Consequence Assessment in Earthquake Risk Management

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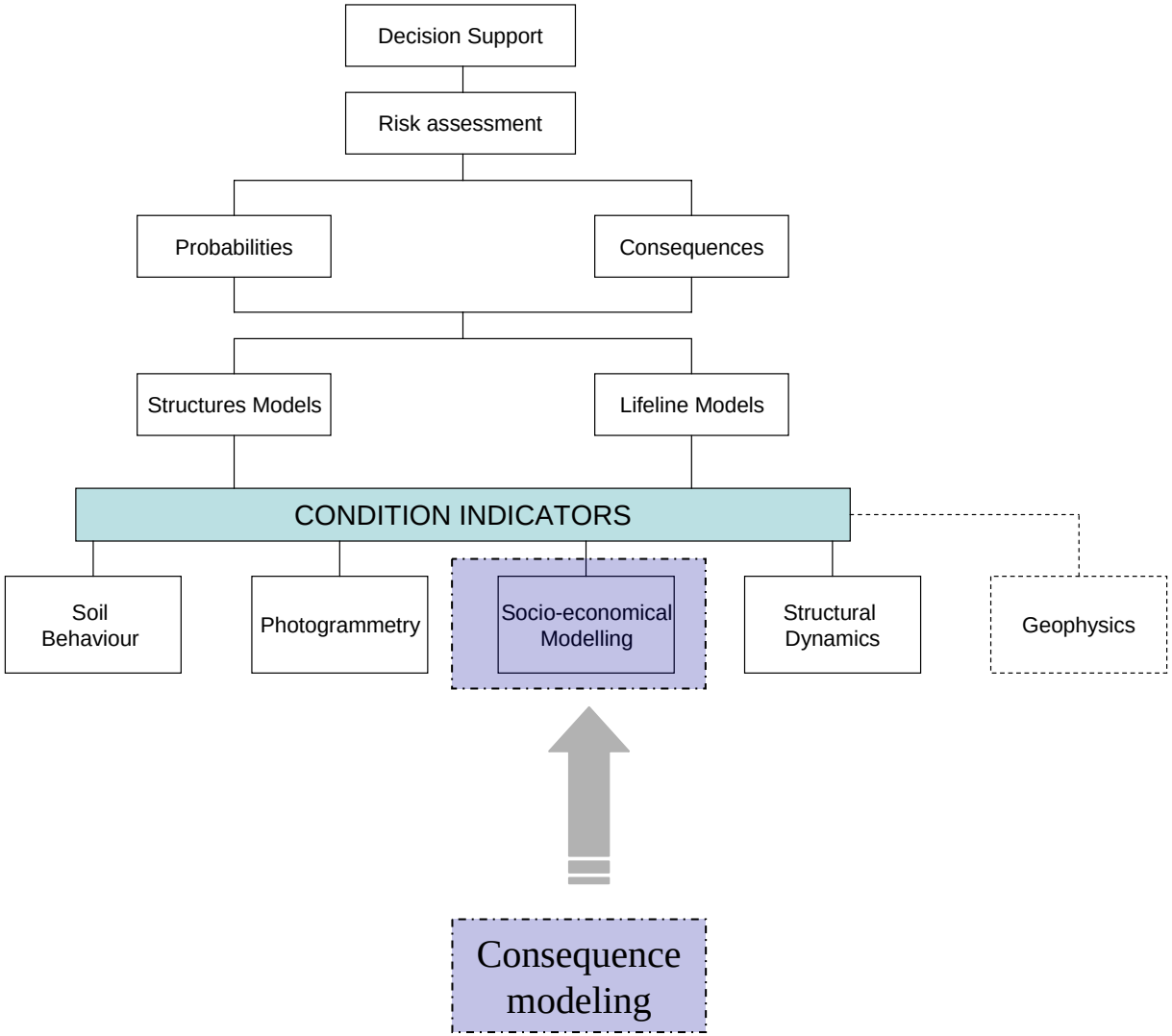
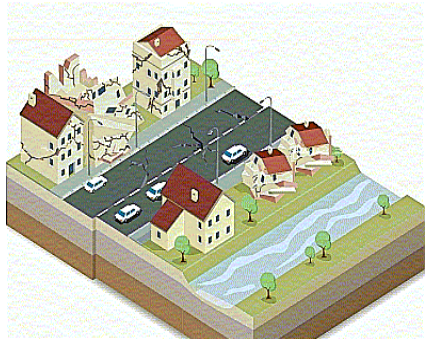
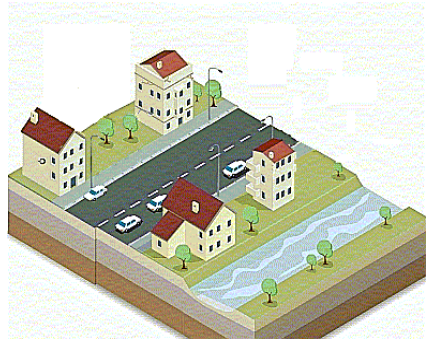
- Introduction
- Earthquake risk management
- Consequence modeling
- Categorization of consequences
- Examples
- Conclusions and future steps







Before

Optimal allocation of available ressources for risk reduction

- strengthening
- rebuilding

in regard to possible earthquakes

During

Damage reduction/Control

Emergency help and rescue

Aftershock hazards

After

Rehabilitation of infrastructure functionality

Condition assessment and updating of reliability and risks

Optimal allocation of ressources for rebuilding and strengthening

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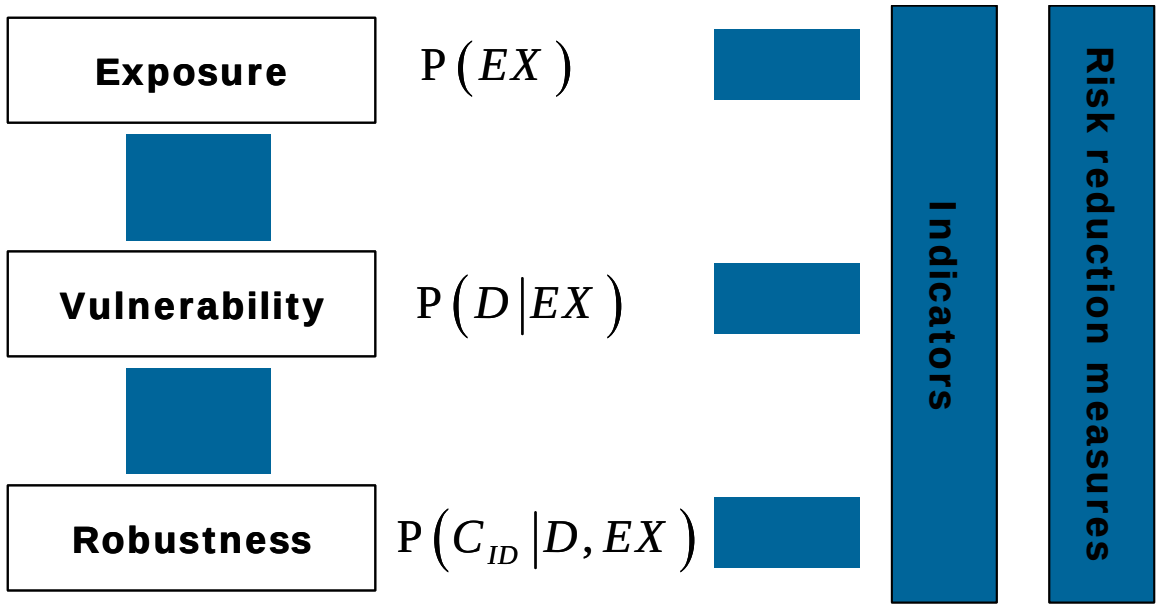
- There are three steps in consequence modeling, namely:
  - Risk Assessment Framework
  - Categorization of Consequences and Corresponding Indicators
  - Economic Quantification

Risk assessment framework



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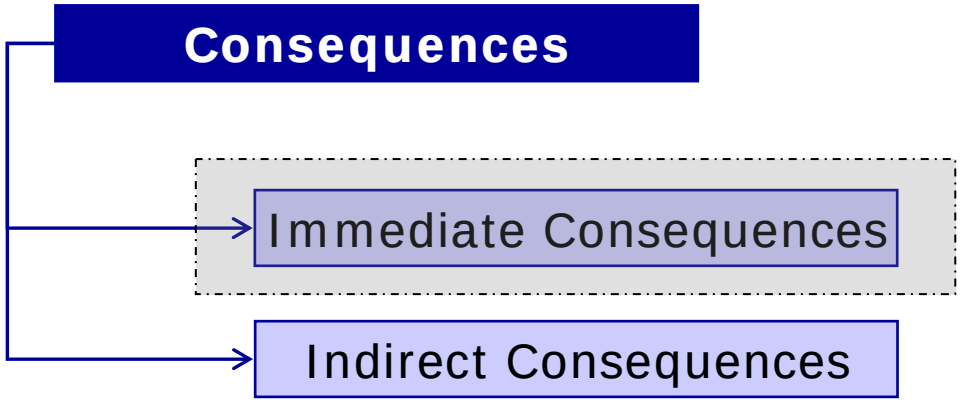

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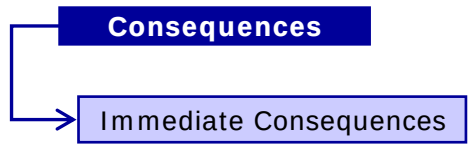
1.Consequences concerning structures and lifelines

- Description of structures and lifelines
- Description of damage

Sector	Structure Repair or Replacement US$ million	Area	Debris Removal US$ million
Commercial	111.90	619200 m^2	--
Manufacturing	11.50	29 units	--
Administrative Buildings	7.35	47 units	--
Housing units	709.50	24000 units	24 (2$/$m^3$)
Education sector	56.30	91 units	--
Health Sector	16.78	72 units	--
Hotels & Restaurants	1.58	5 & 9 units	--
Shopping centers	10	--	--
Historical buildings and Bam citadel	71.45	--	--
Total	**987.36**		**24**



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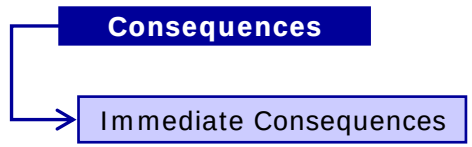
1.Consequences concerning structures and lifelines

Item	Total Damage Cost US$ million	Repair and Reconstruction Cost US$ million
Water supply and distribution	12.10	20.80
Sewerage system	Not available before Earthquake	13.5
Electricity distribution system	15.0	50
Telecommunication systems	7.7	13.6
Roads	33.3	55.50
Natural gas distribution system	Not available before Earthquake	40
Total	**68.10**	**193.40**



2.Social/Economical Consequences

Sector	US$ million
Commercial	91.30
Manufacturing	4.31
Administrative Buildings	--
Housing units	--
Education sector	10.30
Health Sector	--
Social Services	40.21
Hotels & Restaurants	--
Shopping centers	--
Total	**105.91**

Activities	US $ million
Emergency repair and water supply	4.5
Emergency repair and electricity supply	3.0
Emergency repair of telecommunication systems	3
Emergency collecting of the garbage and left-overs	0.1
Total	**10.6**

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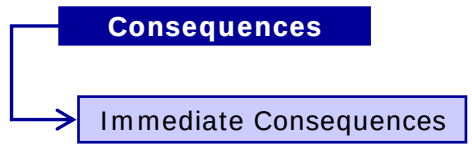

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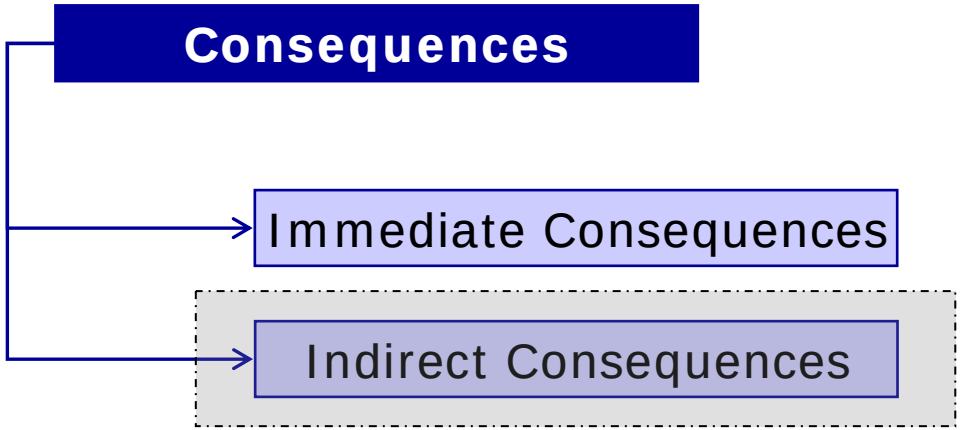
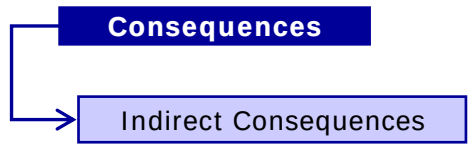


1.Social/Economical Consequences

Activities	Sub activities	US$ million
Agricultural	Horticulture	10.5
	Cropping	2.1
	Live stock	11.9
Commerce	Loss of commercial activity	16.5
Manufacturing		6.7
Social services		40.2
Tourist income		4.2
Temporary schools and universities		14.07
Total		**113.77**



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2.Environmental Consequences

- Environmental consequences include effects on plants, animals, even in the coming generations. In the Bam earthquake case, Not only it did destroy the local infrastructure and killed thousands of people, it also has permanently damaged the local environment. Many palm trees have been destroyed, as are local wells and Qanats. This damage has harmed date production which was an income source for many in the area.

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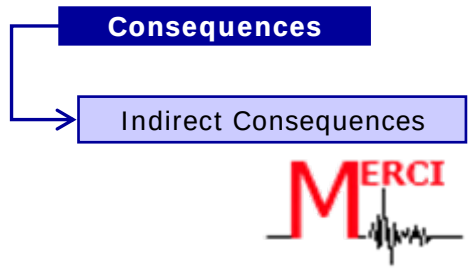
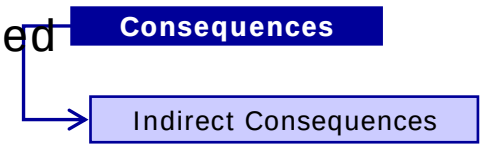


3.Medical Consequences

- The medical consequences are considered to be the costs related to injuries, evacuation and reallocation of the people.
  - Damage Intensity
  - Number of people at risk
  - Number of injured people
- Important factors defining the costs related are:
  - Cause of injury (EQ and structural related)
  - Severity of injury
  - Level and immediacy of treatment
  - Medical Costs
  - The transportation costs of the injured
  - Rescue costs



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4.Psychological Consequences

- Psychological consequences are rarely assessed in risk management area, but are of great importance and can cause less efficiency at work afterwards. They can be classified as fear, helplessness, distress, depression, suicides and etc.

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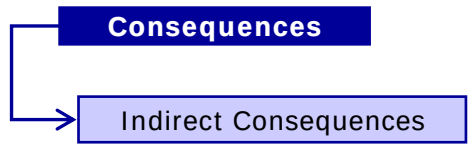
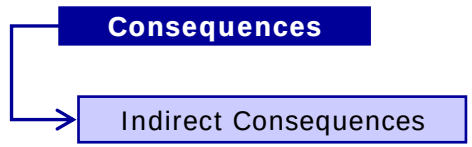


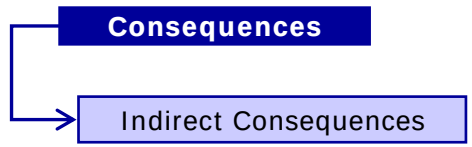
5.Historical and archeological Consequences

- The susceptibility to damage of the cultural heritage is growing every day, due to age, deterioration of materials by geophysical and environmental conditions as well as by human interaction. Cultural heritage is found in most of the countries and thus constitutes a growing concern.
- BAM has a rich cultural heritage. The structural damage sustained from earthquake is considered in the direct consequences but the real loss can not be replaced by monetary amounts in any means.



6.Demographical Consequences

- Demographical consequences are a direct result of human behaviors in different situations and therefore really complicated to be distinguished. In this respect the important issues are:
  - Age
  - Gender
  - Race/Ethnicity
  - Level of education
  - Occupation
  - Income
  - Dependency
  - ...



Conclusions and Future action

- It is very difficult and sometimes impossible to find data regarding the indirect consequences.
- With categorizing the consequences, it is obviouse that considering all kinds of consequences in a single project is impossible and therefore the further research is concentrated only on the direct consequences concerning the structures.

- Define curves which can relate damage states and Volume(m^3)/Area (m^2) with the rebuilding costs.
- ...