Application of Space Technology in Monitoring and Managing Risks, May 24-26, 2017

Implication of Space Technology in Hazard, Risk, Vulnerability and Capacity Assessment

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About RMSI

"RMSI makes the digital & the physical world come together"

Maps

Creating digital Maps that represent our physical world

Networks

Translating digital Networks to physical networks and vice versa

Geo Digital

Developing software that deliver 'Geo Digital Services'

Resources

Exploring and developing natural Resources using digital technology

Sustainable

Conceptualizing models that drive Sustainable development

About RMSI

- Market leader – Amongst the top 3 GIS providers in India
- Employee resource base of over 800+ employees
- Global offices – USA, Canada, UK, Australia, India
- Certifications & Accreditations – CMMi level 5, ISO 9001:2008, ISO 27001, IS0 14001:2004, OHSAS 18001:2007
- Technology partnerships - ESRI, Oracle, Microsoft, GE, Synchronoss
- Track record of having implemented multiple large scale GIS projects across the world
- Enviable employer branding – Consistently featured amongst the top companies to work for in multiple employer surveys such as The Great Places to Work For Survey, and DQ Top 20 study

Key Clients & Partnerships

Technology Partnerships

Environmental Systems Research Institute, Inc.(ESRI)

RMSI is a 'Developer' under the ESRI Business Partner Program

RMSI is a is a 'Member Partner' at the worldwide level, under the Oracle Partner program

RMSI is a Microsoft Silver Certified Partner

RMSI is a 'Certified Solution Provider' for GE Energy Products

RMSI is a business partner with Synchronoss

Presentation Outline

- Sendai Framework –Reference to Space Technology
- Risk Assessment
  - Hazard, Exposure, Vulnerability and Risk definations
- Characterizing Hazard
- Space Technology in Disaster Risk Management
  - Remote Sensing and GIS in Disaster Risk Management
  - Space Technology in Disaster Risk
- Space Technology in Exposure Data Development
- Space Technology in Vulnerability Analysis
- Risk Assessments and its benefits

Sendai Framework - Innovations

- Shift from **disaster loss** to **disaster risk**
- Shift from disaster management to **disaster risk management;**
- Shift from "**what to do?**" to "**how to do?**"
- Focus on **people-centred** preventive approach to DRR
- **Primary** responsibility of States for DRR
- **Shared** responsibility for DRR with stakeholders **"All of Society Engagement and Partnership"**
- Set of global **targets**;
- Set of guiding **principles**;
- **Four priorities for Action**


4 PRIORITIES FOR ACTION
Priority 1
Understanding disaster risk
Policies and practices for DRR should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment
Priority 2
Strengthening disaster risk governance to manage disaster risk
Disaster risk governance at the national, regional and global levels is of great importance for an effective and efficient management of disaster risk
Priority 3
Investing in disaster risk reduction for resilience
Public and private investment in DRR are essential to enhance the economic, social, health & cultural resilience of persons, communities, countries, their assets, as well as environment
Priority 4
Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction
Strengthened disaster preparedness for response, recovery, rehabilitation and reconstruction are critical to build back better
National and local dimensions
Regional and global dimensions

Reference to Space Technology

- **Priority 1. Understanding disaster risk**
  - Understanding disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be leveraged for the purpose of pre-disaster risk assessment, for prevention and mitigation and for the development and implementation of appropriate preparedness and effective response to disasters.
- **To achieve this, it is important:**
- **National and local levels**
- 24 (f) To promote real time access to reliable data, make use of space technology and in situ information, including geographic information systems (GIS), and use information and communications technology innovations to enhance measurement tools and the collection, analysis and dissemination of data
- **Global and regional levels**
- 25 (c) To promote and enhance, through international cooperation, including technology transfer, access to and the sharing and use of non-sensitive data and information, as appropriate, communications and geospatial and space-based technologies and related services; maintain and strengthen in situ and remotely-sensed earth and climate observations; and…

Going back to Sendai Framework innovations

- **Shift from disaster management to disaster risk management;**
- **Shift from "what to do?" to "how to do?"**
- **Focus on people-centred preventive approach to DRR**
- **Etc.**

Expectations to the group of space agencies

through its expertise and technologies

-beyond disaster monitoring after a disaster occurs

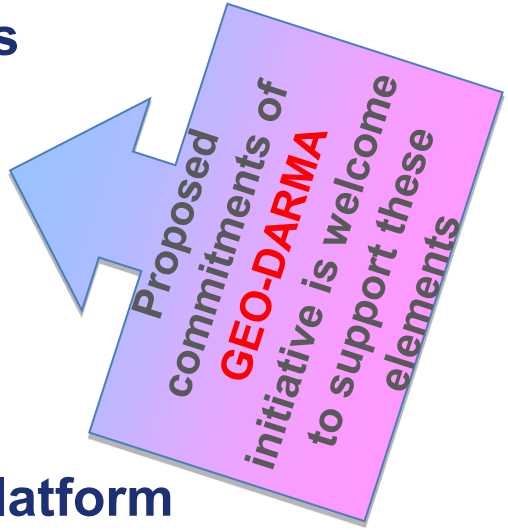
-support disaster risk management

-user friendly

-support risk informed decision making

-support recovery efforts

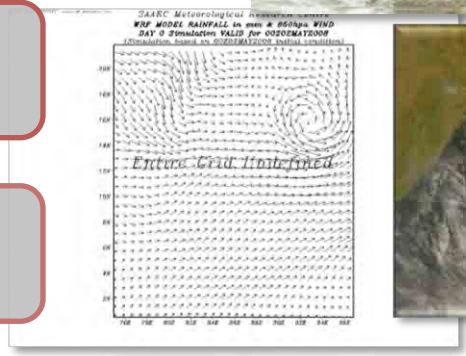
-share progress in Global Platform and Regional Platform



What is Risk Assessment ?

Comprehensive risk assessment that involves:

- **Understanding of current situation, needs and gaps**
- Hazard Assessment
- Exposure Development
- Vulnerability Assessment
- Risk Assessment



Earthquak
Flood
Landslide
Strong Wind..

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Hazards

- Earthquake
- Floods
- Drought
- Cyclone
- Forest Fire
- Land Slides….












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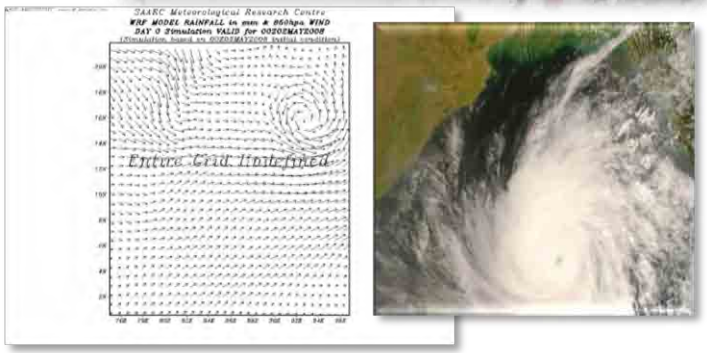
Why Risk Assessment?

- We cannot stop hazards but we can arm ourselves with knowledge
- Disaster preparedness saves lives and livelihoods
- Quantification of risk, temporally and spatially, is essential for mitigating impact of natural hazards
- Risk Assessment enables us to understand how changes in Hazard, Exposure, and Vulnerability can affect Risk



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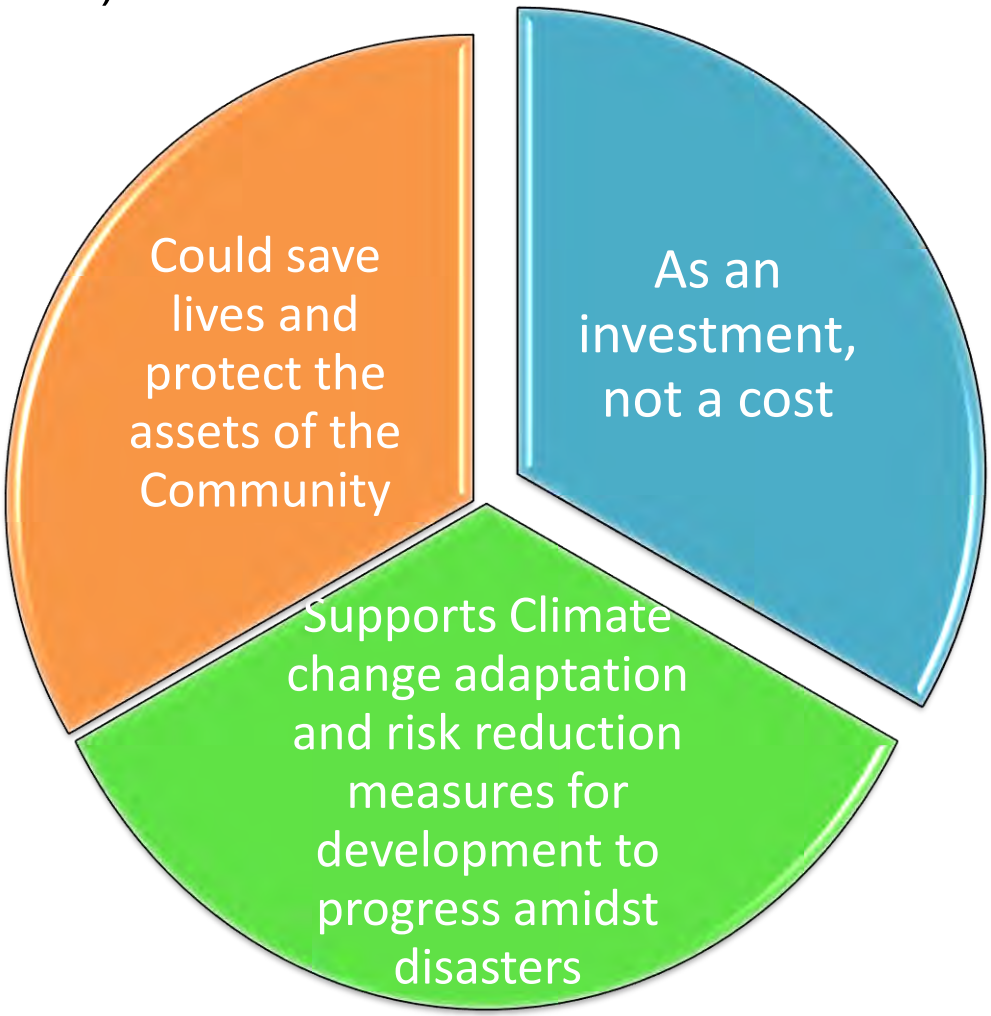
Why Risk Assessment ?

- **Consider Risk Assessment based measures in Disaster Risk Management -** one dollar spent in mitigation saves 10 dollar (intangible benefits)

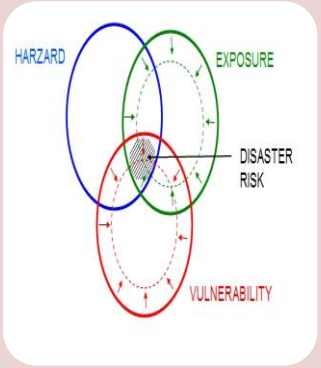


Why Risk Assessment ?

- Increase in demand for infrastructure and economic growth (higher exposure)
  - Often trigger poor construction (**increasing vulnerability**)

- **Gaps in Development and Planning**:
  - **Resource Gap** –Financial and Trained human resources at local level
  - **Capacity Gap** - Local government departments and Community
  - **Participation Gap-** Local stakeholders (including community)
  - **Planning Gap** – Limited integration of DRM in various sectoral planning (water resource, drainage systems, Infrastructure development, etc.)

Hazard, Vulnerability and Risk Assessment– Defination



Hazard

A hazard is a situation that poses a level of threat to life, health, property, or environment.

Exposure

The quantified value of exposure elements

Vulnerability

Vulnerability refers to the inability to withstand the effects of a hazardous event

Risk

Risk is combination of hazard, exposure

and

vulnerability

Risk Assessment – Basic terminology

HAZARD: A hazard is a situation that poses a level of threat to life, health, property, or environment

- **Likelihood (probability) of Occurrence**
- **Can be natural:**
  - **Earthquake, tsunami, flood, landslide, cyclone, strong wind, drought, ….**
- **Can be man-made (human developed systems):**
  - **Road accident, Aviation accident, Oil-Spillage, nuclear power plant accident,……**
- **Can be conflict based:**
  - **civil war, terrorism, nuclear war…..**
- **Hazard versus Disaster**

Disaster

"A serious disruption of the functioning of society, causing widespread human, material, or environmental losses which exceed the ability of affected society to cope using only its own resources"

- The United Nations, 1992

Which is a Disaster ?

- House fire in a city- the house is destroyed, but there are no injuries.
- Forest fire in a village - results in the burning of 1,000 acres of unoccupied land, 5 firefighters need to be admitted to the hospital for various injuries.
- An earthquake occurred – resulting in the damage to 28 km of roads, two bridges collapsed, 18,000 buildings badly damaged/ collapsed, totaling over $200 million in property damage (1/3 of the housing exposure value). 200-300 people died.

Characterizing Hazards

- **You must answer all of the following in terms of your situation:**

  Magnitude and intensity ranges?

  Time, and season?

  Duration ?

  Timeline of development?

  Place and extent of impact area?

  Frequency?

  Can it be predicted?

  Cascading effects?

Characterizing Hazard

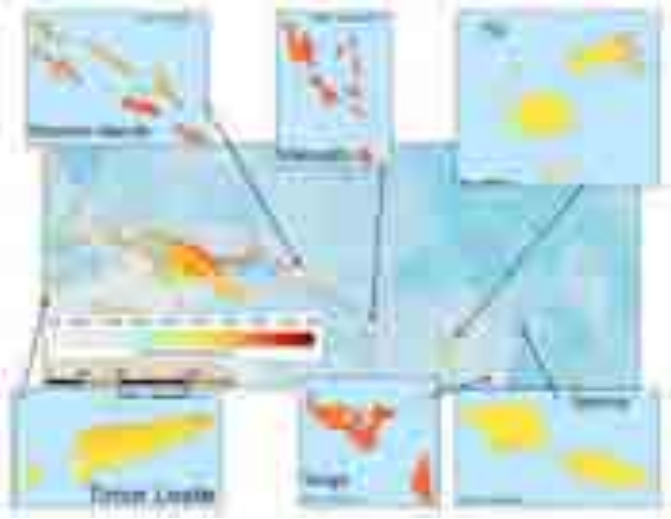
- Higher magnitude and/or intensity > increased hazard
- Time and season -a longer period during which these events typically occur > increased hazard
- Duration - generally longer duration events = increased hazard
- Timeline of development – generally shorter development > increased hazard
- A critical location at risk or a wide-area impact > increased hazard
- Higher intensity and frequency > increased hazard
- Events that can be predicted only with difficulty > higher hazard
- Events that are related to and can be triggered by or trigger other events > higher hazard

The Time Element

Very important to determine what the time horizon of your assessment is

- A short time period (“in the next 2 years”)
  Infrequent events become low hazard
- A longer time period (“in the next 100 years”)
  Infrequent events increase in hazard
- A very long **time** period (“the next 500 years”)
  Infrequent **catastrophic** events become higher hazard

Depiction of Hazard



For a location or an area

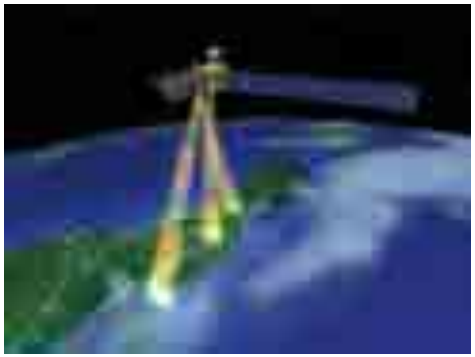
- **Earthquake hazard map**
- **Flood hazard map**
- **Strong wind map**
- **…….**

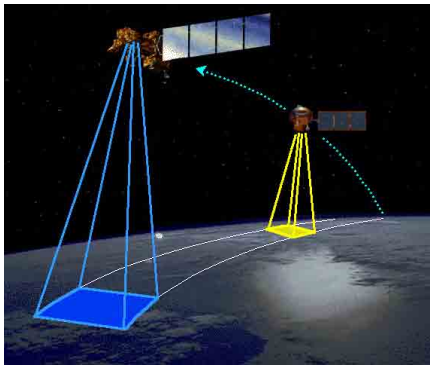
Space Technology in Disaster Risk Management

The space technology can assist Disaster Risk Management Authorities during all the phases of disaster cycle, including

- ❖Hazard Assessment
- ❖Exposure Data Development and its Vulnerability
- ❖Development of Risk Maps
- ❖Early warning /Contingency planning
- ❖Rescue/Relief and Early Recovery
- ❖Reconstruction & Rehabilitation

- ❖ Provision of weather forecasts through Met Deptts (weather satellites)-Rainfall estimation, medium and long term forecast for rains, cyclones etc.
- ❖ Spatial coverage of hazard through (Earth Observation Satellites)
  - ❖Monitoring extent of hazard, synoptic and repetitive coverage of hazard prone areas





Space Technology in Disaster Risk Management

- Develop mechanisms to allow access to the data/ maps/ images for data sharing (Geo-portals etc)

- Bhuvan (ISRO) is such as example

- Real time data for research studies on climate change variables using (space based scientific missions)

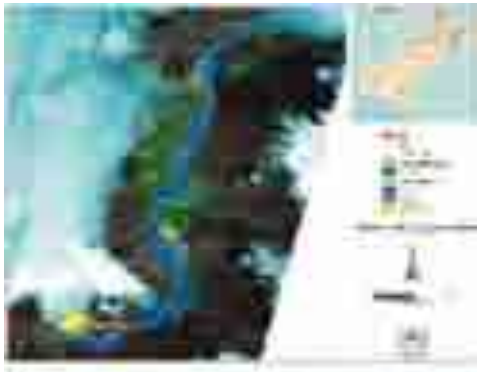
  Megha-Tropiques satellite mission to study the water cycle in the tropical atmosphere in the context of climate change]. A collaborative effort between **ISRO and French CNES**, Megha-Tropiques was successfully deployed into orbit by a PSLV rocket in October 2011.

Remote Sensing in Disaster Risk Management

- RS satellites have different types of sensors on-board, such as, panchromatic, multispectral, infrared and thermal. All these sensors have applications in DRM, though depending on the electromagnetic characteristics of the objects on Earth and the nature of disaster itself
- For example, thermal sensors capture fire hazards, infrared sensors are more suitable for floods and microwave sensors can record soil moisture. Nearly all kinds of hazards, such as, earthquake, volcano, tsunami, forest fire, hurricane and floods can be remotely sensed using RS satellites

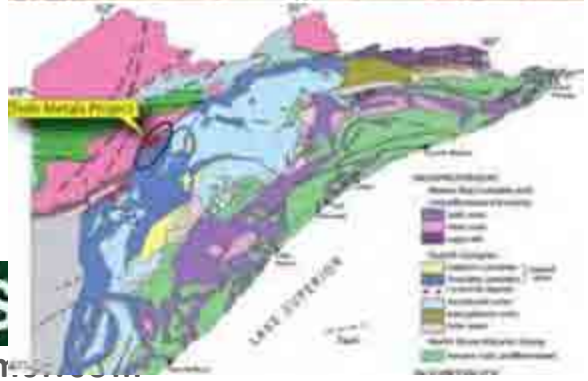
Remote Sensing and GIS in Hazard Risk Management

- **Earthquake, Cyclones, Floods, GLOFS, Landslide, Forest-Fire, etc.**
  - ❖ Identification of regional geological structural trends, folds, lineaments, fracture zones and major faults
  - ❖ Distinguish, classify and analyze landforms of variegated origin
  - ❖ Study and monitor the modification of landforms
  - ❖ Prepare maps of land forms and terrain for detailed analysis (DEM/DTM/DSM)
  - ❖ Analyze dynamic nature of stream erosion, deposition and course change to design flood protection bunds
  - ❖ Asses coastal resources including mangrove forests, salt pans
  - ❖ Monitor rapid processes of erosion, sedimentation
  - ❖ Map coastal configuration, bathymetry, navigation channels and landforms
  - ❖ Monitor areal extent of snow cover
  - ❖ Estimation of snowmelt & rainfall runoff
  - ❖ Study indicators related to glacial hazards
  - ❖ Development of regional glacier database
  - ❖ Classify forest resources extending to inaccessible areas
  - ❖ Monitor desert encroachment, overgrazing and depletion in biomass



- **Monitor, forecast and map various hazards**
- **Prepare hazard and risk maps against each type of hazards**
- **Mapping flood prone areas**
- **Monitor deformation of Earth's surface in unprecedented spatial and temporal resolution through space geodetic techniques such as Global Navigation Satellite System (GNSS including GPS)and Synthetic Aperture Radar (SAR) and InSAR for Volcano and Earthquake hazard early warning.**

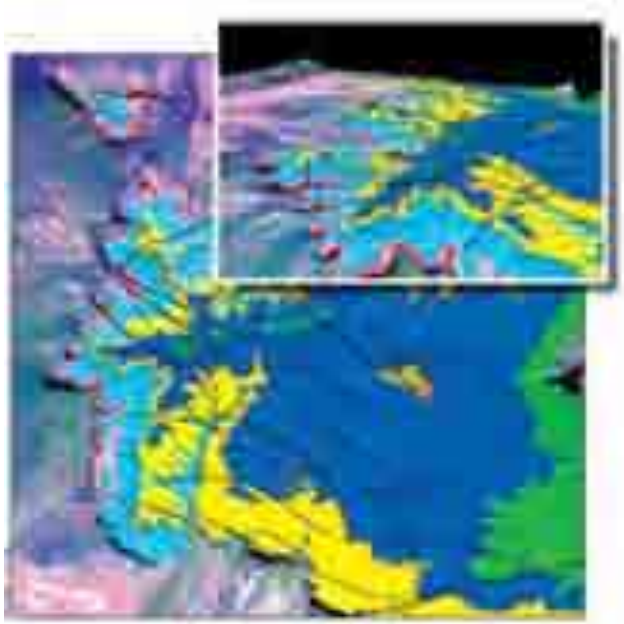
Space Technology for studying various Geological Features and applications



- **Identification of regional structural trends , folds, fault and lineaments**
- **Geological mapping for various applications**

Terrain Information

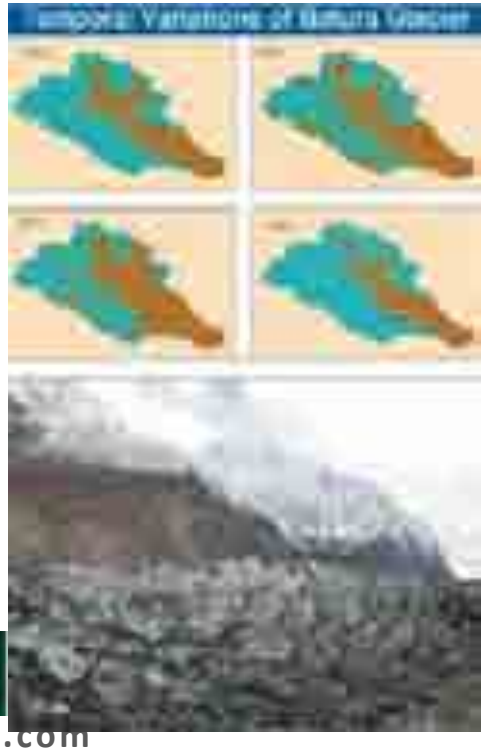
Surface Geological Information



Digital mapping of large and inaccessible areas thus saving time and cost

- **Snow cover and runoff**
- **Precipitation and moisture estimation**
- **Surface energy balance & evapotranspiration**
- **DEM/DTM/DSM**

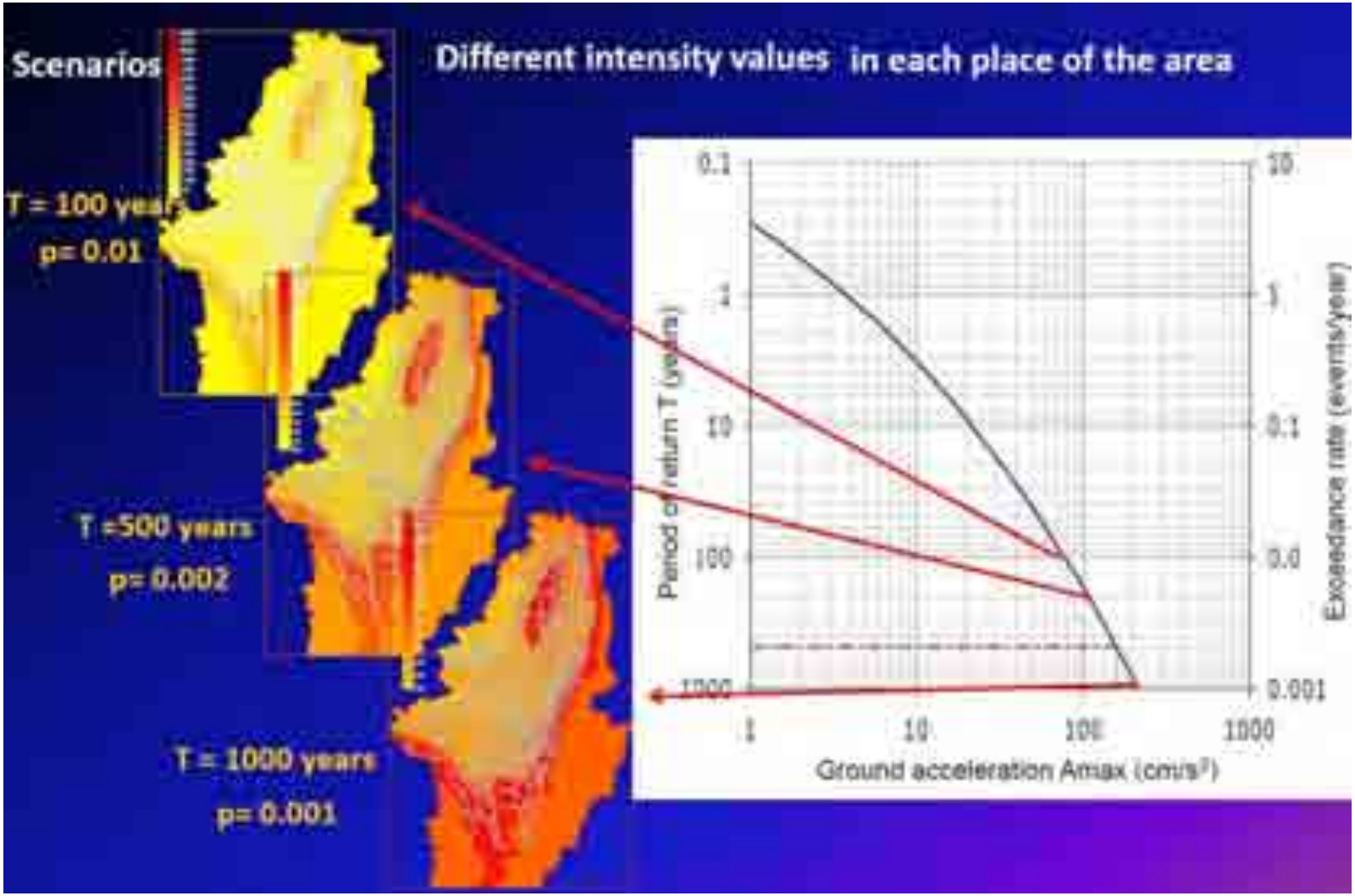
- **Assess coastal resources**
- **Environment impact assessment**
- **Erosion/sedimentation monitoring**
- **Mapping of coastal configuration, navigation channels and landforms**



- **Estimation of variations in glaciers size through historical satellite data**
- **Studying of indicators related to glacial hazards**
- **Development of regional glacier database**

- **Multi tier applications**
- **Integration of external gadgets and data connectivity with multiple servers**
- **RS & GIS customized front end with third party integration feature**

Hazard exceedance curves



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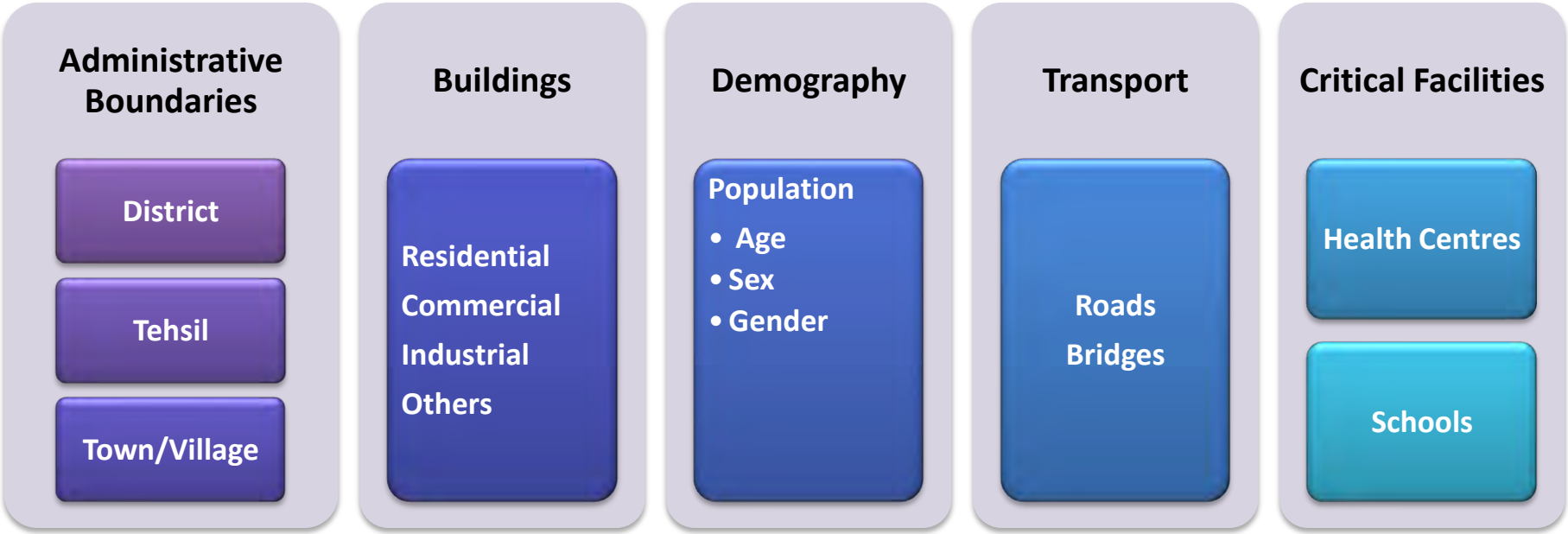
Exposure

- **What is Exposure?**



Exposure Development

Where is the exposure?

What is its value?

What types of buildings, and Infrastructural elements?

Space Technology in Exposure Data Development

- **Preparation of soil maps , LULC for urban planning**
- **Developing Exposure for Infrastructure Assets highways and pipelines**

Satellite Image at Multiple Zoom Levels

Put text like at every scale shown what data type can be captured?

Creation of Building Inventory from High Resolution Satellite Image

Multi-Spectral

High Resolution Satellite Image Merge (**Quickbird**) (Panchromatic and Multispectral Bands Bundle Product)

Panchromatic

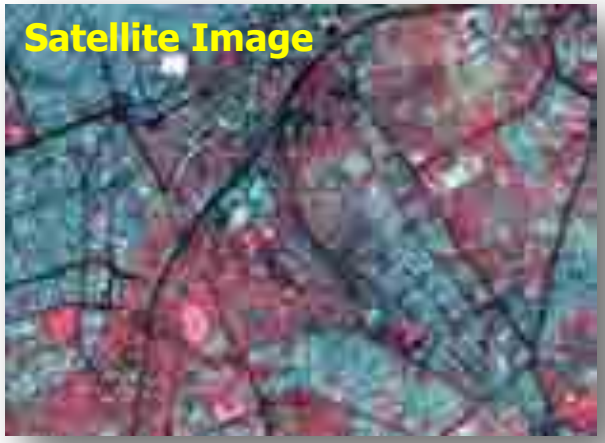
Pan-sharpened

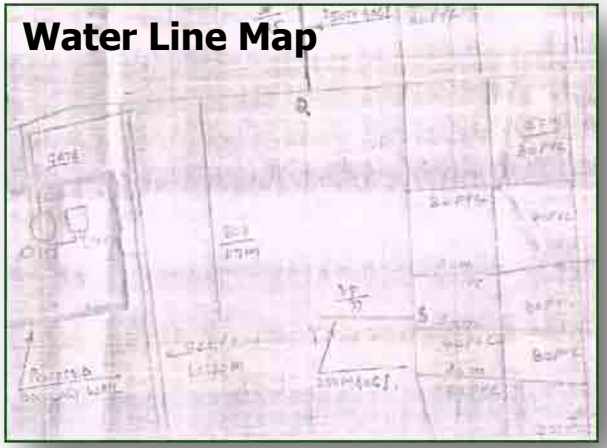
-Building height
- Building use
- Building shape
- Building proximity
- Roof material
- Square footage

Data Creation – Process Flow

- Satellite Images
- Secondary Data
- Thematic Data
- Data Collected from Departments

Base Map Creation





Field Survey

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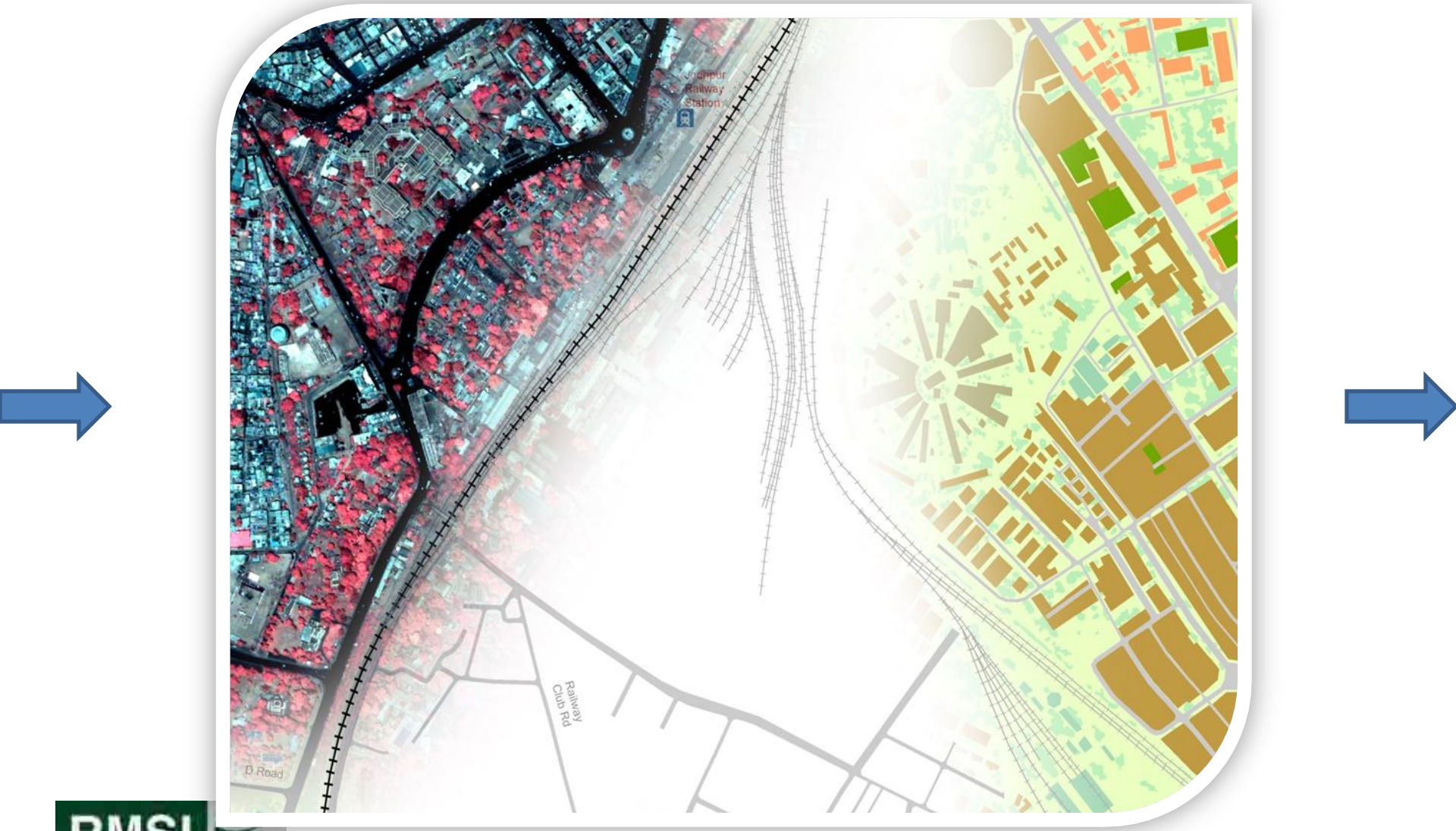
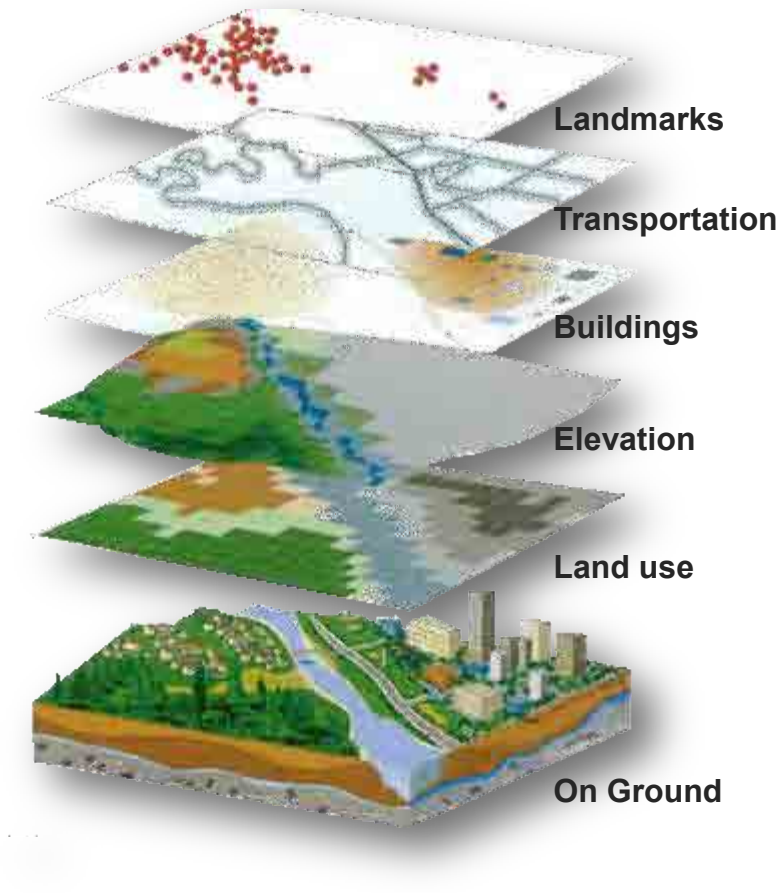
Processing From Satellite Image to Output



Creation of GIS data layers

GIS DATABASE

- Administrative Boundaries
- Educational Institutes
- Tourist Destinations
- Official Building
- Street Network
- Water Network
- Medical & Health Facilities
- Main Powr Lines
- Electric Sub Stations
- Ground Level Reservoirs
- Overhead Tanks
- Parks
- Social and Cultural centers
- Major Bus Depots &Terminals

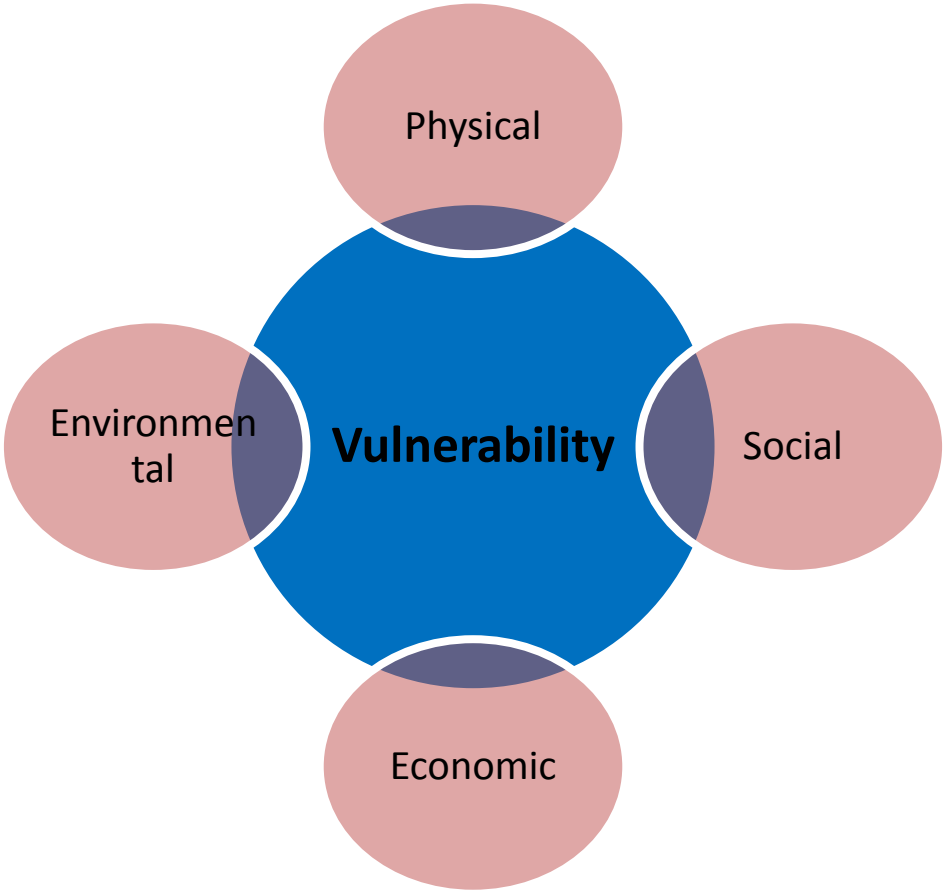


Convert Data to GIS format as per specifications

Vulnerability

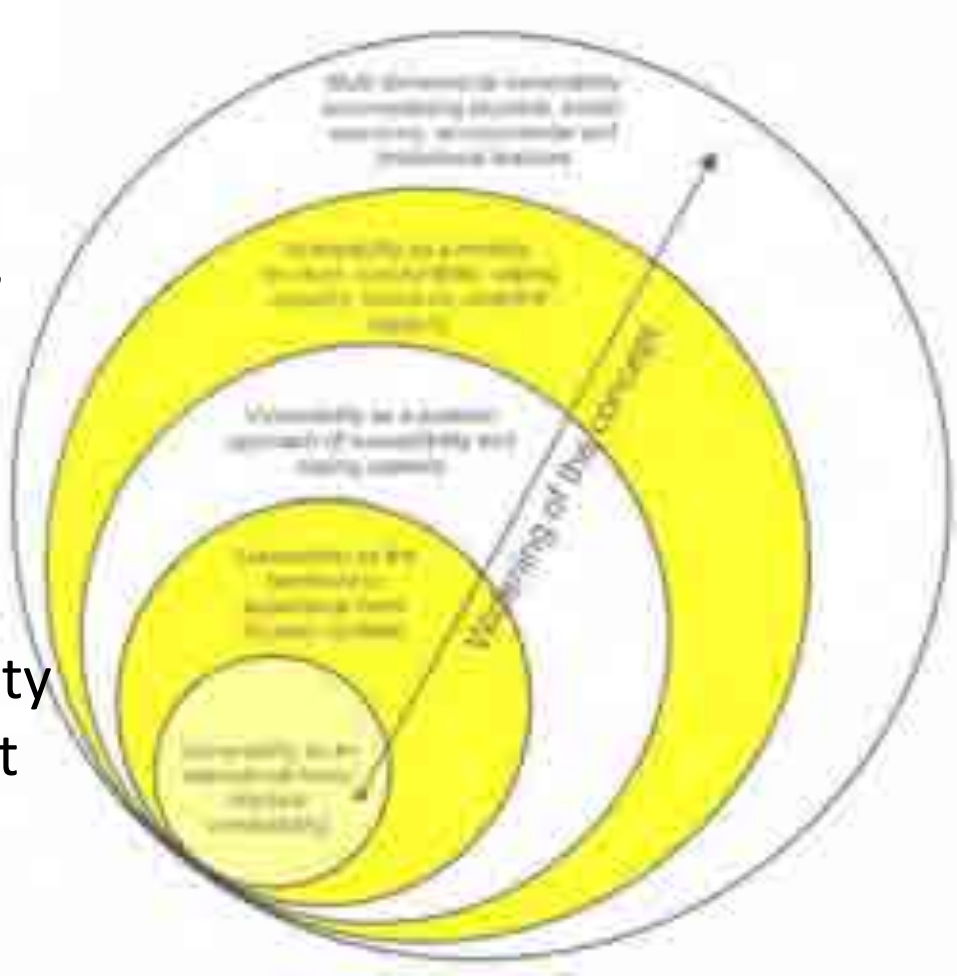
is defined as

- The degree of susceptibility and resilience of the community and environment to hazards



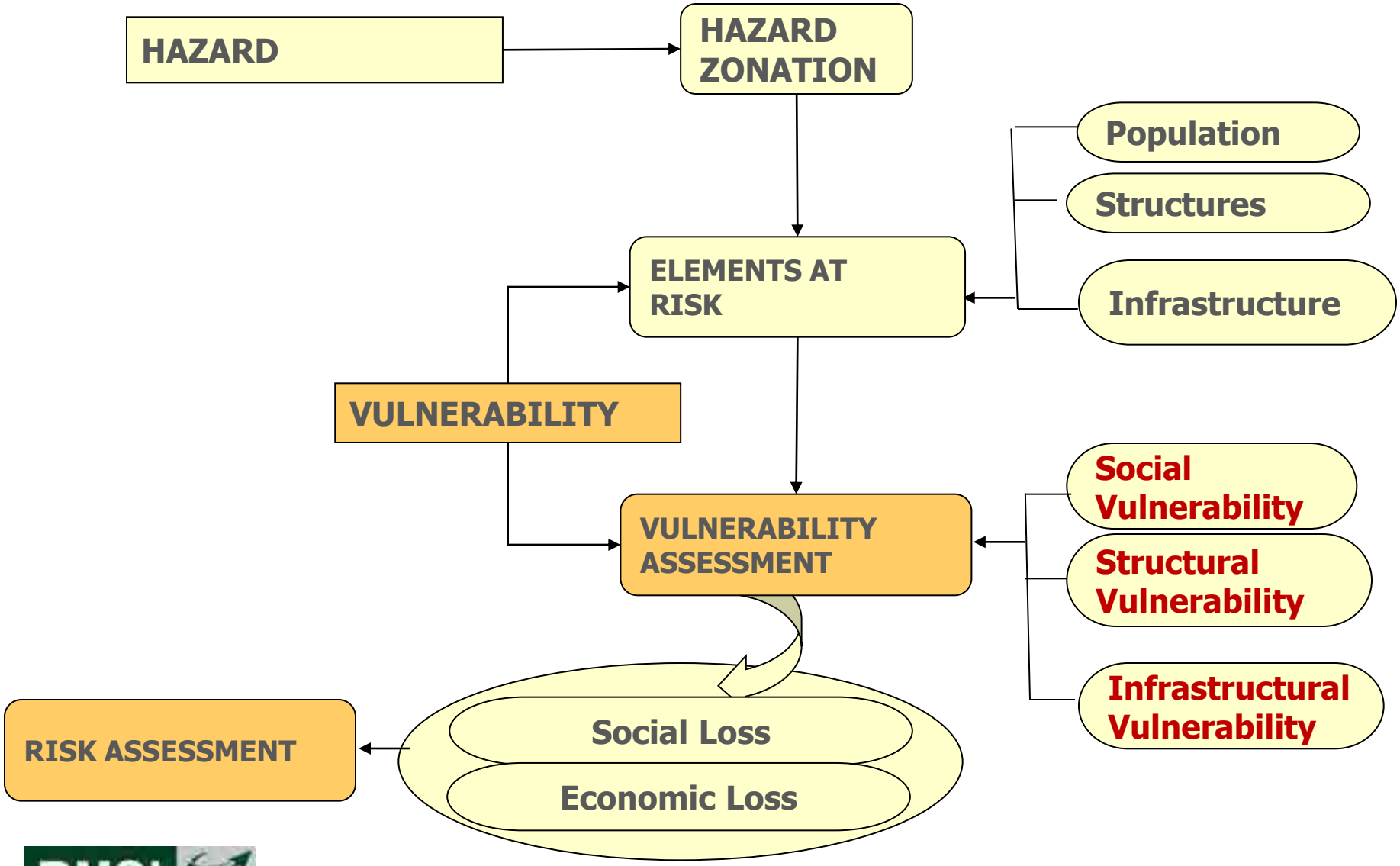
Vulnerability – Multiple Definitions

- **Vulnerability is:**
  - multi-dimensional (e.g. physical, social, economic, environmental, institutional, and human factors define vulnerability);
  - dynamic i.e. vulnerability changes over time;
  - scale-dependent vulnerability can be expressed at different scales from human to household to community to country resolution;
  - Hazard specific

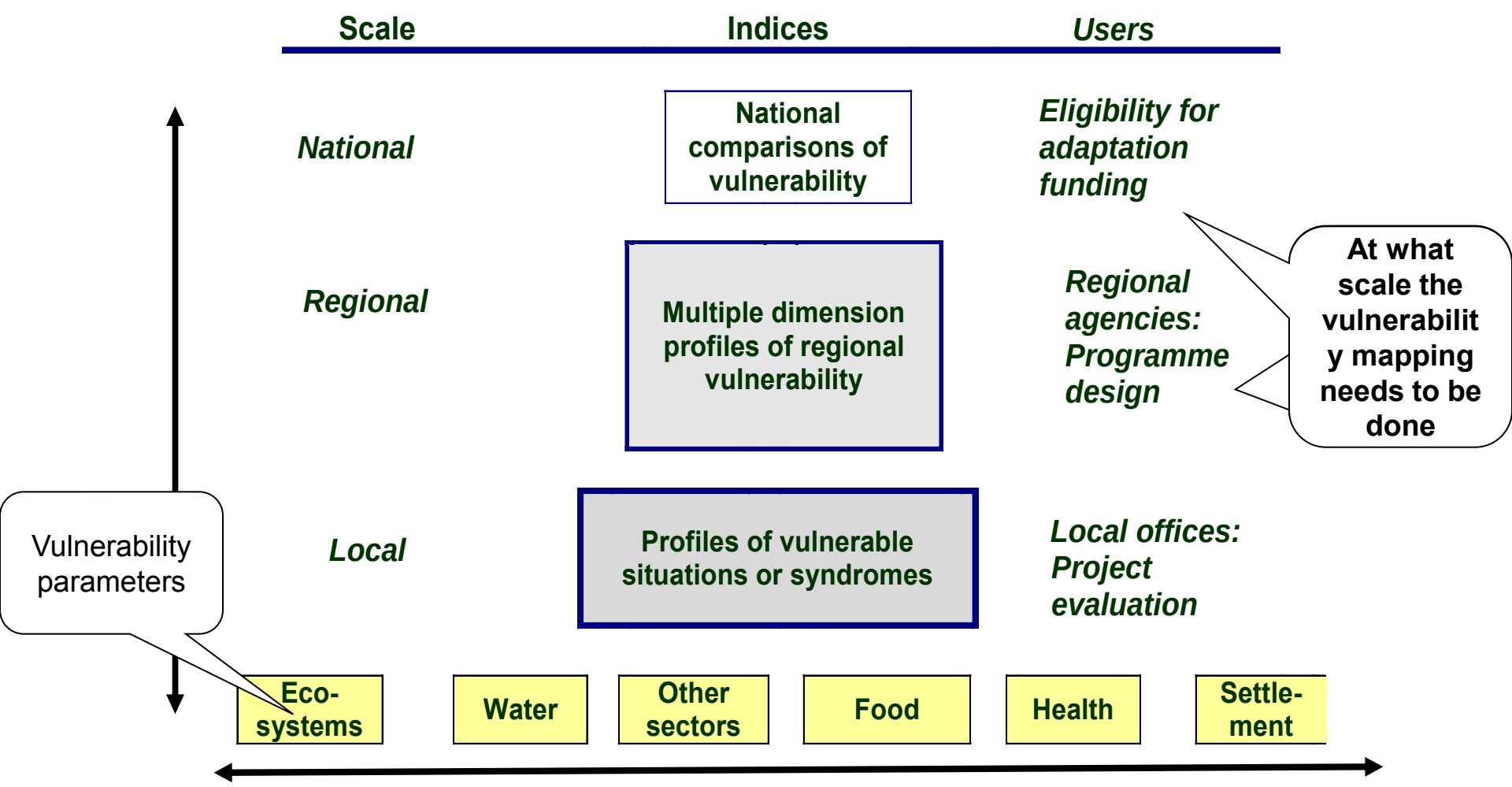


Source:(Birkmann 2005)

Types of Vulnerability



Vulnerability



Why Vulnerability ?

- **Which places are more vulnerable to a hazard?**

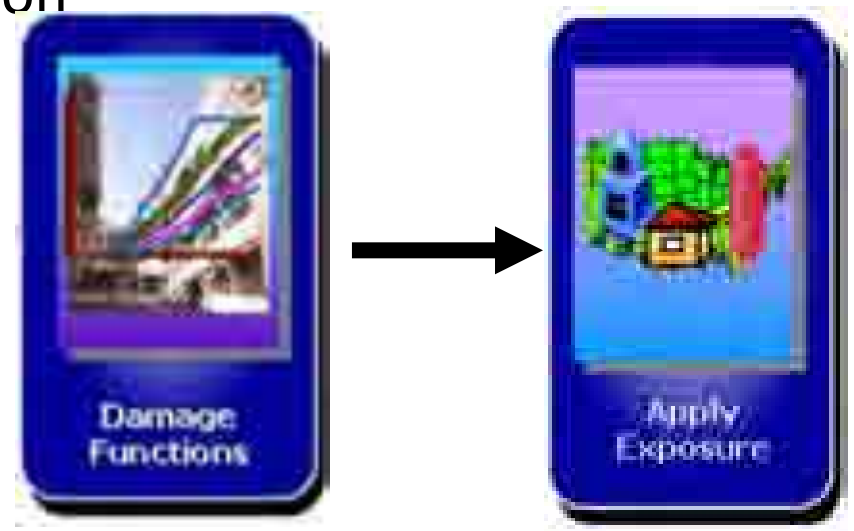
  Targeting geographical region, socio-economic class

- **Who are the vulnerable people?**

  Relative vulnerability among households and individuals

- **What should be done?**

  Link to intervention/ adaptation



Social Vulnerability

- Many aspects of vulnerability , varies significantly within a community and over time
- Coping Ability
  - Resistance
  - Resilience
- Social Environment
  - Age
  - Gender
  - Ethnicity
  - Household type
- Economic Environment
  - Income and Assets
  - Insurance
  - Debts
- Overlay environmental hazard maps with vulnerability maps to determine areas vulnerable to hazards
- Add values, weights, factors for each variable in each layer to represent “Total Vulnerability”

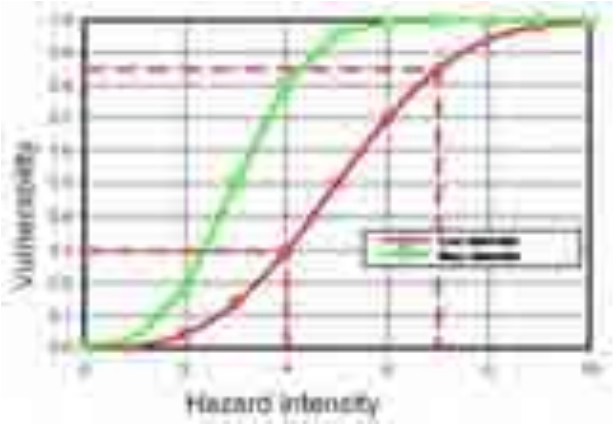
Physical Vulnerability

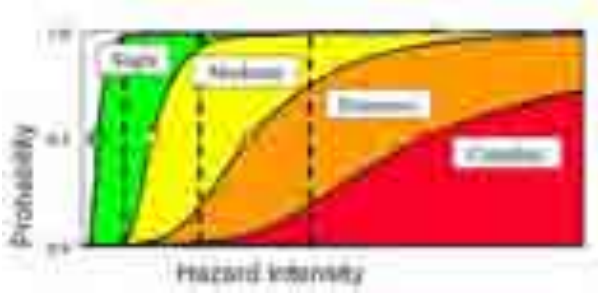
Physical Vulnerability: meaning the potential for physical impact on the built environment and population.

➢ Vulnerability is analyzed per group of constructions (i.e. structural types) having similar damage performance;

➢ It is an intrinsic quality of a structure and it does not depend on location.

- **Vulnerability indices:**
  - based on indicators of vulnerability; mostly no direct relation with the different hazard intensities. These are mostly used for expressing social, economic and environmental vulnerability;
- **Discrete Vulnerability:**
  - the relation between hazard intensity and degree of damage can also be given in a table.
- **Continuous Vulnerability curves:**
  - that are constructed on the basis of the relation between hazard intensities and damage data

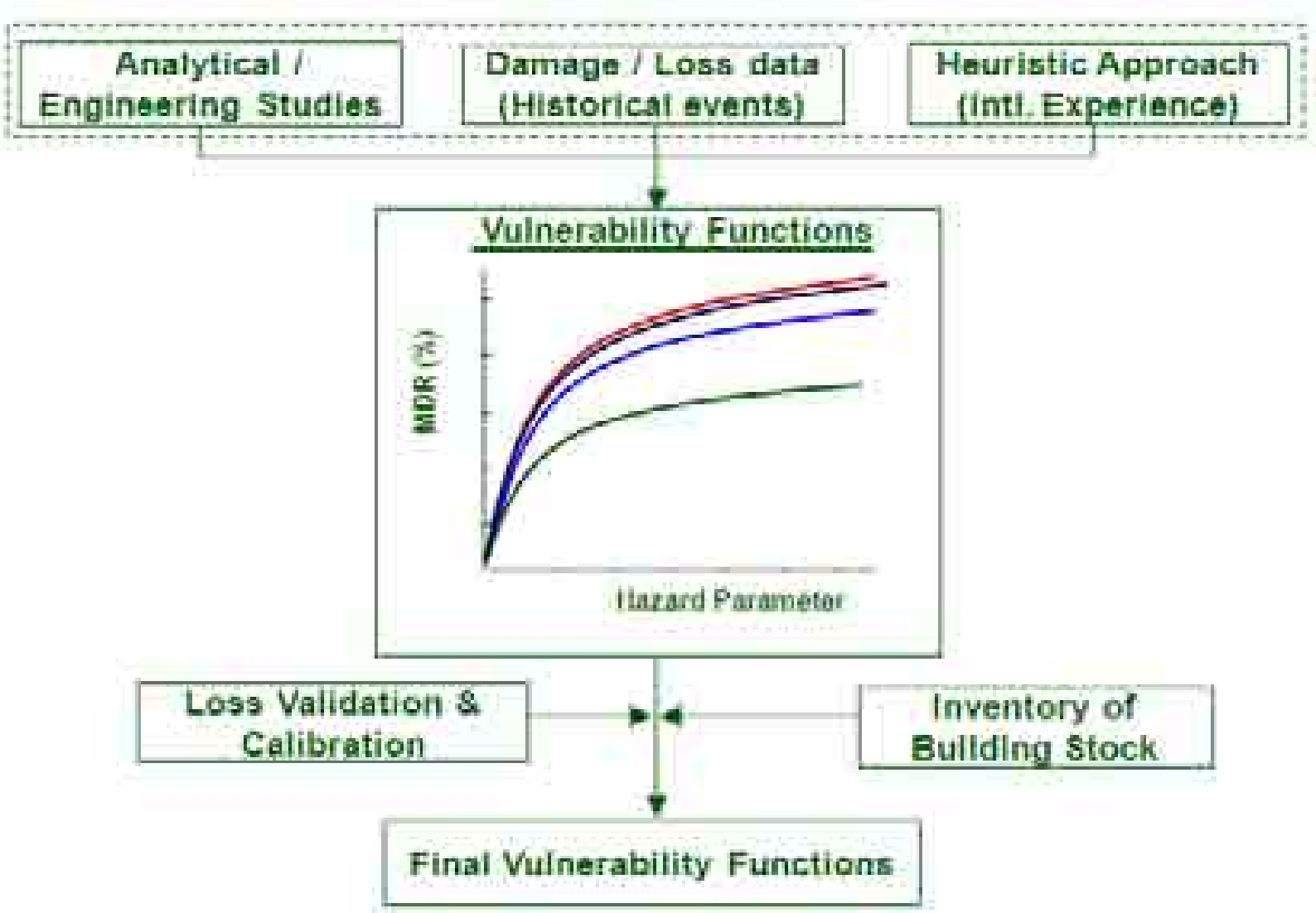




Remote Sensing and GIS in Vulnerability Assessment

- Satellite imagery assists in estimating the damaged to buildings and infrastructure and analyzing severity of vital services which can be used in vulnerability assessment: for example, Structural damage assessment after any Earthquake – can help in calibration of vulnerability curves

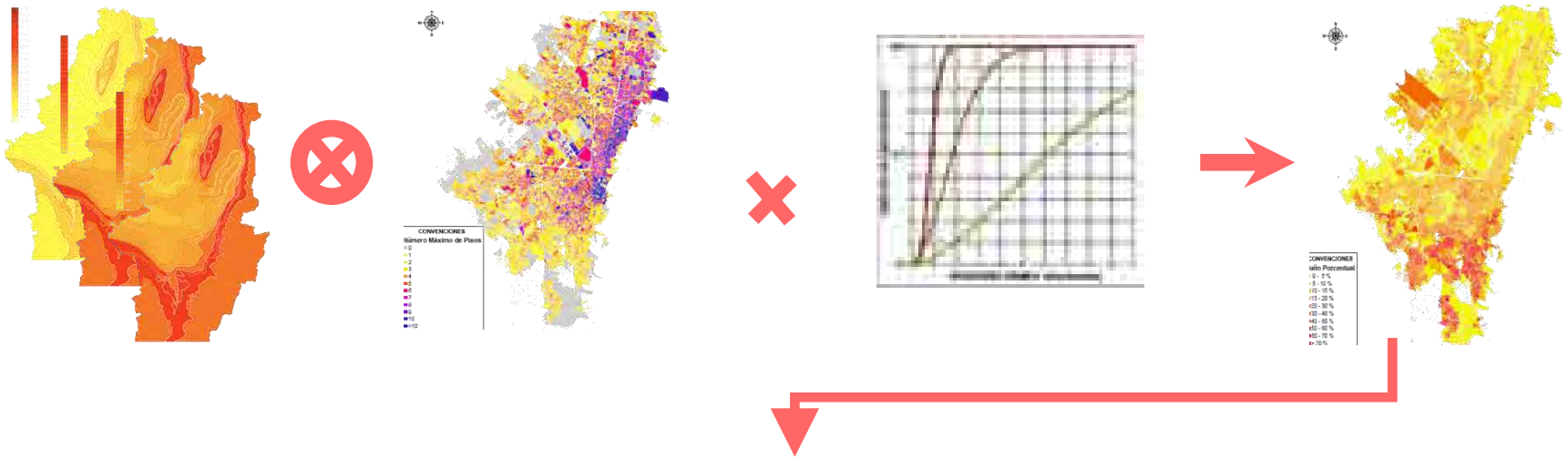
Vulnerability Modeling



Probabilistic Risk Modeling

Exposure and Vulnerability

Hazard	Exposure	Damage Functions	Risk Map
(i.e. earthquake)	(i.e. houses)		(i.e. probable losses)



- Disaster Management

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Population at risk

Individual Risk

Individual risk is the risk of fatality or injury to any individual who lives within the zone impacted by a hazard, or follows a particular pattern of life, that might subject him or her to the consequences of a hazard

Societal Risk

Societal risk is the risk of multiple fatalities or injuries in the society as a whole, and where society would have to carry the burden of a hazard causing a number of deaths, injury, financial, environmental, and other losses

Individual risk

- Individual risk can be calculated as the total risk divided by the population at risk

- For example, if a region with a population of one million people experiences on average 5 deaths from flooding per year, the individual risk of being killed by a flood in that region is 5/1,000,000, usually expressed in orders of magnitude as 5×10^ (–6)

How to express risk?

- **What is the risk of flying by airplane? Is it higher than driving a car?**
  - **What are the risks from driving an automobile?**
  - **There are 15,000,000 accidents per year, 1 in 300 of which result in death, there are 250,000,000 people**

$$Societal\ Risk = 15{,}000{,}000 \frac{accidents}{year} \times \frac{1}{300} \frac{\text{death}}{\text{accidents}} = 50{,}000 \frac{deaths}{year}$$

$$Individual\ Risk = \frac{50{,}000\ deaths / year}{250{,}000{,}000\ people} = 2 \times 10^{-4} \frac{deaths}{person \cdot year}$$

$$Lifetime\ Risk = 2 \times 10^{-4} \frac{deaths}{person \cdot year} \times 70\ years = 0.014 (1\ in\ 70)$$

Risk Assessment

Analysis based on Risk Assessment can be categorized into two broad categories:

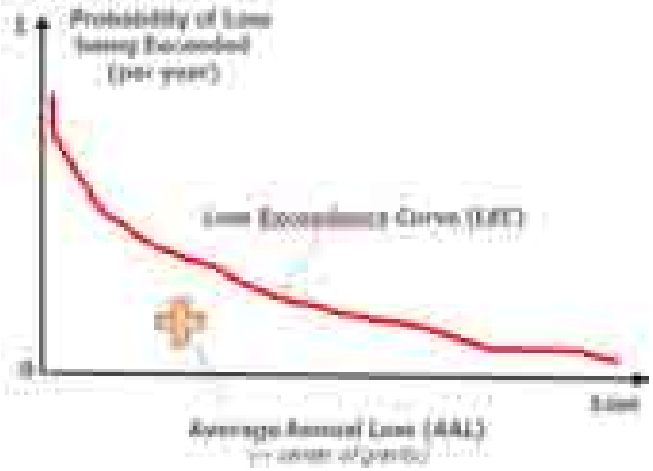
Economic Loss (estimated)

- *Loss Estimation (direct losses)*

Social Impacts (indicative)

- *Casualty*
- *Need assessment of shelters*

From different return period losses (also known as Probable Maximum Losses, PML), you can generate an Loss Exceedance Curve (also known as EP Curve)



Loss Exceedance Curve

Risk Assessment

- For structures, the direct losses can be computed using the **M**ean **D**amage **R**atio (Vulnerability function)
- **AAL** is Loss per year averaged over a long time
- **GIS based risk maps** showing AAL and losses for various key return periods are generated showing the areas likely to get affected
- Exposure elements are categorized :
- **aggregated exposure** and
- **site specific exposure**

AAL provides an insight of investment priorities under hazard mitigation process

Use of GIS in Hazard and Risk Maps for different RP

5 years

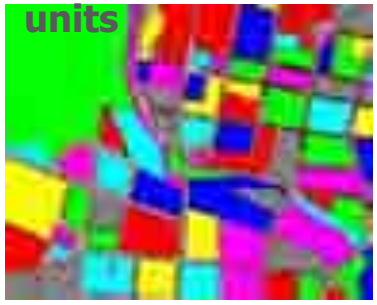
50 years

10 years

100 years

25 years

Mapping units



5 years

50 years

10 years

100 years

25 years

Buildings Affected

RMSI

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Benefits of Risk Assessment

- Risk Assessment allow risk to be quantified and hazard mitigation options to be explored
- Risk is measured both temporally and spatially
- It is possible to reduce the risk, even when hazard is increasing, by decreasing exposure and vulnerability

Benefits of Risk Assessment

- With in-depth understanding of the potential economic losses, you would be
  - Better placed to review the physical, human, and financial exposures
  - Determine the level of risk that can be accepted and the level of risk that should be mitigated

- The paradigm shift

Fate	Choice
Reactive	Proactive
Recovery	Mitigation
Wait and watch	Anticipate and prevent
Ex-post	Ex-ante
Crisis management	Risk management
Ad-hoc efforts	Comprehensive approach
Development at risk	Sustainable development

Risk Management Framework

Emergency Preparedness

- Emergency Response Planning
- Exercises
- Public Awareness
- Communication and Information Management Systems (IMS)
- Technical Emergency Response Capacity

Institutional Capacity Building

- Community Participation
- Legislative Framework
- Training, Education and knowledge Sharing
- Decentralized Emergency Management System
- International Cooperation

Risk Mitigation Investments

- Warning and Monitoring Systems
- Hazard Mapping and Land Use Planning
- Code Refinement and Enforcement
- Hazard Specific Risk Mitigation

Catastrophe Risk Financing

- Ex-Ante Funding Arrangements
- Catastrophe Insurance Pools
- Reserve Funds
- Contingent Capital Facility

Tools for Risk Assessment and Capacity Building

- Open Source versus propriety

- Hazus, EQRISK, HEC-RAS,HEC-GeoRAS, HEC-HMS, HEC-GeoHMS…,

- MIKE Urban, MIKE 21, MIKE Flood, ADCIRC
- Etc.

Questions ?

Thank You

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