DECISION AID MODELS FOR DISASTER MANAGEMENT

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Mathematical Models in Humanitarian Logistics
Universidad Complutense de Madrid (Spain)

UCM Research Group: Mathematical Models for Humanitarian Logistics

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1. Disaster Management

- **Hazard: threatening event or probability of occurrence of a potentially damaging phenomenon within a given time period and area**

  - **Natural:** naturally occurring physical phenomena caused either by rapid or slow onset events which can be **geophysical, hydrological, climatological, meteorological** or **biological**
    - earthquakes, landslides, tsunamis, volcanic activity, avalanches, floods, extreme temperatures, drought, wildfires, cyclones, storms/wave surges, disease epidemics, insect/animal plagues

  - **Technological or Man-made:** events **caused by humans** and occur in or close to human settlements
    - complex emergencies/conflicts, famine, displaced populations, industrial accidents (toxic dumps, radioactive escapes...) and catastrophic transport accidents

1. Disaster Management

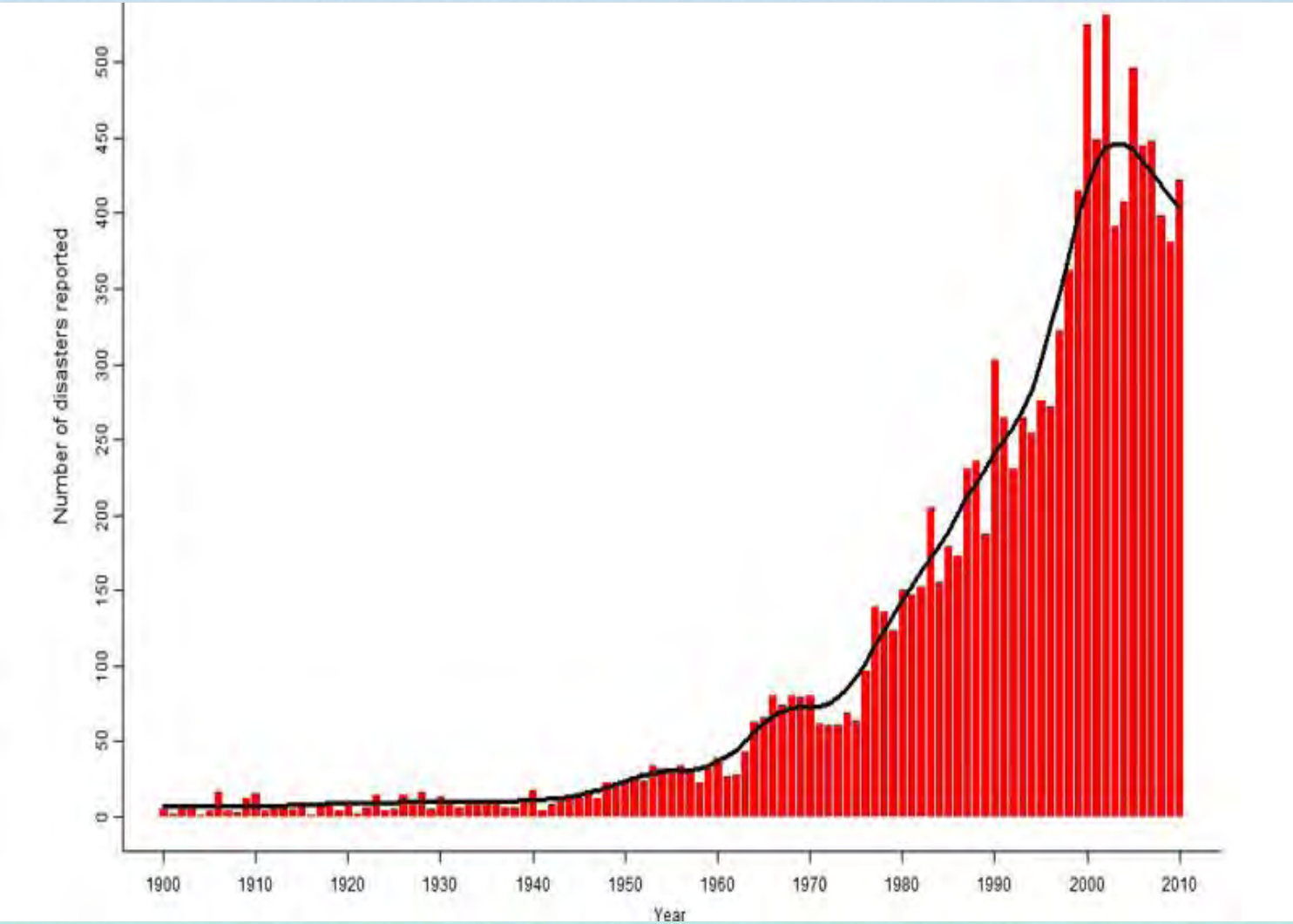
- **Emergencies, Disasters and Catastrophes:**
  - **Emergency:** situation that poses an immediate risk to health, life, property or environment
  - **Disaster:** disruption of the normal functioning of a system or community, which causes a strong impact on people, structures and environment, and goes beyond local capacity of response.
  - **Catastrophe:** extremely large-scale disaster

Sometimes, political decision.

Just as "disasters" are qualitatively different from everyday community emergencies, so are "catastrophes" a qualitative jump over "disasters"

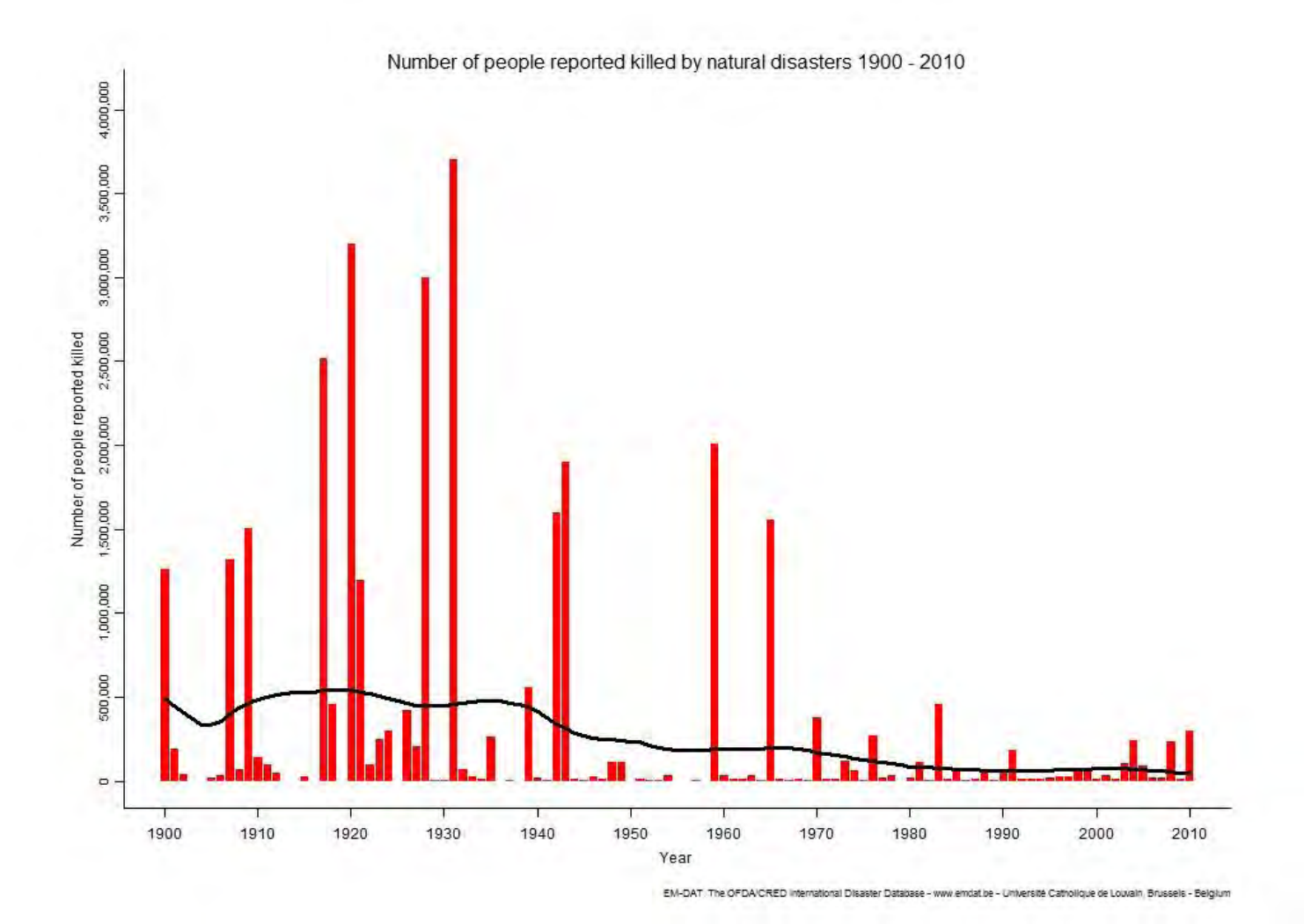
Quarantelli (2006). Catastrophes are Different from Disasters: Some Implications for Crisis Planning and Managing Drawn from Katrina. http://understandingkatrina.ssrc.org/Quarantelli/

1. Disaster Management



EM-DAT database. CRED. http://www.emdat.be/

1. Disaster Management



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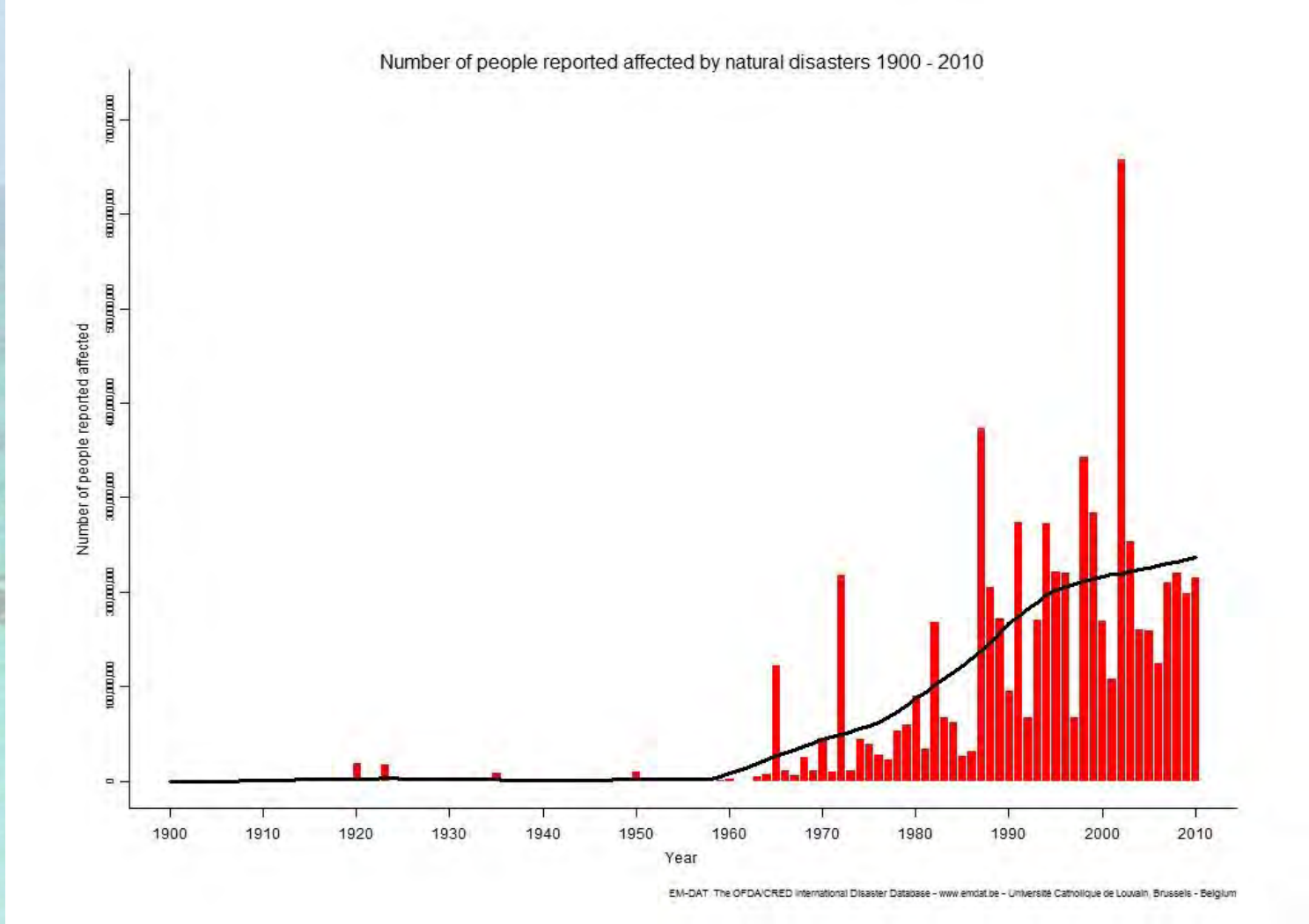
1. Disaster Management

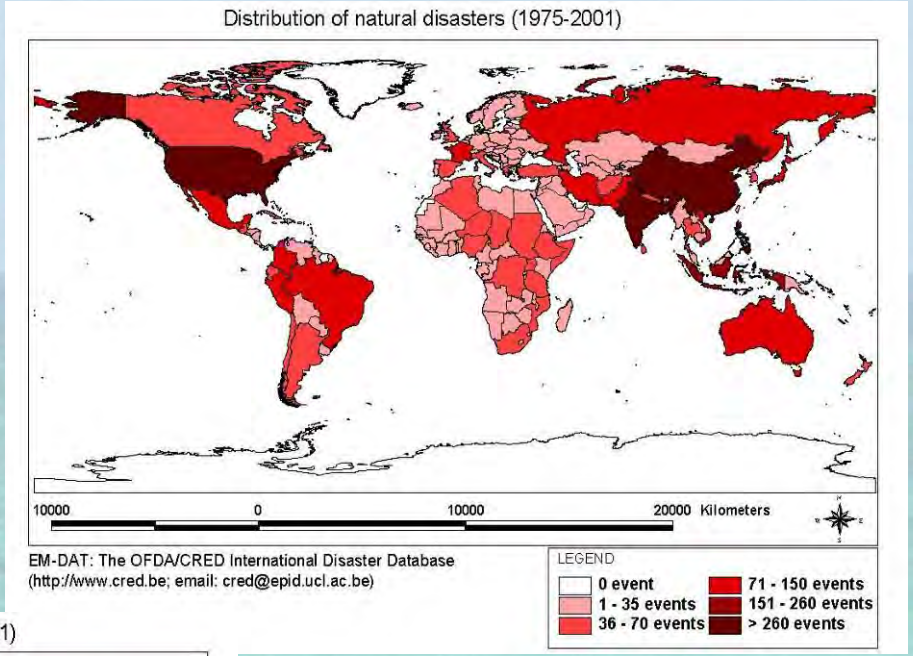


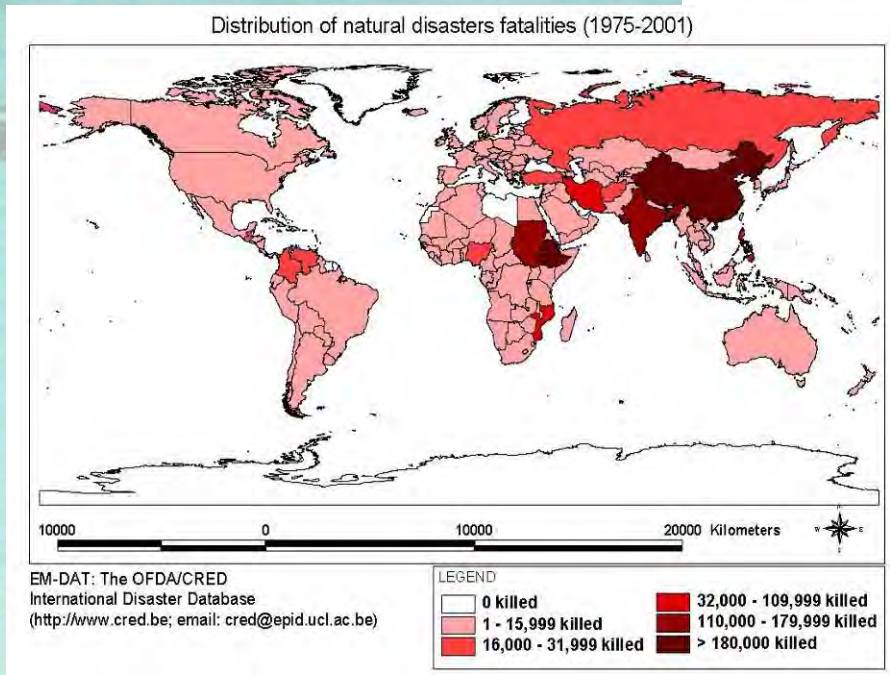
EM-DAT database. CRED. http://www.emdat.be/

Natural disasters caused during 2008 almost 220.000 casualties and loses estimated in more than 142.000 millions of Euros…

1. Disaster Management

The number of casualties is more related to the country vulnerability than to the magnitude of the disaster or the number of disasters





1. Disaster Management

- **Disaster response**:
  - Complex process that involves:
    - severe time pressure
    - high uncertainty
    - many stakeholders
  - **High level of novelty** to deal with the unexpected under uncertainty and time pressure
  - ICT used can **greatly vary from one response situation to another**.
  - Several **autonomous agencies to collaboratively** mitigate, prepare, respond, and recover from heterogeneous and dynamic sets of hazards to society.

1. Disaster Management

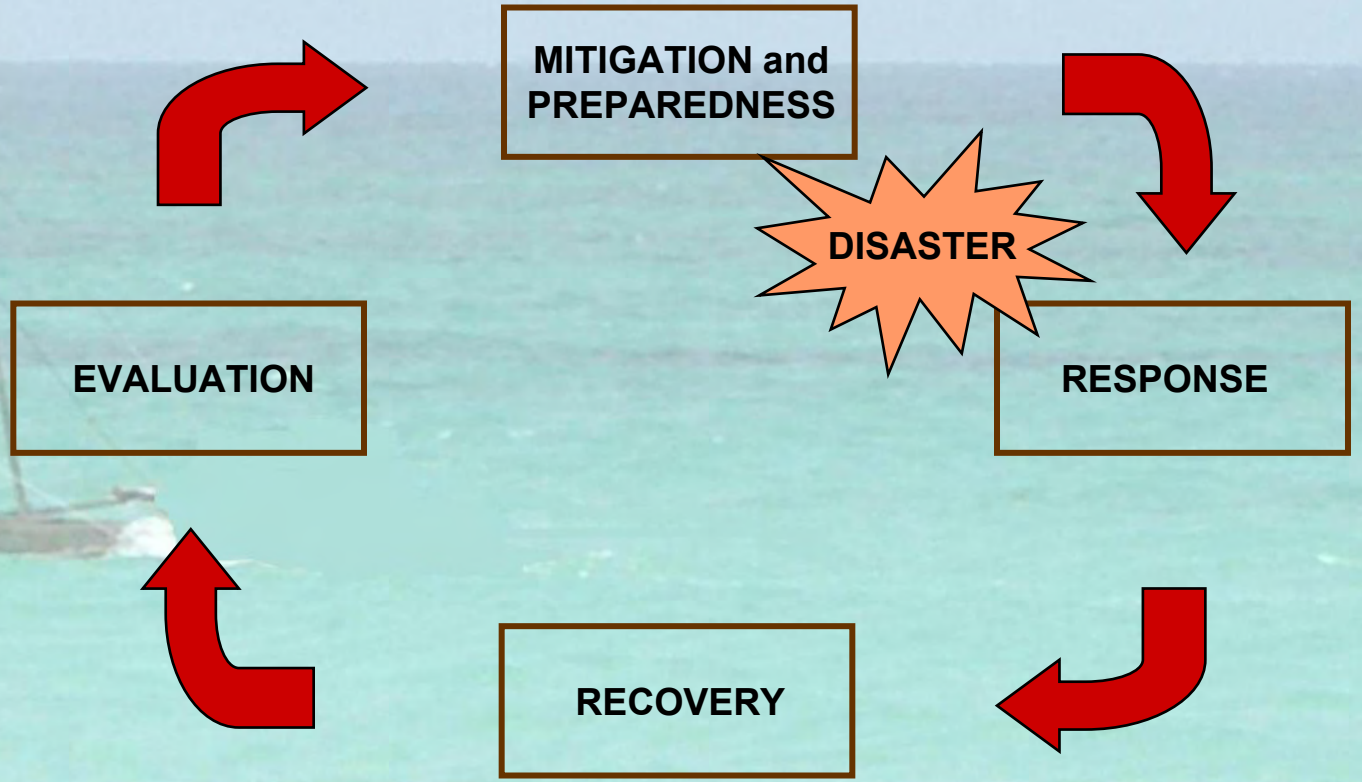
- Agents involved different depending on
  - the type of disaster:
    - technological disaster usually civil protection and locally security agencies
    - natural disasters usually involve also others like NGOs and international agencies
  - the disaster consequences and the place where it strikes
    - vulnerability
    - developing countries usually needs international relief operations because quickly their local capacity to respond is exceeded

1. Disaster Management

- **RELIEF OPERATIONS AGENTS INVOLVED**
  - **Local level:**
    - **Local civil society organisations**
    - **Local agencies and civil protection**
  - **National level:**
    - **National civil protection and national army**
    - **Other national governmental organisations**
    - **National NGOs**
  - **International level:**
    - **Foreign governments and Inter-governmental organisations:**
      European Union: ECHO, USA: USAID
    - **International NGOs for disaster response:**
      - **Red Cross/Red Crescent**
      - **World Vision, MSF, ACF, Oxfam…**
    - **UNITED NATIONS: OCHA. Coordination**
      - **Agencies: WFP, UNICEF, UNPD, UNHCR… and local offices**
    - **IASC (**Inter-Agency Standing Committee): primary mechanism for **inter-agency coordination**. Key UN/non-UN humanitarian partners

1. Disaster Management

Phases of Disaster Management



1. Disasters Management

- **Pre-event tasks: Mitigation & Preparedness**
  - **Mitigation**: measures to prevent or reduce the impacts
  - **Preparedness**: activities that prepare the community
- **Post-event tasks: Response & Recovery**
  - **Response:** employment of resources and emergency procedures to preserve life, property, the environment, and the social, economic, and political structure of the community (**Humanitarian logistics: Humanitarian Supply Chain**)
  - **Recovery:** actions taken after the immediate impact of the disaster to stabilize the community and to restore some semblance of normalcy
- **Evaluation:** Performance evaluation

1. Disasters Management

- **Response: Life cycle and relative resource requirements for a relief mission**
- **4 phases**

(1) assessment – minimal resources are required to identify what is needed, based on disaster characteristics

(2) deployment - resource requirements ramp up to meet a need

(3) sustainment - operations are sustained for a period of time

(4) reconfiguration - operations are reduced, then terminated

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2. Humanitarian Logistics

- **What is "Humanitarian Logistics"?:**

"*The process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials as well as related information, from the point of origin to the point of consumption for the purpose of meeting the end beneficiary's requirements and* ***alleviate the suffering of vulnerable people****.*

It encompasses a set of activities, including preparation, planning, procurement, transportation, storage, history and customs control "

(Humanitarian Logistics Conference, 2004, Fritz Institute)

Disaster management but other relief operations, health supply chains…

2. Humanitarian Logistics

Commercial versus Humanitarian Logistics

- **Business logistics and commercial supply chains:** operations based on forecast demand, inventory control and models that optimise a dynamic system.
- **Humanitarian supply chains main differences**:
  - **unpredictable demand** in terms of timing, geographic location, type of commodity, quantity of commodity;
  - **short lead time and suddenness of demand for large amounts** of a wide variety of products and services;
  - **lack of initial resources** in terms of supply, human resources, technology, capacity and funding.

    (Balcik and Beamon, 2008)
- **Efficacy and Transparency**

2. Humanitarian Logistics

	Commercial	Humanitarian
• **Demand pattern**	Relatively stable, predictable: fixed locations in set quantities	Unpredictable timing, location, type and size. Estimated after needed
• **Lead Time**	Determined by supplier-manufacturer-retailer chain	Almost zero lead times requirements; chain
• **Distribution Network**	Well-defined methods for locating distribution centers	Challeging due to unknowns, last mile considerations
• **Inventory Control**	Well-defined methods for inventory levels	Challenging high variations demands, lead times…
• **Information System**	Well defined, advanced technology	Often unreliable, incomplete or non-existent
• **Strategic Goals**	Maximize profitability and high customer satisfaction	Minimize loss of life and alleviate suffering
• **Performance Measurement**	Resource performance: max profit or min costs	Output performance: time to respond, “customer” satisf.
• **What is demand?**	Products	Supplies and People


Assessment and Planning
Procurement
Warehouse & Inventory
Transport
Fleet Management
Cold Chain
Customs
Distribution
Monitoring & Evaluation
Humanitarian Supply Chain

Contents

3. Decision Aid Models

Mitigation, Preparedness

Planning: emergency protocols,… Risk, uncertainty

Disaster response

Response: Emergency intervention

Initial estrategics decisions:
Assesment of consequences and needs

↓

Medium term decisions (supply chain)

↓

Decisions on the field

Recovery ► Cooperation for development

3. Decision Aid Models

Mitigation, Preparedness

Risk/scenario analysis, optimisation and planning
(stocks, routing, location…)
Multicriteria decisions with high uncertainty

Disaster response

Information… Uncertainty, unreliable, time pressure

Optimisation and re-optimisation of previous planning
Time pressure, multicriteria decisions, uncertainty

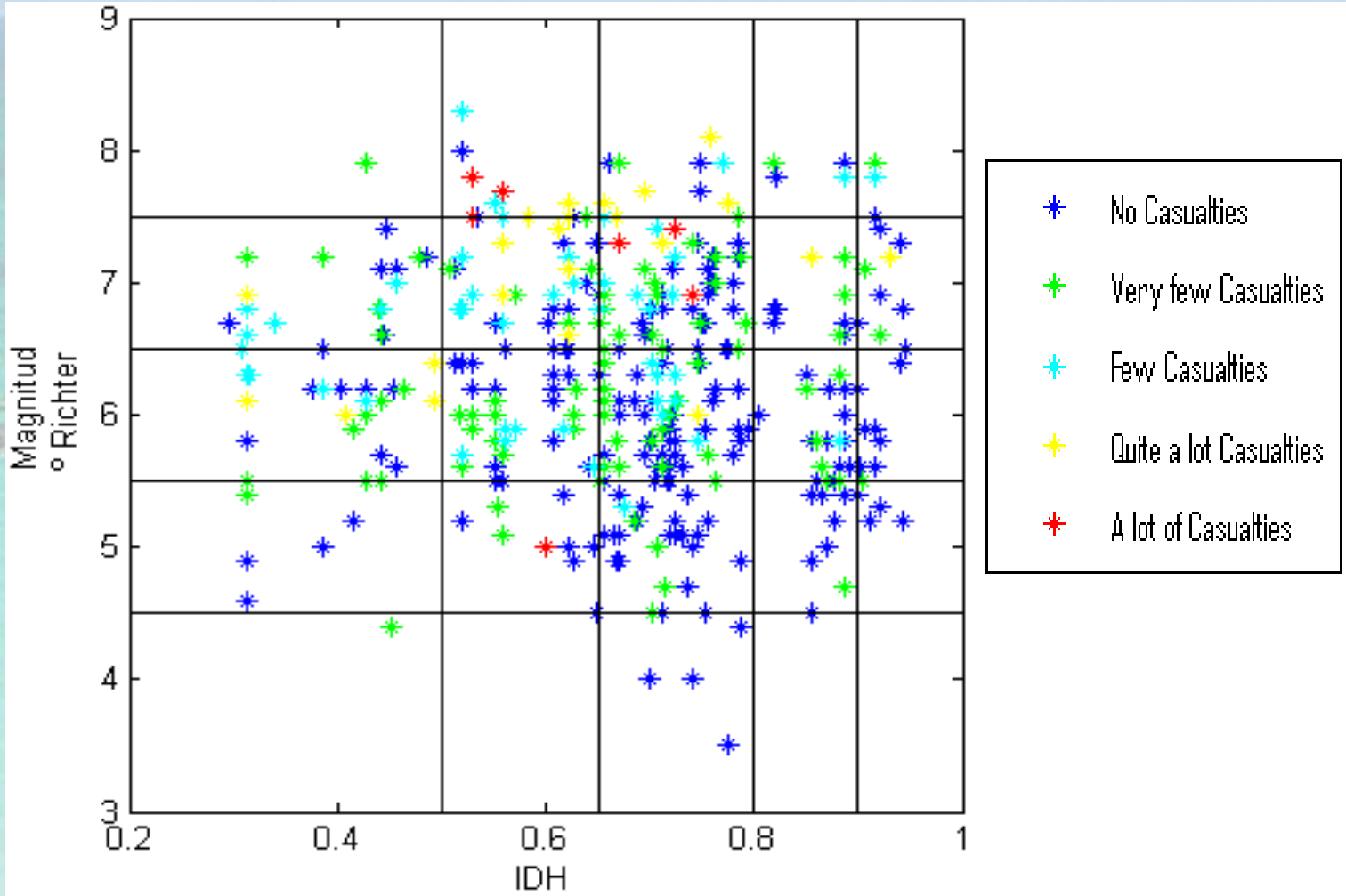
Re-optimisation, very time pressure

Recovery: discrete decisions, present and future impact

3. Decision Aid Models

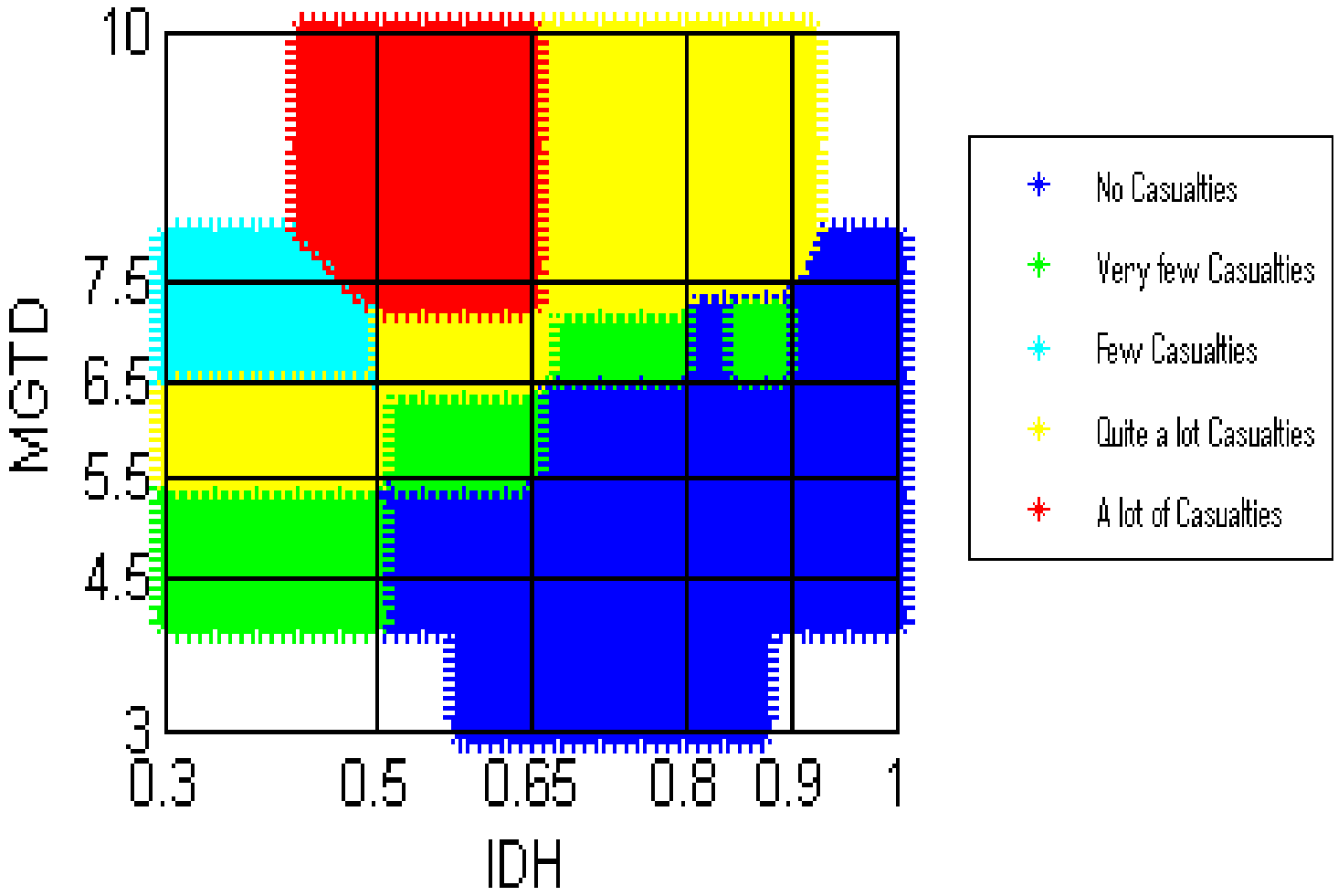
- **Data base EM-DAT www.emdat.be of CRED**

(Centre for Research on the Epidemiology of Disasters)



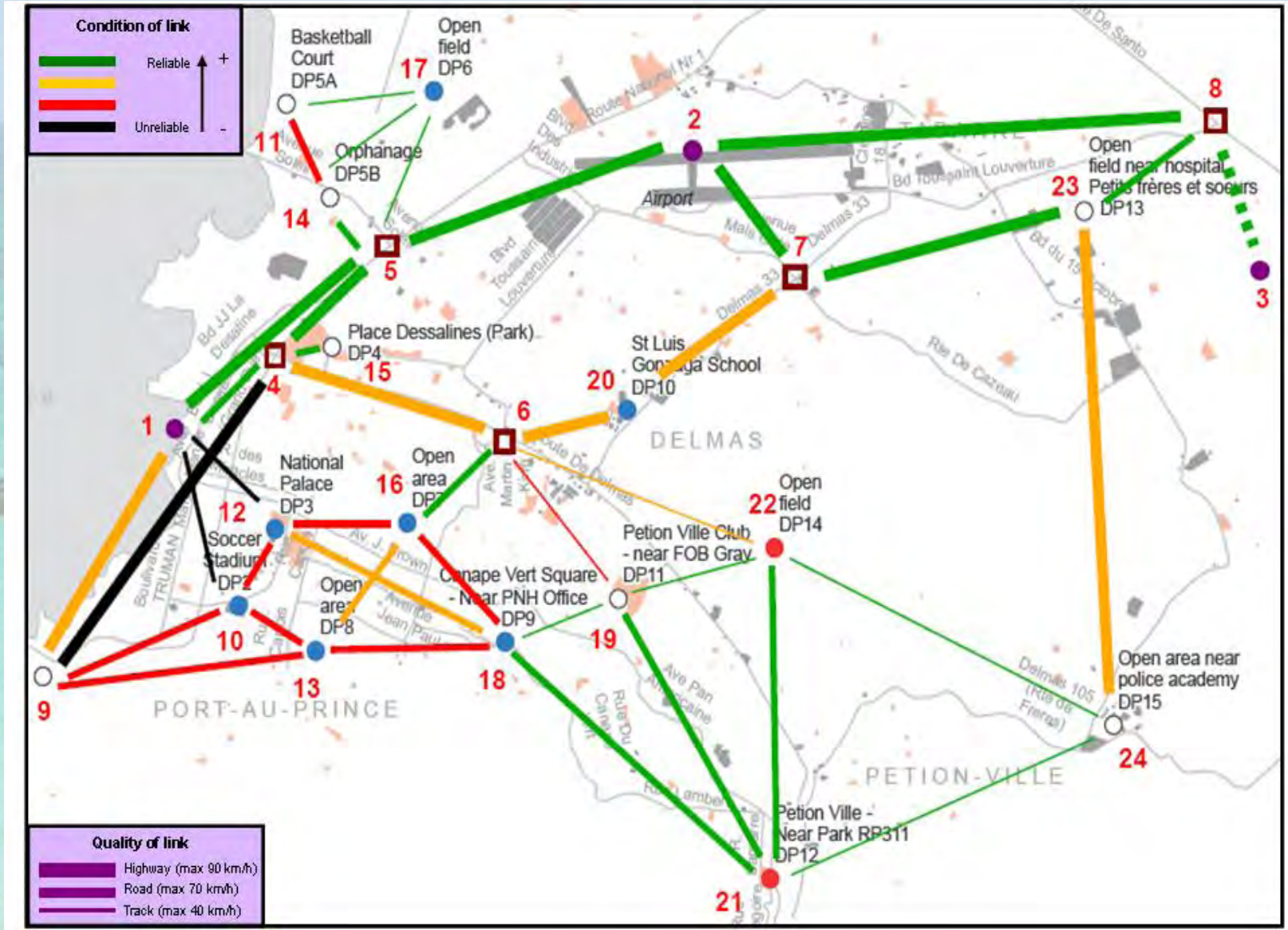
3. Decision Aid Models

Fuzzy classification using bipolar information



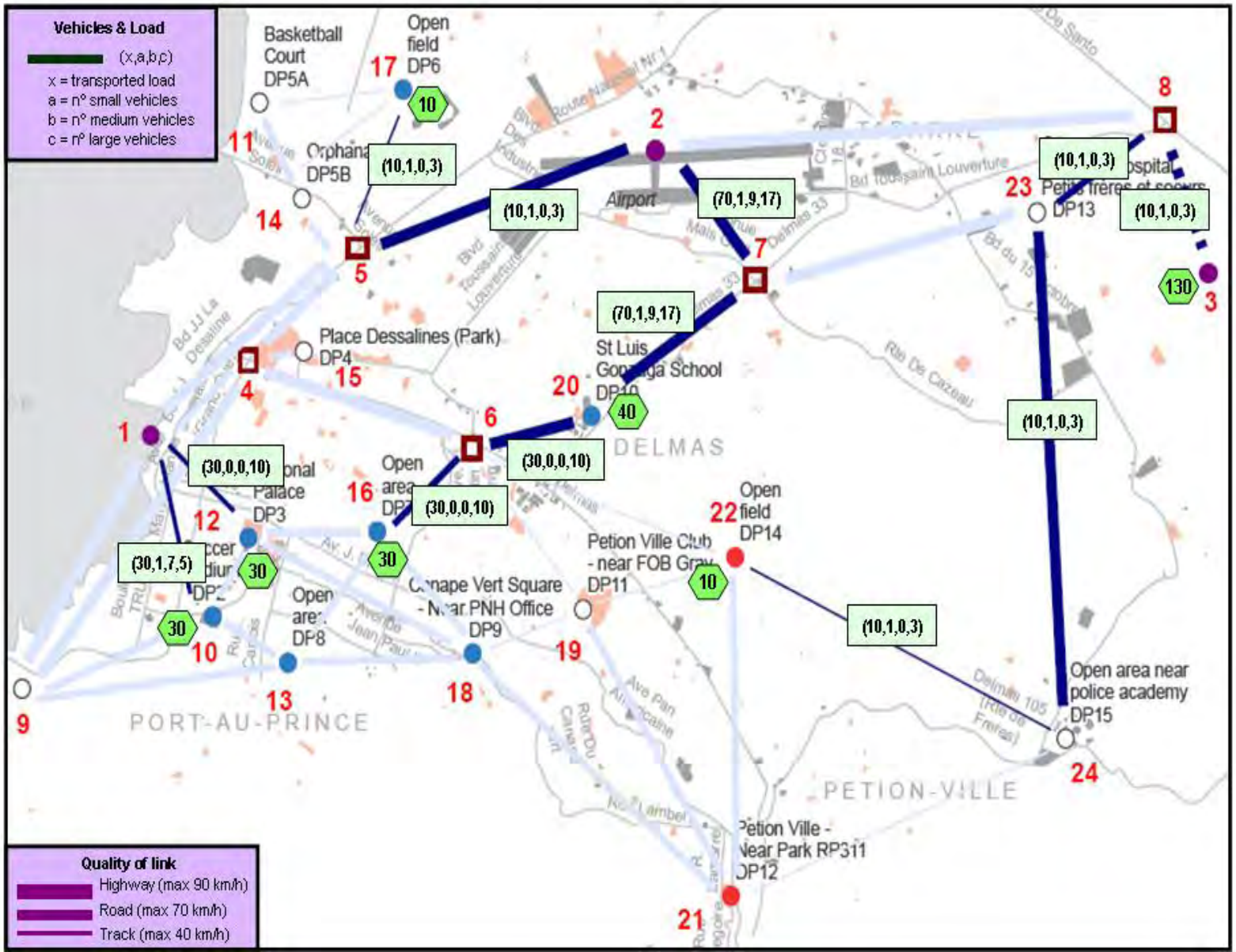
3. Decision Aid Models

Case study: Haiti earthquake 2010



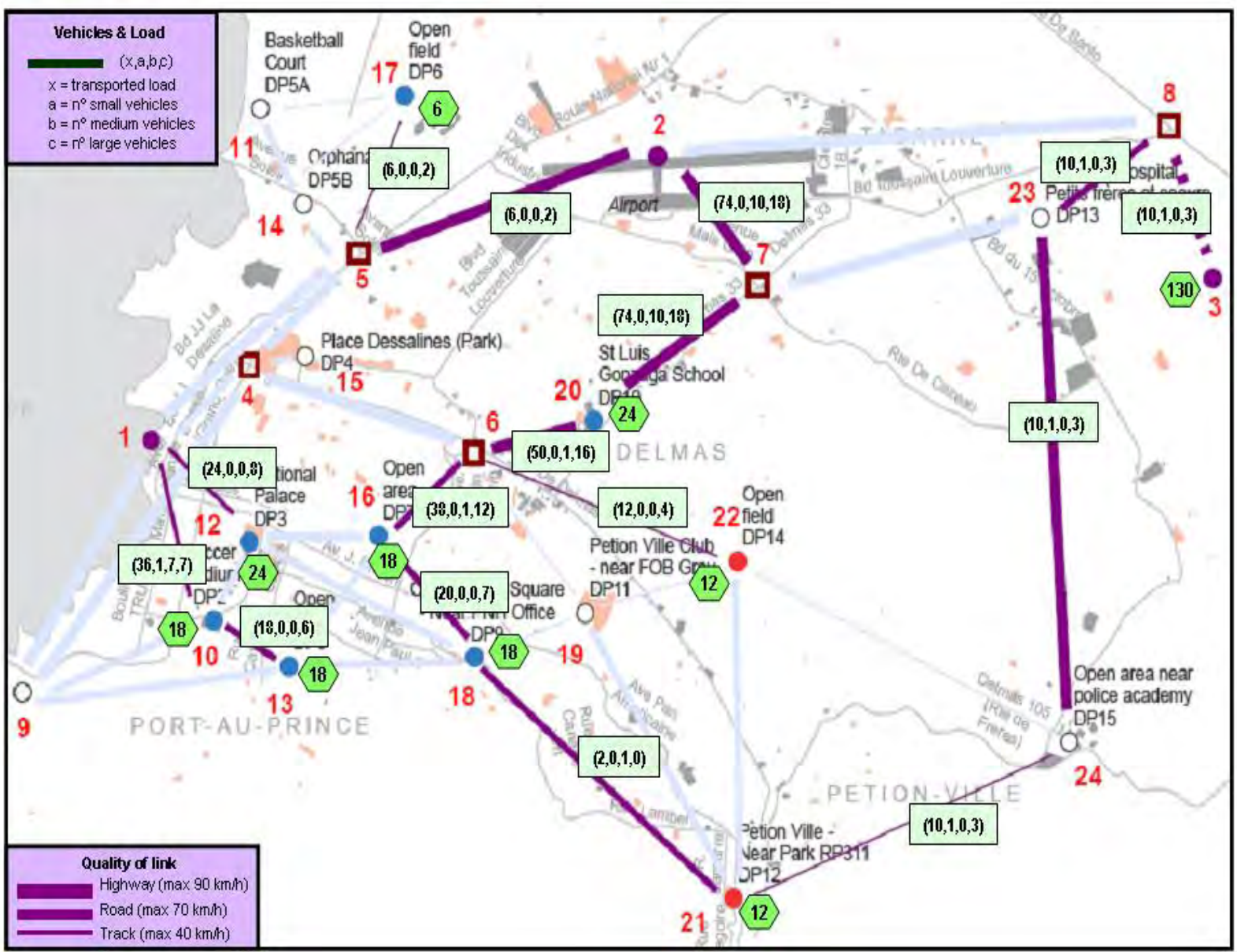
3. Decision Aid Models

Total Cost Itinerary:



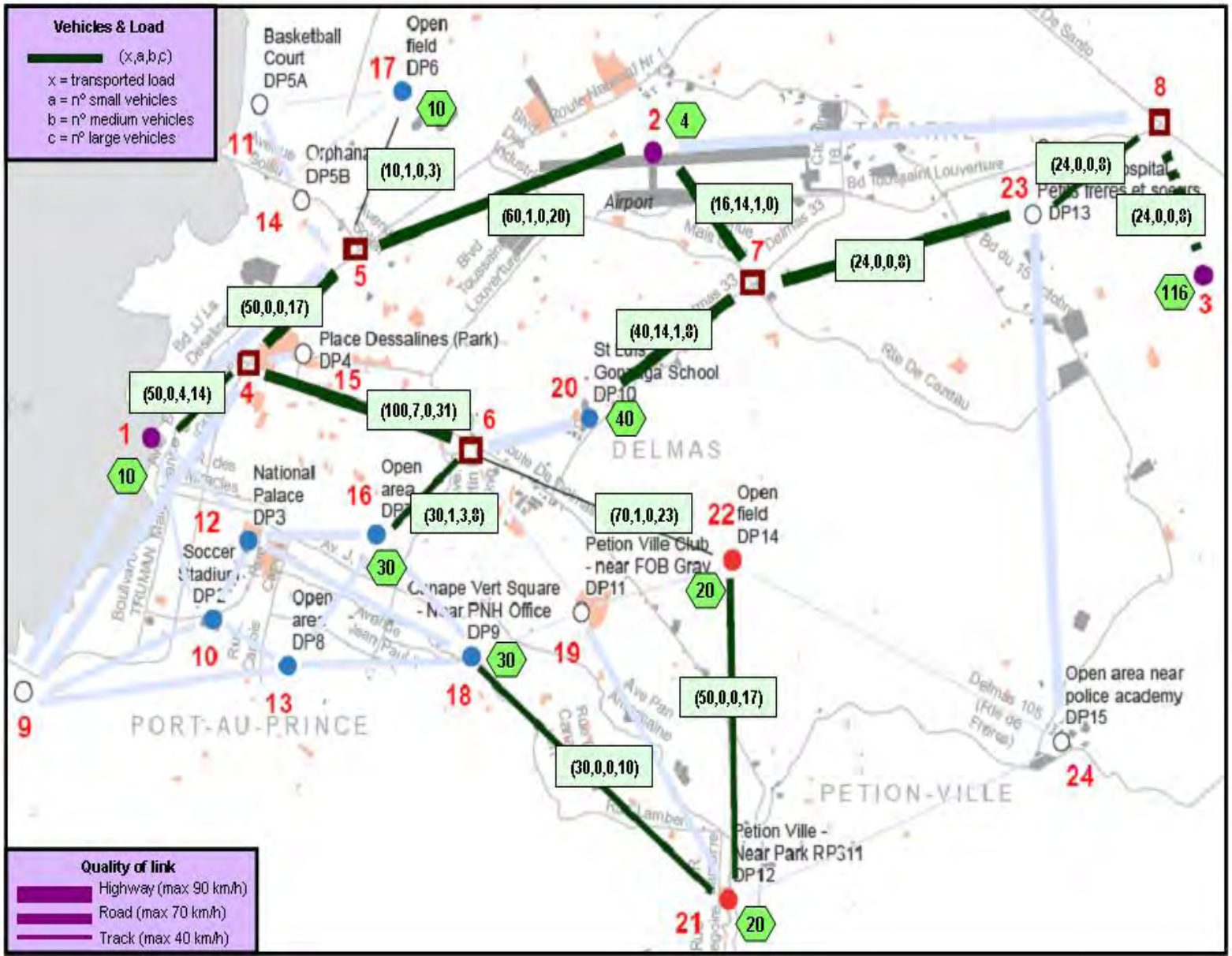
3. Decision Aid Models

Equitable Itinerary:



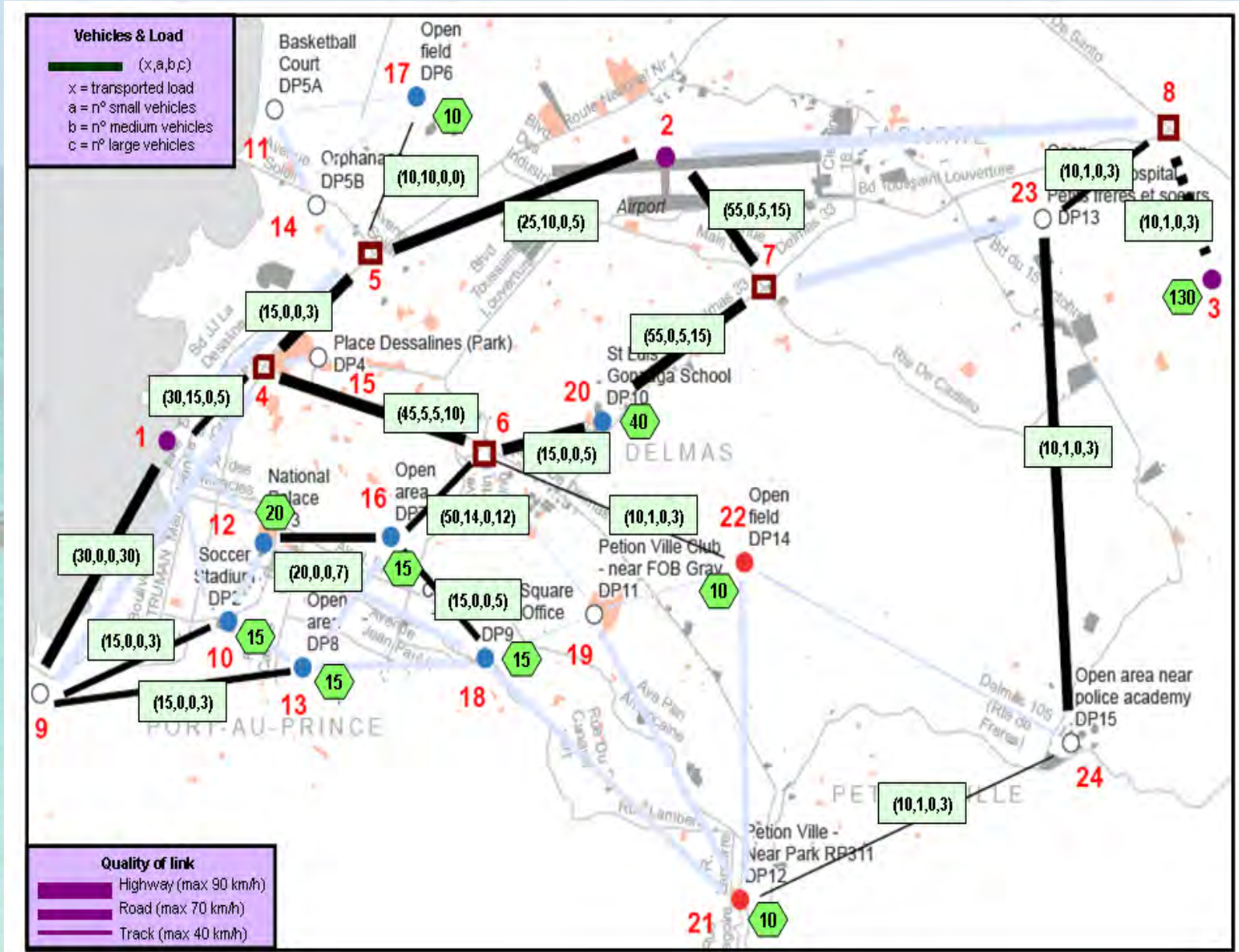
3. Decision Aid Models

Maximum reliability Itinerary:



3. Decision Aid Models

All criteria-weighted Itinerary:



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4. Conclusions

- Disaster management is a very difficult task involving a big amount of stakeholders
- Pre-event tasks are focused on planning and can be developed without time pressure but very high uncertainty
- Post-event tasks are performed under a high time pressure and with main objectives: efficacy and transparency
- Humanitarian logistics and supply chain have significant differences with other logistics
- ICT are becoming basic tools
- Specific decision aid models are required, but until now no much have been developed.
- **Operational research** has to became key tool