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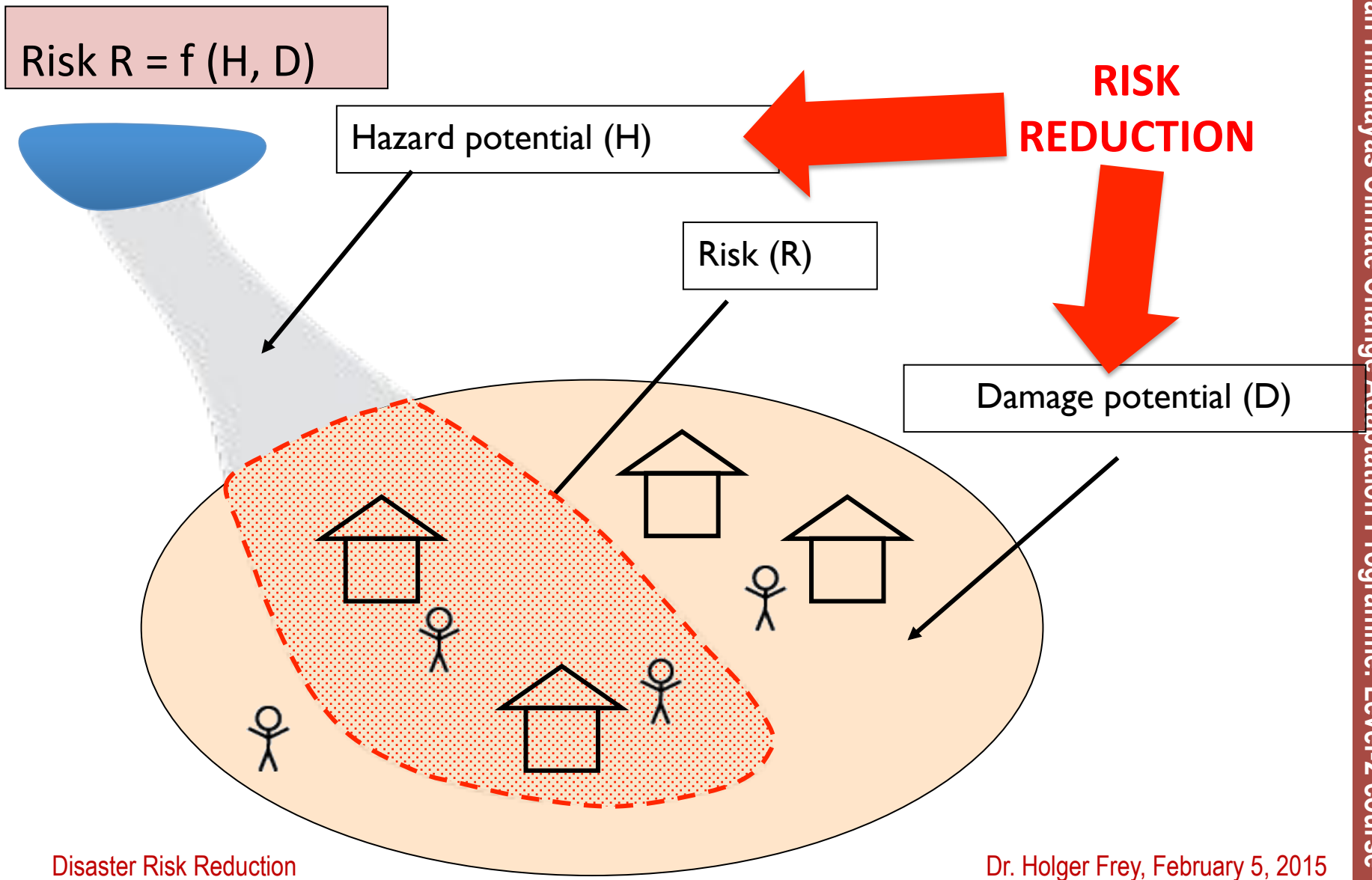
DISASTER RISK REDUCTION

Dr. Holger Frey
University of Zurich, Switzerland

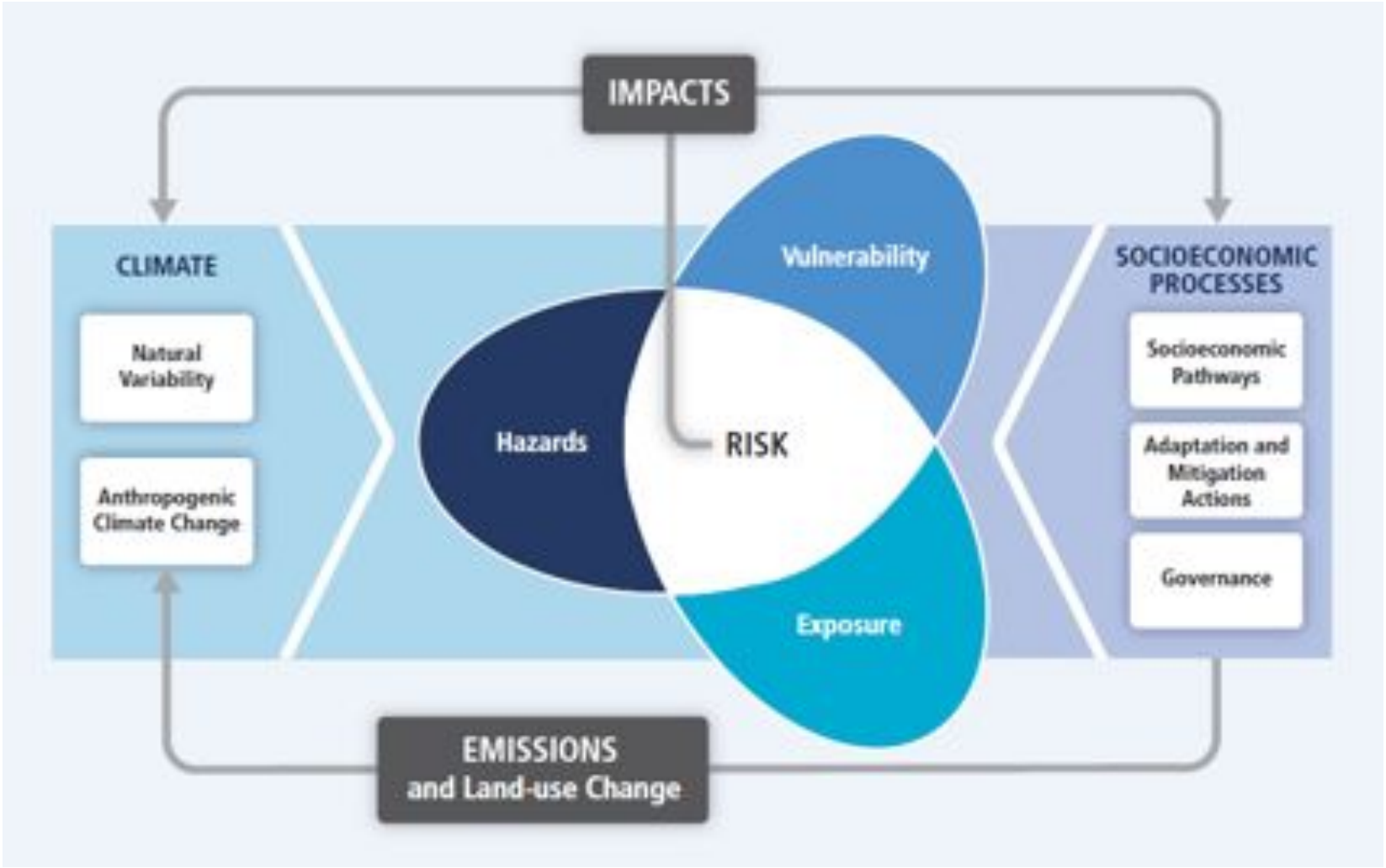
5 February 2015 , JNU

IHCAP – Indian Himalayas Climate Change Adaptation Programme
Capacity building programme “Cryosphere” Level-2 (5 January – 13 February 2015)

Disaster risk reduction

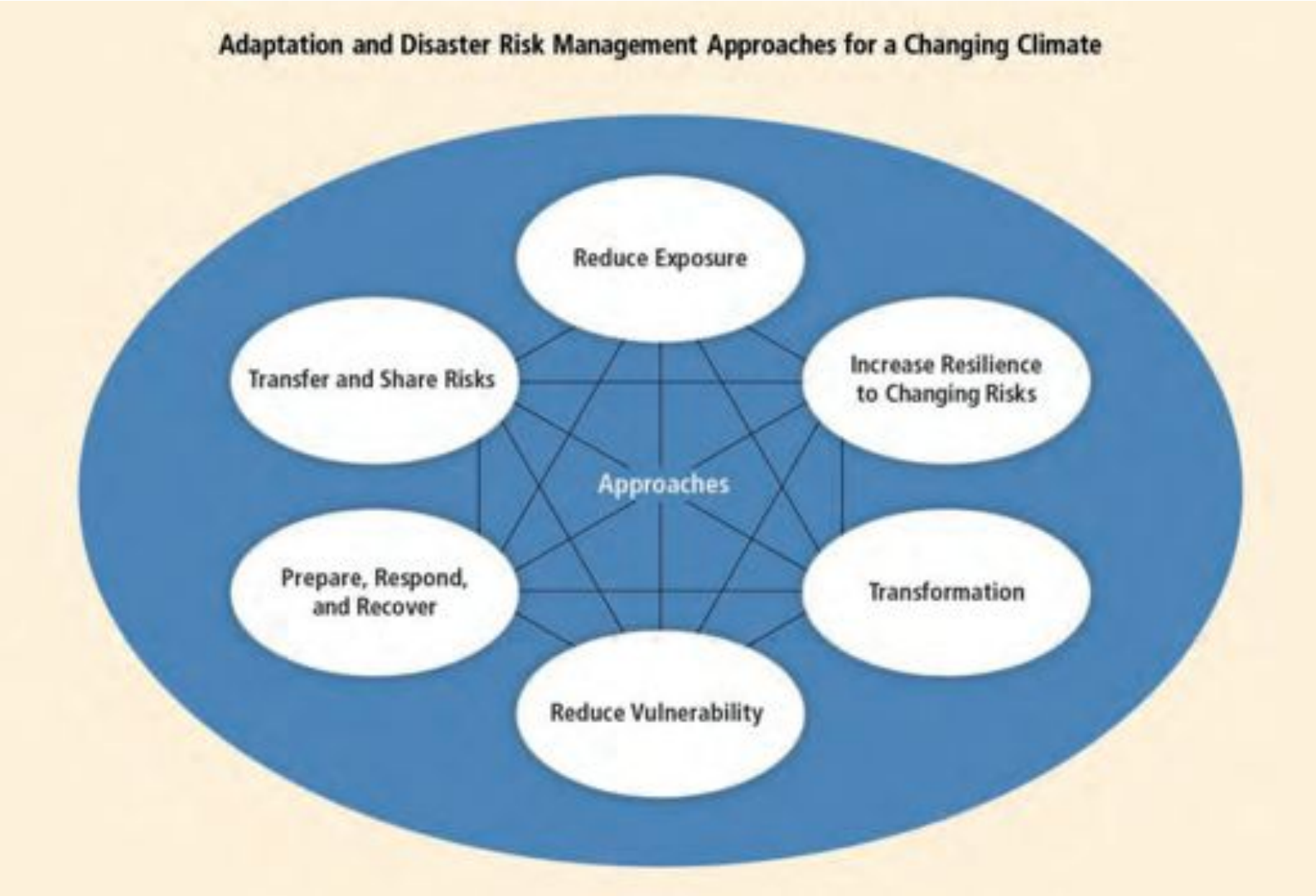


Theoretical frameworks for DRR



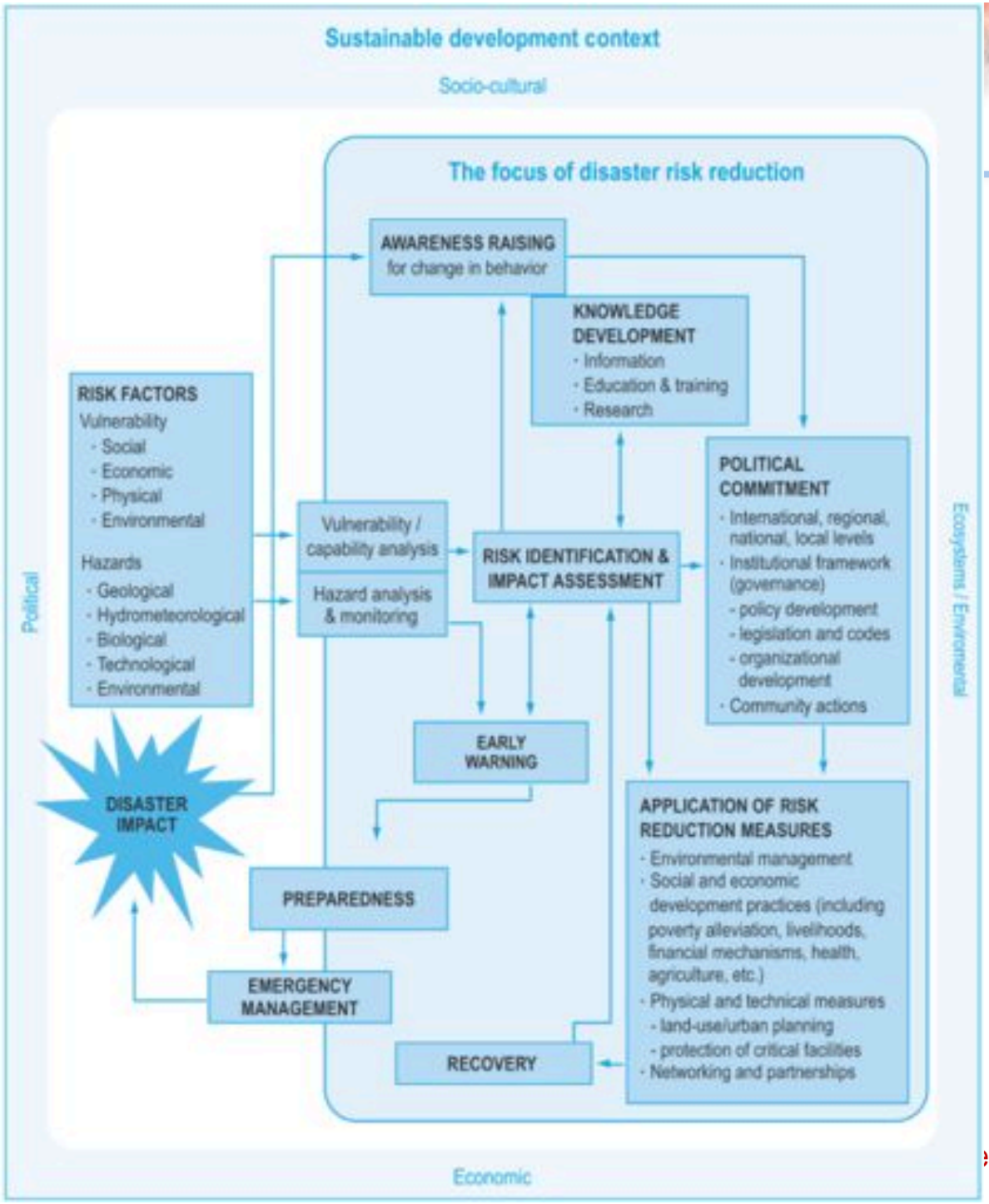
IPCC, 2014 (AR5)

Theoretical frameworks for DRR



IPCC, 2012 (SREX)

Theor



UNFCCC, 2012

Risk reduction strategies

Can be effective on the level of:

1) Hazard (ie, modifying hazard potential)

Fences for stabilizing snow

Artificial lake drainage

Risk reduction strategies

Can be effective on the level of:

2) Damage potential

Flood protection

Avalanche and rockfall protection

Risk reduction strategies

Can be effective on the level of:

3) Disaster Preparedness

Monitoring, early warning systems

Preparing disaster response plans at village level (Red Cross)

Risk reduction strategies

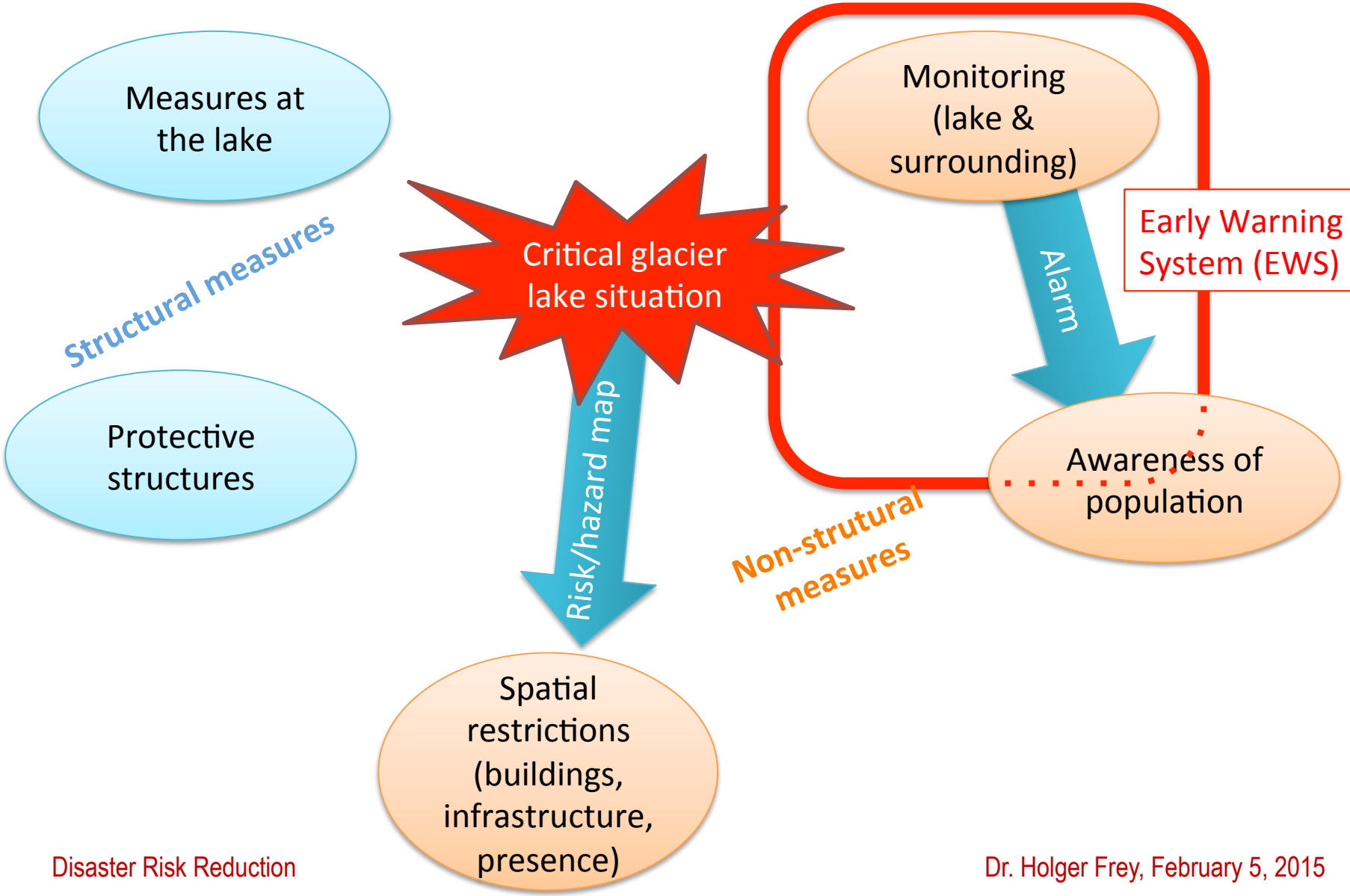
Can be effective on the level of:

4) Responsiveness and recovery

Military often provide most immediate response.

International assistance (e.g., Red Cross, financial aid) delayed, but important for long term recovery.

GLOF Disaster Risk Reduction



EXAMPLES OF DIRECT MEASURES

Measures at glacier lakes

- Remedial actions at glacier lakes in the Cordillera Blanca Peru
- Lower Grindelwald glacier, Switzerland
- Tsho Rholpa, Nepal

Cordillera Blanca

- 8°50’ – 9°35’ S
- 60 peaks > 5700 m a.s.l. (Huascarán 6768 m a.s.l.)
- Glacier area 2010: ~530 km^2
- More than 800 glacial lakes
- Densely populated rio Santa Valley
  (267’000 inhabitants in the Callejón de Huaylas)

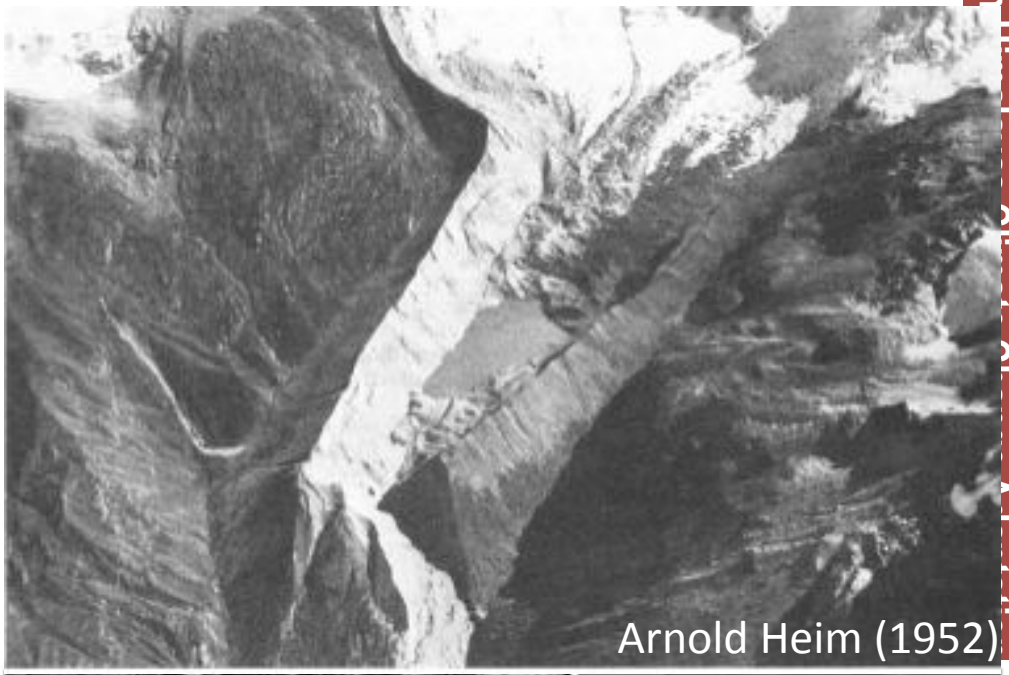
Cordillera Blanca

- Past 150 y: at least 24 GLOFs with > 6000 casualities
- About 20'000 deaths from glacier related processes in the past 60 years

Laguna Palcacocha

- Outburst 1941: Ice avalanche → spillover → destruction of Huaraz, 4,000 lives lost

Noticias é Informaciones *(1942)*



The GLOF's destructive path through the city of Huaraz in 1941. Servicio Aerofotográfico Nacional del Perú

Remedial actions executed in Peru

- GLOF 1941 Laguna Palcacocha

→ Destructions in the city of Huaraz

- Establishment of a group for 'glaciology and hydrological resources'
- Until today: remedial measures at 38 glacier lakes

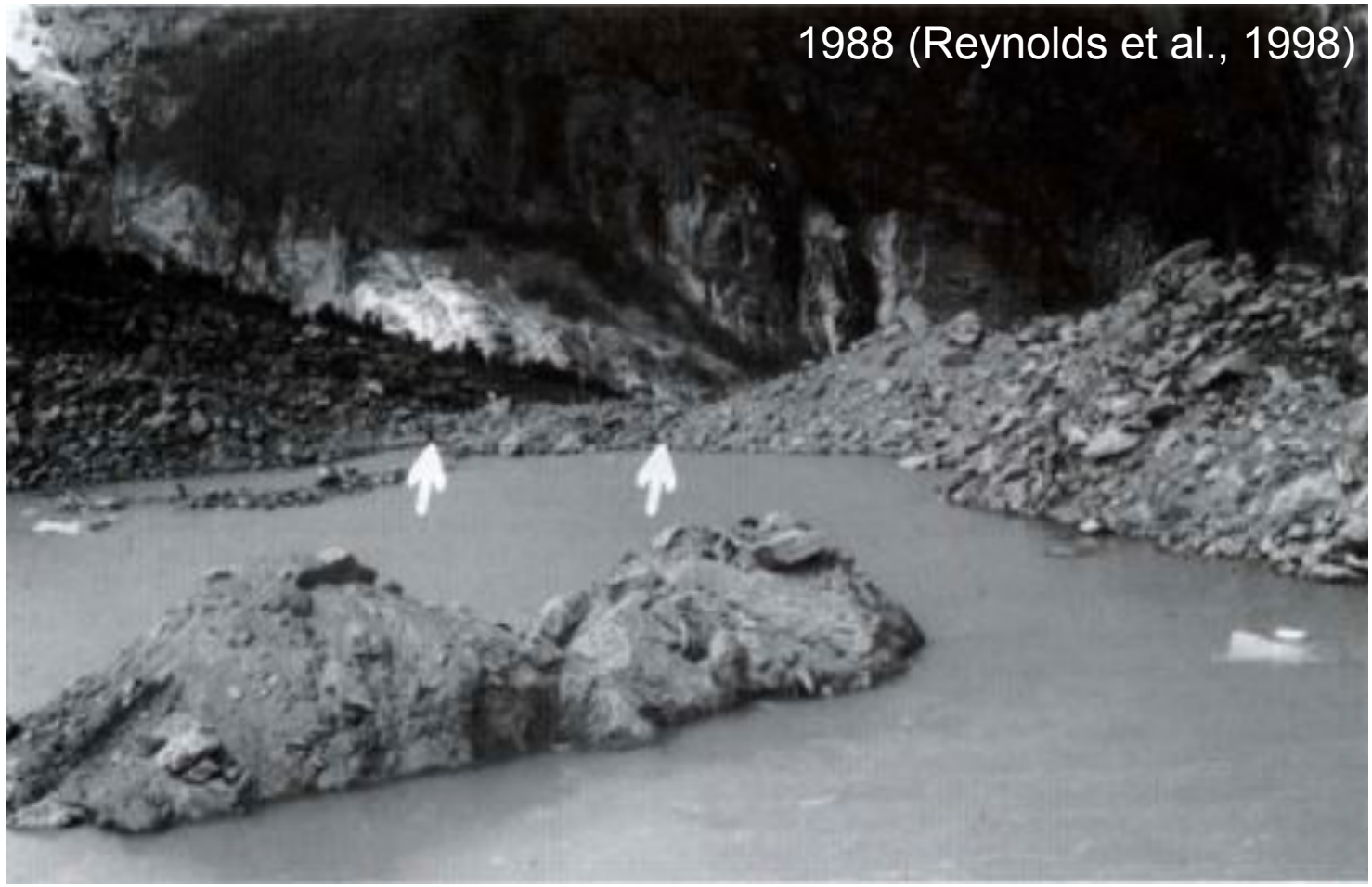
Cordillera Blanca, Peru

Experience since the 1950's

Laguna 513

Tunnels at Laguna 513

- Late 1980's: almost no freeboard, water percolating through ice-cored moraine



Tunnels at Laguna 513

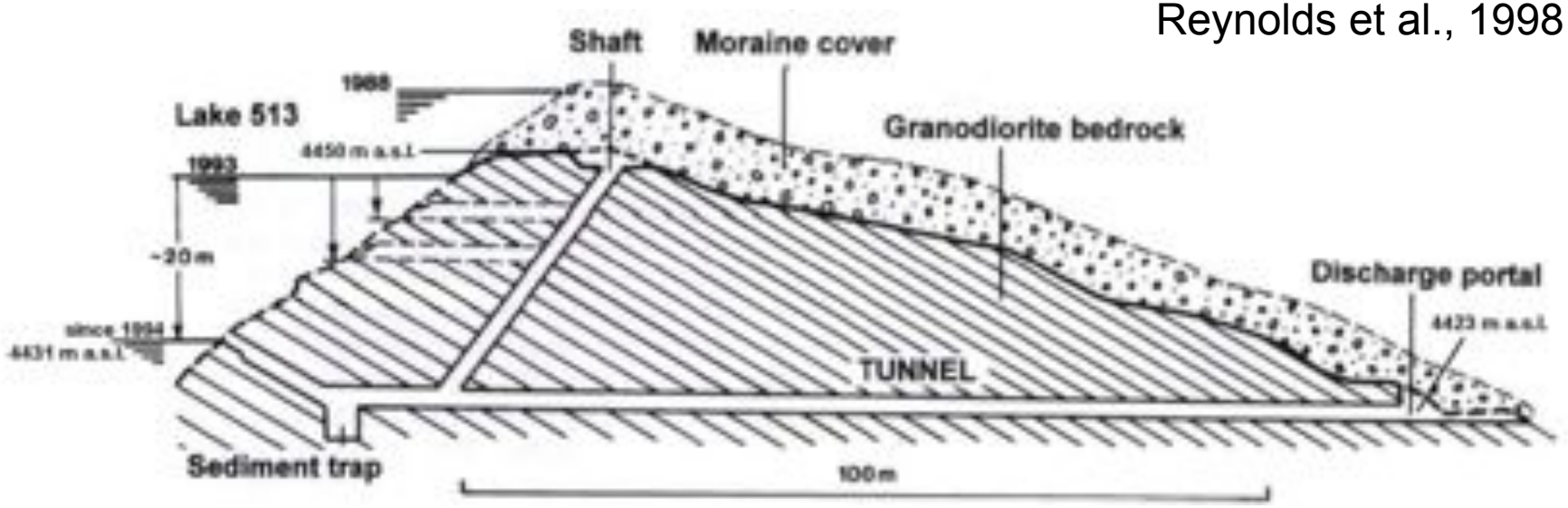
- Siphoning (500 l /sec) → very slow lowering of lake level

Dr. Holger Frey, February 5, 2015

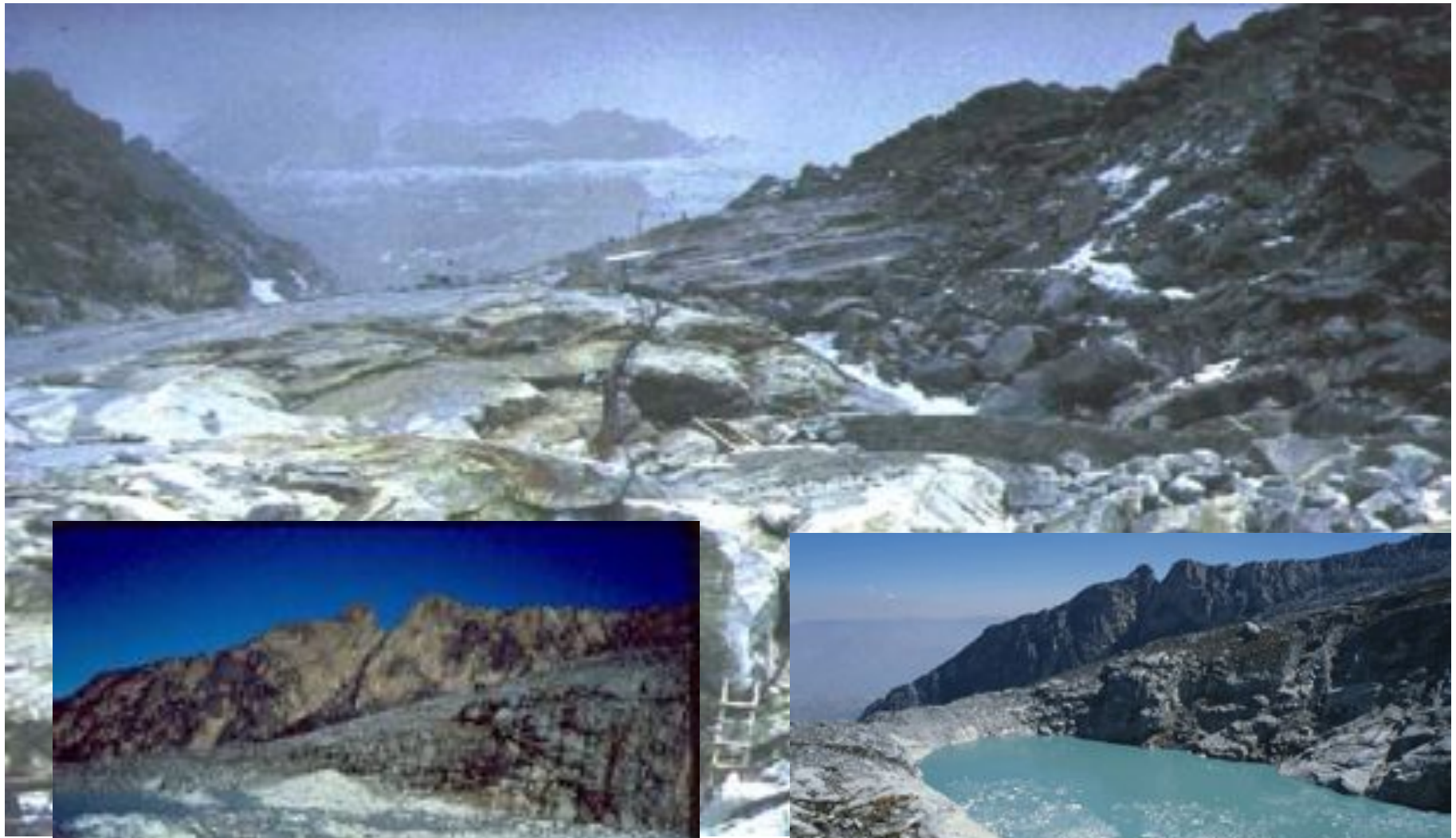
Tunnels at Laguna 513

- 1991: ice avalanche → retrogressive erosion (20–25 m channel) → (few) damages in Carhuaz
  - ➔ Decision to construct a 2m diameter tunnel

Reynolds et al., 1998



Tunnels at Laguna 513



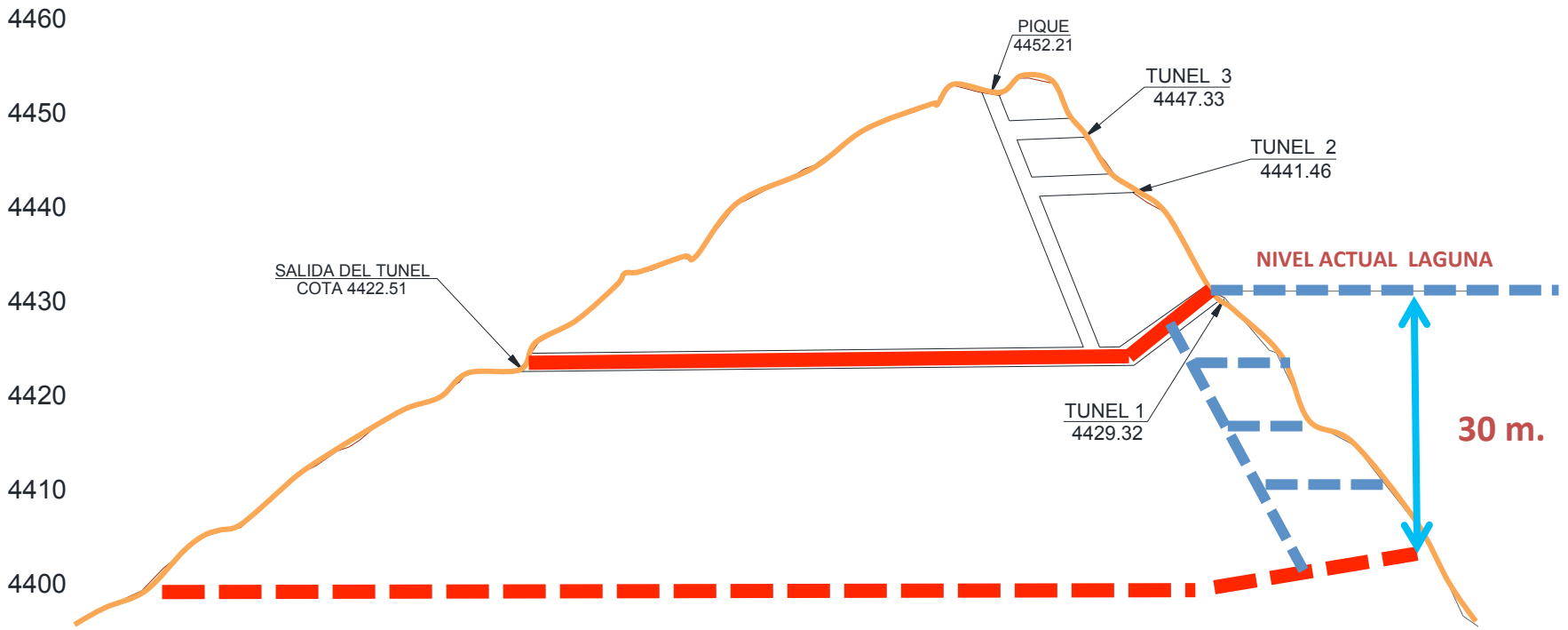
Tunnels at Laguna 513: Today

→ One ice block could increase lake level by 10m! (> 2 Mio m^3)

Tunnels at Laguna 513: Future

- Event 2010 (more to follow…)
- Planning of a further tunnel → lowering by another 30m

C. Portocarrero



More examples from Peru

- Lowering of lake level
- Artificial dam: increase of freeboard / reinforcement of dam

LAGUNA PACCHARARI (1986)

LAGUNA CUCHILLACOCHA (1951)

More examples from Peru

- Open channel through moraine

LAGUNA ARHUAYCOCHA (2000)

More examples from Peru

- Tunnel through moraine

LAGUNA PARÒN
(1984)

Lower Grindelwald Glacier, Switzerland

Outburst May 2008

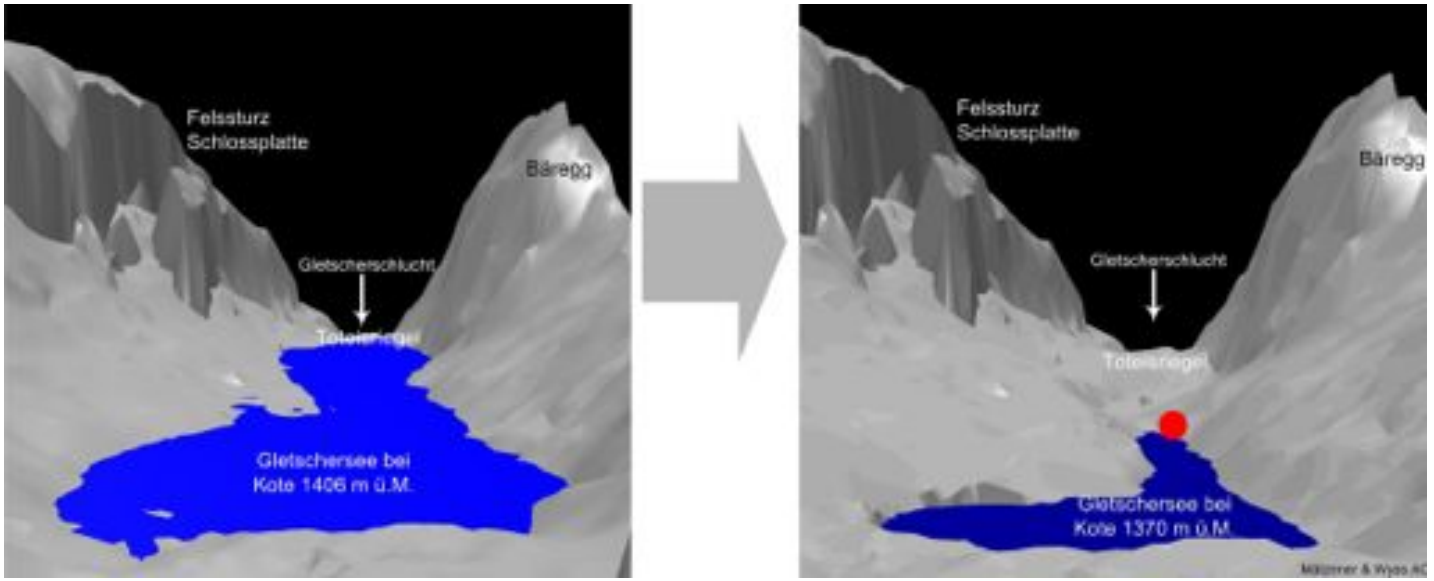
Lower Grindelwald Glacier, Switzerland

Construction of a tunnel

- Length 2km
- Tunnels allows lake level control and transport of construction machines

Construction of a tunnel

- New max. Volume of 500,000 m^3
- New tunnel entries will be required due to lowering of the lake bottom



www.gletschersee.ch

Construction of a tunnel

Programme: Level-2 course

Tsho Rolpa, Nepal

- Volume of ~90 Mio m^3

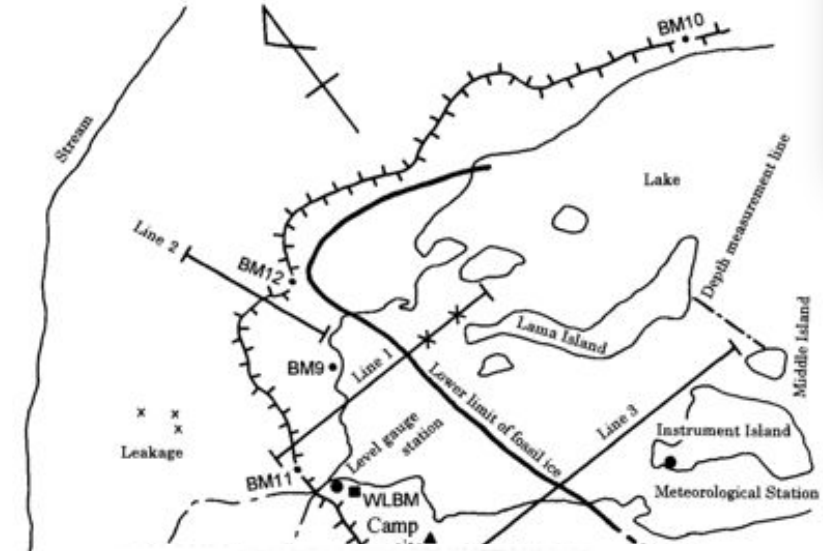
Tsho Rolpa, Nepal

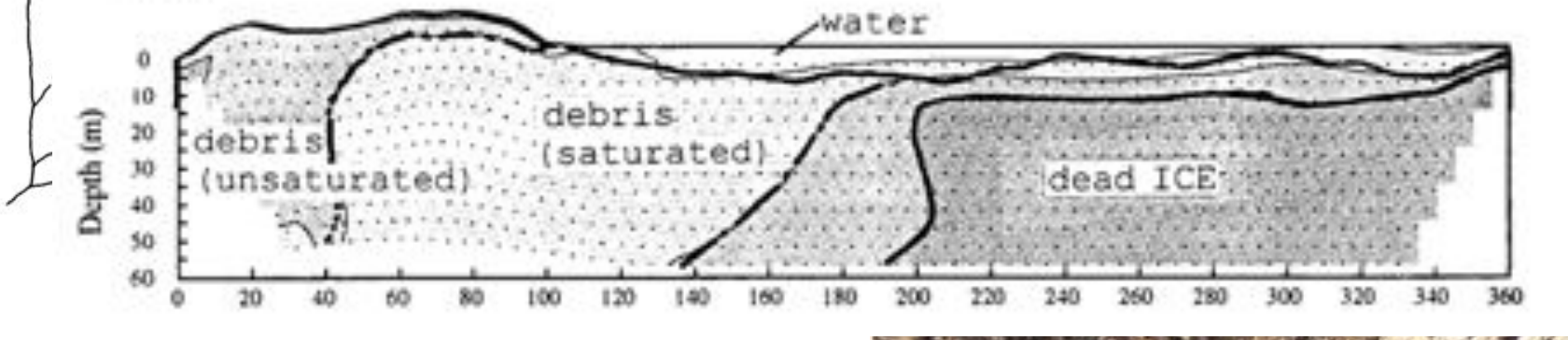
- Dammed by ice-cored LIA moraine
- Almost no freeboard

Y. Tomomi (1998)

Tsho Rolpa, Nepal

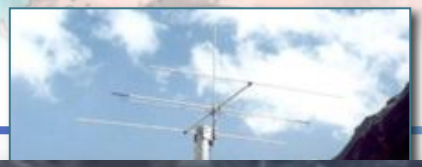
- Ice in dam and underneath lake



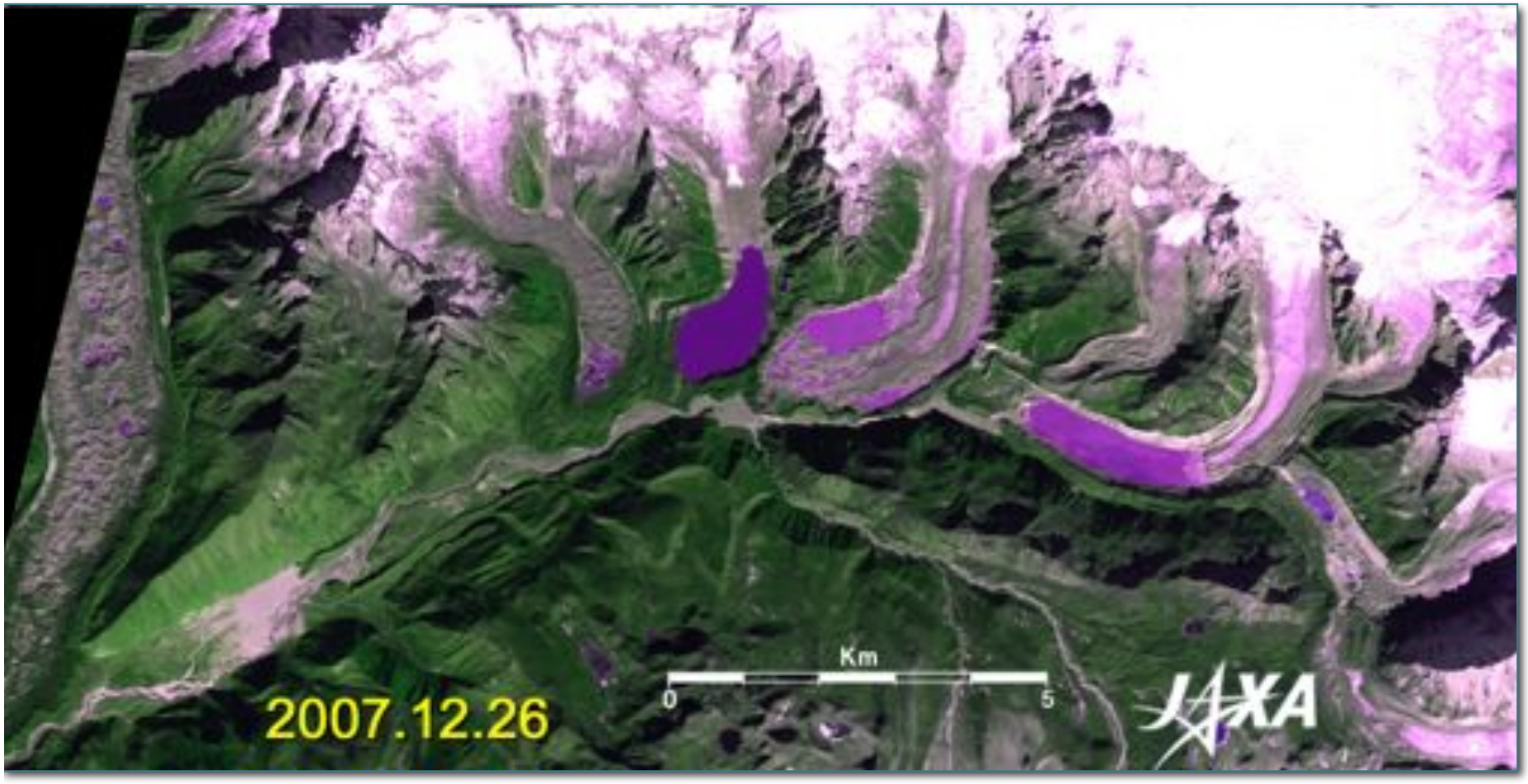


Y. Tomomi (1998)

Tsho Rolpa

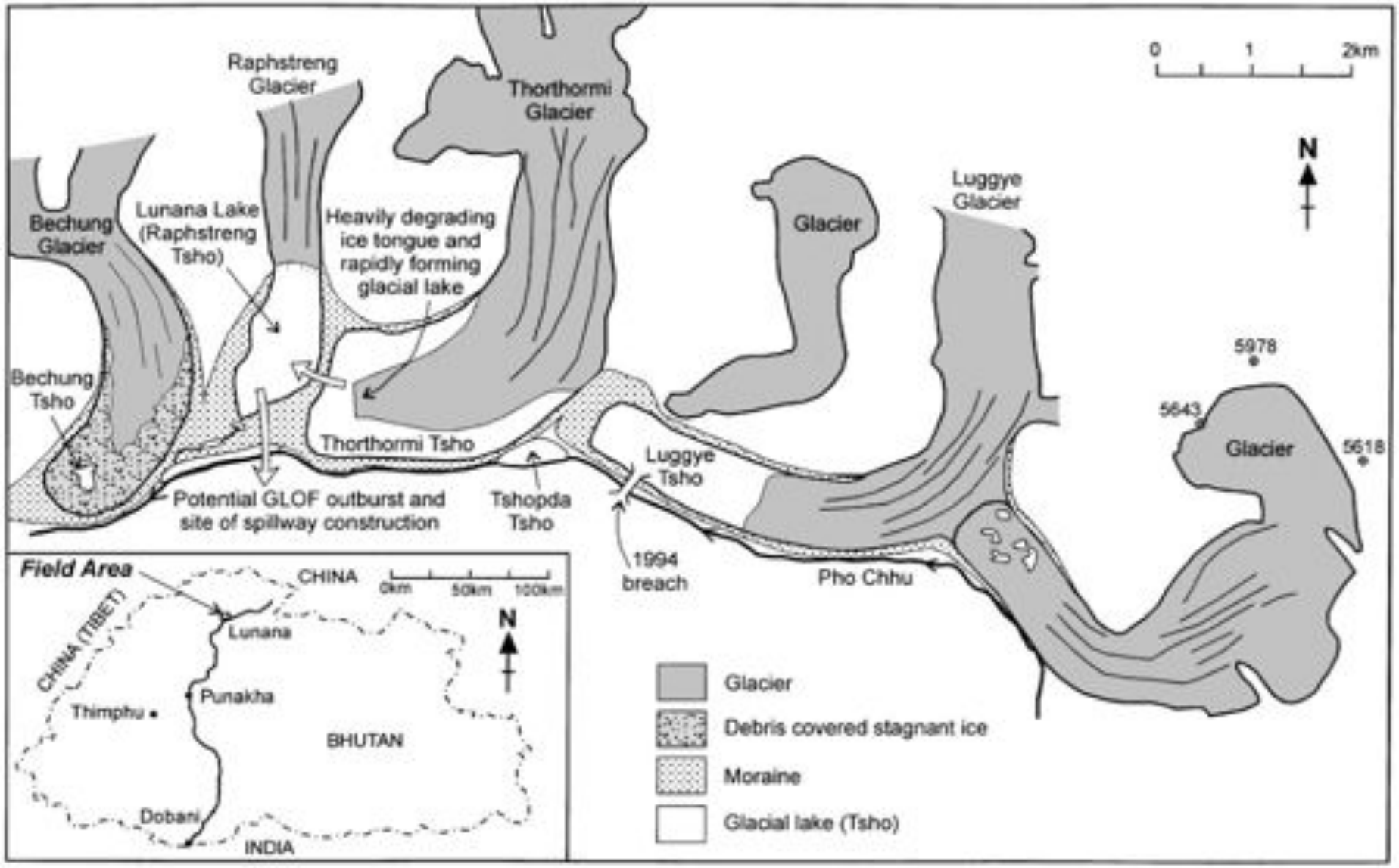


Anticipation



Anticipation

Richardson & Reynolds, 2000

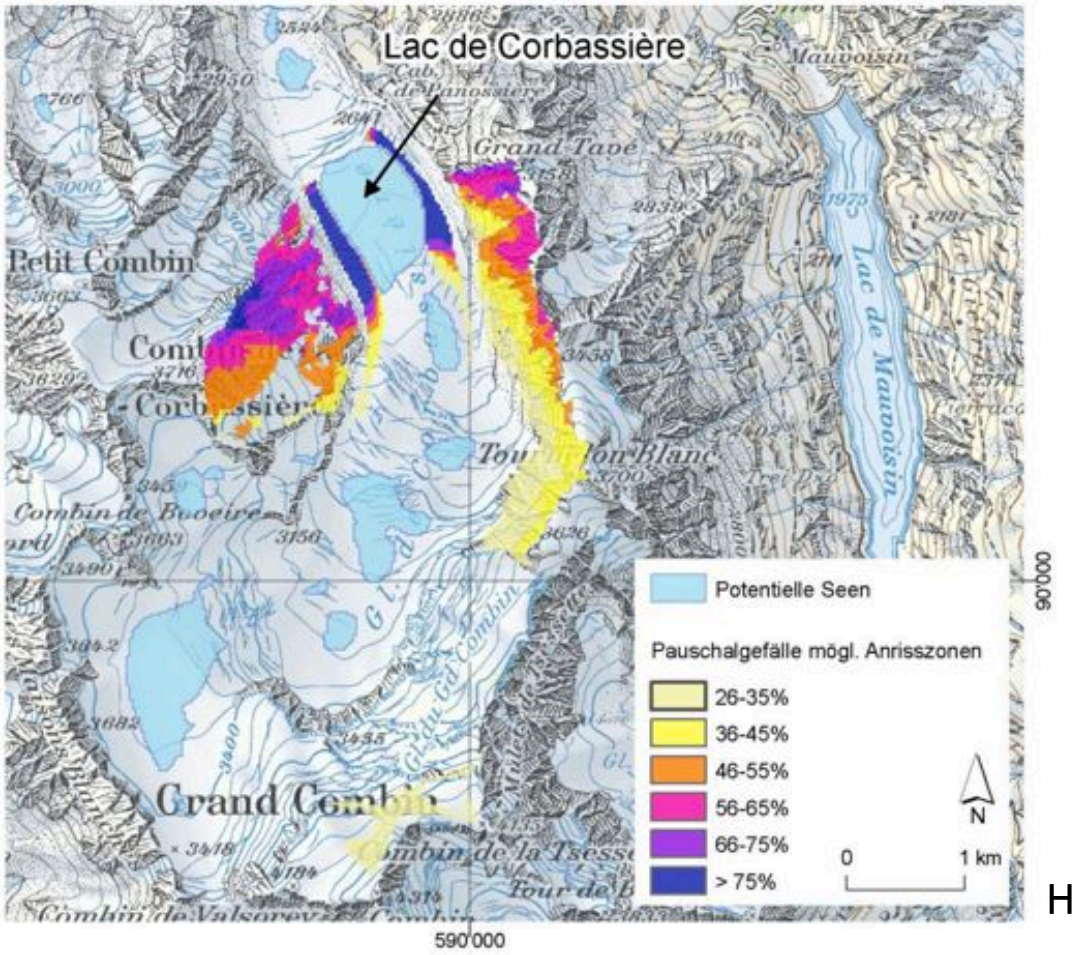


Multi-purpose structures

- Protective structures that can be used for hydropower generation

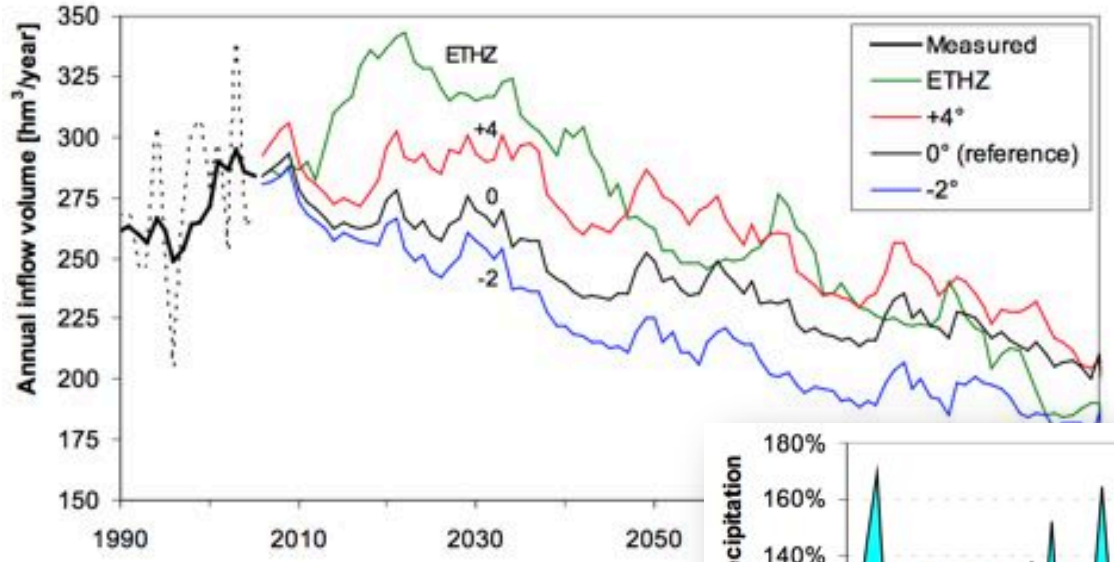
Example Swiss Alps

- Formation of new glacier lake expected for mid 21st century
- Case study for integration of new lake into an existing hydropower scheme



Haeberli et al., 2013

Example Swiss Alps



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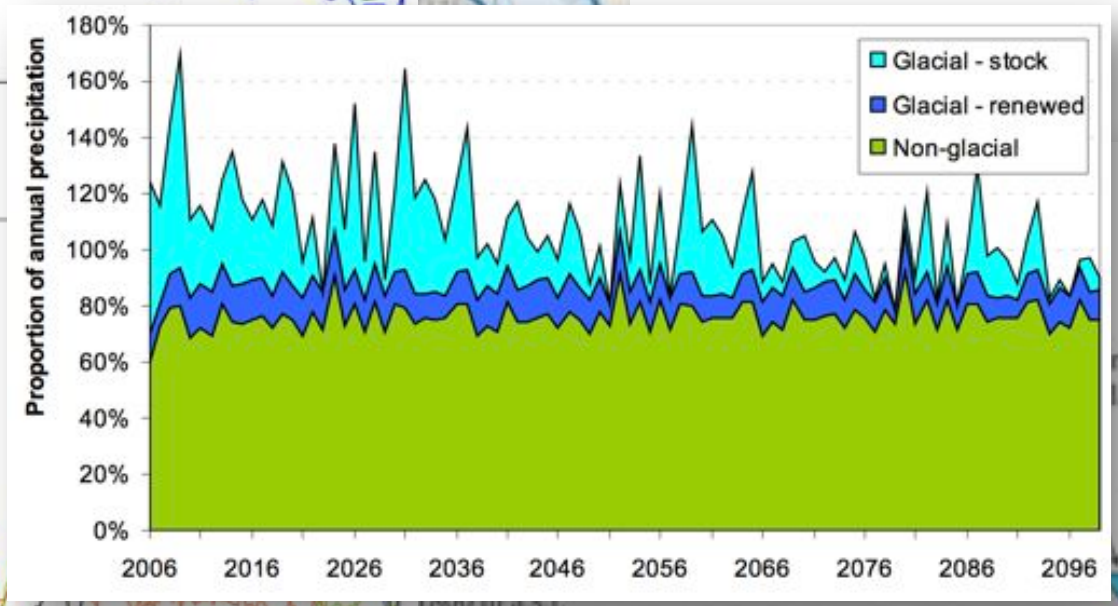
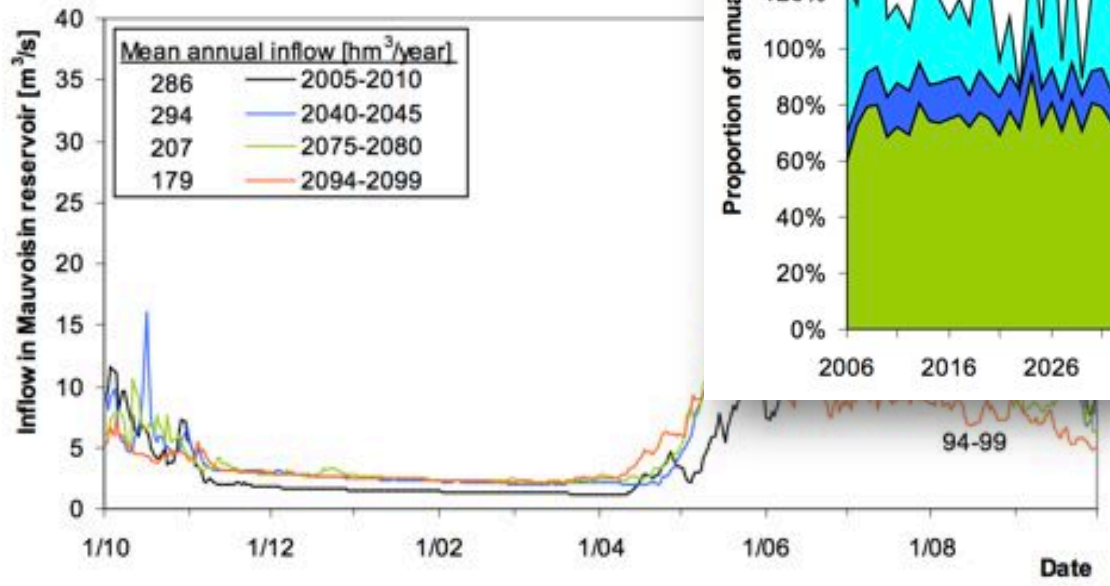




Dr. Holger Frey, February 5, 2015

STRUCTURAL DRR MEASURES: TO REMEMBER

- Structural measures at lakes
  - Lowering of lake level (siphoning, tunnelling, trenching)
  - Raise and/or reinforcement of dam
  - Outlet control

  → Lowering of the *hazard potential*

- Other mass movements: Protective structures

- Measures require maintenance

- Constantly changing conditions require constant observations

- Multi-purpose infrastructures offer interesting opportunities

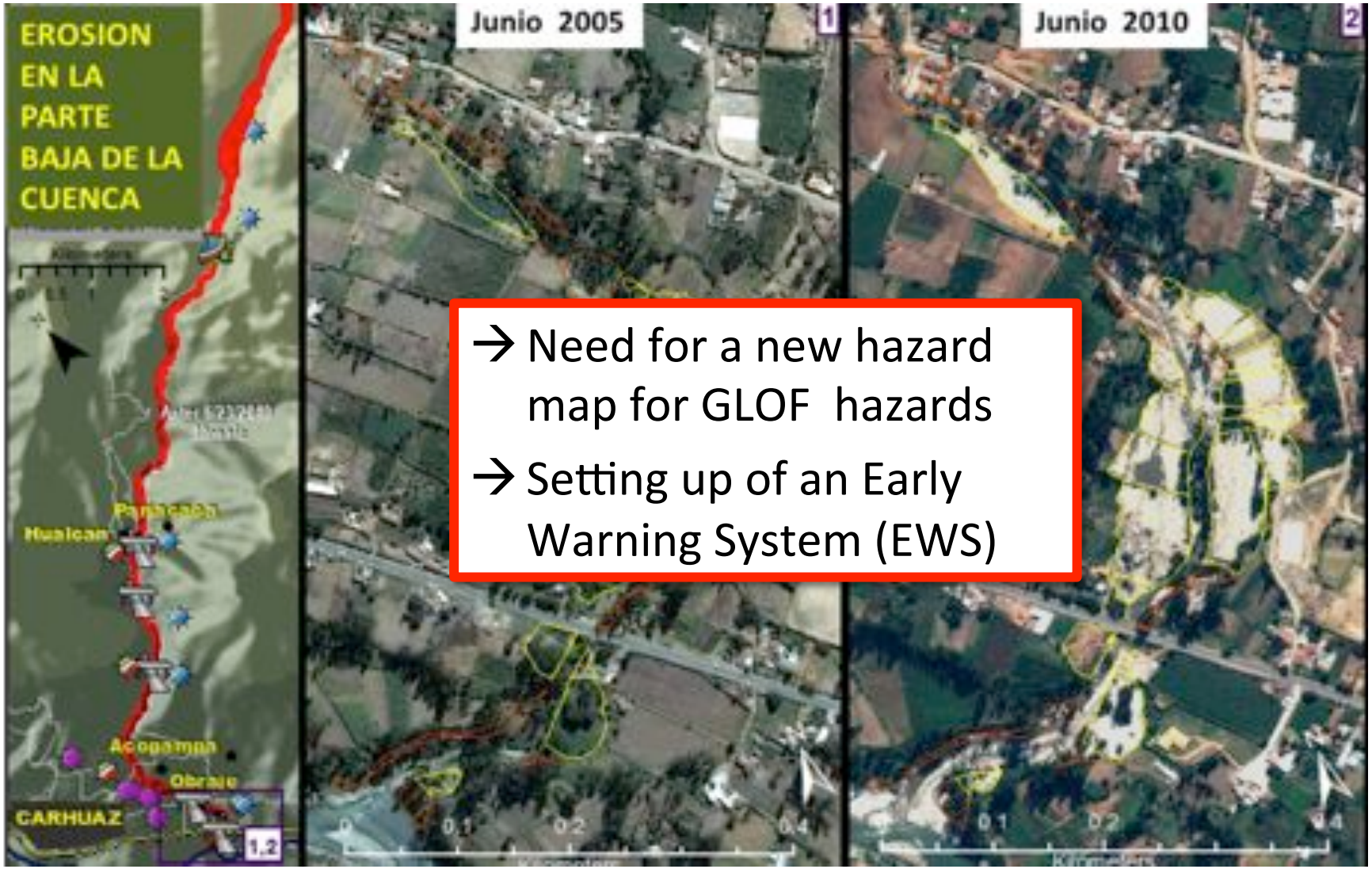
Laguna 513: GLOF 11 April 2010

Lake outburst 11 April 2010

Laguna 513: Event April 2010

Area of the freshwater intake at Pampa Shonquil during the glacial lake outburst flood, April 11, 2010 (photo by Arq. Luis Meza)

Lake outburst 11 April 2010



→ Need for a new hazard map for GLOF hazards

→ Setting up of an Early Warning System (EWS)

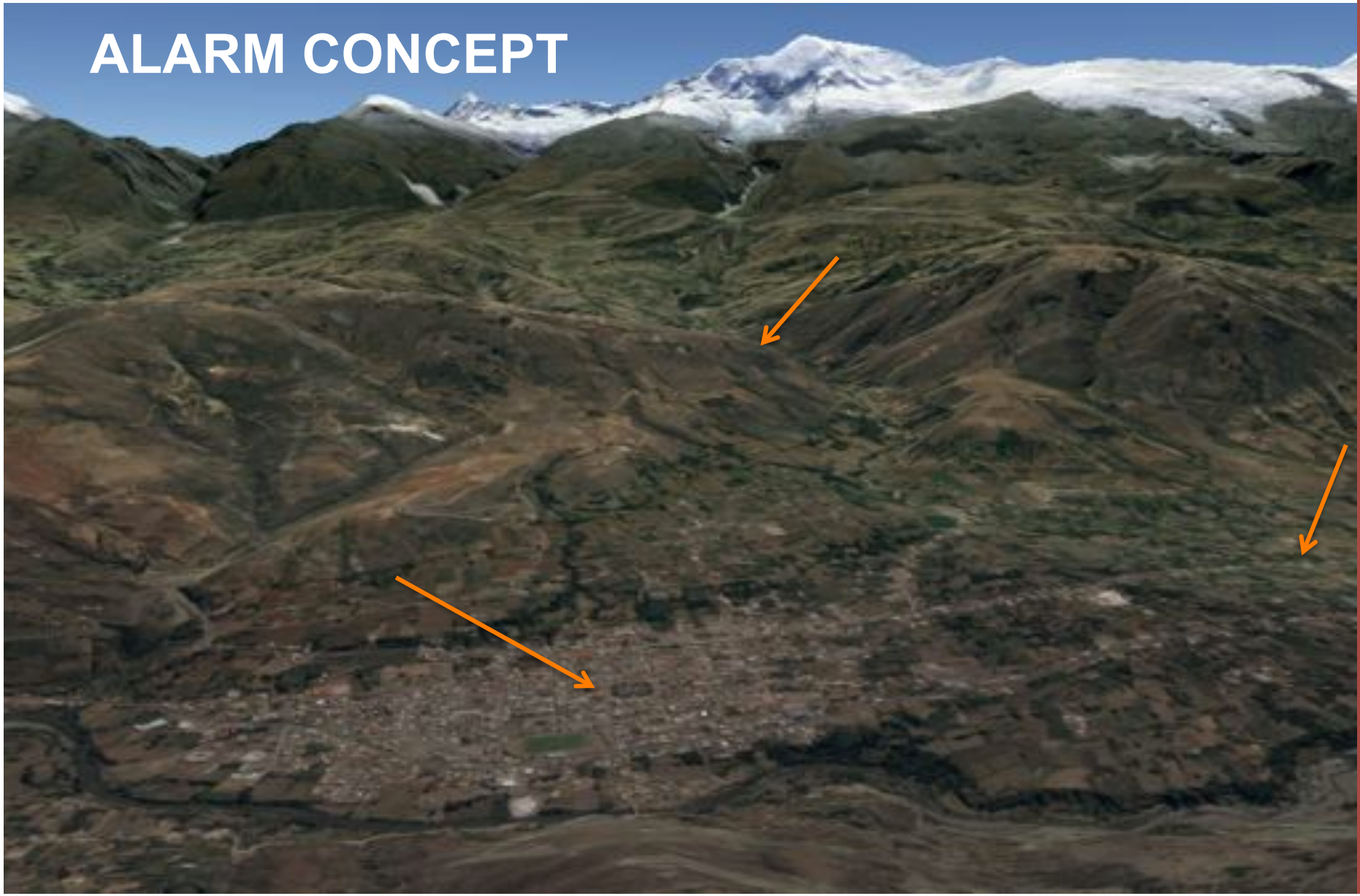
INDIRECT (SOFT) MEASURES

ACTION PLAN

RED WARNING	More than 30 mm rain observed in 1 hour and expected to continue in the next 2 hours. TORRENTIAL	Serious flooding expected in low-lying areas	EVACUATION
ORANGE WARNING	15-30 mm rain observed in 1 hour and expected to continue in the next 2 hours. INTENSE	Flooding is threatening	ALERT for possible evacuation
YELLOW WARNING	7.5-15 mm rain observed in 1 hour and expected to continue in the next 2 hours. HEAVY	Flooding is possible	MONITOR the weather condition

INDIRECT (SOFT) MEASURES

ALARM CONCEPT

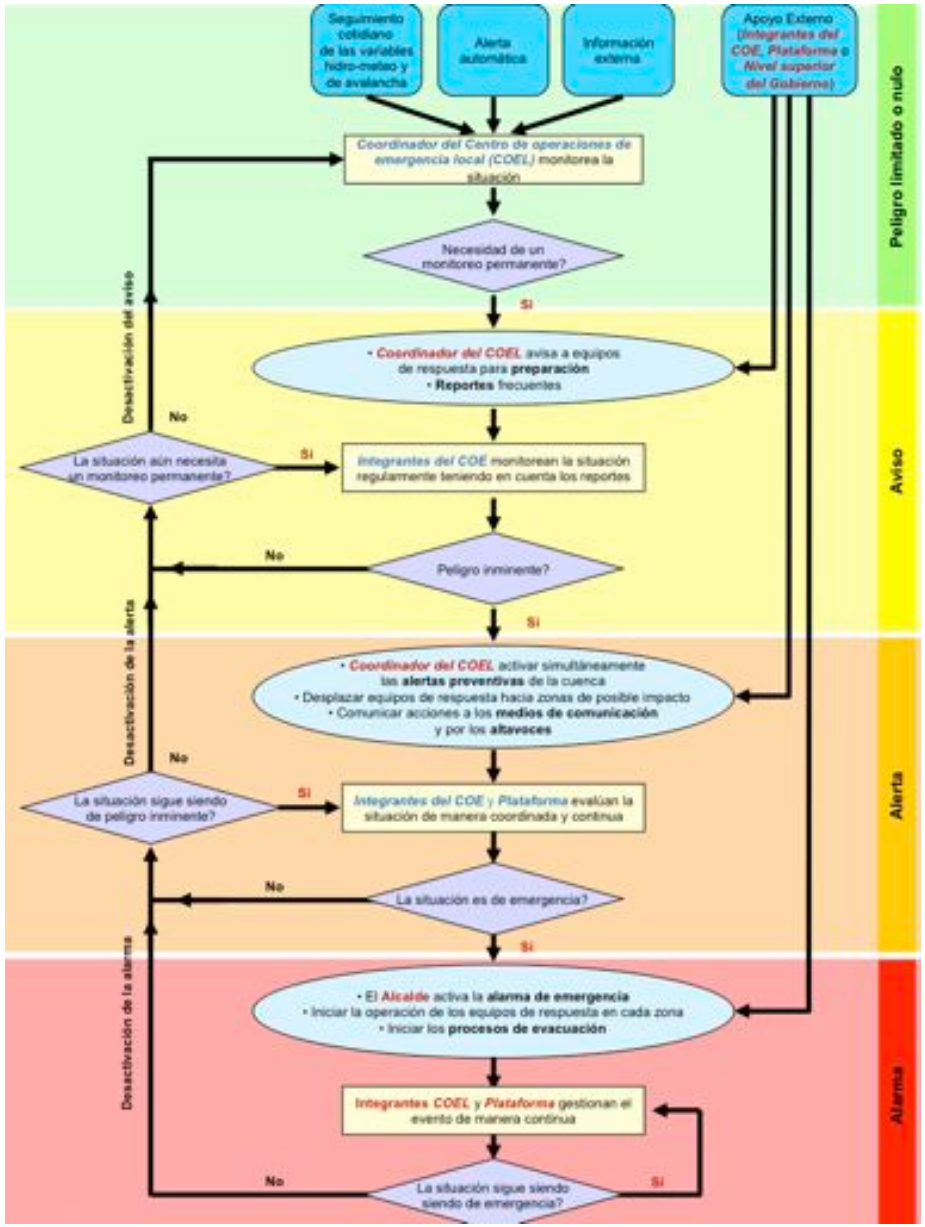


INDIRECT (SOFT) MEASURES

EVACUATION ROUTES

INDIRECT (SOFT) MEASURES

Action plan EWS Carhuaz



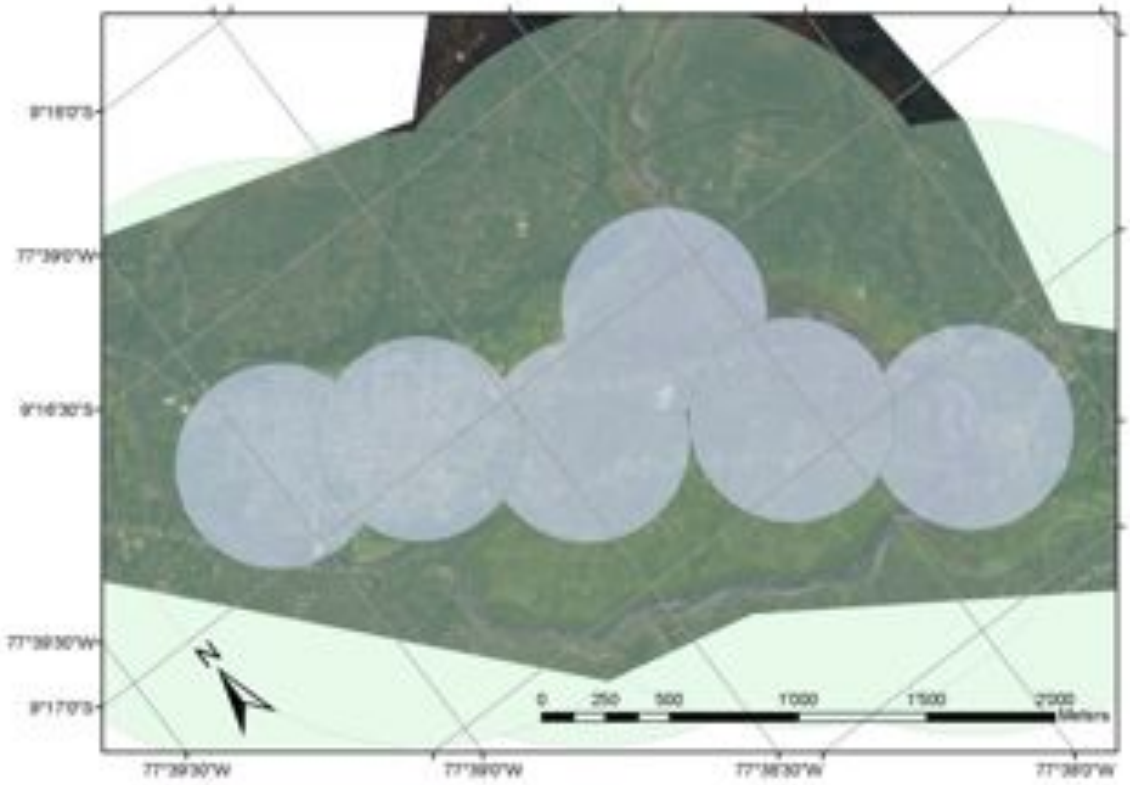
- 4 alert levels
- Operation procedures at each level
- Accompanied by a list with names and cell phone numbers of involved persons (and their deputies)

Alarm concept

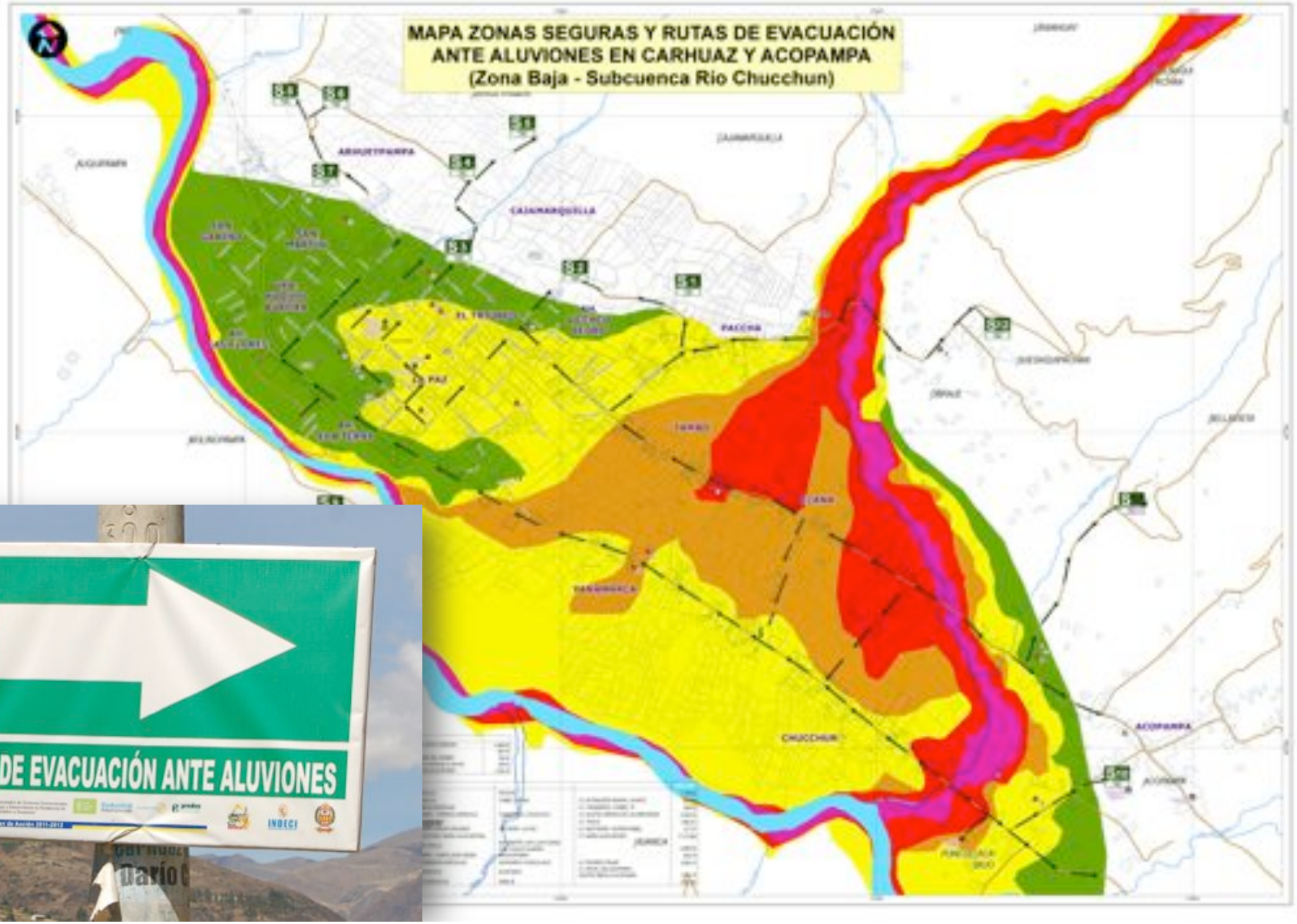
Sirens (combined with loudspeakers?)
→ assessment of conditions required (wind, blackout,…)


HS-40RT

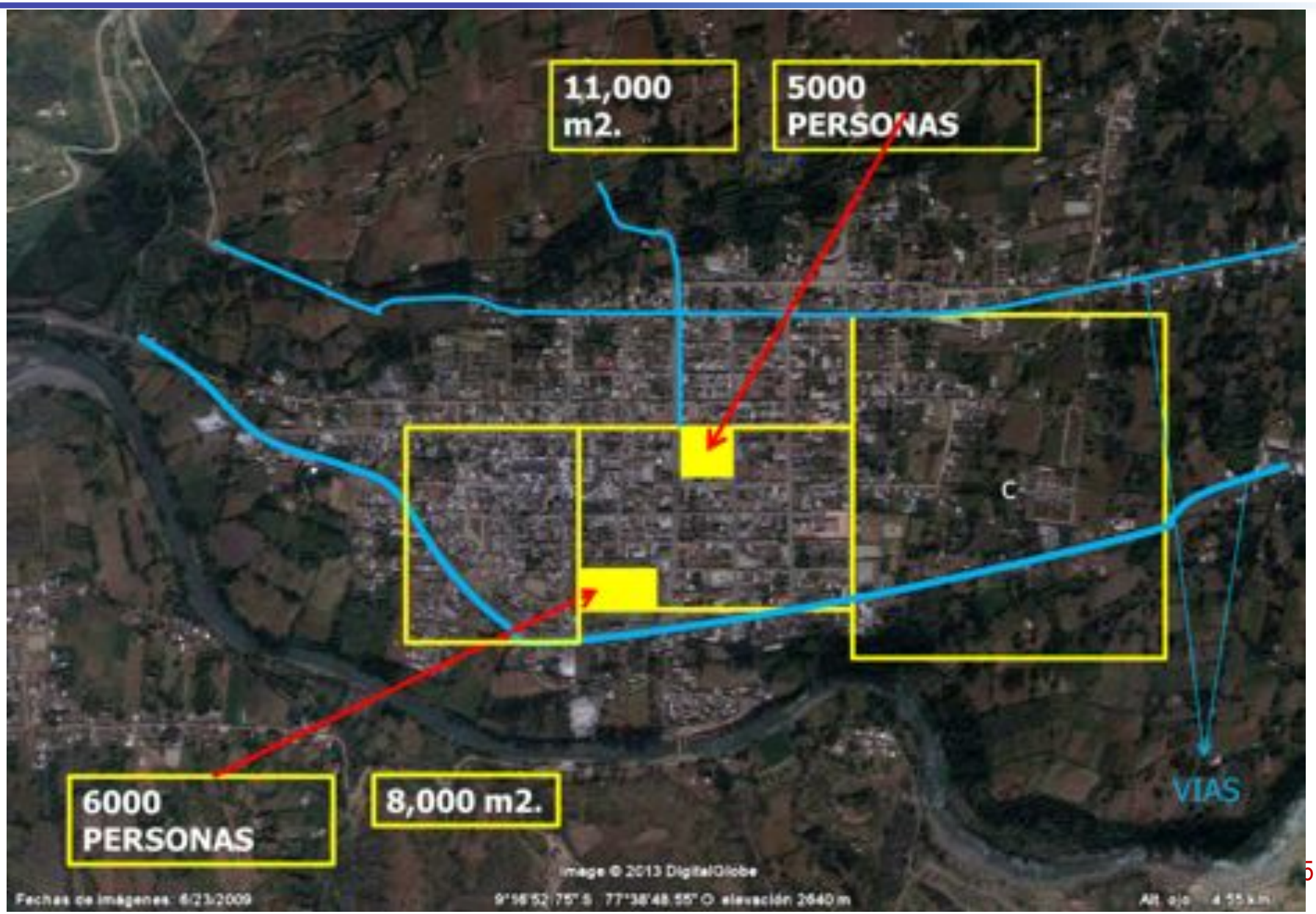
SMS alerts to community leaders



Laguna 513: Evacuation routes



Laguna 513: Assembly points



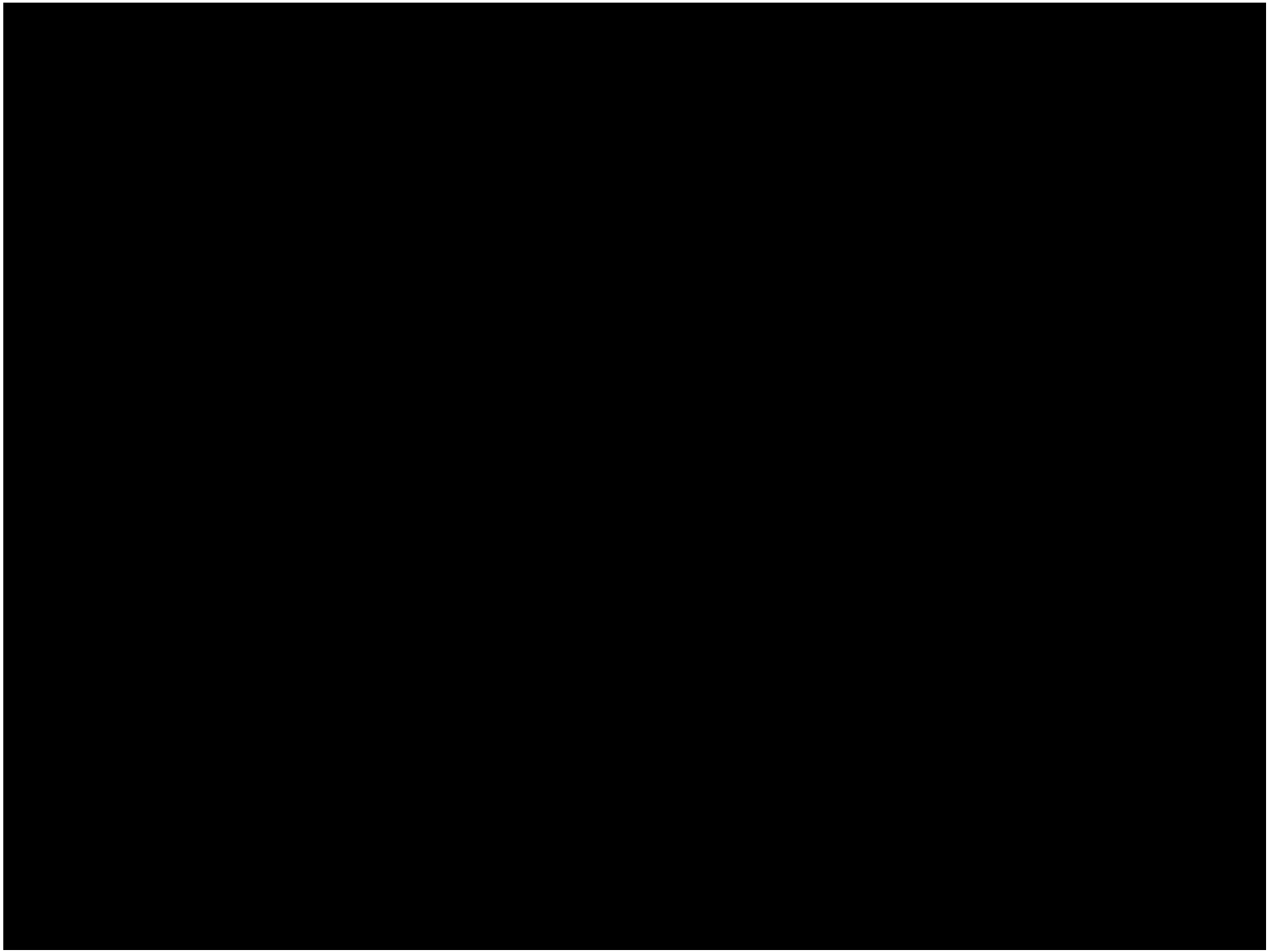
INDIRECT (SOFT) MEASURES

Photos: CARE

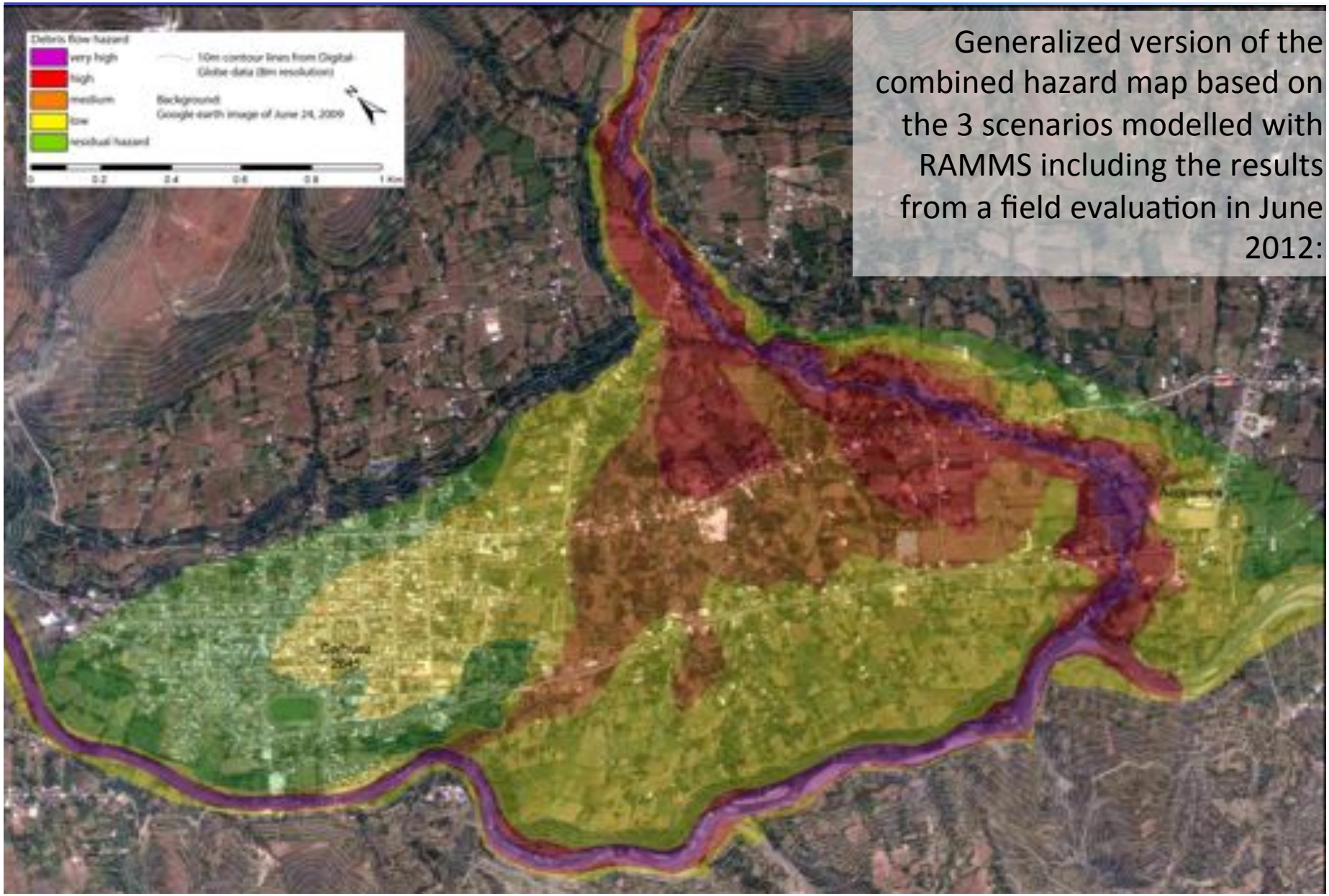
Disaster Risk Reduction

TO REMEMBER

- Structural measures lower the hazard potential
- Indirect, non-structural measures lower the vulnerability and/or exposure
- Direct measures are often more expensive and require more time for implementation
- Socio-economics have a large impact on indirect measures
- Indirect measures require constant revisions and constant contact to the population (communication!)
- Without preparedness and responsiveness of the populations, indirect measures will not be successful



Laguna 513: Compilation of a hazard map



Generalized version of the combined hazard map based on the 3 scenarios modelled with RAMMS including the results from a field evaluation in June 2012:

Laguna 513: Compilation of a risk map