Some Significant Earthquakes

Location	Date	Magnitude	Deaths
Lisbon, Portugal	November 1, 1755	8.6	[illegible]
San Francisco, California	April 18, 1906	8.3	[illegible]
Kansu, China	December 16, 1920	8.5	[illegible]
Tokyo-Yokohama, Japan	September 1, 1923	8.3	[illegible]
Agadir, Morocco	January 13, 1960	5.9	[illegible]
Tangshan, China	July 27, 1976	[illegible]	[illegible]
Guatemala	September 19, 1985	[illegible]	[illegible]
Armenia, USSR	December 7, 1988	6.8	25,000
Northridge, California	January 17, 1994	6.8	60
Kobe, Japan	January 16, 1995	6.8	5,530
Erzincan, Turkey	August 17, [illegible]	[illegible]	[illegible]
Flores, Indonesia	September 20, [illegible]	[illegible]	[illegible]
Irian Jaya, Indonesia	June [illegible]	[illegible]	N/A
Irian Jaya, PNG	September [illegible]	[illegible]	N/A
Iran-Iraq Border	January [illegible]	[illegible]	20,000

Epicentral parameters, alone, are poor predictors of impact.

What Is the relationship between "Hazard" and "Risk"?

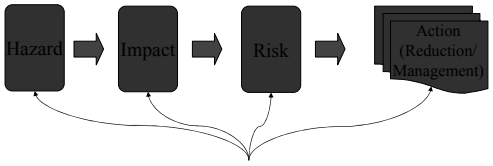
- "Hazard" is a process which has potential human impacts.
- "Risk" is a function of both "hazard" and accumulated human assets.
- "Vulnerability/resiliency" is related to ability to withstand/tolerate/respond.

Sources: USGS,
CIESIN (Columbia University)

Risk Management Framework

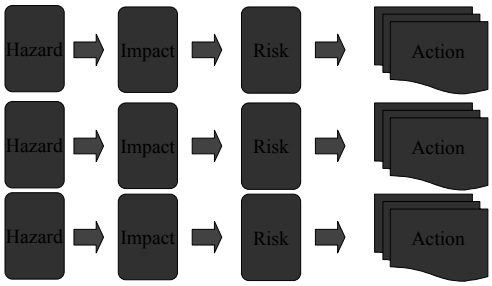
- Hazard Identification
- Vulnerabilities
- Risk Identification and Assessment
- Risk Reduction
- Risk Management

Single Hazard Model

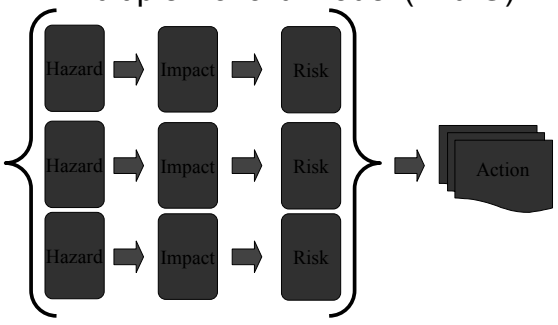


Knowledge areas incomplete, research required

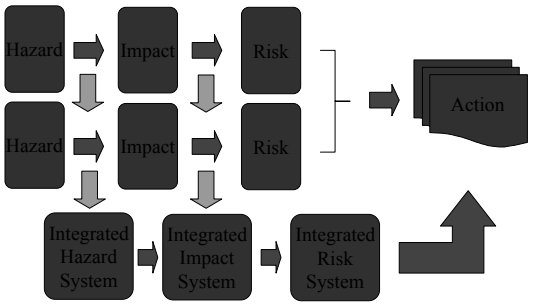
Multiple Hazard Model (1st G)



Multiple Hazard Model (2nd G)



Multiple Hazard Model (3rd G)



Premise: Disaster Resilience is a characteristic of sustainable societies.

- Disaster Resilience will enhance social development.
- Disasters highlight social and economic inequities, and affect the poor disproportionately.
- Thus, Disaster Resilience is an agent of poverty reduction and social stability.
- Disaster Resilience provides an additional incentive for international investment.

The Context

- Urban areas are experiencing rapid and unplanned growth. Proper growth can be channeled to increase prosperity and sustainability.
- Cities are centers of education and culture, fueling innovation and creativity. But they are exposed to natural hazards.

The Context (Continued)

- Building disaster resilient metropolitan areas accomplishes the dual goal of achieving social development and protecting the people and their built environment.
- Integrated urban areas will be centers for the application of sustainable development strategies based on science and rational planning.

The Challenge

Can planning, science, and political will be combined to produce orderly and equitable urban development?

Three Components of Urban Disaster Resilience

1) Rational planning process that includes hazard mitigation as strategic element.
2) Portfolio of Integrated Risk Management Strategies, including financial, regulatory, and market incentives.
3) Emergency preparedness and response.

Examples: Three Cities

Caracas

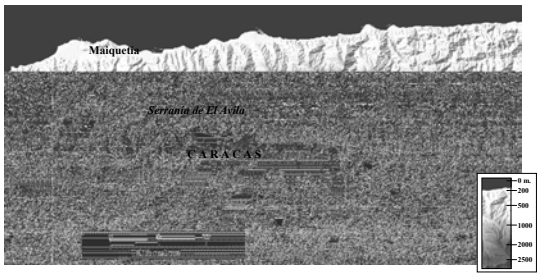
- Landslides, floods, earthquakes
- outline hazard assessment process and relation to urban planning
- Duality of mitigation and physical planning
- Class distinctions and safety

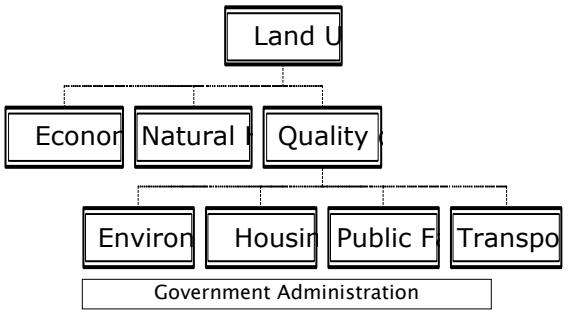
Istanbul

- Earthquakes
- Prediction and faith in/role of science
- Role of public awareness
- How to pay: Benefit-cost analysis of mitigation alternatives and relation to policy
- use of technology and economics

Accra

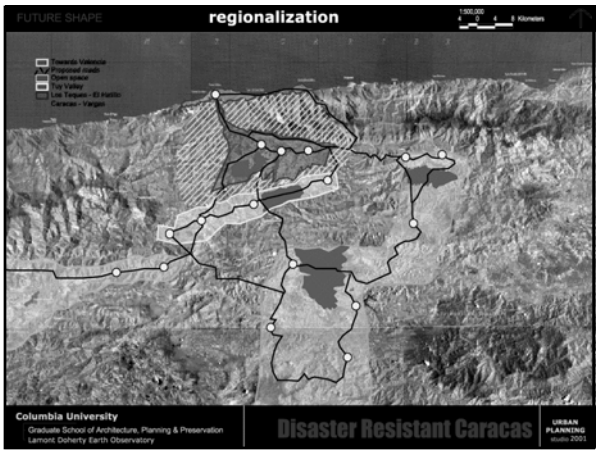
- Chronic vs. catastrophic danger
- Human activity and amplification of hazard
- Integrated mitigation
- Relation between city and hinterlands
- Role in development

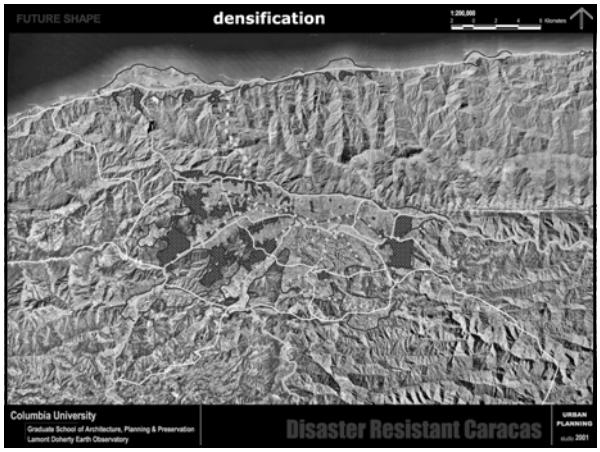

Maiquetía
Serranía de El Avila
C A R A C A S
0 m.
200
500
1000
2000
2500



Caracas will be a regional center in Northern South America and a link to the Caribbean. It will form a locus for the growing service industry including finance, telecommunications, media, technology, and natural resource related to business. Additionally, as a center of education and culture, Caracas will fuel innovation and creativity.

Full Integration of Barrios is Critical to the Future Development of Caracas




FUTURE SHAPE
densification
Columbia University
Graduate School of Architecture, Planning & Preservation
Lamont Doherty Earth Observatory
Disaster Resistant Caracas
URBAN PLANNING


FUTURE SHAPE
densification - barrio integration
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FUTURE SHAPE
densification - barrio integration
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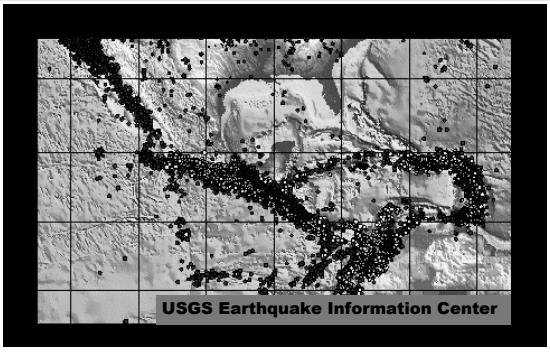
Risk Assessments

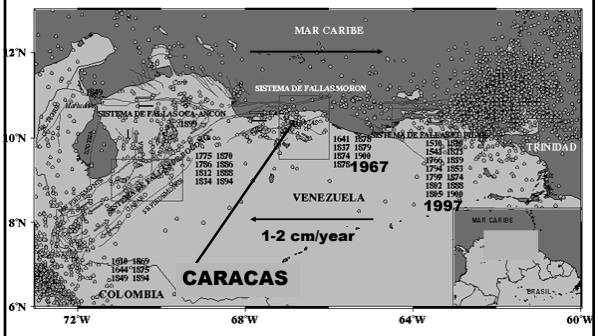
Caracas Faces Two Main Hazards:

- **Earthquakes – The Plate Boundary**
  - Ground shaking
  - Soil failure
  - Landslides

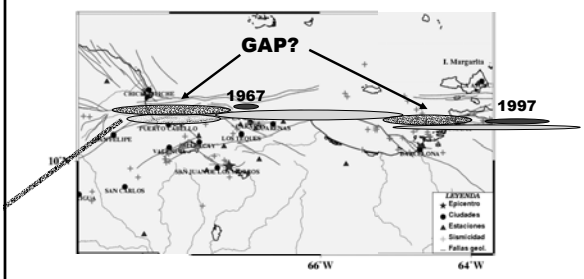
Extreme Rainfall Events
- Flooding
- Mud and debris flows

- **1641** – M 7: **Destroyed most of Caracas**, houses & churches
- **1766** – M 7.7 Damage in Caracas (250–300 year repeat time)
- **1812** – M 8+ **Destroyed Caracas**, killing 10,000 of 50,000 and 16,000 in other cities; Damaged many churches in Caracas and elsewhere.
- **1878** – M 6.1: Cracked walls of houses in Caracas
- **1900** – M 8: Damaged buildings **killing at least 140 people**; 250 aftershocks in 3 years
- **1967** – M 6.5: **Extensive damage** to earthquake-resistant buildings, 300 people killed, 4 buildings collapsed

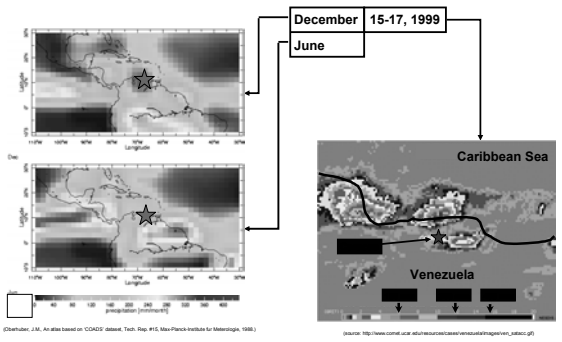




http://www.funvisis.org.ve/htmls/fallas_venezuela.html



http://www.funvisis.org.ve



(Oberhuber, J.M., An atlas based on 'COADS' dataset, Tech. Rep. #15, Max-Planck-Institute fur Meteorologie, 1988.)

(source: http://www.comet.ucar.edu/resources/cases/venezuela/images/ven_satacc.gif)

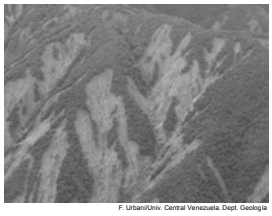
Hazards	**extreme rainfall in vargas/caracas**	General Menu Section Menu Previous page

Normal December Rainfall:	100 mm
December 15-17, 1999:	912 mm
December 1999 Total:	1207 mm

undisturbed:

F. Urbani/Univ. Central Venezuela. Dept. Geologia

disturbed:



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Precipitation threshold:

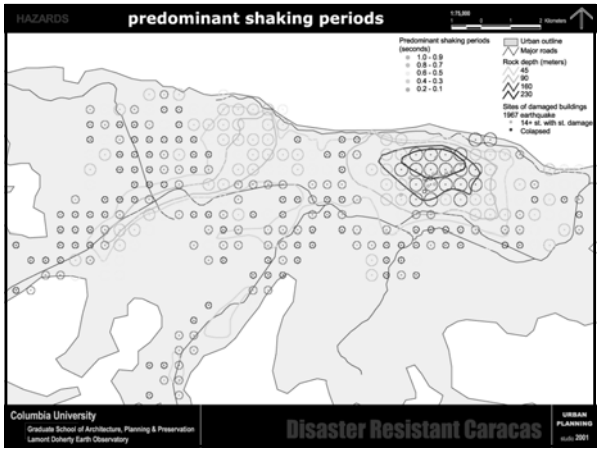
100 mm/24 hours -- some sliding
300 mm/72 hours -- major sliding

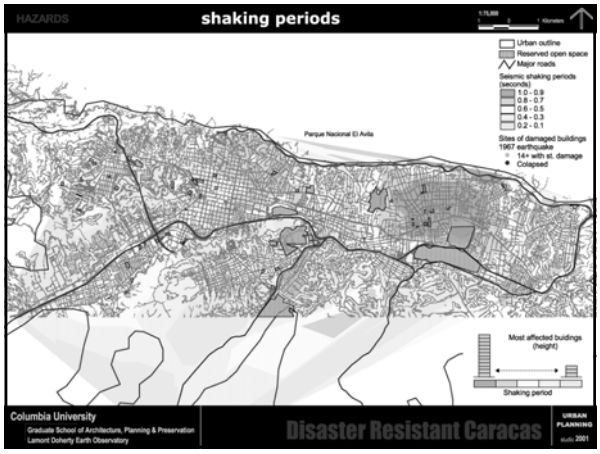
Major flooding events have also occurred in the following years:

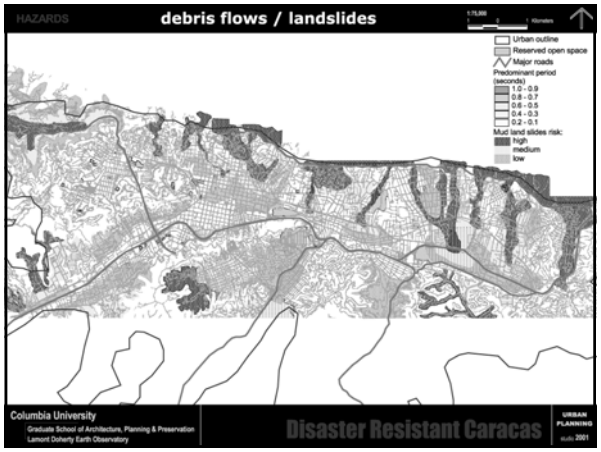
- **1740**
- **1780**
- **1789**
- **1798**
- **1938**
- **1944**
- **1948**
- **1951**
- **1972**
- **1999**

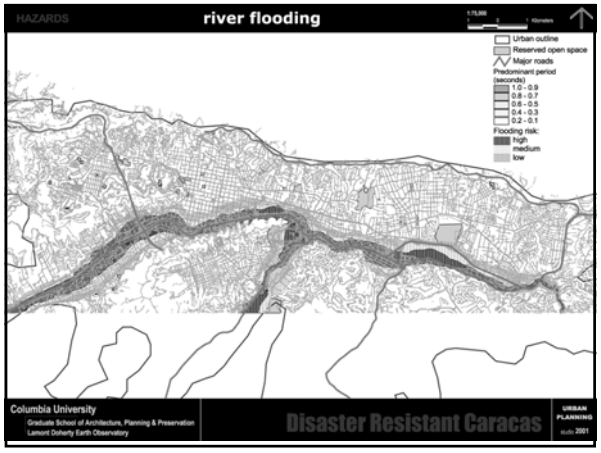
Average recurrence: 25 years

Events of extreme magnitude






HAZARDS
debris flows / landslides
1:75,000
Kilometers
Urban outline
Reserved open space
Major roads
Predominant period (seconds)
1.0 - 0.9
0.8 - 0.7
0.6 - 0.5
0.4 - 0.3
0.2 - 0.1
Mud land slides risk:
high
medium
low
Columbia University
Graduate School of Architecture, Planning & Preservation
Lamont Doherty Earth Observatory
Disaster Resistant Caracas
URBAN PLANNING
studio 2001


HAZARDS
river flooding
1:75,000
Kilometers
Urban outline
Reserved open space
Major roads
Predominant period (seconds)
1.0 - 0.9
0.8 - 0.7
0.6 - 0.5
0.4 - 0.3
0.2 - 0.1
Flooding risk:
high
medium
low
Columbia University
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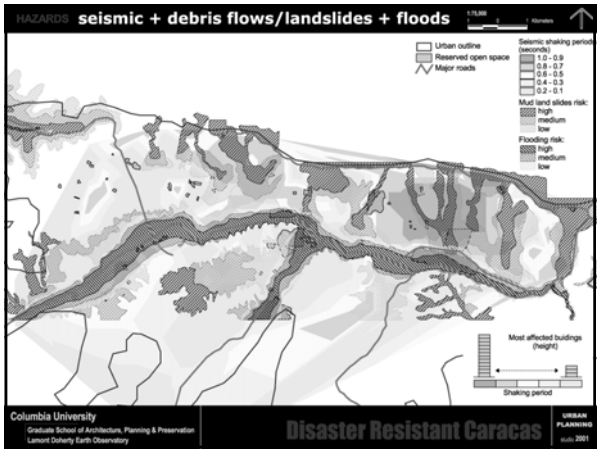
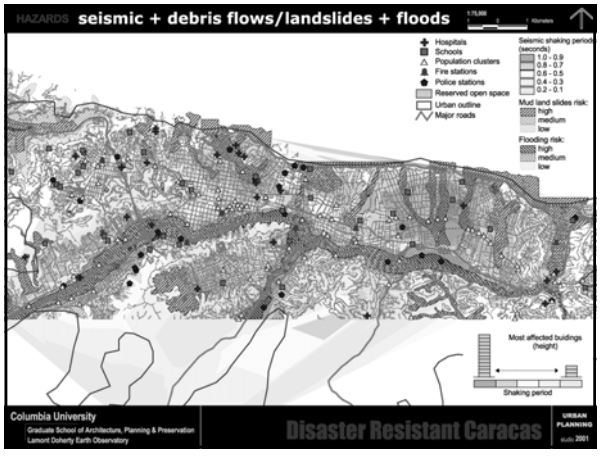
studio 2001

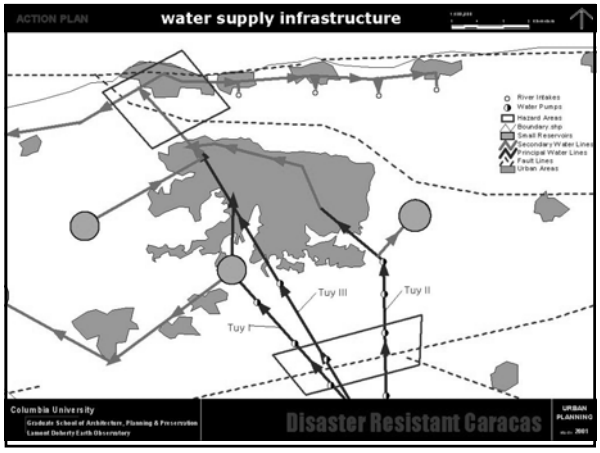

HAZARDS
seismic + debris flows/landslides + floods
1:75,000
Kilometers
Urban outline
Reserved open space
Major roads
Seismic shaking period (seconds)
1.0 - 0.9
0.8 - 0.7
0.6 - 0.5
0.4 - 0.3
0.2 - 0.1
Mud land slides risk:
high
medium
low
Flooding risk:
high
medium
low
Most affected buidings (height)
Shaking period
Columbia University
Graduate School of Architecture, Planning & Preservation
Lamont Doherty Earth Observatory
Disaster Resistant Caracas
URBAN PLANNING
studio 2001

Action Plan

- Emergency Response System
  - Search and Rescue Teams
  - Field Hospitals
  - Power Generation Stations
- Hazard Mitigation Plan
  - Reserved Open Space
  - Evacuation Routes
  - Storage Warehouses

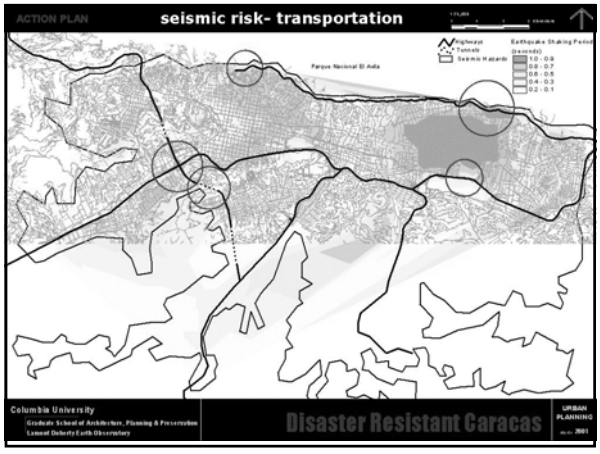


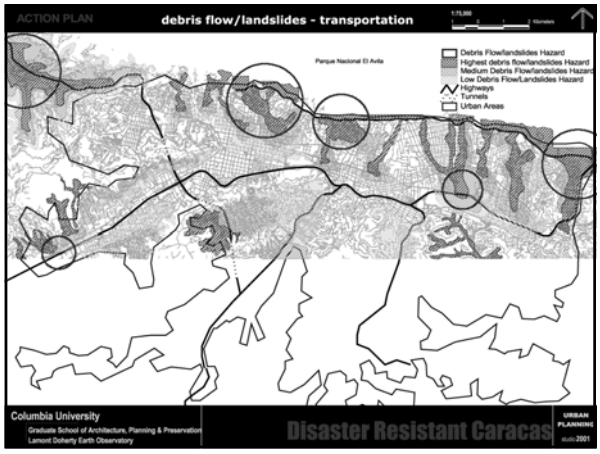
- Water
- Transportation
- Communications
- Electricity
- Fuel and Natural Gas
- Sewage

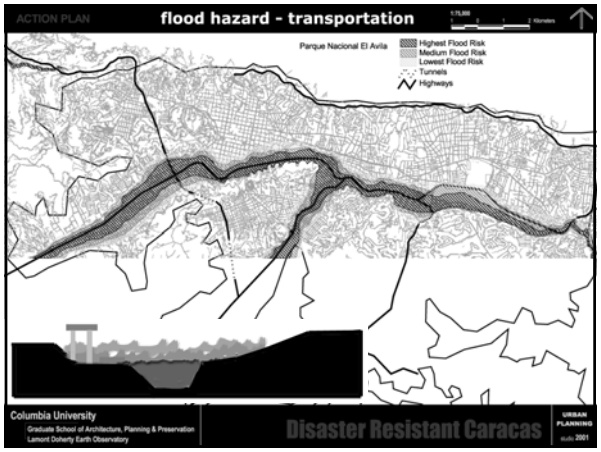


- Robust and Reliable Water Supply System
- Need for Water Storage Inside the City
- Backup Power for Pumping Stations
- Strong Water Distribution System

- Robust and Redundant System
- System to Remain Intact and Operable
  - Reinforcement and Retrofitting of Existing System
- Creation of Strategic Network
  - Network to Include Emergency Routes
  - Improved Access to the Valley and Coast






ACTION PLAN
flood hazard - transportation
Parque Nacional El Avila
Highest Flood Risk
Medium Flood Risk
Lowest Flood Risk
Tunnels
Highways
Columbia University
Graduate School of Architecture, Planning & Preservation
Lamont Doherty Earth Observatory
Disaster Resistant Caracas
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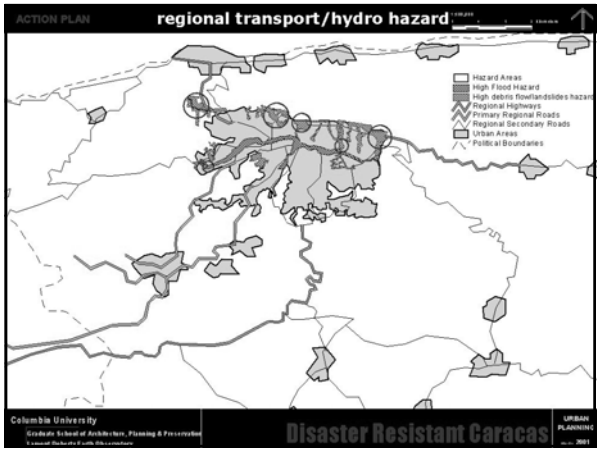
ACTION PLAN
regional transport/hydro hazard
Hazard Areas
High Flood Hazard
High debris flow/landslides hazard
Regional Highways
Primary Regional Roads
Regional Secondary Roads
Urban Areas
Political Boundaries
Columbia University
Disaster Resistant Caracas
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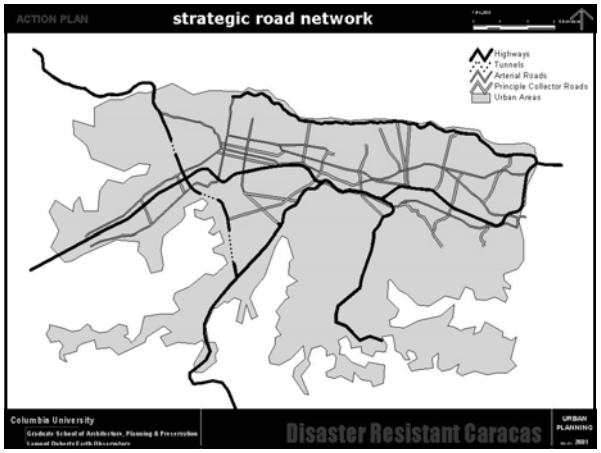
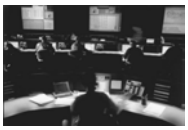

ACTION PLAN
strategic road network
Highways
Tunnels
Arterial Roads
Principle Collector Roads
Urban Areas
Columbia University
Disaster Resistant Caracas
URBAN PLANNING

- Robust and Reliable Communications System
- Emergency Broadcast System
- Unified Emergency communications center
- Prevent gridlock

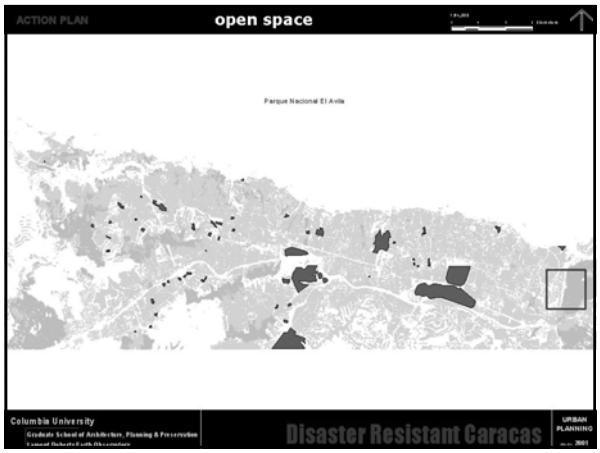


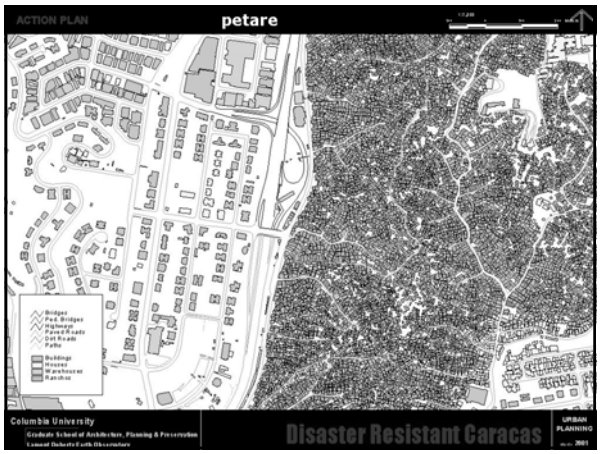
Hospitals, Fire and Police Stations

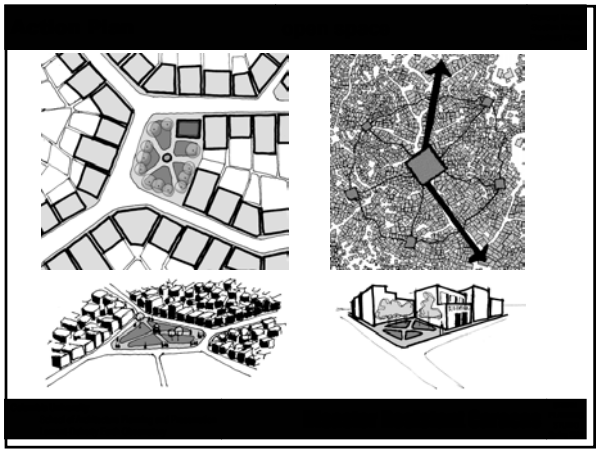
- Access to these facilities must be improved
- New facilities must be built in under-served areas
- Existing facilities must be strengthened and made self-sufficient

Reserved Spaces

- Normal Function
  - Parks and Plazas
  - Recreation Fields
  - Community Centers
  - Gymnasiums
- Disaster Function
  - Evacuation Sites
  - Temporary Shelters
  - Field Hospitals
  - Information Posts
  - Supply Distribution Points

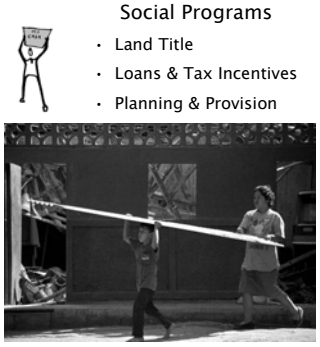


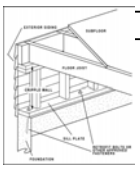




Social Programs

- Land Title
- Loans & Tax Incentives
- Planning & Provision





Physical Programs

- Retrofitting
- Building Codes
- Construction Training

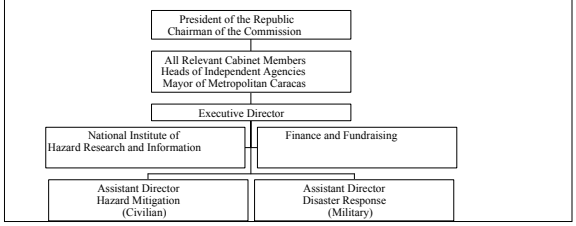
- Life & Death
- Active Community Participation
- Maintain Networks
- Increase Density via Appropriate Design
- Last Resort / Low %

- Pop Culture
- Citywide Theme
- School Curriculum
- Technical Assistance
- Community Disaster Teams

Interactive Training and Educational Exchange

Technical Assistance

Presidential Commission on Hazard Mitigation and Disaster Response



Mexico City, 1985
magnitude 8.1
estimated damage – $5 billion

Kobe, Japan, 1995
magnitude 7.2
estimated damage – $150bn

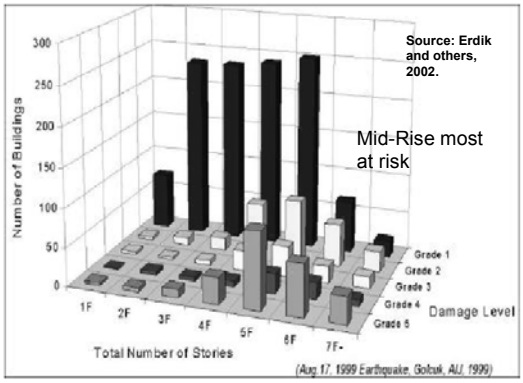
Infrastructure	coastal connector		redundancy
Housing	hardening/ relocation	zoning	land title
Administration	disaster ministry		
Science	data mining	hazard mapping	disaster info clearinghouse
Education	hazard curriculum	volunteer corps	academia
	0-5	5-10	10-20 years

Istanbul

- Earthquakes
- Prediction and faith in/role of science
- Role of public awareness
- How to pay: Benefit-cost analysis of mitigation alternatives and relation to policy
- use of technology and economics

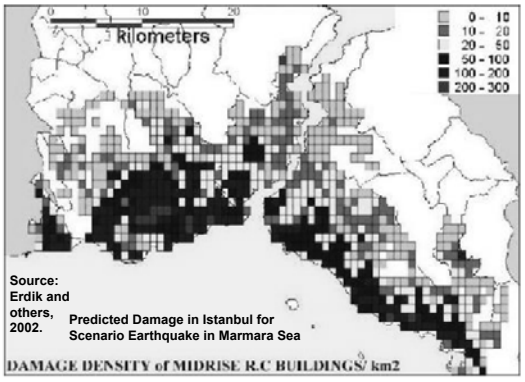
Common construction practice in many countries results in residential buildings subject to “pancake collapse” in earthquakes.

Pancake collapse of apartments in Goliaka, Turkey, 1999
Photo: Nano Seeber



Source: Erdik and others, 2002.

Mid-Rise most at risk



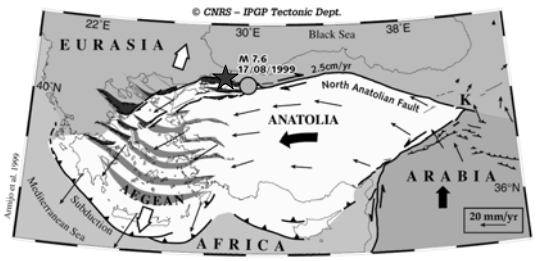
Source: Erdik and others, 2002.

Predicted Damage in Istanbul for Scenario Earthquake in Marmara Sea

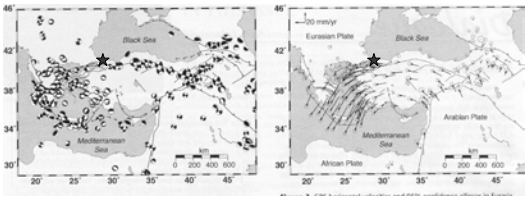
Figure 37. Number of mid-rise R/C buildings expected to receive damage beyond repair (i.e. EMS 1998 Damage Class equal to and above D3)

New and existing construction follows a pattern of inadequate mitigation.

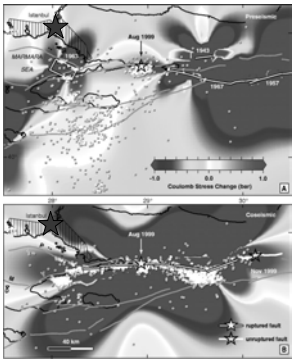
Anatolian Plate is being squeezed westward at about 1 inch year $^{-1}$



The seismicity in the eastern Mediterranean is the consequence of large scale plate motions.



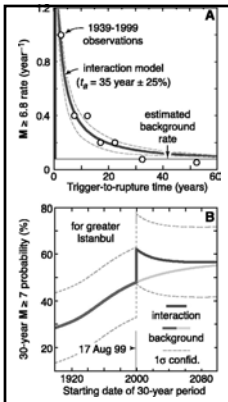
Stress Climate calculations predict earthquakes in NW Turkey



Calculations of stress climate consistent with 1999 event.

1999 sequence creates overstress condition on fault segments in Marmara.

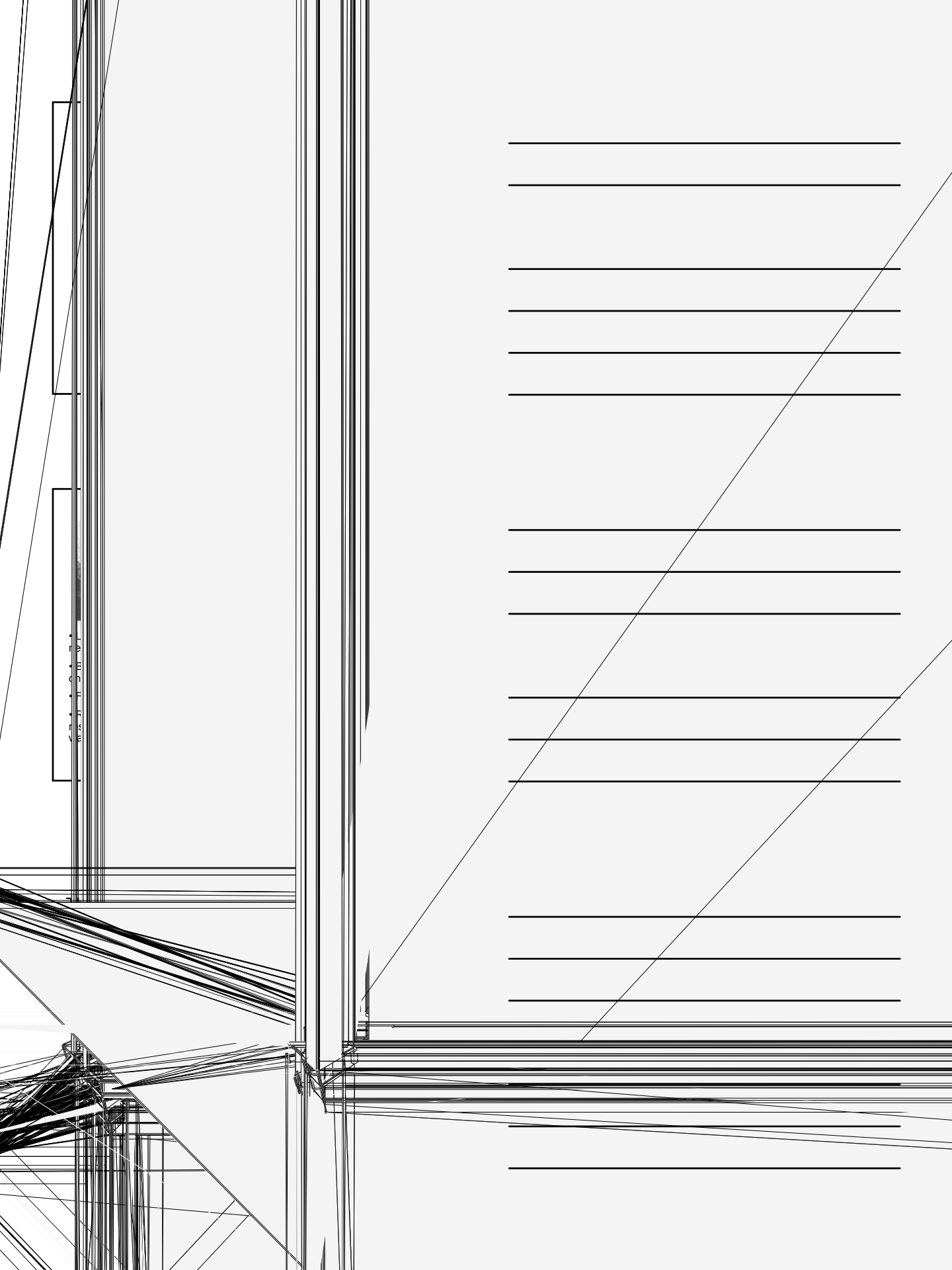
Source: R. Stein USGS



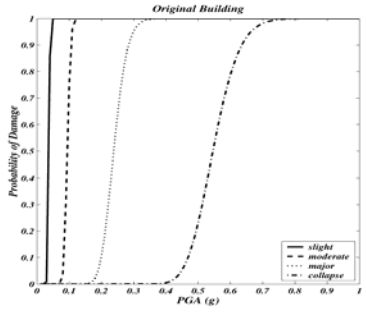
The change in STRESS CLIMATE along the North Anatolian Fault increases the likelihood of a major earthquake within the next few decades.

This probability enhancement (or accelerated likelihood) Is TIME DEPENDENT.

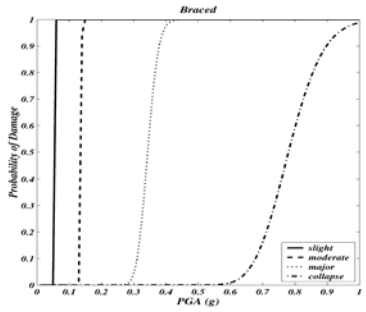
Note error bounds.



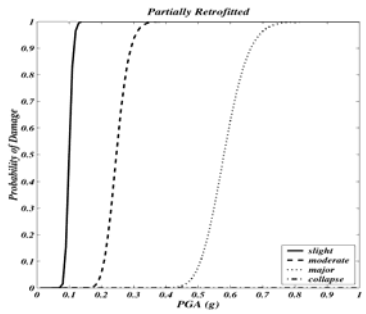
Fragility Curves



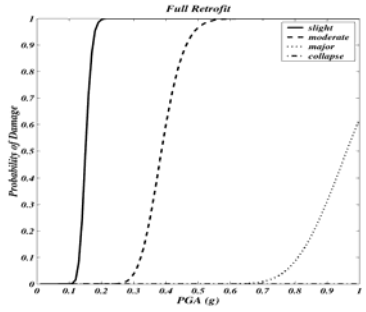
Fragility Curves



Fragility Curves



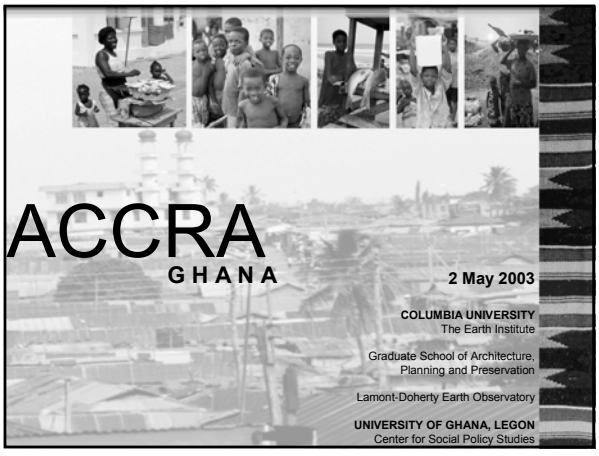
Fragility Curves



Expected Net Present Value With 10 Fatalities
(F=10, V=$1 000 000, in thousands of dollars)

Alternative (Ai)	*i=2*	*i=3*	*i=4*
Time Horizon	***Braced***	***Partial***	***Full***
1	-$49,3	-$58,8	-$113,4
2	-$35,8	-$40,7	-$94,8
3	-$24,3	-$25,2	-$79,0
4	-$14,5	-$11,9	-$65,4
5	-$6,0	-$0,5	-$53,8
10	$21,1	$36,0	-$16,4
25	$41,9	$64,0	$12,2
50	$44,1	$67,0	$15,2

Source: Smyth et al., 2002, in review.



GOALS OF THE STUDIO

To educate

planning students

To participate in the

21st Century Cities project

2

Accra

- Chronic vs. catastrophic danger
- Human activity and amplification of hazard
- Integrated mitigation
- Relation between city and hinterlands
- Role in development

who we are

To assist planning

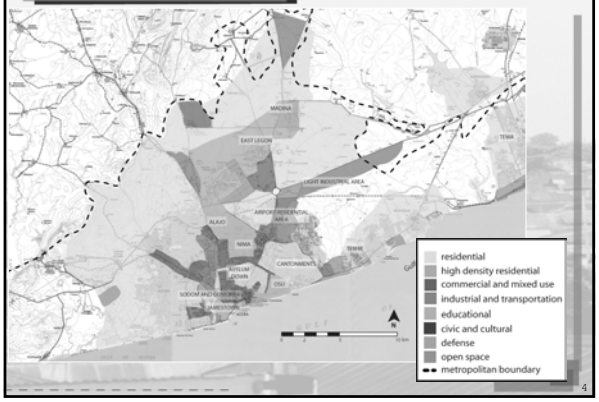
and management

efforts in Accra, Ghana

Dr. Sigurd Grava
Dr. Klaus Jacob
Lisa Fisher
Dr. William Ahadzie
Angela Pace-Moody
Barbara Prevatt
Cynthia Golembeski
David Recht
Grégoire Landel
Jennifer Dickson
Juliette Dellecker
Julie Touber
Maya Sarkar
Molly Price
Moriah McSharry McGrath

2

land use



4

68% of the annual need for new housing units goes unmet

90% of residents dispose of waste in public spaces, water bodies, and open drains

5

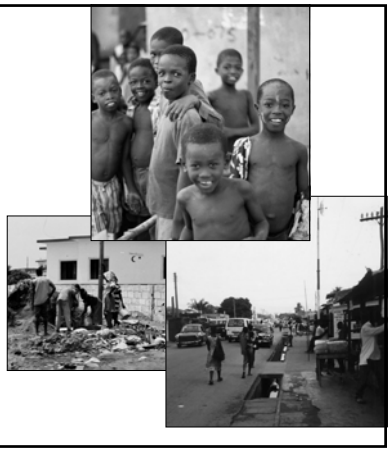
80% of houses do not have indoor plumbing

70% of illness in Ghana is water-related

50% to 70% of workers are employed in the informal economy

5

ALAJO



FOCUS ON ALAJO

- Waste disposal
- Water supply
- Flooding
- Disease

weaknesses

Q(25) Q(100)

25

URBAN DISASTERS

Floods

- Annual occurrence
- Few fatalities
- Compounded by urban environment

7

- Rapid urbanization
- Ineffective land use controls
- Lack of sewer systems
- Inadequate water supply

6

- Public health concerns
- Insufficient housing
- Poverty
- Unequal resource distribution

6

flooding

7

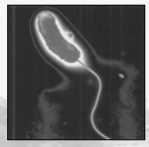
epidemics

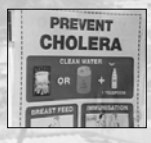
7

URBAN DISASTERS

Epidemics

- Minimal sewer service
- Limited accessibility to potable water
- Cholera and malaria exacerbated by floods





7

special features

21

common solutions

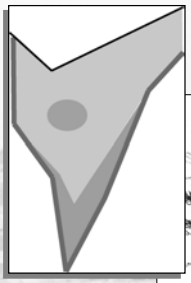
Flooding: Reforestation upstream, designation of floodplains in Alajo, waste removal from the riverbeds

Sanitation: Access to potable water, sewerage, solid waste removal

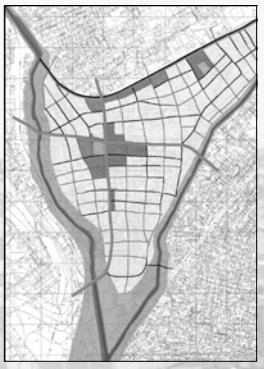
Fires: Emergency vehicle access, expanded street network, effective fire hydrants

26

concept



phases



1. Widen river and designate floodplains
2. Expand street network
3. Create the town center
4. Alleviate traffic on the two main streets

FOCUS ON ALAJO

Alternatives

- No action
- Complete relocation
- Middle ground:

- Social Resiliency
- Town Center
- Participatory Urban Upgrade

PARTICIPATORY URBAN UPGRADE

- Enhance social services
- Promote economic development
- Maximize public safety
- Develop community from within

32

Relation to agriculture

- Economic development requires agricultural reform: soil fertility
- Soil fertility affected by N-fixing crops
- N-fixing crops hold water and reduce flooding in watershed

Solve 2 problems at once?

Sanitation

- Remove garbage from floodways
- Cheap energy?

Solve 3 problems at once?