grover, 2008). Studies were performed on hundreds of countywide flood events in Texas during the period of 1997 – 2001. It was clear that flood damage was related not only to amount of rainfall, but more specifically on scale and type of human development. Casualties were less when significant rainfall prior to the flooding resulted in a "warning" of the public of imminent danger. Living in a built environment implies that the community was created keeping in mind not only protecting the environment from man, but protecting man from the environment. The environment is also protected when communities are created to avoid/survive flooding and other normal or "natural" events, including disasters. However, it must be noted that even with creation of hazard-resistant communities, the presence of casualty-prone (vulnerable) populations will result in significant injury and death. Use of sustainable mitigation strategies concerning public information, mapping and regulations, as well as green location restrictions and use of permeable/semi-permeable surfaces, loss of life and property. It is however, important to note that Zahran et al. (2008) made note of the fact that while structural engineering mitigation approaches to flood control such as costly dams may lead to increased population growth and a false sense of security, especially by vulnerable populations.

One aspect of the consideration of resilience and sustainability is that we cannot stop the natural events of earthquakes, floods, and other natural disasters. That means that we must learn to live with/understand risk, and value it as we create our plans. One aspect of sustainability means living with risk and understanding those aspects of resilience related to living with and within the environment (Paton, 2009).

Emergency management has come to be recognized as a critical piece in the development of sustainable communities (Schneider, 2002). Hazard mitigation must be combined with community planning.

## References

Allen, W., Ataria, W., Apgar, J.M., Harmsworth, G., and Tremblay, L.A. (2009). Kia poni te mahi putaiao – doing science in the right spirit. J. Royal Soc. New Zealand. 39(4): 239-242.

Association for the Advancement of Sustainability in Higher Education (AASHE), Resource Center, Academic Programs. (1010). http://www.aashe.org/resources/programs.php.

Bell, S. and Morse, S. (2008). Sustainability Indicators: Measuring the Immeasurable. Earthscan, London.

Brody, S.D, Zahran, S., Highfield, W.E., Grover, H., Vedlitz, A. (2008). Identifying the impact of the built environment on flood damage in Texas. Disasters:32(1):1-18.

Buckle, P., Mars, G. and Smale S. (2000). New Approaches to Assessing Vulnerability and Resilience . Australian Journal of Emergency Management: Winter Issue: 8-14.

Chakos, A. (2008). Seismic risk reduction sparks community resilience. 14th World Congress on Earthquake Engineering; Beijing. http://www.hks.harvard.edu/taubmancenter/emergencyprep/downloads/seismic_risk.pdf

Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA), Emergency Management Institute (EMI), The College List. (2010). http://training.fema.gov/EMIWeb/edu/collegelist.

Department of Humanitarian Affairs. (1993). Natural Disasters, DHA News, Jan/Feb, pp 26-27. (Geneva: Department of Humanitarian Affairs).

Edwards, A.R. (2005). The Sustainability Revolution: Portrait of a Paradigm Shift. New Society Publishers, Canada.

El-Masri, S. and Tipple, G.. (2002). Natural disaster, mitigation, and sustainability: the case of developing countries. International Planning Studies, 7(2):157-175.

Epstein, M.J. (2008). Making Sustainability Work: Best Practices in managing and measuring Corporate Social, Environmental, and Economic Impacts. Greenleaf Publishing Ltd., Sheffield, UK.

Godschalk, D.R. (2003). Urban hazard mitigation: Creating resilient cities. Nat. Hazards Rev. 4(3): 136-143.

Hagen, J.C. (2009). Emergency management structure for use in the Alaska native (AN) elderly population. Int. J. Emergency Management. 5(3/4): 279-283.

Hoyois, P, Scheuren, J-M., Below, R., and Guha-Sapir, D. (2006). Annual disaster statistical review: Number and trends 2006. Brussels, Belgium: Center for Research on the Epidemiology of Disasters; May, 2007. http://www.preventionweb.net/files/1080_Annual20Disaster20Statistical20Review202006.pdf Accessed February 26, 2010.

International Decade for natural Disaster Reduction. (1996). Cities at Risk: Making Cities Safer..Before Disaster Strikes. (Geneva: International Decade for Natural Disaster Reduction).

IIRR, Cordaid. (2007). Building Resilient Communities: A Training Manual on Community-managed Disaster Risk Reduction. IIRR and Cordaid, Philippines.

James, J.J., Subbarao, I., and Lanier, W.L. (2008). Improving the art and science of disaster medicine and public health preparedness. Mayo Clin Proc. 83(5): 559-562.

Jacobs, J. (2004). Dark Age Ahead. New York, NY.: Random House Publishing.

Kates, R.W., Clark, W.C., Corell, R., Hall, J.M., Jaeger, C.C., Lowe, I., McCarthy, J.J., Schellnhuber, H.J., Bolin, B., Dickson, N.M., Faucheux, S., Gallopin, G.C., Grubler, A., Huntley, B., Jager, J., Jodha, N.S., Kasperson, R.E., Mabogunje, A., Matson, P., Mooney, H. (2001). Environment and development – sustainability science. Science. 292(5517): 641-642.

LeDuc, A. (2006). Establishing mitigation as the cornerstone for community resilience. In the Public Institute Risk Institute 2006 Risk Management Yearbook. pp 1-19.

Natural Hazards Observer. (2000). World Bank launches ProVention Consortium to mitigate disasters in developing nations; and the decade lives on…(p. 9), XXIV(4), pp.3,9.

Paton, D. (2009). Community sustainability and natural hazard resilience: all-hazard and cross-cultural issues in disaster resilience. Int. J. Environmental, Cultural, Economic, and Social Sustainability. 5(1): 345-356.

Pelling, M. (2003). The Vulnerability of Cities: Natural Disasters and Social Resistance. Earthscan Publications, Ltd., London.

Robson, J.P., Miller, A.M., Indrobo, J.C., Burlando, C., Deutsch, N., Kocho-Schellenberg, J-E., Pengelly, R.D., and Turner, K.L. (2009). Building communities of learning: indigenous ways of knowing in contemporary natural resources and environmental management. J. Royal Soc. New Zealand. 39(4): 173-177.

Schneider, R.O. (2002). Hazard mitigation and sustainable community development. Dis. Prevention and Management. 11(2):141-147.

Stephenson, J. and Moller, H. Cross-cultural environmental research and management: challenges and progress. . J. Royal Soc. New Zealand. 39(4): 139-149.

Tobin, G.A. (1999). Sustainability and community resilience: the holy grail of hazards planning. Env. Hazards: 1: 13-25.

Vale, L.J. and Campanella, T.J. (2005). The Resilient City: How Modern Cities Recover From Disaster. Oxford University Press, New York.

Werbach, A. (2009). Strategy for Sustainability: A Business Manifesto. Harvard Business Press, Boston.

United Nations Department of Economic and Social affairs, Population Division. Population Division World Urbanization Prospects: the 2005 revision: executive summary. Geneva, Switzerland: UNHCR;2005. http://www.un.org/esa/population/publications/WUP2005/2005WUPHighlights_Exec_Sum.pdf accessed February 26, 2010

Zahren, S., Brody, S.D., Peacock, W.G., Vedlitz, A. and Grover, H. (2008). Social vulnerability and the natural and built environment: a model of flood casualties in Texas. Disasters, 32(4):537-560.

## Author Biography

Dr. James C. Hagen, Ph.D., MBA, MPH, MEP is a full professor and coordinator of the Disaster Preparedness and Management Certificate Program at the Graham School of Management, Saint Xavier University in Chicago. He is a Certified Emergency Response Coordinator, a Certified Public Health Administrator, and is certified by the Department of Homeland Security as a Master Exercise Planner. He is currently the Regional Director for North America of TIEMS. He is also a licensed Nursing Home Administrator, and has worked in this area to prepare long term care organizations for the special needs of vulnerable populations

Dr. Susan M. Smith, EdD, MSPH, is an Associate Professor of Safety and Health Education at Indiana University Bloomington in the U.S.A.. Dr. Smith's research areas include: building health education and protection strategies to reduce the rate of injuries or death within a community, and enhancing the emergency preparedness and response practices of organizations to enhance the level of protection for children and adults considered to be members of high risk groups during times of crisis or disaster.

# 应急模式下基于全球模式数据库的地震灾害损失评估：

# 以汶川地震为例

**Nina Frolova**

IGE 地震研究中心、俄国科学院，俄国

**Valery Larionov**

极端灾害状态研究中心，俄国

**Jean Bonnin**

格洛布物理研究学院 ，斯特拉斯堡大学，法国

**【摘要】**本文主要对强震后运用全球系统灾害损失评估的可靠性进行了研究。不用风险要素数据对应急模式下的灾害损失评估有很大的影响。历史地震的影响因子数据库可以在全球系统标准以及区域参数仿真模型验证中加以运用。这些仿真模型在从地震强度估计到损失评估等各个阶段中都可以运用，要提高应急模式下损失评估的可靠性必须在国际层面上加强国际协调与研究工作。

**【关键词】**强震；应急模式下损失评估；全球尺度；风险要素数据库；影像数据库；国际合作

# DATA BASES USED IN WORLWIDE SYSTEMS FOR EARTHQUAKE LOSS ESTIMATION IN EMERGENCY MODE: WENCHUAN EARTHQUAKE

**Nina Frolova**[5]

[1] *Seismological Center of IGE, Russian Academy of Sciences, Russian Federation*

**Valery Larionov**[6]

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[5] Seismological Center of IGE, Russian Academy of Sciences, Nikoloyamskaya str. 51, 109004 Moscow, Russian Federation

Email : frolova@comail.ru

[6] Extreme Situations Research Center, Yunykh Lenintsev str. 121/5-72, 109439 Moscow, Russian Federation

Email: lar@esrc.ru

[2] *Extreme Situations Research Center, Russian Federation*

**Jean Bonnin**[7]

[3] *Institut de Physique du Globe, Strasbourg University, France*

## Keywords

Strong earthquakes, loss estimations in "emergency" mode, global scale, data bases on elements at risk, impact data bases, international collaboration

## Abstract

This paper addresses the reliability issues of strong earthquakes loss assessment following strong earthquakes with worldwide Systems' application. The databases on different elements at risk influence strongly the loss estimations in emergency mode. The impact databases on past earthquakes could be used for worldwide system calibration, as well as for verification of regional parameters of simulation models used at all stages from, estimating shaking intensity to assessing the damage to different elements at risk. The need for coordinated efforts and research at international level is stressed if one wants to increase the reliability of loss estimation in "emergency" mode.

## Introduction

The May 12, 2008 Wenchuan earthquake has resulted in great social and economic losses. According to CRED (www.emdat.be) the number of casualties is estimated at 68,858 killed, 18,618 missing and 45.6 millions affected. More than 26 millions buildings were damaged and around 5 millions totally collapsed. Almost 7,000 schools were completely destroyed and many others suffered partial damage. The negative consequences were aggravated by wide spread secondary natural and technological processes.

Timely and correct action just after an event can result in significant benefits in saving lives. In this case the information about possible damage and expected number of casualties is very critical for taking decision about search, rescue operations and offering humanitarian assistance. Such rough information may be provided by, first of all, global systems, in emergency mode.

The reliability of loss estimations through the worldwide systems strongly depends on the databases used in the systems. The databases on different elements at risk, such as population and building stock distribution, as well critical facilities characteristics are very important. The impact databases on past events could be used for worldwide systems' calibration, verification of parameters of simulation models used in the systems at all stages, from estimating shaking intensity to assessing the damage to different elements at risk.

The presentation analyzes the results of expected loss estimations due to the Wenchuan earthquake in emergency mode with different worldwide systems and databases application. The need for coordinated efforts and research at international level is emphasized in order to develop the structure and content of

[7] Institute of Physics of the Earth, Strasbourg University, 5 rue René Descartes, F - 67084 Strasbourg Cédex, France

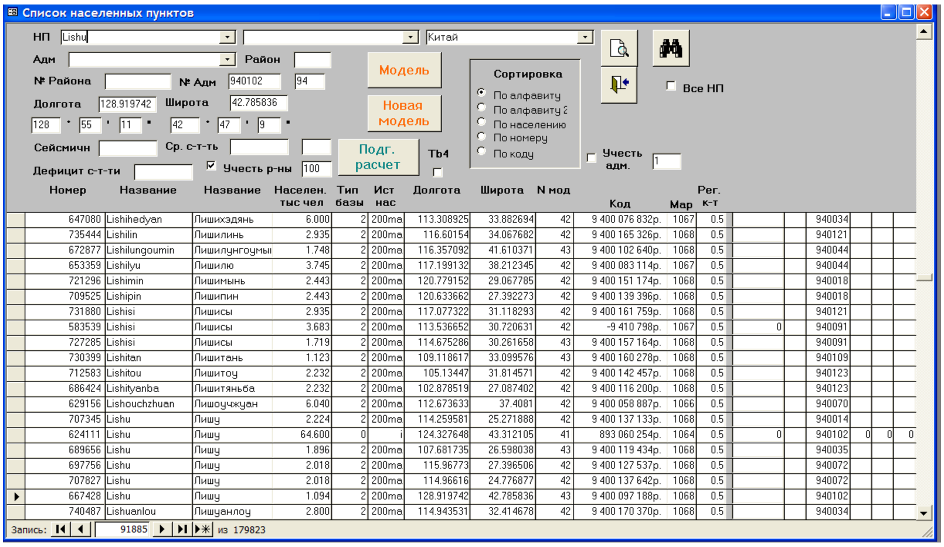
Email: bonnin@selene.u-strasbg.fr

international impact databases, as well as requirements to databases on population and built environment distribution used in worldwide systems for loss estimation in emergency mode.

## Extremum System databases and models

The “Extremum” system, developed in 1990ies by joint efforts of Extreme Situations Research Center (ESRC) Ltd., Seismological Center, Institute of Environmental Geosciences, Russian Academy of Sciences (IEG-RAS), and Civil Defense and Disaster Management Research Institute, Emercom of Russia, is one of the worldwide systems which may be used for earthquakes loss assessment in emergency mode for any earthquake-prone region. Its databases and mathematical models used for simulation of shaking intensity, damage to buildings and structures, number of fatalities and injuries, are regularly updated by ESRC and IEG-RAS. The detailed description of simulation models is given in the 6 volumes’ monograph “Natural Hazards in Russia”, vol. 6 “Natural Risks Assessment and Management” (Larionov & Frolova, 2003; Larionov *et al*. 2003), in the Proceedings of SE-40EEE in Skopje-Ohrid, Macedonia in 2003 (Frolova *et al*., 2003b) and in the Proceedings of TIEMS Annual Conference in Trogir in 2007, Istanbul in 2009 (Frolova *et al*., 2007; Frolova *et al*., 2009). The “Extremum” database on population and building stock (Fig.1) includes the information about 179,823 settlements.

***Fig. 1.*** Fragment of the “Extremum” database on population and building stock distribution for China




| Номер | Название | Название | Населен. тыс чел | Тип базы | Ист нас | Долгота | Широта | N мод | Код | Мар | Рег. к-т | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 647080 | Lishihedyan | Лишихэдянь | 6.000 | 2 | 200ma | 113.308925 | 33.882694 | 42 | 9 400 076 832p. | 1067 | 0.5 | | | 940034 | | | |
| 735444 | Lishilin | Лишилинь | 2.935 | 2 | 200ma | 116.60154 | 34.067682 | 42 | 9 400 165 326p. | 1068 | 0.5 | | | 940121 | | | |
| 672877 | Lishilungoumin | Лишилунгоумы | 1.748 | 2 | 200ma | 116.357092 | 41.610371 | 43 | 9 400 102 640p. | 1068 | 0.5 | | | 940044 | | | |
| 653359 | Lishilyu | Лишилю | 3.745 | 2 | 200ma | 117.199132 | 38.212345 | 42 | 9 400 083 114p. | 1067 | 0.5 | | | 940044 | | | |
| 721296 | Lishimin | Лишимынь | 2.443 | 2 | 200ma | 120.779152 | 29.067785 | 42 | 9 400 151 174p. | 1068 | 0.5 | | | 940018 | | | |
| 709525 | Lishipin | Лишипин | 2.443 | 2 | 200ma | 120.633662 | 27.392273 | 42 | 9 400 139 396p. | 1068 | 0.5 | | | 940018 | | | |
| 731880 | Lishisi | Лишисы | 2.935 | 2 | 200ma | 117.077322 | 31.118293 | 42 | 9 400 161 759p. | 1068 | 0.5 | | | 940121 | | | |
| 583539 | Lishisi | Лишисы | 3.683 | 2 | 200ma | 113.536652 | 30.720631 | 42 | -9 410 798p. | 1067 | 0.5 | 0 | | 940091 | | | |
| 727285 | Lishisi | Лишисы | 1.719 | 2 | 200ma | 114.675286 | 30.261658 | 43 | 9 400 157 164p. | 1068 | 0.5 | | | 940091 | | | |
| 730399 | Lishitan | Лишитань | 1.123 | 2 | 200ma | 109.118617 | 33.099576 | 43 | 9 400 160 278p. | 1068 | 0.5 | | | 940109 | | | |
| 712583 | Lishitou | Лишитоу | 2.232 | 2 | 200ma | 105.13447 | 31.814571 | 42 | 9 400 142 457p. | 1068 | 0.5 | | | 940123 | | | |
| 686424 | Lishityanba | Лишитяньба | 2.232 | 2 | 200ma | 102.878519 | 27.087402 | 42 | 9 400 116 200p. | 1068 | 0.5 | | | 940123 | | | |
| 629156 | Lishouchzhuan | Лишоучжуан | 6.040 | 2 | 200ma | 112.673633 | 37.4081 | 42 | 9 400 058 887p. | 1066 | 0.5 | | | 940070 | | | |
| 707345 | Lishu | Лишу | 2.224 | 2 | 200ma | 114.259581 | 25.271888 | 42 | 9 400 137 133p. | 1068 | 0.5 | | | 940014 | | | |
| 624111 | Lishu | Лишу | 64.600 | 0 | i | 124.327648 | 43.312105 | 41 | 893 060 254p. | 1064 | 0.5 | 0 | | 940102 | 0 | 0 | 0 |
| 689656 | Lishu | Лишу | 1.896 | 2 | 200ma | 107.681735 | 26.598038 | 43 | 9 400 119 434p. | 1068 | 0.5 | | | 940035 | | | |
| 697756 | Lishu | Лишу | 2.018 | 2 | 200ma | 115.96773 | 27.396506 | 42 | 9 400 127 537p. | 1068 | 0.5 | | | 940072 | | | |
| 707827 | Lishu | Лишу | 2.018 | 2 | 200ma | 114.96616 | 24.776877 | 42 | 9 400 137 642p. | 1068 | 0.5 | | | 940072 | | | |
| 667428 | Lishu | Лишу | 1.094 | 2 | 200ma | 128.919742 | 42.785836 | 43 | 9 400 097 188p. | 1068 | 0.5 | | | 940102 | | | |
| 740487 | Lishuanlou | Лишуанлоу | 2.800 | 2 | 200ma | 114.943531 | 32.414678 | 42 | 9 400 170 370p. | 1068 | 0.5 | | | 940034 | | | |

The settlements’ names are given in Russian and English. For each settlement the coordinates are shown, as well as source of information about the number of inhabitants. Information about buildings in “Extremum” System may be detailed (type of structure, materials, date of construction, height and so on) and “averaged”, for instance, the distribution of buildings characterized by different vulnerability levels within the city or city districts. For China there are three default buildings stock models for the settlements of different sizes: for big cities, for towns and for villages. The models include the information about the portion of buildings of different types classified by MMSK-86 scale and their average height. According to MMSK-86 scale the buildings are classified into six groups:

- building types A1, A2 (from local materials);

- building types B, B1, B2 (brick, hewn stone or concrete blocks);
- building types C, C1, C2 (reinforced concrete, frame, large panel and wooden);
- building types E7, E8, E9 (earthquake resistant buildings designed and constructed to withstand the earthquakes with intensity 7, 8, 9).

The table 1 shows the averaged buildings' models for China.

***Table 1***. Averaged characteristics of existing building stock distribution in China

| ***Buildings types according to*** **MMSK-86** | ***City model*** | | ***Town model*** | | ***Village model*** | |
|---|---|---|---|---|---|---|
| | *%* | *h [m]* | *%* | *h[m]* | *%* | *h[m]* |
| **A** | 0.05 | 3 | 0.20 | 3 | 0.50 | 3 |
| **B** | 0.10 | 9 | 0.65 | 6 | 0.35 | 3 |
| **C** | 0.70 | 15 | 0.10 | 15 | 0.15 | 3 |
| **E7** | 0.15 | 27 | 0.05 | 15 | - | - |

The "Extremum" system software allows to introduce new settlement models when detailed and verified information about building stock distribution become available.

During the loss computations due to the Wenchuan earthquake in emergency mode, information about the event parameters (coordinates, origin time, magnitude, depth) was taken from alert seismological centers: Geophysical Survey of Russian Academy of Sciences (GS RAS), European Mediterranean Seismological Center (EMSC), National Earthquake Information Center (NEIC) of USGS. The "Extremum" System impact database for China (Fig. 2), which includes the descriptions of more than 100 events, was used to take into account the regional peculiarities of shaking intensity attenuation.

***Fig. 2.*** Fragment of the "Extremum" System impact knowledge base for China

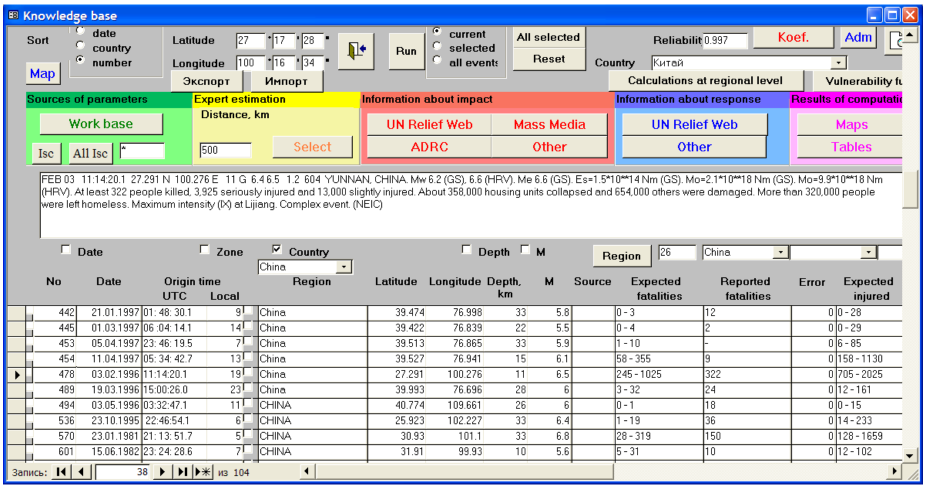
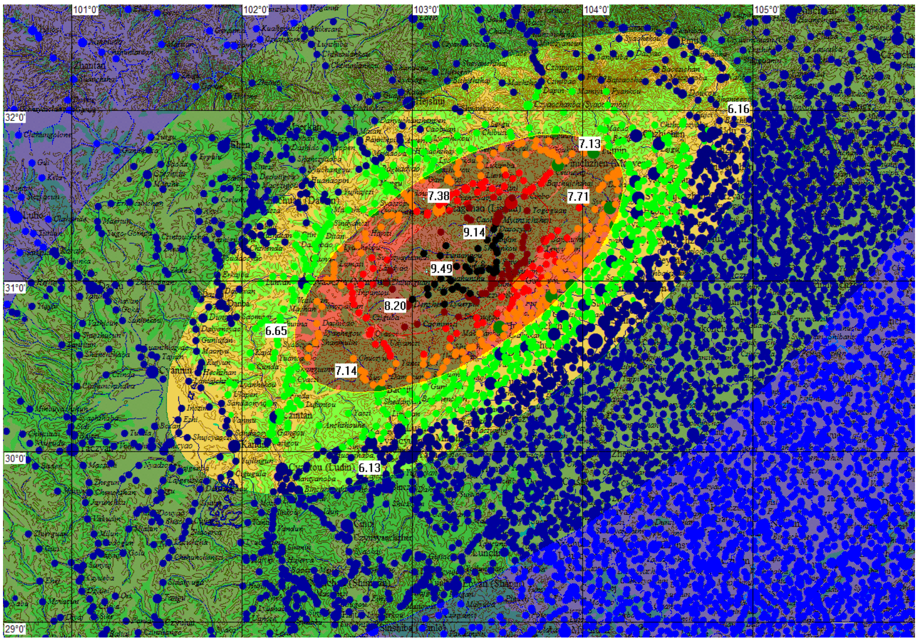



Fig. 3 shows the results of expected loss computations with NEIC data about input event parameters. The circular isoseists obtained with Shebalin equation (Shebalin, 1968) were stretched along the active tectonic faults in order to take into account anisotropy of the medium and source line extension. The different expected shaking intensity maps were computed taking into account various regional coefficient of macroseismic field, different orientation of ellipse axes, as well as empirical data about ratio $k$ of ellipse major and minor semi-axis (for different values of $k$). In the considered case (Fig. 3) $k = 2$. The ellipse major axis is oriented at the angle of 49° according to source mechanism solution.

***Fig. 3.*** Results of possible loss assessment caused by May 12, 2008 earthquake in China; dots are settlements in the stricken area; colour of dots shows the average damage state of building stock (black : total collapse; brown : partial collapse; red : heavy; yellow : moderate; green : slight damage; blue : no damage); figures show the values of expected shaking intensities



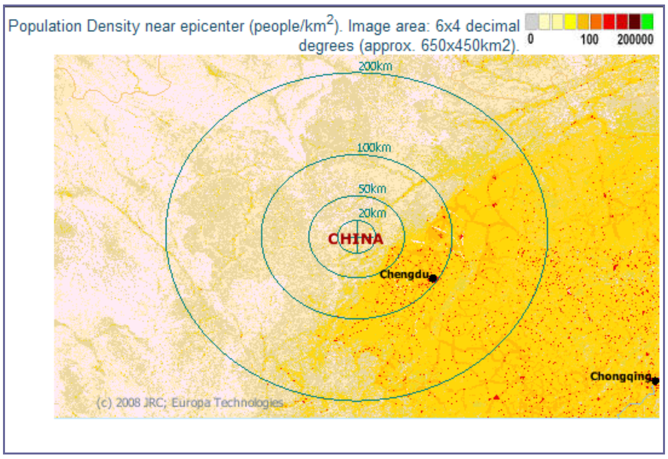

In addition to maps at different scales the results of "Extremum" computations are also presented as tables, where estimates of expected number of fatalities, injuries and homeless are given for the whole stricken area and for each settlement. In the case of the Wenchuan earthquake, the expected number of fatalities was estimated by "Extremum" system as 48,000 – 97,500 people.

The simulated results about expected impact are usually checked later against field observations. The reason for that is first to ascertain the simulated damage for the event under consideration, and then to improve the whole "Extremum" system by calibrating through records of reported damage and social loss kept in the "Extremum" System impact knowledge-base (Bonnin *et al*., 2002; Frolova *et al*., 2003a; Bonnin & Frolova, 2004). The procedure of calibration is described in Frolova et al. (2009).

## GDACS data bases and models

GDACS is another worldwide system used to alert the international community in case of major sudden-onset disasters and to facilitate the coordination of international response during the relief phase of the disaster (de Groeve, 2006; de Groeve *et al*., 2008). It was jointly established by the European Commission's Joint Research Centre and the United Nations Office for Coordination of Humanitarian Affairs (OCHA) in 2004. The disaster alerts are based on automatic hazard information retrieval and real-time GIS-based consequence analysis. The GDACS earthquake impact model is built on the existing seismological infrastructure. Every 5 minutes, GDACS collects information on rapid estimations of earthquake location, magnitude and depth of source from different agencies, like NEIC, EMSC, GEOFON, JMA and others. By reporting the epicenter on the map of population density, GDACS estimates the total population in the affected area within radii of different sizes. Then, it estimates the likelihood need for international humanitarian intervention. Fig. 4 shows a fragment of the alert event report for the Wenchuan earthquake in China on May 12, 2008 from the web-site of the system (http://www.gdacs.org). GDACS received the first event information from USGS (NEIC) at 6:41 UTC (13 min. after the event) and, after calculating the impact, evaluated it as a Red Alert (high humanitarian impact). GDACS automatically sent out 4,500 email, 2,700 SMS and 100 fax alert messages 14 minutes after the event (de Groeve *et al*., 2009).

***Fig. 4.*** Results of possible impact estimation of May 12, 2008 Wenchuan earthquake in China.




| Radius (km) | Population | Density (people/kml) |
|---|---|---|
| 1 | 8 | 8 |
| 2 | 469 | 37 |
| 5 | 1405 | 17 |
| 10 | 5742 | 18 |
| 20 | 18339 | 14 |
| 50 | 671979 | 85 |
| 100 | 9749450 | 310 |
| 200 | 30801890 | 245 |

The database on population used by GDACS is the LandScan population data, from the Oak Ridge National Laboratory (ORNL, 2000; Dobson *et al*., 2000). This dataset has an estimate of the population in every pixel of 30” x 30” (roughly 1km$^2$ at the equator). According to de Groeve *et al.* (2002) the procedure applied to calculate the population in the affected area is the following:

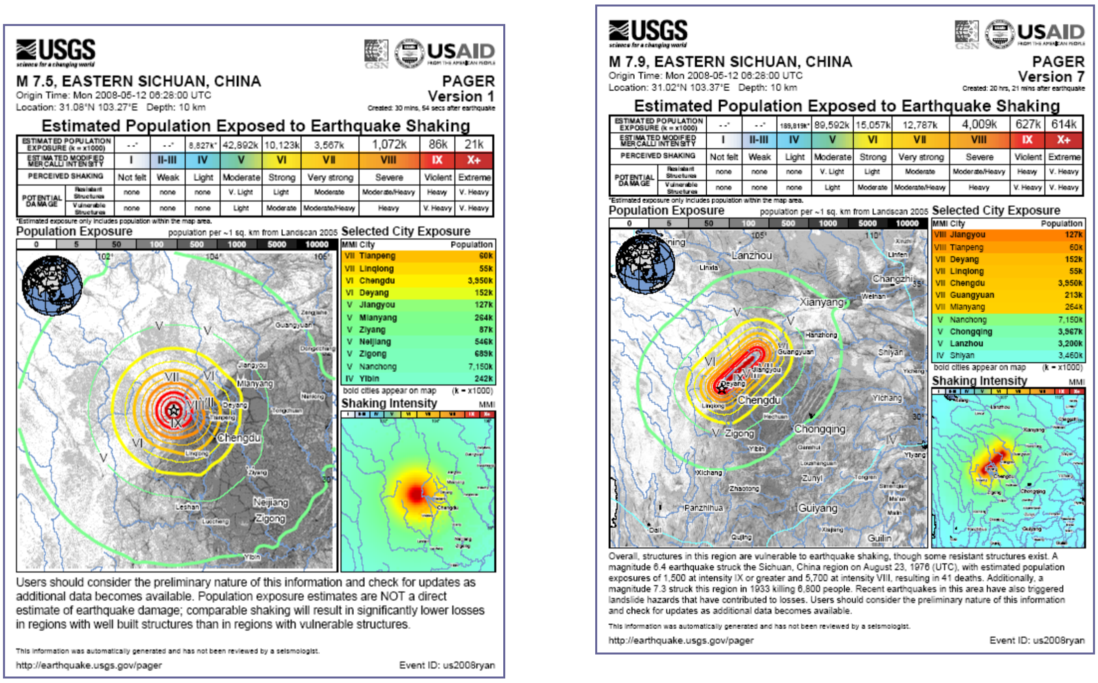
1. In a preprocessing step, the LandScan data are convoluted with a circular area around each pixel using a focal image analysis algorithm calculating the sum of pixels. Several convoluted datasets were created for circle radii of 1, 2, 5, 10 and 50 km.
2. For the determination of the population at the position of an earthquake, a script accesses the pixel value of the convoluted datasets at the given coordinates in order to provide a very quick result.
3. The resulting population numbers are interpreted as a population density within the areas of different radii from 1 up to 200 km. These classes are used in order to communicate population density to decision makers in a qualitative manner.

At present the Working Group on Disaster Information Standards within DGACS aims at developing guidelines for information exchange in the immediate aftermath of major sudden-onset disasters that require international assistance. The purpose of the guidelines is to increase predictability and quality of information in order to facilitate operational planning and decision-making in involved countries and organizations. The guidelines will define responsibilities, expected timeframes and quality of operational information from the affected country and potential responders. This working group will discontinue after completion of its task.

## PAGER data bases and models

PAGER System of US Geological Survey allows to simulate expected shaking intensity by using the methodology and software developed for ShakeMap (http://earthquake.usgs.gov/shakemap). Then, the expected number of inhabitants within the zones of different level of shaking intensity *I* is estimated by using the information on population density from Oak-Ridge National Laboratory's Landscan population database. PAGER is an automated system; it monitors the NEIC near real-time detections of domestic and global earthquakes and issues alarm to emergency agencies and other end-users at national and international levels. Its estimations of exposed population could be revised in case subsequent information about event parameters becomes available and a replacement alarm is issued. Fig. 5 shows an example of possible consequences estimation following the 12 May 2008 Wenchuan earthquake in China. The fig. 5 shows two versions of PAGER System computations: version 1 created within 30 minutes after earthquake and version 7 created within 20.5 hours after the event. The maps of expected shaking intensity distribution are accompanied by the list of selected cities with expected value of intensity *I* on MM scale and number of inhabitants.

***Fig. 5.*** Results of possible consequences estimation following the May 12, 2008 Wenchuan earthquake in China according PAGER system




At present, the PAGER team is developing and testing a more comprehensive version of the system which will include simulation models for casualty assessment (Wald *et al.*, 2008). It is planned that different models from fully empirical to largely analytical approaches will be used for simulation of casualties.

For this purpose, within the PAGER project, through collaborative efforts with Earthquake Engineering Research Institute (EERI)'s World Housing Encyclopedia (WHE, http://www.world-housing.net), the database on built environment is under development. Table 2 shows the distribution of typical buildings for rural and urban areas in China (Jaswal *et al.*, 2008). The following classification of building types are used in PAGER:

**W -** wood, average number of stories 1-3, typical 2 stories;

**A** – adobe block (unbaked dried mud blocks) walls, average number of stories 1-2, typical 1 story;

**RS** – rubble stone (field stone) masonry, average number of stories all, typical 1 story;

**UFB –** unfeinforced fired brick masonry, average number of stories all, typical 1 story;

**UFB1 –** unfeinforced fired brick masonry in mud mortar without timber posts, average number of stories 1-2, typical 1 story;

**UCB –** unreinforced concrete block masonry, lime/cement mortar, any average number of stories, typical 1 story;

**C3 –** nonductile reinforced concrete frame with masonry infill walls, any average number of stories, typical 1 story;

**C1 –** ductile reinforced concrete moment frame, any average number of stories, typical 1 story;

**C2 –** reinforced concrete shear walls**,** average number of stories all, typical 1 story.

***Table 2***. Typical buildings distribution in China (http://earthquake.usgs.gov/pager)

| | **W** | **A** | **RS** | **UFB** | **UFB1** | **UCB** | **C3** | **C1** | **C2** |
|---|---|---|---|---|---|---|---|---|---|
| **Rural_Res** | 10 | 40 | 3 | 10 | 35 | - | 3 | - | - |
| **Urban_Res** | 5 | 4 | 2 | 61 | 5 | 2 | 5 | 12 | 5 |
| **Rural_Non_Res** | 5 | 4 | 3 | 75 | 9 | - | 5 | - | - |
| **Urban_Non_Res** | 2 | - | 1 | 55 | 5 | 2 | - | 20 | 12 |

To calibrate the loss models, the USGS created an Atlas of 3,900 ShakeMaps of significant earthquakes worldwide. The calibration procedure relies on the Atlas and on impact data of past events (fatality and damage) collected by the NEIC.

## Challenges of data bases used for loss assessment worldwide

Simulation codes exist, both in emergency mode and in longer-term mode. The reliability and quality of loss assessment output of the described worldwide systems is directly dependent upon the quality of input data and of the simulation models. An obvious way of improving the whole process is to confront the assessment output with the known consequences of previous events; *i.e*. data on impact of past earthquakes could help "calibrating" somehow the simulation models; furthermore, scenario earthquake approaches suffer from more or less badly-known parameters (inventory of objects-at-risk, vulnerability/fragility functions of buildings submitted to shaking, *etc*.): to a certain extent, these weaknesses can be partially mended through calibration procedure, in addition to improvement of available databases. In this respect, the information on physical and socio-economical consequences of past damaging earthquakes is very critical.

At the moment, data sets on impact of past earthquakes are not readily accessible to many potential users and can hardly be directly applied for comparison with simulated results because of lack the standard formats. For instance, in the Reconnaissance report on the China Wenchuan earthquake May 12, 2008 (Chu-Chieh *et al*., 2008) the classification of buildings in the stricken area is given, which can not be applied for direct comparison with simulation results in "Extremum" and PAGER systems. The authors of the Report introduce the following classes typical for the stricken area buildings: **RC** – reinforced concrete; **HRM** –

half-reinforced masonry (unique structural system which consists of brick column, reinforced concrete beam, and precast concrete hallow floor planks with wire mash) and **URM** – brick, un-reinforced masonry.

Actually, if partial data sets have been developed here and there, no significant initiative has yet been taken to collect, organize, and make easily available the corresponding data. Here, coordinated and international efforts should be undertaken in order, first of all:

1. to analyze the existing, readily accessible, earthquake impact datasets/bases with global, regional, sub-regional, national coverage, and determine the current status regarding the accessibility, completeness, quality and reliability of impact data. The steps to be considered would include:

• a survey of corresponding individual data sets; what are the contents ? how are the data organized within the data sets ?

• under what form(at) are the records stored : hard copies, digital, pointers to other databases; *etc*.?

• are the data sources identified ?

• quality and reliability of data;

• are the data freely accessible? are they more or less classified ?

2. to discuss “ontology” of data/metadata in the field, and general formats and methods for impact data accumulation. The steps to be considered would include:

• specify what types of data are desirable within an ideal, “modern” database: events’ source parameters, macroseismic effects, engineering consequences, damage to populations, socio-economical impact, response measures, … ?

• the problems of several, non-necessarily matching, sources;

• “political” estimations *versus* “actual” estimations.

3. to initiate the development of software in order to accumulate and analyze the information about the well-documented past earthquakes: social and economic losses.

• how to organize a “virtual” database by connecting to individual datasets/bases through a procedure transparent for the users;

• creation of dedicated interfaces to automatically “re-format” the available data sets and leave each data set owner free of organizing his/her original data sets the way he/she wants, yet preserving “integrity” of data.

4. to initiate the development of an international “distributed knowledge-base” on physical and socio-economical consequences of damaging earthquakes.

5. to identify the mechanism for access requests and activities related to knowledge-base maintenance.

## Conclusions

The present paper gives a brief description of three worldwide systems and their databases used for loss assessment following strong earthquakes, in “emergency” mode. The analysis of simulation outputs and used input data allows to draw the conclusion that priority should be given to verification and standardization of databases on elements at risk and impact databases about past strong earthquakes in order to increase the reliability of the results.

On the whole, analysis of three worldwide systems for expected loss assessment in “emergency” mode showed that they can be applied for loss estimations just after the event, these estimations are of great value for longer-term mode. In future, coordinated efforts and research at international level is badly needed if one wants to increase the reliability of loss estimation in "emergency" mode at global level.

## References

Bonnin J., Frolova N., Kozlov M., Larionov V., Sushchev S., Ugarov A. (2002 ), Experience of "Extremum" System Application for Operative Earthquake Loss Assessment. *Proc. 28th General ESC Assembly*, Genoa, Italy.

Bonnin J., Frolova N. (2004), Near Real-Time Loss Assessment Due To Strong Earthquakes: The State of The Art. *Proc. XXIXth General Assembly of European Seismological Commission (ESC2004)*, Potsdam, Germany.

Chu-Chieh J., Juin-Fu, (2008), Reconnaissance report on the China Wenchuan earthquake May 12, 2008, NCREE Newsletter volume 3 number 3 September 2008.

de Groeve P.T., (2006), Global Disaster Alert and Coordination System – Earthquake alerts for international humanitarian response, Proc. IDRC2006, Davos, Switzerland.

de Groeve P.T., Annunziato A., Gadenz S., Vernaccini L., Erberik A., Yilmaz T. (2008), Real-time impact estimation of large earthquakes using USGS Shakemaps, *Proc. IDRC2008*, Davos, Switzerland.

de Groeve P.T., Peter T., Annunziato A., Vernaccini L. (2009), Global Disaster Alert and Coordination System, http://www.gdacs.org/about.asp.

de Groeve P.T., Ehrlich D. (2002), DMA Earthquake Alert Tool: A decision support tool for humanitarian aid, JRC, http://www.gdacs.org/about.asp.

Dobson, J. E., Bright E. A., Coleman P. R., Durfee R. C., and Worley B. A. (2000), A Global Poulation Database for Estimating Population at Risk. *Photogrammetric Engineering & Remote Sensing* 66 (7).

Frolova N.I., Larionov V.I., Nikolaev A.V., Kozlov M.A., Ugarov A.N. (2003a), Analysis of Real Time Earthquake Information Applied For Possible Loss Assessment, *Proc. TIEMS2003 Conference*, Sofia Antipolis, France.

Frolova N., Kozlov M., Larionov V., Sushchev S., Ugarov A. (2003b), Extremum System for Earthquake Risk And Loss Assessment, *Proc. of SE-40EEE*, Skopje-Ohrid, Macedonia.

Frolova N., Larionov V., Bonnin J. (2007), Simulation-based information systems for multi-hazard risk and near real time loss estimations due to strong earthquakes, *Proc. TIEMS2007 Conference*, Trogir, Croatia.

Frolova N., Larionov V., Bonnin J. (2009), Challenges Of Global Earthquake Loss Estimation In Emergency Mode, *Proc. TIEMS2009 Conference*, Istanbul, Turkey.

Jaiswal K.S., Wald D.J., (2008), Creating Building Inventory for Earthquake Loss Assessment and Rik Management. Open-File Report 2008-1160, USGS.

Larionov V., Frolova N. (2003), Peculiarities of seismic vulnerability estimations. *In* : Natural Hazards in Russia, volume 6: Natural Risks Assessment and Management, *Publishing House "Kruk"*, Moscow, pp.120-131. (in Russian).

Larionov V., Sushchev S., Ugarov A., Frolova N. (2003), Seismic risk assessment with GIS-technology application. *In* : Natural Hazards in Russia, volume 6: Natural Risks Assessment and Management, *Publishing House "Kruk"*, Moscow, pp. 209-231. (in Russian).

ORNL, 2000. Global Ambient Population, (2000), http://sedac.ciesin.org/plue/gpw/landscan/main.html

Shebalin N.V. (1968), Procedures of engineering seismological data application for seismic zoning. *In*: Seismic zoning of the USSR, Nauka, Moscow, pp.95-121 (in Russian).

Wald D. J., Earle P. S, Allen T. I., Jaiswal K, Porter K., Hearne M. (2008), Development of the U.S. Geological Survey's Prompt Assessment of Global Earthquakes for Response (PAGER) System, *Proc. 31st ESC Assembly*, Crete, Greece.

## Author Biographies:

Dr. Nina Frolova is a senior scientific researcher with Seismological Center of IGE, Russian Academy of Sciences. She has contributed to studies on earthquake hazards and risk reduction and activities of UNDRO, UNESCO, IDNDR on earthquake preparedness since 1985. The Soviet of Ministries awarded Dr. Nina Frolova, along with others, the USSR prize in 1984 for her work on the seismic load assessment and earthquake resistance of high dams. In 2005 she was awarded by UNESCO, the GARD Medal for distinguished professional leadership and personal commitment to ongoing programs on disaster reduction. Dr. Nina Frolova is a responsible scientist for the ESC WG "Earthquake Preparedness and Civil Defence". She is a TIEMS Directors' Board Member and GARD Vice-President for the Asian Region.

Dr. Valeri Larionov is Vice-General Director of Extreme Situations Research Center. He has contributed to research on emergency response since 1972. He is an expert in assessment and management of natural and technological risk; organization of management and response to emergency situations; industrial safety, assessment and management of seismic risk. At present he has conducted researches on expected loss assessment due to natural and technological hazards and emergency management with GIS technology application. The Russian Federation government awarded Dr. Valeri Larionov, along with others, the prizes in 1999 and 2001 for the work on development of the Russian federal system for monitoring and forecast emergency situations.

Dr. Jean Bonnin is (honorary) full professor with the Institute of Physics of the Earth, Strasbourg University, France. He has devoted a large part of his activity to the problems posed by usage of data in solid Earth geophysics. He has been awarded in 2004 CODATA International Prize for his contributions in the field. Since a few years he has contributed to topics related to risk management by trying to improve the dialogue between scientists/engineers and decision makers.

# 如何实现有效援助：班达亚齐和四川援助机制比较

**伍国春**

中国地震局地球物理研究所

**【摘要】**本文的目的是研究如何在灾难发生时进行有效地援助。通过对班达亚齐、印度尼西亚和中国四川的援助机制的陈述，本文讨论了政府和非政府组织在灾难援助过程中的关系，并提倡二者在灾难援助过程中的交互响应。

回顾历史灾难，苏门答腊地震在国际援助方面是无可匹敌的。同样地，在中国灾难历史中，汶川地震吸引了大量的国际和国内援助。虽然在巨大外界救援基础上促进了两地的发展，但班达亚齐和汶川却见证了因政府参与角色不同，在房屋复原方面产生的不同结果。

研究表明，适应中国化的援助机制发挥了积极作用：1）华人社区履行了部分职责；2）应急组织，特别是在麦丹应急组发挥了积极作用；3）在麦丹和班达亚齐的应急组织和关联的援助组织，甚至在亚洲东南的中国组织；4）渗透在华人社区中的援助组织和班达亚齐当地的应急组织；5）当地和国际组织的合作渗透在整个班达亚齐和麦丹华人社区的日常生活中。

印度尼西亚和中国的灾难援助响应模式非常不同。在印度尼西亚，非政府组织作用显著；而在中国，政府发挥着领导作用。对汶川地震的研究显示：1）当地政府在地震中遭到破坏；2）志愿者、受害人和政府之间的适应机制在震后出现；3）在当地政府的协调下，援助团体的适应机制有效运作；4）当地政府恢复后，适应机制转移到当地政府。

**【关键词】**灾难；政府和非政府组织；交互响应；响应模式；援助机制

# HOW EFFECTIVE AID MIGHT BE: A COMPARATIVE STUDY ON THE AID MECHANISMS IN BANDA ACEH AND SICHUAN

**Guochun Wu**

*Institute of Geophysics China Earthquake Administration, China*[18]

**Keywords**

[1] MinzuDaxue Nanlu 5th , Haidian District, Beijing ,China Email: guochunwu@cea-igp.ac.cn

Catastrophe, government and NGO, interactive response, response patterns, aid mechanisms

## Abstract

The purpose of this study is to investigate how effective aid might be in a catastrophe. This paper names assistant aid by communities or NGOs as framework mutual assistant aid. After describing aid mechanisms in Banda Aceh, Indonesia and Sichuan, China, this paper discusses relationship between government and NGOs and promotes interactive responses for disaster aid. Effective aid bases on the premise of good relationship between government and NGOs.

In the history of disasters, the Sumatra Earthquake was unrivalled in terms of international aid. Likewise, in the Chinese history of disasters, the Wenchuan Earthquake attracted the largest amount of international and domestic aid. Though both helped along by huge external aid, Banda Aceh and Wenchuan witnessed different results in housing restoration due to the different roles of the governments.

The research shows that the adaptation mechanism for the Chinese-Ethnic aid groups played an active role: (1) Groups within the Chinese community played some role. (2) Emergency groups, especially emergency groups in Medan played an active role. (3)Emergency groups linked the aid groups in Medan and Banda Aceh, even Chinese groups in South-eastern Asia. (4)Local emergency groups in Banda Aceh penetrated their aids into the Chinese community. (5) Cooperation among local and global groups was embedded in the daily life of the Chinese community across Banda Aceh and Medan.

The Indonesian and Chinese response patterns are very different. In Indonesia, NGOs functioned actively while in China governments played a leading role. Research on Wenchuan Earthquake finds that (1) some local governments were damaged by the Earthquake;(2) adaptation mechanisms among volunteers, victims and governments emerged after the earthquake; (3) the adaptation mechanisms for aid groups operated effectively including coordination with the local government; and (4) with recovery of the local government, the adaptation mechanism was transferred to the local government.

## Introduction

The Indian Ocean Tsunami on December 26th, 2004 brought huge losses to Aceh Indonesia. Banda Aceh, the capital of the province of Nanggroe Aceh Darussalam (hereinafter , NAD), had a population of about 250,000 before the tsunami. After the tsunami, however, “over 60,000 died or were missing”, taking up 1/4 of the original population (Kimata et al. 2006:94）. Likewise, the Wenchuan Earthquake in China on May 12th, 2008 also caused catastrophic losses. In the Wenchuan Earthquake, 68,712 died and 17,921 were missing (The Chinese Government Web).

Both earthquakes took place in developing countries and attracted enormous aid from the outside world. In the history of disasters, the Sumatra Earthquake was unrivalled in terms of

international aid. Likewise, in the Chinese history of disasters, the Wenchuan Earthquake attracted the largest amount of international and domestic aid.

Recovery and reconstruction of the two affected areas, however, were not the same. Research by the Nagoya University shows that the pace of restoration in Banda Aceh was slow in the overall sense (M.Takahashi et al.

2007). In terms of post-disaster housing restoration, in Banda Aceh, 73.3% of the surveyed population indicated that they had housing problems one month after the tsunami. The figure declined to 60.4% one year later. However, three years after the tsunami, 47.3% of the surveyed were still frustrated by housing problems. As to who rendered them great support vis-a-vis aided housing reconstruction, 56%of the surveyed mentioned International NGOs, 30.7% indicated central government (including BRR)(Takahashi et al. 2008:37）. Compared with Banda Aceh, in Wenchuan, 40.7% of the affected population lived in temporary housing two months after the earthquake. One year after the earthquake, however, this figure already declined to 9.8%, with 90.2% of the residents living in permanent housings （CASTED , 2009:17）.

Though both attracting huge external aid, Banda Aceh and Wenchuan witnessed different results in housing restoration due to the different roles of the governments. "Disasters often require the assistance of outsiders and multiple levels of government , thereby leading to multijurisdictional response operations "（Drabek and McEntire, 2002:206）. However, "executive bodies in general are unable to respond in a timely manner immediately after disasters"（Raphael, 1986=1989:220）. Compared with developed countries, capacity of governments in developing countries for emergency responses is critical to post-disaster restoration. As such, when discussing effectiveness of NGO-oriented adaptation mechanisms, one must clarify the roles of governments therein.

Setting the precondition where governments under the two case studies played different roles, this thesis explores the possibility for effective aid. To better study effectiveness of NGO aid, this thesis also explores the underlying reasons why the minority Chinese ethnic group, excluded in Banda Aceh, was able to achieve restoration ahead of the entire affected area with little government aid.

After definition of the concepts "public assistance aid system" and "mutual assistance aid system" (2.1), the thesis introduces the methodologies used for data collection (2.2). Analysis of the case study features a detailed description of the relief and aid situations in Banda Aceh, how the Chinese community took refuge and got assisted as well as the structure and functions of the Chinese assistance system (3.1). Afterward, literature is cited to describe the Wenchuan Relief and Assistance Model that was dominated by government assistance and supplemented by public aid (3.2). In the conclusion, the thesis discusses similarities and differences between the Banda Aceh Chinese aid system and the Wenchuan aid structure and the key elements to ensure effective public assistance after catastrophes (4).

## Theory and Method

### Theory

Disasters, especially catastrophes, tend to result in drastic social changes. "The disaster process may generally be understood as the process that covers different stages such as dissolution of social systems, the consequent initiation of emergency social systems and recovery of routine social systems" （Tanaka, 2001:135）. Responses of emergency social systems tend to differ in line with different case studies. Such difference is all the more prominent between developing and developed countries. The larger the disaster, the more difficult to respond via singular organization. At present, a rich variety of organizations participate in responses of emergency social systems.

This research studies post-disaster assistance from the perspectives of "self assistance ・ mutual assistance ・ public assistance". First, in disaster reduction systems, the state plays an increasingly important role while businesses, individuals and/or communities are also indispensable components; the issue is how the three parties cooperate with each other (Yoshii, 2007:209). Second, this concept helps understand the differences between developing and developed countries with regard to responses on the premises of disaster prevention.

According to different assistors, this thesis defines "self-assistance system" as the social system that supports self-assisting activities within the emergency aid system, "mutual-assistance aid system" as the social system that supports mutual assistance activities and "public-assistance aid system" as the emergency social system that maintains "public assistance" activities. In a self-assistance system, assistors are mainly the disaster victims, their family members, relatives and friends. Assistors of a mutual-assistance aid system differ in different societies, mainly including communities, religious organizations, community organizations and volunteer groups. For a public-assistance aid system, assistors are executive bodies such as governments and local self-governance bodies. This thesis focuses on the relationship between "mutual-assistance aid system" and "public-assistance aid system". Based on this, this paper discusses the role of mutual-assistance aid system.

Because "executive bodies in general are unable to respond in a timely manner immediately after disasters" （Raphael, 1986=1989:220）, operation of public assistance aid systems differ from society to society. This thesis regards operation of disaster prevention organizations and legal systems as the minimum criteria for judgement. Organizational operation covers executive bodies from the central to local levels while legal improvement includes presence or absence of drillings or plans for disaster prevention.

With the concepts of public assistance aid system and mutual assistance aid system thus defined, the thesis goes on to sort out the two concepts from the temporal and spatial perspectives. In the temporal sense, there is the issue of whether public assistance aid systems already existing prior to disasters function properly after disasters occur while how mutual assistance aid systems operate tend to be critically linked to prior-disaster social conditions. By social conditions, the thesis refers to the existence patterns of non-government or civil society groups, with special attention attached to activities of communities and volunteers. In this thesis, study of post-disaster aid activities concentrates on the period when emergency aid transits to recovery and restoration. Study of activities in affected and non-affected areas from the spatial perspective finds local, national and global differences between public assistance aid system and mutual assistance aid system in line with different activity and resource mobilization spaces of different assistors.

## Method

Data related to the Indonesian part of the thesis was acquired by the author through local semi-structured interviews. Such interviews were conducted twice in Banda Aceh, respectively on November 26th and December 1st, 2006 and December 1st and 13th, 2007. Prior to the in-situ interview in 2006, the author consulted Chinese media coverages on Banda Aceh online (including those from Mainland China, Malaysia and Chinese Taiwan) as pre-interview survey. The first field survey done in 2006 targeted President of the NAD Chinese Charity Foundation and managers of Chinese facilities as well as representatives of International NGOs such as Oxfam, World Vision and USAID. Although survey data about International

NGOs were not used directly in the thesis, such survey was critical to an overall impression of overseas aid in the tsunami affected areas. The second field survey was conducted in 2007, mainly covering managers and presidents of Chinese facilities and heads of Taiwanese aid organizations. In addition to interviews, the author also undertook participatory observation in medical lectures and religious activities organized by local Chinese. During the 2007 field survey, the author gained assistance from local Indonesians, visited Chinese markets and previous Chinese schools and collected information about local Chinese life. Finally, on January 30th, 2008, the author had an international telephone interview with the President of North Sumatra Chinese Association Disaster Relief Committee in Medan.

Data about Sichuan, China came from field investigation and literature method. Most of the data are second-hand materials including publicly available government information and interview data Chinese scholars developed after the earthquake.

## Results

## Aid for Indonesian Chinese

Disaster Impacts and Aid in Banda Aceh

Discussion about aid for Indonesian Chinese need be based on field studies of disaster impacts in Banda Aceh. First, due to death of local civil servants plus the fairly limited level of public assistance aid systems in Indonesia, and worse even, due to the fact that Aceh was an area of martial law as the result of its independence movement, the post-disaster public assistance aid system in Aceh was unable to fully realize its role. In the tsunami affected areas, overseas aid groups headed by the UN replaced the functions of such a public assistance aid system to some extent. The problem was the inter-organizational coordination among these overseas aid groups and indeed the disputes between the Indonesian Government and the overseas volunteer groups.

The tsunami exerted such social impacts on Banda Aceh that the local Chinese business people predicted that “it would take at least 5 years to restore to the pre-tsunami level”. Nevertheless, with the entry of large amounts of overseas aid into the affected areas, signs of recovery appeared in two years after the disaster）.

In the affected areas, all kinds of groups were engaged in relief and assistance. One year after the tsunami, Nagoya University Research Group conducted a questionnaire survey in Banda Aceh. For the question “Who is/are the most reliable in restoration?”, “40.2% of the respondents answered overseas NGOs, 36.2% answered relatives.” 49.6％ replied that due to economic considerations, they trusted NGOs all the more. About 60% of the respondents mentioned that relatives were their spiritual support while 30% indicated friends were such spiritual support. NGO hereby refers to “non-government organizations, volunteer groups outside the government, or non-profit organizations and religious bodies”. Correspondingly, only 9.4％ indicated that local governments were the most trustable source in restoration while those mentioned the Central Government took up 3.1％, the lowest percentage. The same survey also shows that “only 5.5% mentioned that local individuals and/or communities were the most reliable” (Tanaka, 2006:155-156). Interviews found, however, that community played the role of media when attaining external aid such as food, living materials and plans for housing reconstruction. Communication between community leaders and local governments or overseas NGOs enabled successful consultations (ditto:158-160 ).

In December 2007，research team of Nagoya University conducted another questionnaire survey for the three-year process of post-tsunami reconstruction. As the result of the first survey, for supporters of the housing reconstruction, over half the respondents mentioned the significance of international NGOs across the target villages (Fig.1).

Interviews and other studies conducted in the affected areas found that the affected population relied on overseas aid from emergency rescue and assistance to post-disaster recovery and reconstruction. Overseas economic assistance, of particular importance to the affected areas, reached affected individuals through the community media. In terms of spatial analysis, such aid that uses the community as the media is local mutual assistance aid while overseas aid is global mutual assistance aid, i.e., the latter reaches the tsunami victims through the former.

While the affected areas relied on global economic assistance, in Banda Aceh, the Chinese is an excluded ethnic minority, but restoration of the Chinese came much more efficiently. In their aid process, mutual assistance aid played a critical role. The following chapter will

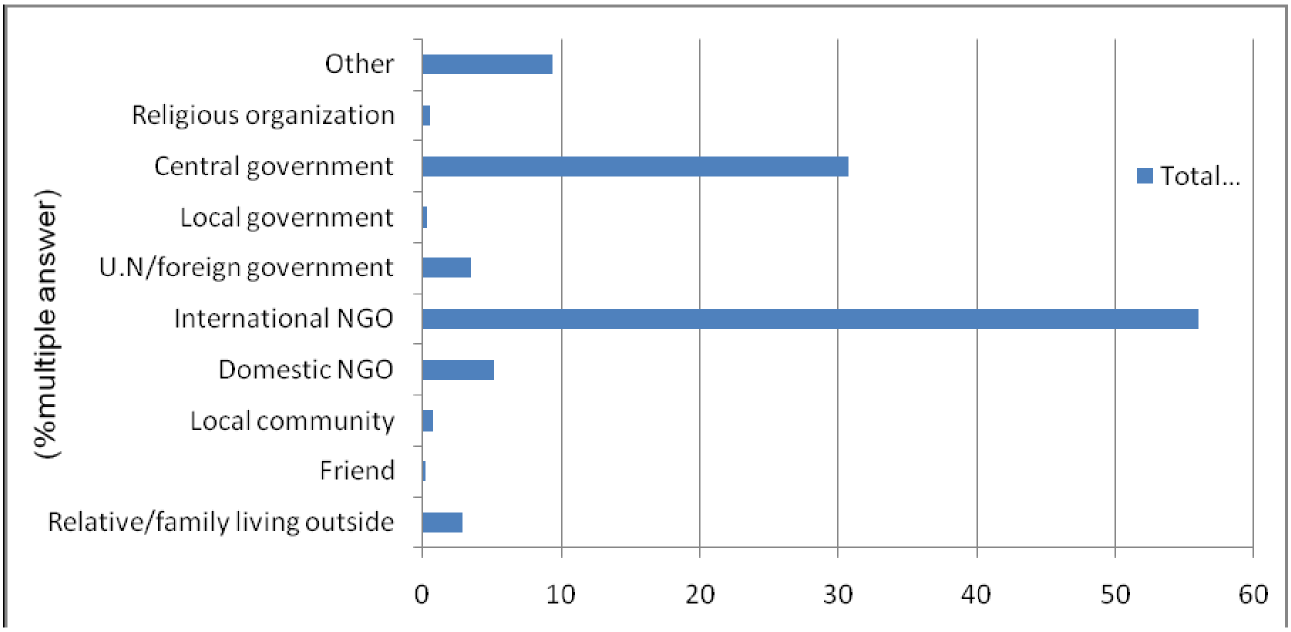



**Fig.1** supporting body for housing reconstruction

（Date reproduced in line with Table 7 by Takahashi.M. et al.2008;37）

discuss the situation where the Chinese ethnic group took refuge and analyze the organizational structure and functions of the Chinese mutual assistance aid system.

The Volunteer Coordination Mechanism for Chinese Ethnic Group: Refuge and Assistance

Because of the constant exclusions since the 1960s, there were about 4,000 Chinese living in Aceh before the tsunami, around 1.67％ of the total provincial population, lower than the proportion of Chinese in other Indonesian areas. After the tsunami, in fear of plunder and deterioration of living conditions in the affected areas, many Chinese left Aceh for refuge in Medan. In Mulian, a village in suburban Medan, the Chinese aid organizations in Medan and the Mutual Assistance Association of Mulia joined hands to set up a refugee camp for Chinese. At the peak time, about 6,500 refugees were registered at the camp. Registration at the refugee camp helped the collection of statistics about the survival of Chinese. The registered could also access aid materials. However, not all the registered lived in the village. In fact, only 200 of them lived in the village (data as of January 7th, 2005). Including those at the camp, there were about 1,500 took refuge in the village. The rest of the registered stayed at their own homes or homes of their relatives or friends in Medan for refuge.

After the tsunami, 500-600 Chinese remained in Banda Aceh where the largest refuge was the Hokien Huay Kuan in which about 100 Chinese households stayed for 4 months after the tsunami. In fact, Chinese religious facilities became refuges. Out of the 5 Chinese religious facilities in Banda Aceh, only Hokien Huay Kuan and Hainan Huay Kuan became refuges for Chinese. Immediately after the tsunami, only the Chinese and Hokien Huay Kuan and the NAD Chinese Methodist Church came out sound and intact. Therefore, one week afterward, the Hokien Huay Kuan became a refuge. It was half a year after the tsunami that the restored Hainan Huay Kuan was used as refuge.

In June 2005, with all Chinese returning to the affected areas, the refugee camp of Mulia Village was closed down. Until that time, the camp played multiple functions, i.e., not only accepting refugees but also operating as the receiving end of aid materials and premise for information exchange. Although staying with relatives, many victims went to the village for information. The village was thus able to produce statistics about missing people and refugees. It was because of this village that various aid organizations learned where to deliver aid materials. Consequently, many organizations sent aid materials to the refugee camp in Mulia Village.

With regard to assistance to the Chinese ethnic group, in addition to the above community-based aid organizations, emergency groups also played core roles. After the tsunami, temporary emergency groups came into being in three areas: The North Sumatra Chinese Disaster Relief Committee was set up in Medan near the affected areas, the NAD Aceh Chinese Charity Foundation in tsunami affected Banda Aceh and Indonesian Chinese Disaster Relief Centre in Jakarta, Capital of Indonesian, far way from the affected areas. Of the three emergency groups, those in Medan and Jakarta organized extensive aid activities. The Medan one, in particular, played a key role. For the Chinese refugees that relied heavily on external aid both psychologically and physically, the Disaster Relief Committee in Medan rendered them the greatest economic support.

Prior to the tsunami, there were only 65 Chinese groups in Medan, all of which participated in aid efforts after the tsunami. To unify actions, the North Sumatra Chinese Disaster Relief Committee (hereinafter referred to as “Medan Disaster Relief Committee”) was established on January 7th, 2005. Thanks to coverage about Mulian Village and Medan Disaster Relief Committee by Chinese media, the Chinese Charity Foundation, Macau Red Cross, etc all donated money and aid materials. Also because of the existence of the village, the local government of Banda Aceh visited the village, requesting the Chinese there to return to the affected areas.

Activities of the Medan Disaster Relief Committee were conducted in Medan and Banda Aceh respectively. The Committee organized its over 40 members into Financial Team, Medical Team, Education Team, Resident Resettlement Team and Mobilization Team. The Medical Team mainly assisted the Mainland China Aid Team as well as Singaporean and Chinese Taiwan medical aid efforts subject to no ethnic limitations. With 10 members, the Education Team aimed at helping children whose parents had taken refuge in Medan to access local school education. Ultimately, there were over 1,000 children joined Medan schools. The Resident Resettlement Team cooperated with the Mulia Mutual Assistance Association to ensure residences for refugees. At the beginning, refugees in Medan were classified into Chinese or Muslims and subsequently sent to different aid organizations. Chinese were sent to their relatives or Mulia Village. Around 1,500 victims were arranged into vacant houses and over 400 villager households in the village for refuge. In April, 2005 when the situation in the affected areas stabilized, the Mobilization Team of Medan Disaster Relief Committee started work. They mainly mobilized the victims to return to Banda Aceh. First, they led the Chinese refugees in Medan back to Banda Aceh for confirmation of the local conditions. In this end, they prepared two big couches that went to and fro between Medan and Banda Aceh every day. Upon return, the Chinese informed that the sewerage pipelines were blocked in Banda Aceh, hence impossible for them to return to normal life. After confirming accuracy of the information, the Medan Disaster Relief Committee contacted the Banda Aceh Government. Learning that the later did not have fund to do the repair, the committee donated the fund to restore the sewerage system and waste-water treatment facilities.

The Medan Disaster Relief Committee worked in Banda Aceh as entrusted. To begin with, it set up the "Aceh Relief Station" in the affected areas one week after the tsunami. The Relief Station, located at the Hokien Huay Kuan, was operated by managers of the Huay Kuan and funded by the Medan Disaster Relief Committee to pay for meals and living expenses of tsunami victims.

The Medan Disaster Relief Committee mobilized resources from Chinese groups in Medan and connected Medan with Jakarta via the Chinese Disaster Relief Centre in Jakarta. Should its efforts stop as such, its aid to the affected areas would be limited to Indonesia alone. In fact, the Medan Disaster Relief Committee also mobilized economic resources from the Chinese community in Malaysia including the Federation of Chinese Associations, the Hainan Huay Kuan, the Nanyang Press Foundation, Sin Chew Media and Teachers Confederation. The Medan Disaster Relief Committee was set up as an aid organization focusing on "middle and lower class Chinese". Reportage by Chinese media, however, attracted attention of the international Chinese society and the committee eventually gained aid from Mainland China and Macau.

With generous donations from the global Chinese communities, the Medan Disaster Relief Committee was able to carry out a rich variety of aid activities. In about 6 month's emergency aid, the committee provided food and shelter to more than 7,500 Chinese victims and distributed USD 3 million disaster relief fund to 1,250 Chinese households. Moreover, with support from the Nanyang Press Group of Malaysia, the committee set up the "National Patriotic Fund" for the 43 tsunami orphans. Through the committee, about USD 6 million was mobilized for emergency aid.

In summary, aid for the Chinese ethnic group centred around the emergency group, the Medan Disaster Relief Committee, and extended to involve Chinese communities all over the world. On the other hand, such cross-regional aid was able to penetrate into the local society thanks to aid organizations that already existed and operated in the affected areas prior to the tsunami. Resource mobilization ability of emergency groups was linked with already existing Chinese networks which extended into Chinese communities in South East Asia such as Medan, Malaysia or even Singapore and Hong Kong. However, should there be no such emergency organizations in Medan, aid for the Indonesian Chinese might well have remained just small-scale aid limited to Chinese alone. Without support from government, the Medan Disaster Relief Committee played the major role of the volunteer coordination mechanism for Chinese ethnic group.

## The Volunteer Coordination Mechanism for Wenchuan Earthquake in China

In May 2009, the Information Office of the PRC State Council indicated in China's Disaster Reduction Action that "After the catastrophic earthquake in Wenchuan of Sichuan Province, the public in general, businesses and social organizations in China all participated in emergency aid, with over 3 million volunteers from home and abroad penetrating into affected areas and more than 10 million volunteers joining off-site disaster relief efforts". (Xinhua News Agency: HP 2009.12.12)

A summary of relevant literature finds that coordination of volunteers after the Wenchuan Earthquake featured two categories: coordination organizations set up in affected areas and those established in nearby non-affected areas.

Category 1 Coordination Body came into being in Zundao Township, a severely affected area. Due to the death of major township leaders in the earthquake and the huge post-quake work load, the "Volunteer Coordination Office" was set up in Zundao through coordination efforts by renown Chinese enterprises. The office coordinated volunteer activities under the guidance of the Township Youth League. On September 26th, 2008, the Social Resources Coordination Panel was initiated chaired by the Township Party Secretary General and with Deputy Township Party Secretary General and business volunteers holding deputy positions. The Social Resources Coordination Office was established under the leadership of the Panel but headed by corporate volunteers. Hence, this was a temporary organization connecting the government, business community and volunteers. Corporate volunteers dominated this coordination mechanism, conducive to mobilization of economic and material resources.

Category 2 Coordination Mechanism was represented by the NGO Confederation in Chengdu. During the emergency aid stage, two volunteer coordination bodies sprang up out of the existing civil society organizations, namely, the "5·12 Civil Society Assistance and Service Centre" and the "NGO Joint Office for Disaster Relief in Sichuan". In addition, Chengdu also witnessed the birth of a temporary International NGO Volunteer Centre. However, due to the lack of local knowledge on the part of overseas organizations and the inability of foreigners to enter the affected areas, domestic volunteers found it hard to cooperate with such an ad hoc International NGOs （Han, 2009:250）.

The above two volunteer coordination mechanisms are unique in their respective action patterns and organizational compositions. On May 15th, 2008, the Chengdu Urban River Research Society established the "5·12 Civil Society Assistance and Service Centre" in cooperation with other civil society organizations. The Centre mainly provided aid information services to volunteers and civil society organizations that participated in the 5·12 quake relief efforts under the principles of "Party Committee leadership, government accountability, society cooperation, and public participation". The "5·12 Civil Society Assistance and

Service Centre" was based on volunteer groups already existing prior to the earthquake with its main organizors also located in Chengdu. The Centre consisted of 34 member organizations among which 17 were working in Sichuan. 8 out of these 17 were members of the Sichan Youth Volunteer Project. In terms of organizational nature, the 34 members included 18 local organizations, 6 international development bodies, 4 foundations and NGO support organizations, 3 volunteer organizations and 3 Internet philanthropic bodies （Zhu et al. 2009:74）.

The "NGO Joint Office for Disaster Relief in Sichuan" born on May 14th, 2008, existed for 3 weeks after the earthquake. Its member organizations were volunteer groups no longer located in either affected areas or Chengdu. Online contact was its main form of action. "During the quake emergency relief period, the office boasted 77,000-page monthly traffic volume with peak click of single post reply reaching 7.7million times and total amount of integrated relief information exceeding 1,100 pieces". Actions of the Office were completed by its frontline coordination team. Over 40 local NGOs combined to collect disaster relief materials, recruit vehicle fleets, conducted demand investigation in the affected areas and provided services for other NGOs and volunteer groups under coordination of the Office. During the action period, the NGO Joint Office for Disaster Relief in Sichuan helped transfer emergency aid materials valued at RMB11million in total.

After the Wenchuan Earthquake, a large number of volunteers participated in after-quake assistance, the first of its kind in the Chinese history. The coordination mechanism for volunteer organizations came into being in actual practice. In their aid actions, such mechanisms self-consciously accepted government guidance or coordinated with governments at different levels. Their member organizations included official NGOs, which ensured continuity of their activities. In addition, although such coordination mechanism were of a temporary post-quake nature, the participating organizations already conducted activities locally prior to the earthquake, ensuring the feasibility of carrying out organized aid activities and mobilizing off-site resources. This applied to international aid organizations in particular. Compared with ad hoc aid bodies born after the earthquake, those groups that had long experiences of local aid were able to join post-quake assistance networks for joint activities with greater ease.

## Discussion

Response patterns between Indonesia and China are very different. In Indonesia, NGOs played an active role while in China governments played the leading role.

The research shows that the adaptation mechanism for the Chinese-Ethnic aid groups played an active role: (1) groups within the Chinese community played some role; (2) Emergency groups, especially emergency groups in Medan played an active role; (3) Emergency groups linked the aid groups in Medan and Banda Aceh, even Chinese groups in South-eastern Asia. (4) Local emergency groups in Banda Aceh penetrated their aids to the Chinese community. (5) Cooperation among local and global groups was embedded in the daily life of the Chinese community across Banda Aceh and Medan.

Research on Wenchuan Earthquake finds that (1) some local governments were damaged by the Earthquake; (2) adaptation mechanisms among volunteers, victims and governments emerged after the earthquake; (3) the adaptation mechanisms for aid groups operated effectively including coordination with the local government; and (4) with recovery of the local government recovered, the adaptation mechanism was transferred to the local government.

The two case studies enjoy the following commonalities. First, aid organizations based on existing social groups and born after catastrophes became nodes of the aid organization networks. Confederation of larger aid organizations may mobilize more resources from non-affected areas to affected areas. Second, among the aid organization coordination mechanism, the extensive disaster relief organizations set up in large cities nearest to the affected areas played a key role. It is thus imperative to establish interactive mechanisms in areas prone to disasters. Third, the coordination mechanisms in the two case studies replaced government functions to some extent. In terms of difference, the Indonesian Chinese coordination mechanism fully substituted government functions ranging from collecting statistics about casualties to operation of refuges. This had something to do with disaster impacts on the local governments and weak disaster relief capability of the Central Government on the one hand and with long-term exclusion of Chinese ethnic groups in Indonesia on the other. In China, the volunteer coordination mechanisms mainly played the role of providing integrated information about affected areas, which was indispensable from the strong government functions in China. Fourthly, such aid coordination mechanism could be both inter-organizational and between the government and NGOs. Roles played by public assistance aid systems tend to determine such different relations. Finally, comparison of the two case studies finds that the categories of organizations that get involved in post-disaster aid tend to be linked to the existence of local civil society organizations prior to the disasters. In order to effectively build up capacity for disaster prevention and reduction, provision of disaster preparation programs applicable to existence patterns of local social groups is an inevitable choice. Likewise, the cooperation between government and NGOs links to the effectiveness of aid. Especially in developing countries, not only the capacity for government, but also NGOs should be improved.

## References

Beverley, R. (1986).When Disaster Strikes: How Individuals and Communities Cope With Catastrophe, Basic Books New York. (＝2004，Misuzushobou, Tokyo, Japan, In Japanese)

CASTED, (2009). Restoration and Reconstruction in Sichuan Earthquake-hit Areas: a Household Survey Report, Chinese Academy of Science and Technology for Development，Beijing, China.

Zhu , J. et al (Eds.).（2009）. Obligation, Action, And Cooperation: Case Studies On NGOs′ Participation In Wenchun Earthquake Relief, Beijing University Press, Beijing, China.

Takahashi, M. et al (2007). Restoration after the Sumatra Earthquake Tsunami in Banda Aceh: Based on the Results of Interdisciplinary Researches by Nagoya University, J. Natural Disaster Science, Vol. 29, No.2, pp.53-61.Kyoto, Japan.

Takahashi, M. et al (2008).The Questionnaire Survey of December 2007: Preliminary Descriptions, The 4th Investigation Report of 2004 Northern Sumatra Earthquake, pp.33-44.

Graduate School of Environment Studies Nagoya University, Nagoya, Japan.

Tanaka，S.(2001).From Hanshin-Awaji Research to Urban Research, Kaneko, I. and Morioka, K.(Eds.), pp.129-148.Minervashobo, Kyoto, Japan.

Tanaka, S. (2006)，Aid Approaches for Recovery and Reconstruction，Kimata, M. et al (Eds.). Great Earthquake came: Learn From Sumatra Earthquake Tsunami, pp.152-164，JIJI Press LTD, Tokyo, Japan.

Thoma,E. Drabek & D. A. McEntire,（2002）.Emergent Phenomena and Multi-organizational Coordination in Disasters: Lessons from the Research Literature, Int. J. Mass Emergencies and Disasters, Vol. 20, No.2, pp.197-224. Newton, USA.

Xinhua News Agency. (2009).http;//www.xnhuanet.com. Last Accessed 12th Dec. 2009.

Han , J. (2009). A Study On NGO Participation In The Emergency Aid For Wenchuan Earthquake, Beijing University Press , Beijing, China.

Yoshii,H. (2007).Frontier of Disaster Prevention ystem, Oyane, J. et al (Eds.). Introduction to Sociology of Disaster, pp204-210. Koubundou, Tokyo, Japan．

The Chinese Government. (2009). http://www.gov.cn/jrzg/2009-05/07/content_1307669.htm. Last Accessed 12 th Dec. 2009.

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## Author Biography

Ph.D. in Sociology with main research interests in disaster responses, especially comparative sociological studies on disaster aid.

Major Publications:

Wu, G. (2007). Quasi-organizational Mobilization and What NGOs Can do in the Field of

Disaster Help", The Annals of Japan Association for Unban Sociology, Vol. 25, pp.95-110.

Harvest-sha, Tokyo, Japan.

Wu, G. (2006). The Present Condition and Challenges of the Disaster Response in China,”

Institute of Social Safety Science, Vol. 8, pp.217-224. Tokyo, Japan.

Wu,G. (2005). Emergency-management Concept Appears in China,” The sociological

Review of Nagoya University, Vol.26, pp.117-132. Nagoya, Japan.

Wu,G.(2007). What Non-governmental Organization Responded After the Indian Ocean

Tsunami,” The Sociological Review of Nagoya University, Vol.28, pp.67-82.Nagoya, Japan.

Tanaka, S., Tabuchi, R., Kimura, R. and Wu, G. (2006), “Tsunami Evacuation Behavior

Reconsidered", Journal of Japan Society for Natural Disaster Science, Vol.26, No.3, pp.183-195. Kyoto, Japan.

# 基于手机的中国地震应急救援移动信息平台

**胡卫建 [1]，李楷 [2]，张天罡 [1]，张鹤 [1]，王东明 [1]，赵兰迎 [1]，张云昌 [1]，李磊 [1]，徐一帆 [1]，  李立 [1]，王建平 [1]**

1 中国地震应急搜救中心 北京 100049

2 中国科学院地理科学与资源研究所 北京 100101

**【摘要】**由于在现场能够方便地提供采集、通讯、信息处理等功能，基于移动通讯网的移动信息技术必将成为今后提高应急救援效能的重要技术途径。因此，许多研究工作已经在该领域展开，例如地图协同操作，数据传输协议等。然而，关于运行中的移动应急信息平台实现框架的研究却很少，本文重点介绍了由中国地震应急搜救中心（NERSS）开发并已投入使用的移动信息平台（EQMRR）。该平台提供了信息分发，数据共享，位置服务以及灾区分析等功能，从而协助救援队员在现场查询地图、应急预案、灾情数据库。如果连接网络，EQMRR 还能够在救援队员与指挥部之间进行信息交换。在实际工作中，上述功能可对救援行动的决策和指挥提供极大的帮助。

**【关键词】**移动应急；应急救援

# AN INFORMATION PLATFORM FOR CHINESE NATIONAL EARTHQUAKE RESPONSE SUPPORT OPERATION BASED ON CELLULAR PHONE

**Hu weijian[1], Li kai[2] , Zhang tiangang[1], Zhang he[1], Wang dongming[1], Zhao lanying[1], Zhang yunchang[1], Li lei1, Xu yifan[1], Li li[1],Wang jianping[1]**

1 *National Earthquake Response Support Server, Beijing, 100049, China*

2 *Institute of Geographical Sciences and Natural Resources Research, CAS, Beijing, 100101, China*

## Key word

mobile response, earthquake response support operation

## Abstract

By providing better gathering, communication and processing information on site, we believe that mobile information technology can be a valuable tool to increase the speed, precision, efficiency and effectiveness

of rescuing operations after earthquake. Therefore, there is so much work which focuses on those aspects, such as collaborative operation of map browse, data transformation protocol. However, the introduction about an implemental framework of running a mobile response platform is rarely proposed. This paper constructs a mobile information platform of earthquake mobile response and rescue (EQMRR) developed by National Earthquake Response Support Server (NERSS), which have applied in the earthquake rescuing in china. EQMRR provides functions including message dispatch, data sharing, location service and disaster area analysis, which assists team members to access maps, predefined response plans, property information and access hazardous material databases. Relying on wireless networks, it is possible for EQMRR to exchange information between team members and headquarters, which is great helpful for making decision and planning.

## 1 background

The interest in mobile information technology for emergency response (ER) comes from the simple fact that an important part of this work is done in the field. With little or no infrastructure to rely on, ER operatives have to make do with the tools they bring along. The system support strategic plan and decision making is very valuable. However the effects of emergency response work eventually have to be created on site. As current and foreseeable innovations in mobile information, mobile system can provide better gathering, communication and processing of relevant information between all actors involved, unquestionably mobile information technology can increase the speed, precision, efficiency and effectiveness of their operations. In China, especially suffering from Wenchuan earthquake, an effective ER information platform is in dire need. The platform must support large scale rescue in extreme hard disaster environment. Therefore a mobile response system is an indispensable part for entire platform. This paper introduces an Earthquake Mobile Rescue Response platform (EQMRR) which deploy on cellular phone.

This paper is divided into five parts. After making a survey on the related research work about mobile response system in section 2, we conduct the requirements of mobile responding system in section 3. Then, section 4 introduces the framework of EQMRR, and we present actual results of EQMRR, including the position track and time cost of data transfer to verify the practicality.

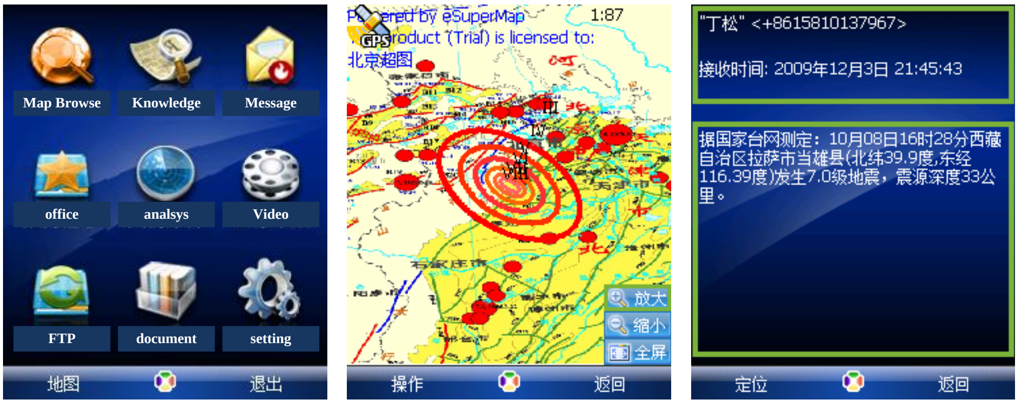
## 2 Relation research

The great potential benefit that usable mobile IT could yield in the domain of emergency response and the specific design challenges for such technologies in this particularly unforgiving domain, that there are lots of work been propose from different disciplines and backgrounds. Especially, First International Workshop on Mobile Information Technology for Emergency Response was held in 2007, Sankt Augustin, Germany, which indicated the research in this domain is already getting into the mature period.

There are four main domains in this research. Firstly, standardization is discussed. Although it may become an obstacle to innovation, standardization might help in building solutions from well proven technologies and that it would also foster interoperability. Secondly, the question of how all the information that might be obtained from mobile information technology is discussed. It specific team members need information that is relevant for their current task [1]. Thirdly, the importance of understanding and designing for the actual work of emergency response professionals was stressed. On a more serious note it was stressed that empirical studies to understand the actual work and needs of ER professionals is one of the weak points of current research and development that needs to be extended. At last, the co-operation of client and service is discussed [2] [3]. Besides efficiency is considering, security of communication has brought into sight. This paper proposes an application which integrates some of above research result.

## 3 Requirements

Considering the extreme environment of rescue operation, the mobile platform must provide necessary and sufficient functions. At the site, most of infrastructure may destroy, so position location and direction navigation is important. This requirement includes two aspects. First, a team member needs to know his own position by receiving GNSS signal and markup to the electric map. Second, in order to guarantee security of all actors, control center needs to trace all actors. With wireless network, client can sends its coordinate and other data back to control center system. Even if team members happen to meet dangerous, first-aid personnel will set out promptly.




**Main Menu** **isoseismal line analysis** **Control message**

Figure 1 requirements of mobile response platform

As smart phones grow in popularity, mobile client was not only a simple communication tool but also a work assistant for rescue actor [4]. First, knowledge search function is so important; actor in-site can look up official documents, area maps, emergency plan and phone book. Second, mobile phone is also able to do some valuable computing such as isoseismal line analysis, nearby dangerous point search. Especially, mobile GIS technology shows a great potential for assistant rescue [5].

The information communication is the most useful function for mobile response. With wireless network (Wi-Fi, GPRS, 3G), lots of information(form, photo, audio, video) captured on-site can be submitted to control center, while command and messages of center control can promptly published to every actor. High speed network will achieve control remote rescue operation.

## 4 Implement

EQMRR is typical mobile client/Severer system. The framework is shown in Fig.2, which is made up with 6 levels. EQMRR's user includes team director, specialist, researcher, and rescue actor. User level defines the users' permissions according to their duty, Service level provide API for mobile client invoking, which include file transfer service, analysis service, message service, location based service, video transfer service. All above service follows Service-oriented architecture (SOA) standard. Those services implement in application level. All data is managed in database, which include toolkits resource, history of the disaster, electric map and economy statics. All this parts must run on operation system and hardware.

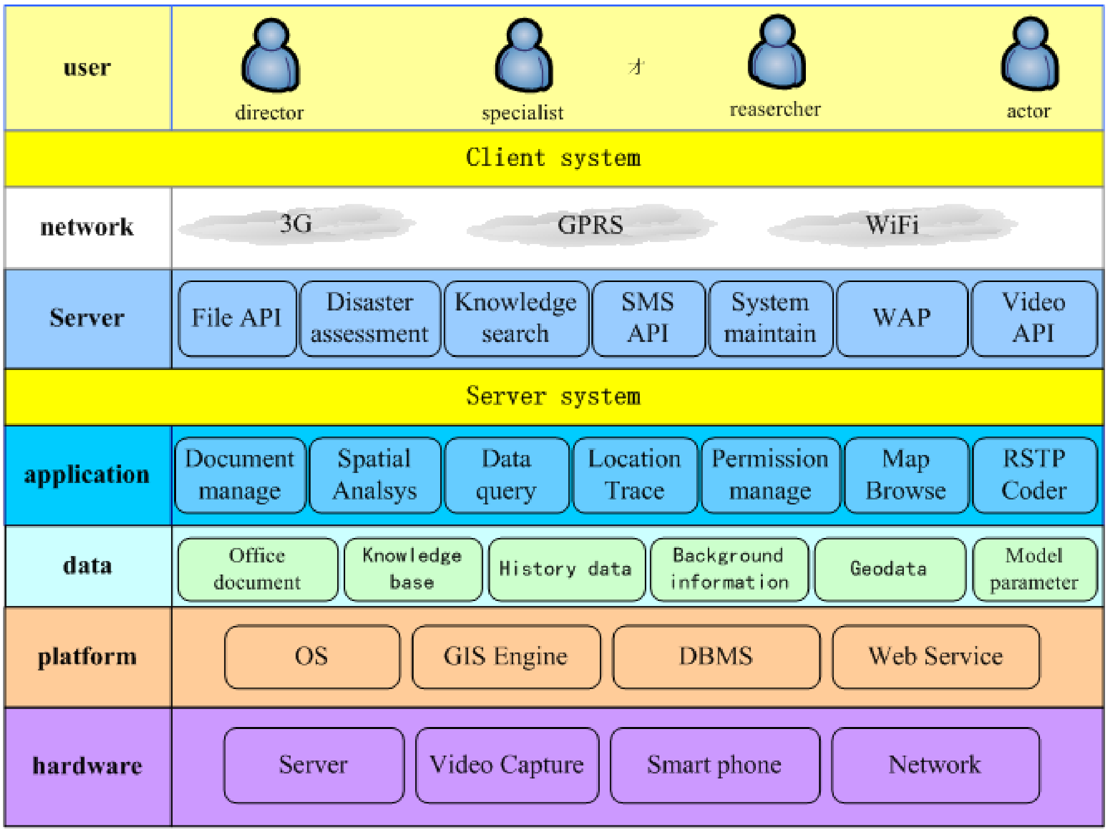



Figure 2 the logic framework of EQMRR

The protocol of communication is core of whole system. Video signal code by Real Time Streaming Protocol (RTSP), Message sent by Short Message Service (SMS), form query uses hypertext Markup Language (HTML), web publishes according to Wireless Application Protocol (WAP).

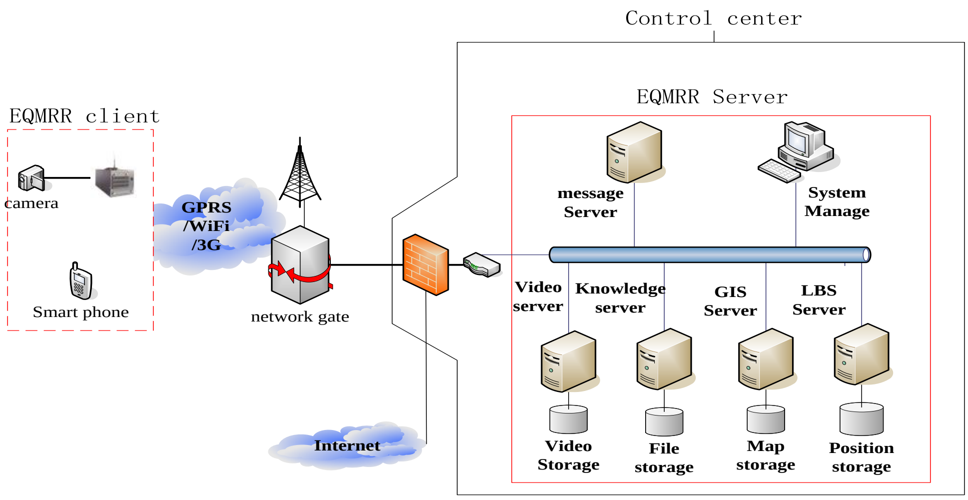



Figure 3 the running time structure of EQMRR

## 5 conclude

Through validating, EQMRR has been adopted by NERSS. It will play an important role in earthquake rescue. On one hand EQMRR is able to enhance rescuer's generating capacity of the field. On the other hand unobstructed communication increases the efficiency. Field data supports the design making in control center, and command also pass down the communicated to emergency response personnel. In future, it can be predicted a real time, high mobility, multi-purpose information process platform will indispensable in disaster rescue.

## Reference

[1] Hernández Ernst, V. and M. Ostrovskii, Intelligent Cartographic Presentations for Emergency Situations. Mobile Response, 2007: p. 77-84.

[2] Cheung, A., Grandison, T., Johnson, H., Schönauer, S.: Ïhf ñ ťy: A Generic Platform for Application Development and Information Sharing on Mobile Devices. In: Sixth International ACM Workshop on Data Engineering for Wireless and Mobile Access (MobiDE) 2007, Beijing, China (June 2007)

[3] Gómez Bello, P., et al. , Improving Communication for Mobile Devices in Disaster Response. Mobile Response, 2007: p. 126-134.

[4] Want, R., Pering, T., Danneels, G., Kumar, M., Sundar, M., Light, J.: The Personal Server:Changing the Way We Think about Ubiquitous Computing. In: Borriello, G., Holmquist,L.E. (eds.) UbiComp 2002. LNCS, vol. 2498, pp. 194–209. Springer, Heidelberg (2002)

[5] Simon, R., Fröhlich, P., Anegg, H.: Beyond Location Based - The Spatially Aware Mobile Phone. In (W2GIS 2006). Proceedings of the 6th International Symposium on Web and Wireless Geographical Information Systems, Hong Kong, China, December 4-5, 2006. LNCS, Springer, Heidelberg (2006)

# 汶川 8.0 级地震灾害紧急响应及救援行动

**曲国胜，宁宝坤，孙刚，刘亢，胡卫健，司洪波**
中国地震局，中国地震应急搜救中心

**【摘要】**通过综合分析和调查 2008 年 5 月 12 日汶川 8.0 级地震灾害的分布区域，可将灾区分为三个主要灾区。

（1）从映秀，银厂沟，红白镇，清平，高川，茶平，北川，陈家坝，平通，南坝，石坎，水关，马公到东河口的中龙门山重灾区，挟持在龙门山中央逆冲和右旋界走滑断层之间，伴随着宽度几十米的原地喷冒体和山体滑坡，这些喷冒体等沿龙门山中央断裂带和活动断层分布。

（2）前龙门山从漩口镇，虹口，白鹭，汉王重灾区，西北谁谁到小坝，而根据前龙门山逆冲和右旋走滑断层为界，与许多大 S companying 查莱滑坡，崩塌，挂在墙上或沿龙门山前地表破裂和活动断层。从漩口镇，虹口，白鹭，汉旺到小坝的前龙门山重灾区，挟持在龙门山前山逆冲和右旋界走滑断层之间，伴随着崩塌和山体滑坡，这些滑坡带等沿龙门山前山断裂带和活动断层分布。

（3）四川盆地西部建筑物和基础设施损失较轻的中等轻灾区，沿龙门山前山逆冲和右旋走滑断层分布。

通过综合分析，结果表明，由汶川 8.0 级地震引起的龙门山中央和前山断裂带，分布着大量的滑坡、崩塌和引起大量的建筑物毁坏。结果还表明汶川地震前一两天的应急救援工作受到了大量滑坡带和堰塞湖的影响，影响范围大约沿着前山断裂带有 100 公里长，同时这些滑坡也阻断了龙门山前山的道路，桥梁和铁路。龙门山中央重灾区变成了信息中断和救援的孤岛。

因此，在这些地区的救援行动，主要是自救或第一响应人救援。同时还发现，当地的专业团队救出更多的幸存者，如成都，德阳，和绵阳救援队，然后是其他的省级和国际救援队。

**【关键词】**汶川 8.级地震，灾害，应急响应，救援行动。

# DISASTER EMERGENCY RESPONSE AND RESCUE OPERATIONS OF WENCHUAN MS 8.0 EARTHQUAKE

**Qu Guosheng, Ning Baokun, Sun Gang, Liu Kang, Hu Weijian and Si Hongbo**

*National Earthquake Response Support Service (NERSS), China Earthquake Administration (CEA), P.R. China*

## Abstract

The comprehensive investigation of 12, May, 2008, Wenchuan Ms 8.0 earthquake disaster area show that there are three major disaster zones: (1) Central Longmen Mountain severe disaster zone from Yingxiu, Yinchanggou, Hongbaizhen, Qingping, Gaochuan, Chaping, Beichuan, Chenjiaba, Pingtong, Nanba, Shikan, Shuiguan, Magong, Shiba to Donghekou, which bounded by the central Longmen Mountain thrust and dextral strike-slip faults, companying with some dozens of large scale in situ erupted rocks of pluvial fan, and rock-fall and landslides, in the hanging wall or along the Central Longmen Mountain surface ruptures and active faults. (2) Front Longmen Mountain heavy disaster zone from Xuankou, Hongkou, Bailu, Hanwang, Northwest Shuishui to Xiaoba, which bounded by the front Longmen Mountain thrust and dextral strike-slip faults, companying with many large scale landslides and collapses, in the hanging wall or along the Front Longmen Mountain surface ruptures and active faults. (3) Western Sichuan Basin moderate-light disaster zone with light damages of buildings and infrastructures, in the lying wall of front Longmen Mountain thrust and dextral strike-slip faults. By the comprehensive analysis, it is found that the distribution of central and front Longmen Mountain surface ruptures caused by Wenchuan Ms8.0 earthquake control the

distributions of large scale of landslides, and caused severe damages of buildings and infrastructures and casualties. It is found that the emergency response and rescue operations of Wenchuan earthquake in early 1-2 days were severe affected and delayed due to the large scale of landslides belts and quake-lakes within 100 km along and caused by the Front Longmen Mountains surface ruptures which cut whole of the roads, bridges and railway in front belts of Longmen Mountains. Central Longmen Mountain severe disaster zone become isolated islands for disaster information, communication, professional rescue operation. So the rescue operations in these area were mainly depended on self-rescues or first responders. It is also found that the local professional USAR team save more survives, such as Chengdu, Deyang, and Mianyang, then the other USAR teams from provincial and international rescue teams.

## Key Words

Wenchuan Ms 8.0 Earthquake, Disaster, Emergency Response, Rescue Operation

## 1 Introduction

In the history of China, there are several catastrophic earthquakes caused heavy casualties and economic losses. In 1303, the 8.0-magnitude earthquake in Hongtong, Shanxi, China caused 200,000 deaths. In 1556, the 8.5-magnitude earthquake in Huaxian County, Shanxi, China and the plague after the disaster caused 830,000 deaths. In 1668, the 8.5-magnitude earthquake in Tancheng, Shangdong, China caused 50,000 deaths. In 1920, the 8.5-magnitude earthquake in Haiyuan, Gansu Province, China caused 234,000 deaths. In 1976, the 7.8-magnitude earthquake in Tangshan, Hebei Province, China caused 242,000 deaths. All of these huge earthquakes made a great casualty and economic losses are concerned with the compression from India plate to Tibet plateau and then to Northern China Basin area.

In 14:28, 12, May, 2008, a huge earthquake with magnitude 8.0 occur in Wenchuan, Sichuan, China, which caused 87,000 death, 370,000 injured, the economics losses 845.1 billion Yuan, RMB, and 50,000,000 homeless persons.

After Wenchuan 8.0 earthquake, there are many experts focus on the mechanism and disaster of this huge earthquake. This paper is focus on the emergence responses and rescue operation of this catastrophe. Through the comprehensive investigations in Wenchuan earthquake impacted area on disasters and related emergency response and rescue operation, some principles were found: the emergency response and rescue operations of Wenchuan earthquake in early 1-2 days were severe affected and delayed by Front Longmen Mountains landslides. The Central Longmen Mountain severe disaster zone is the isolated islands for disaster information, communication, and professional rescue operation. So the rescue operations in these area were mainly depended on self-rescues or first responders.

## 2 Distributions of Wenchuan Ms 8.0 Earthquake Disasters

Wenchuan Ms 8.0 earthquake makes severe damages to Sichuan, Shanxi and Gansu, as well as Chongqing and Ningxia Province. Billion of the buildings and infrastructures were destroyed or damaged. The distribution of Wenchuan Ms 8.0 earthquake disasters area can be identified into Central Longmen Mountains thrust--strike-slip faults--rockfall and large scale landslide belts (CLM Faults--Rockfall Belts), and Front Longmen Mountains Thrust Faults--Landslide Belts (FLM Faults--Landslide Belts) as well as rear LM light damaged area and Sichuan Basin light damaged area (Fig.1, Fig.2).

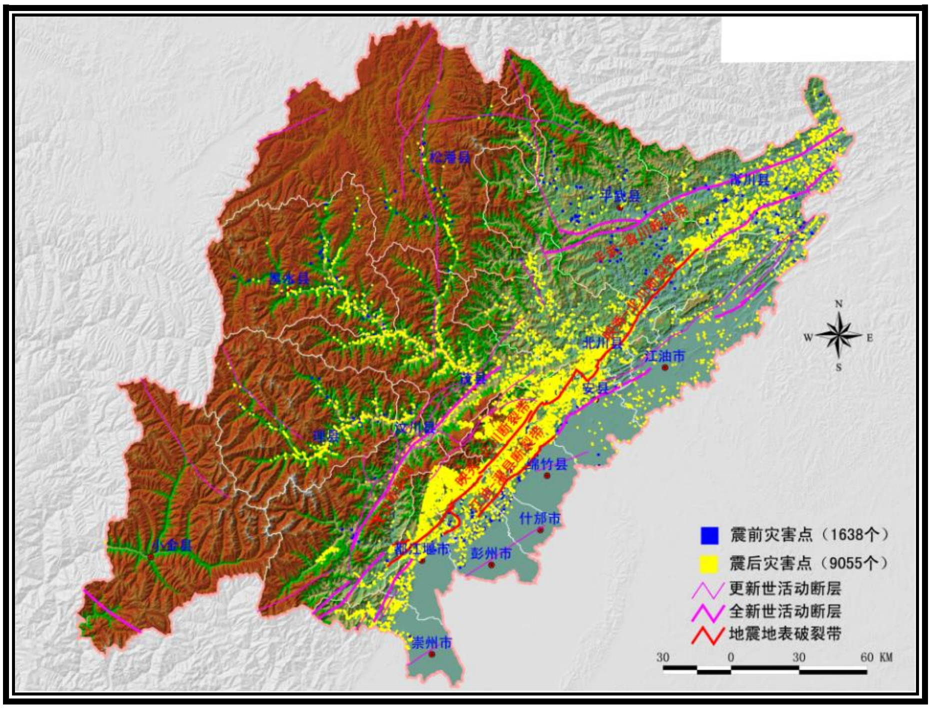



Fig.1 Distribution of landslides caused by Wenchuan earthquake
(Based on Huang Runqiu, 2008)

## 2.1 Geological structures of Longmen Mountains

Longmen Mountains locate in the west Sichuan Province with strike NE-SW as the east boundary of Tibet thrusting to the Yangtze Plate. Longmen Mountains consist of a series of thrust sheets and folded belts. It could be divided into the rear Longmen Mountains thrust belts, central Longmen Mountains (CLM) thrust belts, and front Longmen Mountains (FLM) thrust belts. Whole of the thrust belts thrust to the eastward of the foreland basin (Fig.3). Structures of Longmen Mountains along strike could be divided into three segments: the North Segment, the Middle Segment and the South Segment (Fig.3).

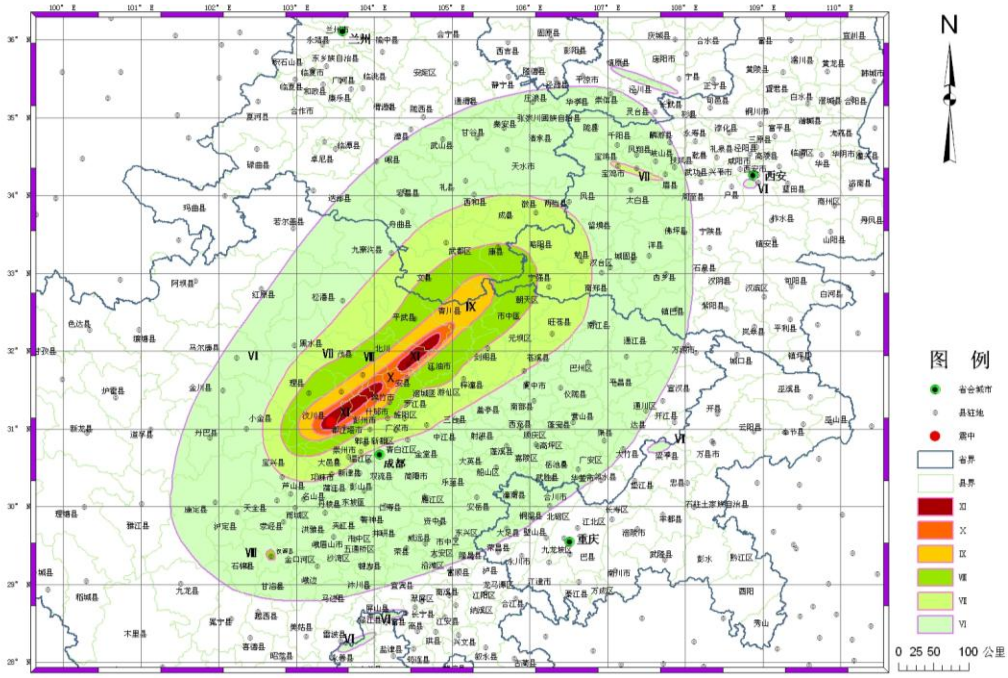



Fig. 2 Intensity Map of Wenchuan Earthquake (Based on CEA, 2008)

The North Segment is located in the North of Macaotan, with the thrusting mountains directly to the deformed Yangtze platform. The surface ruptures of Wenchuan earthquake have the dextral strike-slip (offset 3.0m) and vertical (offset 3.0-6.0m) displacements along Beichuan-Chenjiaba-Guixi-Pingtong-Nanba-Shikan and southwest of Donghekou where distribute a large scale rock-fall and landslide belts and severe damaged buildings and infrastructures. The front thrust faults of this segment didn’t move during the earthquake, so there are no heavy damages.

The Middle Segment is located from Dujiangyan or Yingxiuzhen to the south of Anxian, the thrusting mountains directly to the foreland basin of Sichuan. Wenchuan Ms 8.0 earthquake cause two surface rupture zones in this segment. One is the Central Longmen Mountains Fault surface rupture (total length is about 320Km). Another is the Front Thrust Fault surface rupture (total length is about 72Km) (Fig.3). Two surface ruptures are thrust fault thrusting from mountains to basin area.

## 2.2 Disaster along the Central LM Faults--Rockfall Belts

This belt is severe damaged with intensity X-XI from Yingxiu, Longmenshan, Hongbai, Qingping, Gaochuan, Chaping, Beichuan, Chenjiaba, Guixi, Pingtong, Xiangyan, Nanba, Shikan, Magong, Shiba, to Hongguang about 320km. The main features are as follows:

(1) The Central Longmen Mountains faults are thrust mainly in middle segment, and thrust-strike-slip faults in north segment, NE strike, dipping to NW. The vertical offset is about 5-6m, and the largest offset is 9m. Component of strike-slip displacement increases from SW to NE with horizontal displacement of 3-4m. There are about 35-40 large scale rockfalls and landslides which probably caused by the local shallow gas trap exploration during the fault rupture.

(2) The Central Longmen Mountains faults and large scale rockfalls caused about 30-40 towns and cities severe damaged and some of them disappeared under large scale landslides. Most lost and death persons were caused along this surface rupture zone. For example, Beichuan city, Yingxiu town were total destroyed due to the surface rupture across the city or town (Fig.4).

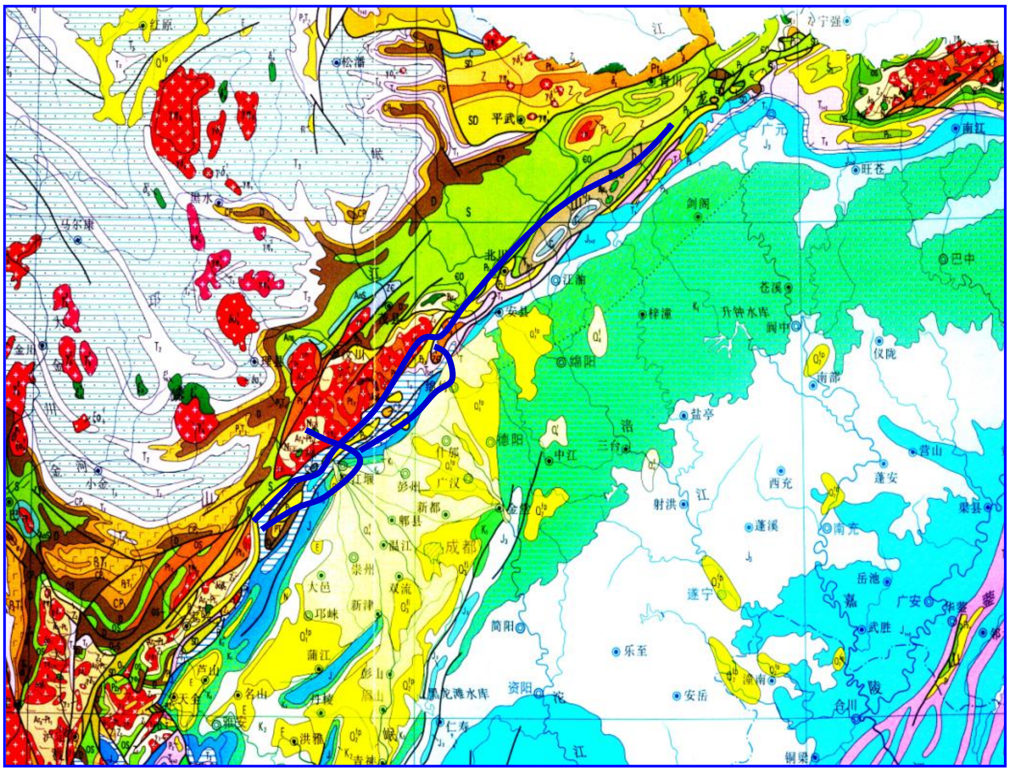


Fig.3 Geological, Structural Segmentation and Surface Ruptures of Longmen Mountains

South Segment is located in the South Dujiangyan where no surface ruptures and no heavy damaged.

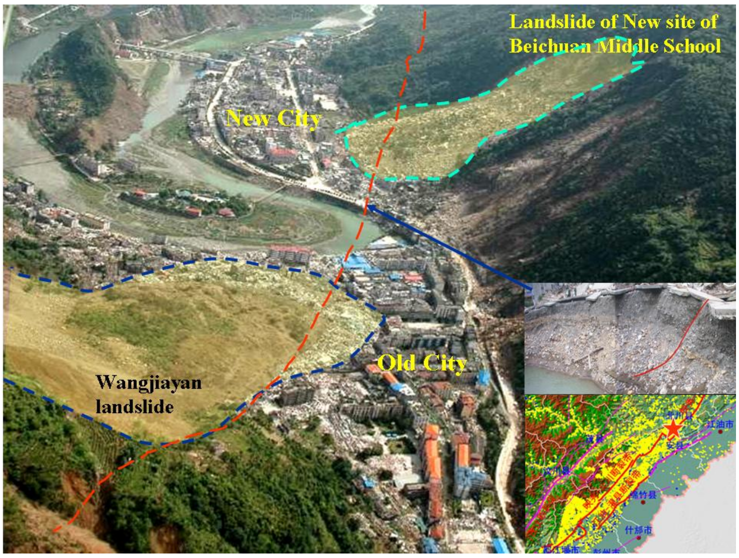



Fig.4 Beichuan city destroyed under the surface ruptures and landslides

## 2.3 Disaster along the Longmen Mountains Front Thrust Faults--Landslide Belts

This belt is severe damaged also with intensity IX-X from west of Dujiangyan, Hongkou, Xiang'e Xiaoyudong, Bajiao, Yinghua, to Hanwang about 72km. The surface ruptures consist of two arcuate thrust faults which caused heavy damages of buildings, highways, railways, industry factories. The main features are as follows:

The Front Longmen Mountains thrusts are thrust faults, NE strike, dipping to NW which only developed in middle segment of Longmen Mountains. The vertical displacement is about 2-3m, which become a bland thrust in NE of Hanwang town (Fig.5). There are two arcuate thrust belts. One is Hongkou-Xiaoyudong arcuate thrust fault with thrust features of thrust (eastward)-oblique thrust (from SW to NE) and strike-slip (sinistral slip). Another is Bailu-Hanwang arcuate thrust fault with thrust features of thrust (eastward)-oblique thrust (from SW to NE) and strike-slip (sinistral slip). There are many middle and large scale landslides and quake-lakes caused by two arcuate thrust belts where many countryside roads and highways, bridges destroyed. For example, there are 10km landslides and 5 big quake-lakes belts from Qingping to Hanwang which covered and cut the highway so that the rescue teams couldn't go into the Qingping town during the first 2 days after Wenchuan earthquake (Fig.6). The front landslide and quake-lakes belts display about 100km long along the front belts of the Middle Longmen Mountains caused by the fault ruptures.

### 2.4 LM light damaged zones

LM light damaged zones are located between the Central LM Faults--Rockfall Belts and Front LM Thrust Faults--Landslide Belts. The wideness of this light damaged zone is about 5-10km. There are no or less landslides, light damages of buildings and infrastructures.

### 2.5 Sichuan Basin light damaged area

Sichuan Basin light damaged area is located in west Sichuan plain. There are light damages of buildings and infrastructures and the damage degree (intensity) change very quick toward the basin (Fig. 2).


Fig.5 Surface ruptures and deformed Railway in Hanwang Town

## 3 Emergency Responses of Wenchuan Ms 8.0 Earthquake

### 3.1 Emergency responses

Depends on the earthquake disaster situations, the earthquake disaster response levels could be classified into 4 grades in China domestic: catastrophe, serious disaster, moderate disaster, light disaster (Table 1).

Fig.6 More then 10 thousand person's evacuation along the former highway from Qingping to Hanwang in 15, May, 2008

Table 1 Classification of Earthquake Disaster Grades in China

| Grades of Disaster | Critical Level | | Early Decision |
|---|---|---|---|
| | Death Toll | GDP /Economic Losses | High Density Population Area |
| Catastrophe | Over 300 | Over 1％ | Large than 7.0 |
| Serious Disaster | 50－299 | | 6.5－7.0 |
| Moderate Disaster | 20－49 | | 6.0－6.5 |
| Light Disaster | Less 20 | | 5.0－6.0 |

After 10 minutes of Wenchuan Ms 8.0 earthquake occurred, the parameters of this earthquake were received, and then, the emergency response were started up:

Central government response: After earthquake, the first class response is start up. Primer Wen Jiabao start up from Beijing to Chengdu two hours later of the earthquake.

China Earthquake Administration (CEA) response: First class start up in 2：40. More then 10000 persons will be dead by the estimation of NERSS in 15:00 and give disaster information support. CISAR and On-site Working Team were organized and information, equipments and logistic were prepared. CISAR and On-site Working Team arrived Nanyuan Airport of Beijing in 18：00. Two army airplanes start up in 20:00, and arrived at Chengdu in 22:40.

Local government response: provincial, regional and county level of Sichuan, Shanxi, Gansu governments operate as self organized, first responders, and self-rescues just after the earthquake.

By the comprehensive investigation, the time sequence of the response and rescue teams arriving at the disaster sites as shown in Fig.7.

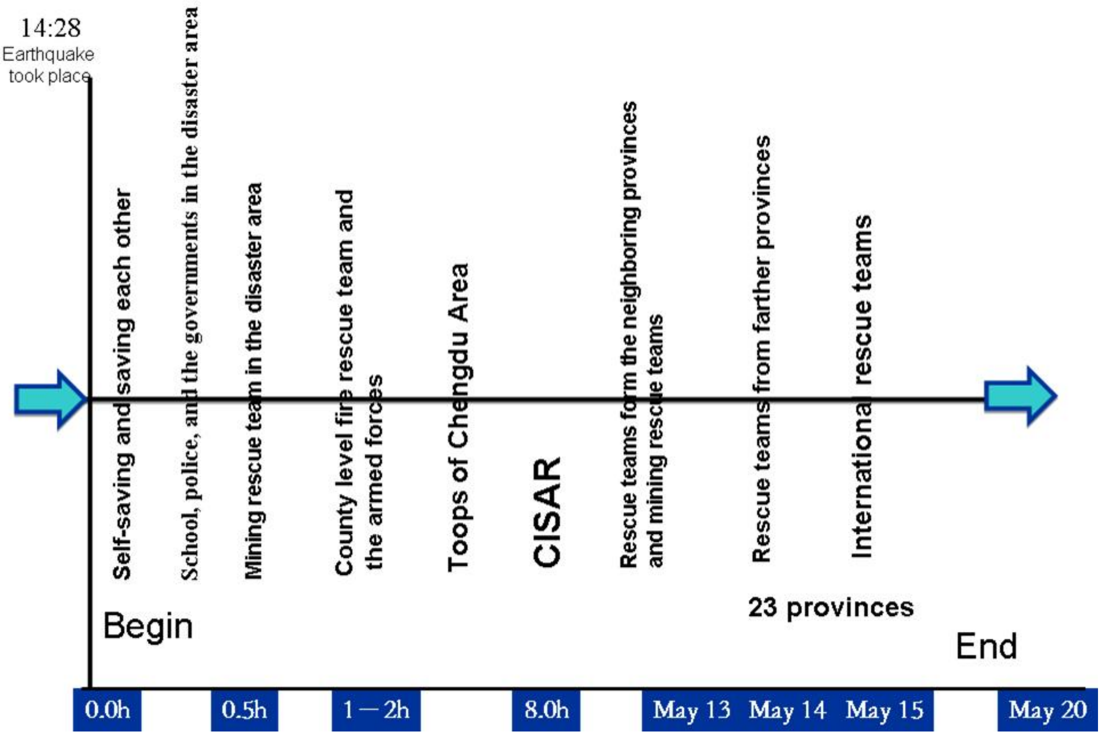



Fig.7 Emergency response sequences of rescue teams in Wenchuan Earthquake

### 3.2 Natural Barriers analysis for Emergency Response and SAR operations

Although the responses from governments were very quickly, but when the rescue teams who come from outside of disaster area arrived to Sichuan disaster area, there are many difficulties for them to go into the deep mountains and severe disaster area. There are no information, no communication, no transportation, no any supports for the deep mountains and severe disaster area.

Disaster distribution show that FLM thrust-landslide belts form the first natural barrier so that the disaster information, victims, injured persons couldn’t communicate and transport outside of disaster area (Fig.6). And SAR resources, equipments and logistic supports couldn’t transport into the disaster area. Communication and highway interrupted totally by landslides in 130000$Km^2$.

CLM thrust-rockfall belts form the second natural barrier that make many towns and cities disappear and no SAR resources, equipments and logistic supports go into these area in early two days.

So in 12-14, May, 2008, the responses of earthquake rescues in severe damaged mountains area are not effectively due to the FLM landslides and CLM rockfalls and large scale landslides. The main operations are self-rescues by first responders.

Fig.8 show that the temporal and spatial distribution of professional rescue teams change in the rescue operation of Wenchuan Earthquake. Fig.8a show that there are only 4 professional rescue teams involved in Chengdu, Deyang, Mianyang, and National Earthquake Disaster SAR Team (CISAR) in the disaster area in 12, May, but they were in the western Sichuan plain area even if premier minister Wenjiabao ask the rescue teams must arrived at the severe damaged area. Fig.8b show that there are 16 professional rescue teams in the disaster area in 13, May, but they were 6 teams arrived at the severe damaged area of Central Longmen Mountains. Fig.8c show that there are 36 professional rescue teams in the disaster area in 14, May, but they were 13 teams arrived at the severe damaged area of Central Longmen Mountains. There are no professional rescue teams operated in Central Longmen Mountains from Yingxiu to Chaping due to the large scale of landslides about 100km long along Front Longmen Mountains which cut off the highways, bridges, communication and other infrastructures.

On May 12, 2008, twenty provinces started up their rescue teams, but only CISAR arrived in the disaster area on the same day, so it is very urgent to plan and construct regional and local rescue team!

## 4.2. Analysis of the operation effects of professional SAR's

1) According to the statistics, many of the survivals were rescued from building ruins primarily by the fire and rescue teams in Sichuan Province, such as Chengdu, Deyang, and Mianyang, the secondarily by CISAR, the thirdly by the mining rescue team and that from other provinces, and the fourthly by some of the provincial and international rescue teams, which had rescue the least or nobody.

2) The rescue teams arriving at the site the earliest and familiar with the local situation have rescued the most survivals, while those arriving at the site the latest and not familiar with the local situation have rescued only a few or nobody.

3) The rescuing forces were distributed unevenly. In the area where information channel and road are smooth, such as in Dujiangyan, the rescuing forces arrived the earliest and were even surplus, so the rescued were the most. However, in the towns along the central fault of Longmen Mountains and the large rockfall, the rescuing forces arrived very late, e.g. the PLA and some professional rescue teams arrived after May 14, so few of the buried were saved.

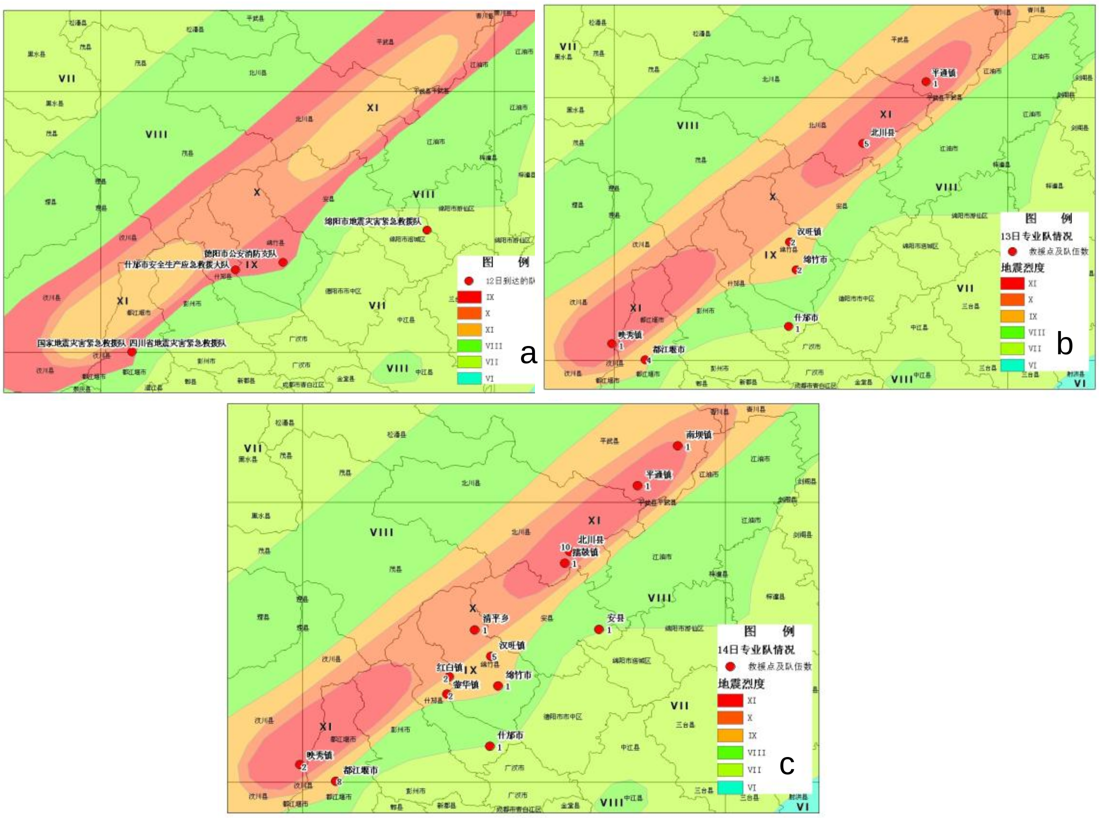



Fig. 8 Distributions and locations of professional SAR teams operated in Wenchuan earthquake disaster area in 12 (a), 13 (b) and 14 (c), May, 2008

## 5 Experiences and Lessons

### 5.1 Experiences

1) The judgment of disaster situation is accurate and response of disaster is quick, so the rescue operation is timely. 14 minutes after the earthquake, CEA judged quickly and accurately the magnitude and intensity of Wenchuan Earthquake and decided that CISAR will start up totally. The rescue teams were organized and converged. The high quality rescue equipment were prepared quickly and dispatched orderly in accordance with level I response plan, so the response is effectively. CISAR arrived at the disaster area and obtained the golden time that provide favorable conditions for successful rescue. Disaster information was accurately for CISAR from central government so that CISAR change their locations very quickly during the rescue operation from Dujiangyan city, Hanang town, Xingxiu town to Beichuan city (Fig.9).

2) On-site effective commanding, coordination of central government is high effectively. The on-site general commanding center ordered and gave information to CISAR to rescue survives in Dujiangyan, Hanwang Town, and Yingxiu Town etc (Fig.9).

3) Scientific planning, searching and rescuing on site operation. The guidance of “Doing the Best and Rescuing Scientifically” has actually summarized a technical flow including on-site rescue planning, comprehensive searching, effective rescue, and on-site medical treatment and first aid etc.. The scientific working flows are as follows: Firstly, survey in details the ruins and decide the classification of the ruins,

know well the pre-earthquake situation and use of the building, identify the risks, investigate the possible space, draw plans of the structures of the ruins, and worked out rules for the rescue. Secondly, adopt single item and comprehensive searching method for determining the location of the buried survivals. Thirdly, work out plan on scientific rescue, and select the best position for life-rescue channel construction and the best dynamic rescuing method, so as to rescue the buried survivals. Fourthly, on-site medical treatments are necessary, including in-time transfusion, simple treatment with traumatic injury, and safety protection of the rescued, so as to ensure safety of the survivals.

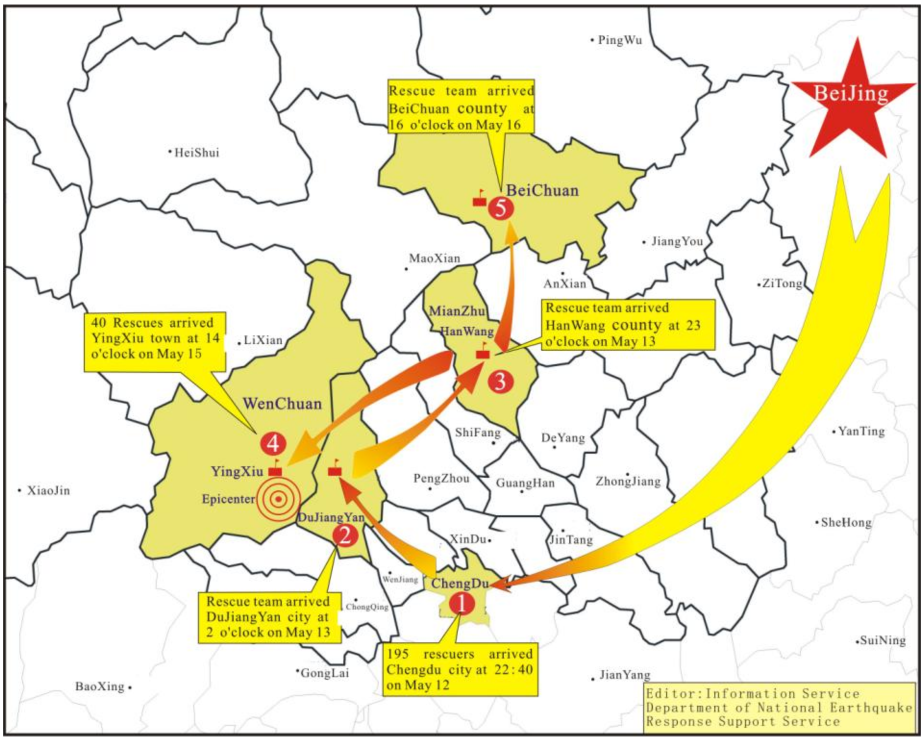



Fig.9 Rescue operation and locations of CISAR in Wenchuan earthquake

4) Rapid judgment on post-earthquake disaster situation and effective guarantee for equipment and training. The rapid judgment on post-earthquake disaster situation, effective guarantee for rescue equipments in daily time and operation time as well as regular training each year, and highly experienced experts and the trainers team become the powerful guarantee for the successful rescue in the very severe disaster.

### 5.2 Lessons

1) At the early stage of the rescue after Wenchuan Earthquake, as communication, highway, bridges and road were broken off, the information on disaster situation could not be obtained and sent rapidly to the on-site commanding center, so the disaster situation and degree were not very clear; from May 13 to 14, the communication by maritime satellite was also jammed, so the order could not be sent in time. As no accurate information could be obtained, the rescue teams could not reach to the area that the rescue are needed imminence, and so the proper opportunities for rescue were lost to a certain extent.

2) As the disaster situation was not clear and the communication was jammed, the rescue decision-making ability was not very high. The on-site SAR teams could not obtain the information quickly and the rear information supporters could not provide information service support quickly and sufficiently. Presently,

the technical system can not provide complete service for rescue decision-making. In the rescue operation of Wenchuan Earthquake, information and tracking service were only provided for CISAR as it’s unable to provide for all the professional rescue teams.

3) During the Wenchuan earthquake rescue mission, unified command and coordination are not enough for the on-site coordination of professional teams. In the situation that the disaster range was very large and the degree was very high, the rescuing forces were surplus in some areas while inadequate in some severe disaster areas.

## Conclusions

There are three major disaster zones: Central Longmen Mountain severe disaster zone companying with large scale rock-fall and landslides, Front Longmen Mountain heavy disaster zone companying with many large scale landslides and collapses, Western Sichuan Basin moderate-light disaster zone. It is found that the distribution of central and front Longmen Mountain surface ruptures caused by Wenchuan Ms8.0 earthquake control the distributions of large scale of landslides, and caused severe damages of buildings and infrastructures and casualties.

It is found that due to the large scale of landslides belts and quake-lakes within 100 km along and caused by the Front Longmen Mountains surface ruptures which cut whole of the roads, bridges and railway in front belts of Longmen Mountains, the emergency response and rescue operations of Wenchuan earthquake in early 1-2 days were severe affected and delayed by these natural barrier.

Central Longmen Mountain severe disaster zone become isolated islands for disaster information, communication, professional rescue operation. So the rescue operations in these area were mainly depended on self-rescues or first responders. It is also found that the local professional USAR team save more survives, then the other USAR teams from provincial and international rescue teams.

## Reference

Web site of China Earthquake Administration (CEA), 2008, Special Report of Wenchuan Earthquake.

QU Guosheng, WANG Jinzhong, LI Guangjun, Zhanghui, and WU Zhiqiang et al (edit.), 2009, Cases on Professional SAR Rescues on Wenchuan Ms8.0 Earthquake. Seismology Publishing House (Beijing).

HUANG Runqiu, XU Qiang (edit.), 2008, Catastrophic landslides in Chin. Science Press Beijing.

QU Guosheng, YU Fujiang and Ning Baokun et al, 2009, Earthquake Disasters. In: Natural Disaster Mitigation--a scientific and practical approach, P. 23-57, edit by the interAcademy Panel on International Issues. Science Press Beijing.

# 气候变化对尼泊尔国家的影响：尼泊尔人的观点

**Meen B. Poudyal Chhetri， PhD9**

**【摘要】**背景: 尼泊尔是一个面临着多元化气候变化危害的国家， 多变的地球气候条件， 初期的地质学， 无计划的定居， 森林采伐的环境退化以及人口的增长。 气候变化对当今的多元化危害是一个非常关键的因素。

正文: 尼泊尔国家主要是季风气候。 季风气候中间夹杂着梅雨的天气，高度影响了整个国家，其中包括自然灾害，例如洪水，山体滑坡， 骤发洪水，泥石流， 山泥倾泻和 冰川湖爆发洪水。 找到了原因是由于全球变暖， 冰川湖中的水位大量上涨。 100 年前世界的平均温度比在 1000 年前迅速提升。 该温度的提升导致冰雪在范围内溶化， 使得当今的事物可能在未来更加的去向于冰川湖爆发洪水。 潜在的威胁了冰川湖的增长在尼泊尔， 以尼泊尔北部山脉包括高于 3，252 的冰川垮塌，致使 26 个潜在的危险。

结论: 温室气体来自人类的活动，其中主要是由于气候的变化和全球的变暖所导致的令人惊恐的局势。 多样的研究显示恳切地需要计算挪用碳，最基本的是计算生态学的不平衡，不合理的采伐所造成的影响。停止对森林的采伐和建立健康的环境的关键议题是所有政府对气候变暖的政策。 那时将对发展中国家的亿万穷苦人民提供一条能够获得利益的道路。 比如政策将帮助减少对森林的不合理采伐，包括生态平衡和允许国家对于与二氧化碳的斗争做出成绩。 另一方面， 发展中国家的污染比现存的京都允许范围内的污染要多，根据能够买氧气归结于平衡他们的排放污染程度，而且帮助建立森林保护计划和项目。

**【关键词】**危害；容易受影响的；冰川湖爆发洪水；潜在的；碳

# EFFECTS OF CLIMATE CHANGE IN NEPAL: THE NEPALESE PERSPECTIVE

**Meen B. Poudyal Chhetri, PhD**[10]

## Keywords

Hazards, susceptible, GLOFs, potential, carbon

## ABSTRACT

10 *Chairperson of Disaster Preparedness Network–Nepal (DPNet) and General Secretary of Nepal Center for Disaster Management (NCDM), Kathmandu, Nepal*

**Background:** Nepal is exposed to multiple hazards due to the climate change, variable geo-climatic conditions, young geology, unplanned settlements, deforestation environmental degradation and increasing population. Climate change is one of the key factors for the occurrences of multiple hazards.

**Context:** Monsoon climate is predominant in Nepal. Torrential rains during the monsoon render the country highly susceptible to water induced natural disasters such as floods, landslides, flash floods, debris flows, slope failures and Glacier Lake Outburst Floods (GLOFs). It is found that due to global warming, the volume of water in the Glacial lakes is on the rise. In the last 100 years the world's average temperature has risen rapidly than in the last 10,000 years. The temperature rise has caused snow melt in the region, making the possibility of occurrence of more GLOFs in the future. The potential threat of GLOFs is growing in Nepal as Nepal's Northern part of the mountain contain over 3,252 glaciers - out of which 26 are potentially dangerous.

**Conclusion:** Greenhouse gases from human activities are among the major causes for the alarming situations of climate change and global warming. Various studies show pressing need to calculate carbon appropriation, the basis for calculating the impact of ecological imbalance particularly - deforestation. Stopping deforestation and building healthy environment should be the key issues in climate change policy of every government. Then it will provide a way for millions of poor people in developing countries to benefit directly. Such policy will help to reduce deforestation, maintain ecological balance and allow the nations to sell credits for successful programs combating carbon dioxide. On the other hand, developed countries that pollute more than the allowed limits under the existing Kyoto accord would be able to buy the carbon credits to balance their emission levels and help to fund forest protection plan and programs.

## 1. Background:

Nepal, a small and land locked country in South Asia is exposed to multiple hazards due to the variable geo-climatic conditions, young geology, unplanned settlements, deforestation environmental degradation and increasing population. Climate change is one of the key factors for the occurrences of various types of disasters. The vast altitudinal variation within a short span of about 193 km, ranging from 60 meters to 8848 meters above sea level makes the country an abundant storehouse of bio-diversity and ecological niches with diverse agro-climatic zones ranging from the sub-tropical to the alpine and tundra (Poudyal Chhetri and Bhattarai 2001). On the other hand, increasing population, rapid and unplanned urbanization and other economic activities in vulnerable areas are other contributing factors to increase hazards. Hence, Nepal is a global hot spot for several types of disasters.

The South Asian monsoon is one of the most important and influential phenomena of the earth's climate system. The modern large-scale, time averaged seasonal variations in the South Asian monsoon system are fairly well understood and are linked to the greater heat capacity of the ocean relative to the surrounding land masses. During summer in the Northern Hemisphere, the Tibetan Plateau warms rapidly relative to the Indian Ocean. The resulting low pressure over Asia and higher pressure over the ocean gives rise to the strong low-level atmospheric pressure gradient that, in turn, generates the south-west monsoon from the Indian Ocean. In years of low snowfall, the Tibetan Plateau is able to warm earlier and generate stronger monsoonal circulation. Deep snow and associated influences on albedo (reflected light or radiation) and soil hydrology delay and weaken the monsoon. The South Asian monsoon during the last glacial period was significantly weaker than at present, and was abruptly strengthened during the beginning of Holocene Period around 12,000 years ago (Overpeck and Cole 2007). In the winter, the continent cools relative to the ocean, the pressure gradient is completely reversed, and the dominant flow across the Arabian Sea becomes north easterly and, therefore, the South Asian region receives little precipitation. Arguments based on physical phenomena clearly indicate that global warming will cause an increase of evaporation from the ocean. A warmer atmosphere can carry more moisture, which can lead to larger amounts of precipitable water. Global warming will also induce higher temperature differences between land and sea surfaces, causing an increased transport of precipitable water to the continents and an increase in frequency of intense rainfall. Recent results from global coupled models generally agree with these scenarios. The global coupled ocean-atmosphere climate model of the National Centre for Atmospheric Research produces greater mean precipitation in the South Asian summer monsoon region (Lal et al. 1998).

## 2. The Global Context:

Studies have shown that in the last 100 years the world's average temperature has risen rapidly than in the last 10,000 years. The scale of temperature rise is in increasing trend. Out of the 10 recorded warmest years in history, nine were recorded during the last decade. The global mean temperature is expected to increase between 1.4 to 5.8 ℃ over the next hundred years. The adverse effects of such change in global climate are seen in the Himalayas where glaciers and glacial lakes have been changed into huge threats. Himalayan glaciers are retreating at rates ranging from 10 to 60 m per year and many small glaciers (<0.2 sq.km) have vanished. The boundary of most of the high altitude valley glaciers in Bhutan, China and Nepal are diminishing quickly. Glaciers in the Himalaya are thinning faster than elsewhere in the world. In this situation, some scientists have estimated that they might disappear by the year 2035. Thus, climate change is shrinking the mountain glaciers and directly affecting the landscape and threatening water supplies all over the world. In such a way, the Himalayan glaciers can be considered as a reliable indicator of climate change. It is a matter of grave concern to millions of people depending upon the water resources coming from these glaciers.

The greater Himalayan region - the roof of the world has the largest concentrations of glaciers and permafrost outside the polar region, with nearly 33,000 km 2 of glacier coverage. It is the most extensive and rugged high altitude areas on Earth. The 15,000 Himalayan glaciers that create the "Water Tower of Asia" - the largest block of fresh water outside the Polar Ice Caps - have been melting forever. But they are suddenly melting so fast that they are drying up. It will take decades, but at the rate the earth is warming, they may disappear earlier. These "Water Towers of Asia" contribute crucially to the water supply of hundreds millions of people during dry season, feeding seven of Asia's great rivers: the Ganga, Indus, Brahmaputra, Salween, Mekong, Yangtze and Huang He in which basins more than 1.3 billion people find their livelihoods. The region also includes rare and endangered species like rhinos, tigers, elephants, snow leopards, red pandas, Himalayan black bears and many more other flora and fauna. The Himalayas may never be the same again. The forests growing on the roof of the world are disappearing and the rate of deforestation is so rapid that a quarter of animal and plant species native to this biodiversity hotspot, including tigers and leopards, could be gone by the end of the century (Upreti, 2008).

For the last 10,000 years we have been living in a remarkably stable climate that has allowed the whole of human development to take place, now we see the potential for sudden changes of between 2 and 6 degrees Celsius (by the end of this century). We just do not know what the world is like at those temperatures. We are climbing out of the safe zone (Corell 2007).

## 3. Effects of Global Warming in the Nepalese Mountains and Beyond:

Mountain regions occupy about a quarter of the global terrestrial land surface and provide goods and services to more than half of the inhabitants. The rise of the Himalaya and Tibetan Plateau together that started about 50 million years before caused a tremendous impact on the regional and global climate of the world. The

Himalayan region has long been recognized as extremely rich in animal and especially plant diversity. Himalayan watersheds harbor more diverse ecosystems than the Amazon. The rise of the Himalaya and Tibetan Plateau together caused a tremendous impact on the regional and global climate of the world. During the summer season warm moist wind blows from ocean to land. While in winter time, cold dry wind blows from land to ocean. Monsoon circulation involves a change of approximately 180 degree in the direction of wind between the summer and winter (Upreti, 2008).

Physiographically, the country is divided into five regions namely: the Tarai (flat and fertile southern plain land that extends from east to west of Nepal), the Churiya hills (very fragile small hilly region of Nepal), the Middle hills, the High hills and the Himalayas. Ecologically, the country is divided into three regions running from north to south, namely; *the Tarai, the Hills* and *the Mountains.* Nepal is influenced by monsoonic rainfall which starts from the middle of June and lasts until the middle of September. Nepal also experiences some amount of rainfall during the winter between January to March. However, about 85 percent of total precipitation occurs during the monsoon. The monsoonic rain first strikes the south eastern part of the country and gradually moves towards the west, with diminishing intensity. Thus the eastern part of the country generally experiences more rain than the western part during this season. On the contrary, the rain in winter, caused by western disturbances, enters Nepal from the west and gradually moves eastward with diminishing intensity. In both cases, the rainfall intensity is maximum in the Hilly regions of the central part of the country, particularly the southern flanks of the Annapurna Range goes on decreasing both on the Northern and Southern sides. This is mainly due to highly spatially varying topography resulting in varying orographic effects in the country. During the monsoon about 64 percent of the rainfall drains out immediately as surface runoff. Of the remaining 36 percent, some is retained in the form of snow in the high Himalayas, some percolates through the ground as groundwater, and some is lost by evaporation and transpiration. The retained water in the forms of snow and ground water acts as natural reservoirs which feed the rivers to keep them flowing during the dry season. In the Northern Himalayan region precipitation occurs in the form of snow. Glaciers and snow melt influence the hydrological behavior of the major rivers. Nearly 8 percent of the country's area is estimated to be under permanent snow cover. Snow fall is estimated to contribute about 10 percent of the total precipitation. The potential evapotranspiration (PET) ranges from over 1350 mm per year in the central and eastern Tarai regions to less than 750 mm in the Eastern Himalayas. In the mid-western and far western Tarai regions it is observed to be about 1150 mm per year (Poudyal Chhetri and Bhattarai 2001).

Studies show that rainfall patterns are influenced by climatological phenomena including the El Nino/Southern Oscillation as well as changes in regional-scale land and sea surface temperature (Mirza, 2003). Studies also indicate that local variations in rainfall amounts and timing can be high, with ridges receiving four to five times the amounts that valley do (Higuchi et. Al. 1982; Barros and Lang, 2003).

Nepal’s 83% land mass is mountainous terrain. The wide range in altitudinal variation along its width gives rise to a steep and rugged topography and extreme relief. Steep and unstable slopes, rugged terrain, active geodynamic processes and intense monsoon rains make the Himalaya an active and fragile mountain range. As the nature of the Himalaya suggests, landslides and debris flows and floods are the main types of water-induced hazards in the region and in Nepal. These hazards time to time wipe out entire villages, wash out roads, bridges, canals and hydropower plants and damage hectares of valuable agricultural land during the monsoon season. Besides substantial economic losses, more than 320 people on average lose their lives in the Nepal Himalaya alone. Other losses from these hazards are on a rise every year. Many factors trigger debris mass movement or debris flows. Among the most common triggers in the Himalaya are prolonged or heavy monsoon rains. Rainfall can lead to mass movement of debris by reducing the internal or binding strength of soil and other materials through three different mechanisms. The saturation of soil materials increases the weight of slope materials and creates greater gravitational force. Saturation of soil materials can reduce the cohesive bond of individual soil particles and water can serve as a lubricant along the interface between soil and rock and along the weakness zones of rocks, such as joints, cracks and fault planes. The first two mechanisms often act in combination. Rainfall intensity and duration thresholds for triggering landslides have been widely identified in many different climates and geological settings. Caine and Mool (1982) estimate a threshold rain of 100 mm day-1 to trigger a landslide and lead to a debris flow such as had happened in the Kolphu Khola drainage basin area, central Nepal in 1980. The intensity and duration of rainfall that can initiate a landslide depends on many factors. However, most landslides and debris flows reported in the Nepal Himalaya are either associated with intense or sustained monsoon precipitation (Dhital 2003, Adhikari and Koshimizu 2005).

There is likely to be increased severity and frequency of monsoonal storms and flooding in the Himalayas, which are expected outcomes of climate change, may significantly alter the area's erosion, river discharge and sediment dynamics. Eventually, this may affect existing hydropower reservoirs, as well as those planned for construction in the Himalayas. Part of the generated sediment may be deposited on agricultural lands or in irrigation canals and streams, which will contribute to deterioration in crop production and in the quality of agricultural lands.

Geo-scientists have found that due to global warming, the number and volume of glacier-lake outburst flood hazards are on the rise. Some of these floods have produced discharge rates of up to 30,000 $m^3$/sec and can run for distances of 200 km (Richardson and Reynolds, 2000). Considering the average vertical lapse rate of 6.5 ℃ per kilometer, it was found that almost 20% of the present glaciated area above 5000 meter altitude are likely to be snow and glacier free area with an increase of air temperature by 1 ℃. Similarly, 3 ℃ and 4 ℃ rise in temperature could result into the loss of 58% and 70% of snow and glaciated areas respectively. Such changes are likely to contribute to the faster development of glacier lakes leading consequently to the increase in potential of glacier-lake outburst flood hazards. Also, increase in precipitation by more than 20% is likely to cause significant increase in sediment delivery and more than 20% increase in annual sediment deposit could be expected in a scenario of 50% increase in annual precipitation (MoPE, 2004). The above figures and situation warn us on the effect of global warming and climate change in the GLOFs. The outburst of huge GLOFs may cause enormous loss not only in Nepal that will extend up to North India, Bhutan and China.

Global climate change is affecting the Himalaya much faster than previously thought and mountaineers have been the first to notice the changes: more frequent avalanches, more crevasses and exposed rock faces where there used to be snowfields. Cho Oyu and Chomolungma (Mt. Everest) are considered the easier to climb, but have become more difficult in the past 25 years. On the area leading up to the bottom of the Himalaya there are now small lakes and ice slush rivers forming during the spring season, says Brice. The ice walls of the 'Magic Highway' leading to Advanced Base Camp are now half the size of what they used to be 20 years ago. On the Nepal side, Chomolungma has also changed dramatically since Edmund Hillary and Tenzing Norgay first climbed it in 1953. "When my colleague Guy Cotter first guided an expedition to Everest the Hillary Step was completely covered in snow and ice in 2004 it was just rock," says Mike Roberts, who has led expeditions to Everest since 2002. "The entire stretch from the south summit to the true summit is now pure rock."

## 4. GHG Effects:

Global climate change –driven largely by human induced warming of greenhouse gases (GHG) – is a growing threat to humanity. The world experienced a surface temperature rise of 0.6 ℃ on average during the 20th century, and the temperature by year 2100 is projected to go as high as 6.4 ℃ relative to 1990 if GHG emissions are not reduced (IPCC 2007). But time has shown that given the dependence of global economic systems on fossil fuels, and the time required for new technologies that reduce or replace fossil fuels, to integrate into the global marketplace, significant reduction in GHG emissions is unlikely to occur soon enough to avoid climate impacts. Significant harm from observed climate change on the environment and on society is already occurring worldwide and more severe and widespread impacts lie ahead. Climate change impacts on the geo-environment of the Nepal Himalaya are significant.

Greenhouse gases (GHG) from human activities are among the major causes for this alarming situation. Although hazards do not necessarily lead to disasters unless the people are exposed, ill equipped to respond and incapable to cope with the hazard. While by the help of science and technology, most of the disasters can be predicted and mitigated, impacts reduced and communities protected. Nevertheless, due to the inability to reap the benefits of such scientific advancements, the people of Nepal are left with no choice other than facing it and trying to get prepared to minimize the negative impacts. People have to know about the characteristic of the hazard, self-exposure to the vulnerability and capability to plan and execute appropriate actions during disasters. Countries causing the majority of emissions should recognize their responsibility for climate change and help developing countries like Nepal to adapt to it to ensure their long-term sustainability. While adaptive measures and interventions to protect human health from the consequences of climate change need immediate attention, mitigation measures, such as reduced greenhouse gas emissions, are vital.

## 5. Can we defuse The Global Warming?

Experts firmly believe that most glaciers worldwide are retreating inevitably to their final demise. Global warming is a real fact and ice melting is the right signal of potentially disastrous consequences. Yet most gloom-and-doom climate scenarios exaggerate trends of the agents that drive global warming. Study of these factors has revealed that global warming can be slowed and stopped, with practical actions that yield a cleaner, healthier atmosphere, however.

## 6. Impact of Climate Change in Nepal:

Climate change is a matter of grave concern in Nepal. Although developing countries have a less direct impact on global warming, in the last few decades, climate change has tremendously impacted the glacier ecosystem in the Nepalese Himalayas. Climate change is not just an environmental phenomenon but also an economic, social and political issue in Nepal. From the point of view of climate change, Nepal is among the most vulnerable countries in the world. Himalayan Study is important because of the four reasons, namely; role of Himalaya on global climate, present impact of global warming in the water balance in high mountain areas, the impact of climate change in flora and fauna and the socio-economic impact of climate change in subsistence farming.

The major impacts of climate change in Nepal are: increased glacier-lake outburst flood hazards, increased variability of river runoff, increased sediments, increased evaporation from reservoirs and impacts on watershed. As a result glacier melt and precipitation patterns would occur. Nepal has wide variety of species. A study has found that 2.4% of biodiversity may be lost with climate change. Obviously climate change will affect agriculture. While majority of the people of Nepal depend on agricultural crops like rice, maize and wheat. Higher temperatures, increased evapo-transpiration and decreased winter precipitation may result into droughts. It should be considered as an early warning for food security.

The average maximum temperature in Nepal between 1977 and 1999 has increased by 0.9 ℃, at a rate of 0.03 ℃ to 0.12 ℃ per year, whereas the global average surface temperature rise of the last century was 0.6 ±0.2 ℃. (Shrestha et al. 1999) and is estimated to have gone even higher since then. This is one of the highest registered rates of temperature rise in the world. The observed trend of rising temperature in Nepal is challenging the IPCC projections, as it seems that land areas will warm more rapidly than the global average.

As stated in earlier section, monsoon climate is predominant in Nepal. Torrential rains during the monsoon render the country highly susceptible to water induced natural disasters such as floods, landslides, flash floods, debris flows and slope failures. Although rainy days are decreasing, high-intensity rainfall events are increasing, resulting into increase in magnitude and frequency of water-induced disasters. On the other hand, potential threat of Glacier Lake Outburst Floods (GLOF) is also growing. GLOF occurs when the moraine damming of a glacial lake suddenly collapses and releases large quantities of water resulting in a high velocity surge, causing devastating floods and debris transport downstream.

In the Himalayan region of Nepal glacier lakes are common. Glaciers were formed in the Himalaya between the 15th and 19th century, during the Little Ice Age (Yamada, 1993). A glacier lake originates from a glacier and usually forms at its terminus. According to ICIMOD (2007), the Nepal Himalaya has more than 2323 glacier lakes with areas larger than 0.03 sq. km. As a glacier melts, melt water is stored within the lateral and end moraines creating a glacier ice or ice cores and moraines and will continue to grow as the ice melts. The Imja, for example, “was just a small pond in 1960s” but in recent, it has radius of 1 km. and stores 2.9 millions cubic metres of water (Watanabe et. al. 1994). The Koshi River Basin, the Gandaki River Basin, the Karnali River Basin and the Mahakali River Basin contain 1,062, 338, 907 and 16 lakes respectively. Dudh Koshi Sub-Basin, the largest basin in Nepal, is also the most densely glaciated region of the country (Bajracharya et. al., 2007).

Out of the 2323 glacial lakes, 26 are potentially dangerous. The areas of Upper Barun, Lower Barun, Chamlangtsho, Tsho Rolpa, Sabou, Dudh Kunda, Majang, Imja, and Thulagi have been identified as dangerous glacier lakes. These lakes contain huge volumes of water and remain in unstable condition. As a result, they can burst any time and a natural catastrophe would cause loss of life and property. About 14 such glacier lake outburst floods have been experienced between 1935 and 1991. A GLOF of 1985 caused a 10 to 15 meter high surge of water and debris to flood down the Bhote Koshi and Dudh Koshi Rivers for 90 kilometers which swept away a hydropower plant. At its peak, 2,000 $m^3$/sec was discharged (Poudyal Chhetri and Bhattarai 2001).

Almost 20% of the glaciated areas in Nepal above 5000 m are likely to be snow and glacier free area at an increase of air temperature by 1 ℃. Two degree Celsius rise in temperature can cause the loss of almost 40 % of the areas. Similarly, 3 ℃ and 4 ℃ rise in temperature can result in the loss of about 58 % and 70 % of snow and glacier areas, respectively.

“The rapid melting of Himalayan glaciers will first increase the volume of water in rivers causing widespread flooding,” said Jennifer Morgan, Director of WWF’s Global Climate Change Program. “But in a few decades this situation will change and the water level in rivers will decline, meaning massive economic and environmental problems for people in Western China, Nepal, Pakistan and Northern India.”

## 7. Effects of Climate Change in Livelihoods:

The UN's Intergovernmental Panel on Climate Change (IPCC) reported that if current trends continue, 80 per cent of the Himalayan glaciers, the water source for a sixth of the world's population could disappear in 30 years if the current rate of emissions is not reduced, though recently some reservation on the timing of the disappearance has been shown. If, even the present rate of warming is continued for a couple of decades, plant species will not be able to migrate fast enough and could result into species extinction. Amid these projections, several plants and animals are already reported as threatened species together with noticeable biodiversity loss in Nepal. Like the water-induced disasters, intensity and frequency of drought is already on a rise and the projected change in temperature and precipitation pattern would result a further decline in crop yield.

With a predominantly agrarian economy where about 81 percent of the over 30 million people reside in rural areas in Nepal, traditional, self-sustaining hills and mountain farming systems have been disrupted owing to increased population and fertile top soil erosion combined with deforestation, so that migration from the hills and mountains to the fertile Tarai region and haphazardly developed urban centers are increasing at an unprecedented scale. Consequently, the poor, uneducated and unemployed people are compelled to make a living by settling in flood and land slide prone areas in the hills as well as the plains and the urban areas which are now became more vulnerable to disasters due to climate change and global warming. Lack of effective land use and settlement regulations have contributed to increased vulnerability to floods and other hazards caused by both natural and anthropogenic factors (Poudyal Chhetri and Bhattarai 2001).

On the other hand, forest area is significantly reduced in Nepal mainly due to human activities. Tarai forest has decreased at an annual rate of 1.3 %, while hill forest has decreased at the rate of 2.3 % from 1978/79 to 1994/95. In the whole of the country from 1978/79 to 1994/95, forest area has decreased at an annual rate of 1.7 %, whereas forest and shrub together have decreased at an annual rate of 0.5 % (FRISP, 1999).

## 8. Climate change and Health Hazard:

Climate change may aggravate the water quality. The possible increase in differences between wet and dry seasons may imply wetter wet seasons and drier dry seasons. Access to safe water is limited throughout the Himalaya. If dry seasons become even drier, this problem will grow.

It is a well known fact that unavailability of water leads to poor sanitation. As a result, the risk of water-borne diseases will increase. Climate change will also affect infectious diseases transmitted by insects, i.e., vector-borne diseases like malaria, yellow fever, and schistosomiases. Once temperatures increase beyond the comfort range of human tolerance, thermal stress will result in discomfort, physiological stress, ill health, or even death. Heat causes clinical syndromes, heatstroke being the most serious and occurring when body temperature exceeds 40.6 ℃. While adaptive measures and interventions to protect human health from the consequences of climate change need immediate attention, mitigation measures, such as reduced greenhouse gas emissions, are vital.

Many vector-borne and water-borne infectious diseases are known to be sensitive to warm climatic conditions, and some of these effects, such as Japanese Encephalitis, Malaria and Kala-azar cases are already on a rise under the observed warming in Nepal. Nepal is especially vulnerable to climate change because a large share of their economies is in climate-sensitive sectors and its adaptive capacity is low due to limited human, financial and institutional and technological capacity.

## 9. Conclusion:

This is high time to realize that adverse impacts of climate change, variability and extremes would be impeding factors to attain the set goals of the government. As a result the government end up with very little expenses in disaster preparedness activities compared to huge amount of resources that have to be spent during and post-disaster relief. Although United Nations Framework on Climate Change and the Kyoto Protocol allow emission producers to offset their emissions by paying others to carry out emission reducing activities. It is to be noted that various studies show pressing need to calculate carbon appropriation, the basis for calculating the impact of ecological imbalance particularly - deforestation. Stopping deforestation and building healthy environment should be the key issues in climate change policy of every government. Then it will provide a way for millions of poor people in developing countries to benefit directly. In the same way, such policy will help to reduce deforestation, maintain ecological balance and allow the nations to sell credits for successful programs combating carbon dioxide. On the other hand, developed countries that pollute more than the allowed limits under the existing Kyoto accord should buy the carbon credits to increase their emission levels and help to fund forest protection plan and programs.

Since the disaster management system in Nepal is basically limited to response – it needs to focus more on preparedness and mitigation by addressing adverse effects of climate change. Other plan and policies of the government should also be proactive in lieu of reactive approach. Disaster preparedness and improved agriculture is necessary and important to reduce the vulnerability to climate change and possible hazard and disasters.

Institutions in Nepal are facing several limitations in conducting modeling studies to assess the impacts of climate change in water resources. One of the biggest limitations is the lack of reliable observation data to verify the model results. Inadequate human and technical resource is another hindrance in this regards. Nepal feels that some of the gaps can be bridged by sharing of satellite data conducting regional trainings and real time sharing of observational data. It is imperative for the governments in the region to have good climate change policies with strong focus on impact adaptation. To avoid negative impacts on the socio-economy of the region planning for adaptation measures is essential. For adaptation planning, it is essential to understand how the climate of the region might change in the future and how the change might impact the hydrological regime of the river basins. Climate modeling has been an important tool to understand how the climate might evolve in the future while hydrological modeling can provide insights on how the projected climate might impact the hydrological regime of the river basins.

The performance can be greatly enhanced if the activities can be conducted in close collaboration among the countries that are conducting their activities in isolated manner e.g. the climatic scenarios can be developed for regional scale while individual countries can generate higher resolution scenarios for national scales. Similarly, hydrological model can be run at basin scales, while higher resolution models can be run at catchment scales by individual countries. There is the opportunity of learning among the countries to develop regional climate change scenarios and basin-wide scenarios of water availability under the climate change situation.

## References

**Adhikari, D. P.,** 2003. Monitoring the Monsoon in the Himalayas: Observations in Central Nepal, Monthly Weather Review, Vol. 131, pp. 1408-1427, June, 2001.

**Adhikari, D.P.; Koshimizu, S.,** 2005. 'Debris Flow Disaster in Larcha, Upper Bhotekoshi Valley, central Nepal'. In The Island Arc, 14 (4): 410-423.

**Bajracharya, B., Shrestha, A. B., Rajbhandari, L.,** 2007. Glacial Lake Outburst Floods in the Sagarmatha Region: Hazard Assessment Using GIS and Hydrodynamic Modelling, Mountain Research and Development, Vol. 27, pp. 336-344, Kathmandu.

**Bhattarai, D. and Poudyal Chhetri M. B.** 2001, Mitigation and Management of Floods in Nepal, Ministry of Home Affairs, HMG/Nepal.

**Caine, N.; Mool, P.K.** 1982. 'Landslide in the Kolphu Khola Drainage, Middle Mountains, Nepal'. In Mountain Research and Development, 2: 157-67.

**Corell, R.**, 2007. Chairman of the Arctic Climate Change Impact Assessment (ACCIA).

**Dhital, M.R.,** 2003. 'Causes and Consequences of the 1993 Debris Flows and Landslides in the Kulekhani Watershed, Central Nepal'.

**Higuchi, K., Ageta, Y. and Yasunari, T.,** 1982. Characteristics of Precipitation During the Monsoon Season in High Mountain Areas of the Nepal Himalaya, Hydrological Aspects of Alpine and High Mountain Areas, July, International Association of Hydrological Sciences, (IAHS), Publ. No. 138.

**ICIMOD,** 1996. Database of Key Indicators of Sustainable Mountain Development in Nepal, Mountain Environment and Resources Information Service (MENRIS), pp.85, ISBN 92-9115-516-0, Kathmandu.

**ICIMOD,** 2007. Disaster Preparedness for Natural Hazards, Current Status in Nepal, International Center for Integrated Mountain Development (ICIMOD), Kathmandu.

**IPCC,** 2007b. Climate Change 2007: The Physical Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge: University Press, United Kingdom and New York, USA. URL: http://ipcc-wg1.ucar.edu/wg1/wg1-report.html.

**Kansakar, S., Hannah, D., Gerrad, J., Rees, G.,** 2004. Spatial Patterns in the Precipitation Regime of Nepal, International Journal of Climatology, Vol. 24, pp. 1645-1659.

**Lal, M., Whetton P.H., Pittock A. B., Chakraborty B**., (1998) 'Simulation of Present-Day Climate Over the Indian Subcontinent by General Circulation Model.' In Terrestrial, Atmospheric and Oceanic Science, 9(1): 69-96

**Mirza, M.Q.,** 2003. Three Recent Extreme Floods in Bangladesh: A Hydro-Meteorological Analysis, In Flood Problem and Management in South Asia, Mirza, M. Q. and Dixit, A. (eds.), pp. 35-64, Kulwer Academic Publishers, 3300 AZ Dordrecht, The Netherlands.

**Mool, P. K.,** 1995. Glacier Lake Outburst Flood in Nepal, Journal of Nepal, Geological Society, Vol. 11, Special Issue, pp. 273-280, Kathmandu.

**Nepal Disaster Report: The Hazardscape and Vulnerability,** 2009. Disaster Preparedness Network-Nepal.

**Overpeck, J.T.; Cole, J.E.** 2007. 'Climate Change Lesson From a Distant Monsoon.' In Nature, 445: 270-271

**Richardson, S. D.** and **Reynolds, J. M.** 2000a. An overview of glacial hazards in the Himalayas. *Quaternary International*, **65-66,** 31–47.

**Roberts, M. and Brice,** 2006. While Speaking With The Media in Kathmandu.

**Shrestha, A.B.; Wake, C.P.; Mayewski, P.A.; Dibb, J.E.** (1999) 'Maximum Temperature Trends in the Himalaya and Its Vicinity: An Analysis Based on Temperature Records From Nepal for the Period 1971-94. In Journal of Climate, 12: 2775-2787.

**Upreti, B. N.,** 2008**.** Climate change and its Implication in the Himalayan region, A Paper Presented at the Queensland University of Technology, Australia.

**Watanabe, T., Ives, I. D., and Hammond, J. E., 1994.** Rapid Growth of a Glacial Lake in Khumbu Himal, Himalaya, Prospects for Catastrophic Flood, Mountain Research and Development, Vol. 14, No. 4, pp. 329-340.

**Yamada, T.,** 1993. Glacier Lakes and Their Outburst Floods in The Nepal Himalaya, pp. 37, Published by the Water and Energy Commission Secretariat (WES), Kathmandu.