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Risk based approaches for long-term plan of coastal flood defences- A Vietnam case

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Outline

- Background
- Flood defences in Vietnam
- Research question and Study approach
- Application: Vietnam coastal flood defences
- Conclusions

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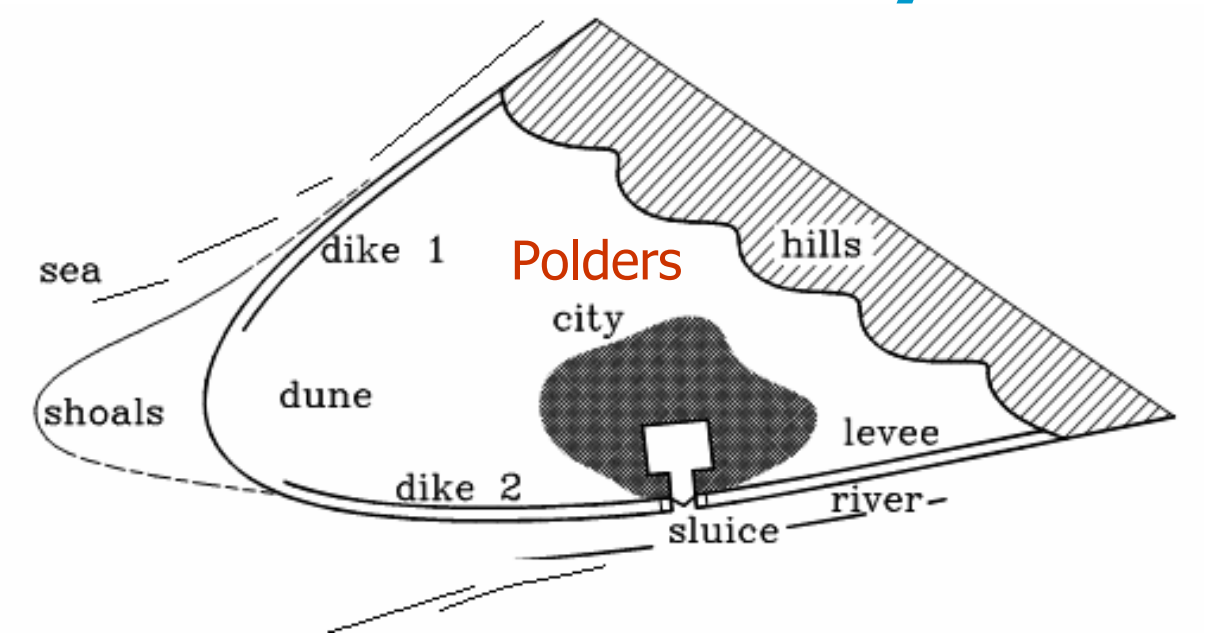
a flood defence system



Main interests:

- What is the actual safety of the protected polders?
- Whether safe is safe enough?

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Flood risk attention/how to reduce

Last years:

- New Orleans is still recovering
- River floods in the UK and Asia
- Floods in Bangladesh, thousands fatalities
- Recent cyclones in Myanma, serious losses of life

More attentions to reduce flood risk, e.g.:

- Preparing emergency as well as longterm management for floods
- More preference for other types of measures: insurance, evacuation, or compartiment dikes, etc.

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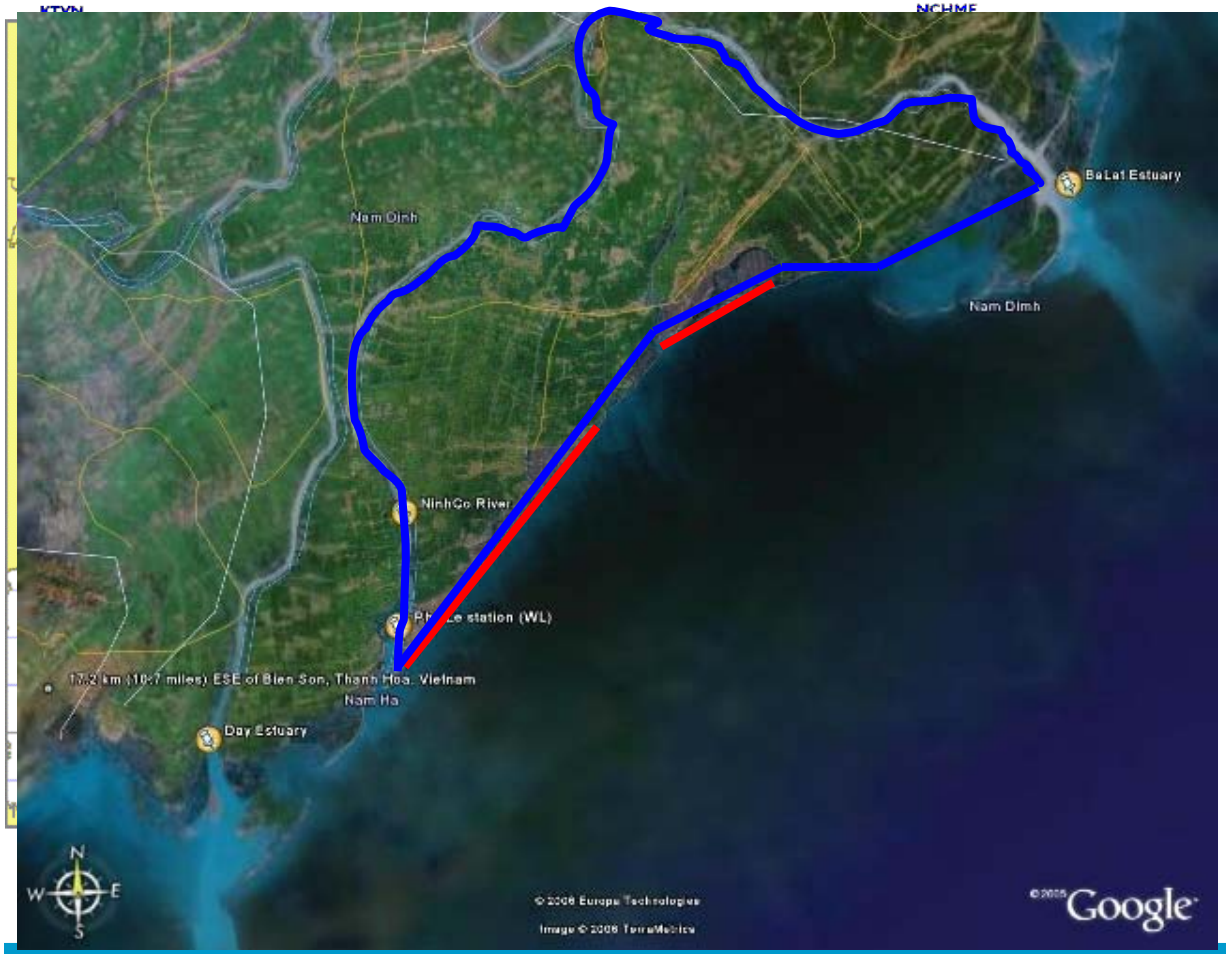
Damrey typhoon 25-28th SEP 2005

Trung tâm Dự báo Khí tượng Thuỷ văn Trung ương
National Center for Hydro-Meteorological Forecasting



With wind force at Beaufort scale 12 (118 to 133 km per hour),
>50 year return period

<u>Consequences:</u>
-25 kilometers of sea dikes were broken
- Sea water flooding of 5 km coastal strips
- Total direct losses: $US 500 Mil.

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How to deal with flood?

Safety Chain concept [Project: Chain of Safety, BE-NL]

- Pro-action: Leave the area/take a decision in advance
- Prevention: Sufficient protection systems/higher dikes
- Preparation: Making plan when thing goes wrong
- Repression/Mitigation: Reducing flood consequences
- Repair
- Learning

Elements should all be addressed, but…this is not relevent if looking at the cost benefit and compossition of the chain itself

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How to deal with floods?

Safety Chain concept

- Pro-action
- **Prevention**
- Preparation
- Repression/Mitigation
- Repair
- Learning

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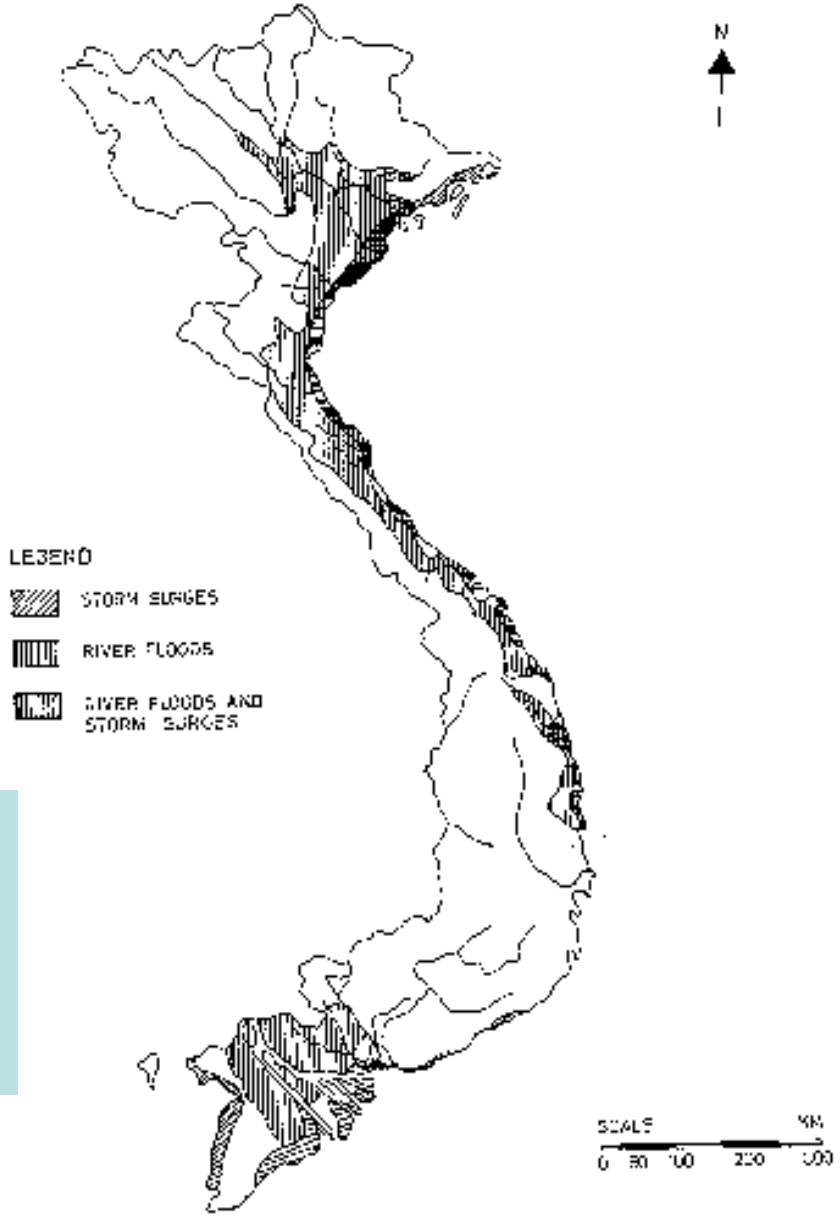
Flood defences in Vietnam

- Tropical monsoon area
- Typhoons: 6-10 times/year
- Extensive river networks
- Long, low-lying coastal strip, but high populated (>1500 inha/km2)



Flood defence system:

- 6000 km primary river dikes
- 2000 km of sea dikes

Flood defences in Vietnam

Current Safety standards:

- River dikes: 1/100 to 1/50 per year;
- Sea dikes: 1/25 to 1/20 per year

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Flood defences in Vietnam

Safety Assessment of the current situation:

- Water defense system of Viet Nam is relatively at low safety levels
- fails regularly, mostly with sea dikes system (Sea dikes are designed for 1/25 year, but it fails once in every 3 years)
- Since 1953, there are numbers of flood disasters which caused loss of more than 20,000 lives and $US 7.5 billion.
- Annual economic damages due to typhoon and flood ~1.5% of Vietnam GDP (experiences from last 10 years)

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1998

2007

Research questions

- What is the actual safety level?
- How safe is safe enough (e.g 1/50 years or 1/100)?

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Study approach

- Probabilistic safety assessment of the existing system [P_{sys}]
- Risk based approach to determine the acceptable risk level.
- Based on the acceptable risk the Safety level/standard can be set/re-set for the flood defence system

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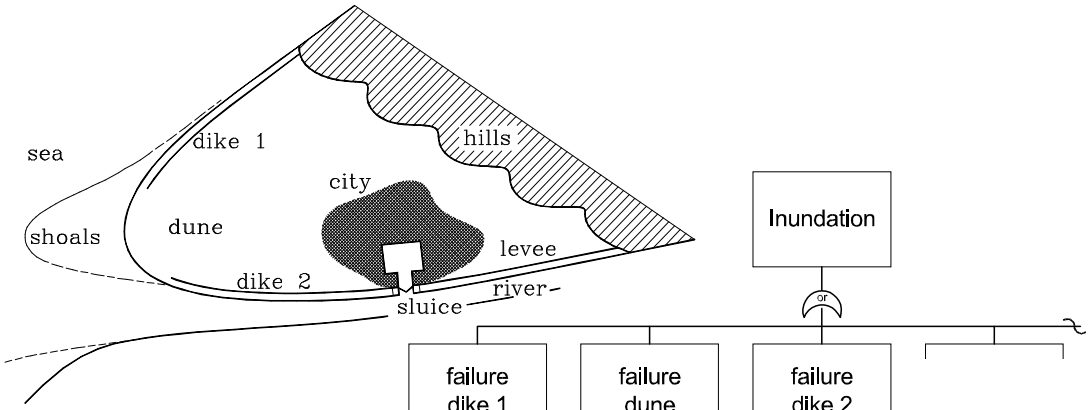
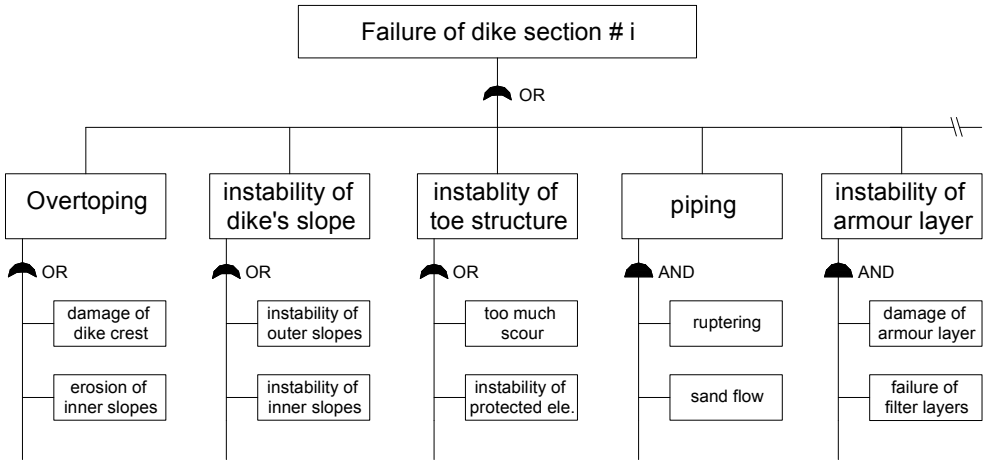
Probabilitic safety assessment-1st Q





- System description- Fault tree construction
- LSF & Determination of failure probability of every failure mode/ component, P_f^i
- Combine/determination of system failure probability, P_{sys}

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Acceptable risk- 2nd Q

Three points of view:

- Individual risk
- Societal risk
- Economic risk

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Individual risk

- IR is defined as the probability that an average unprotected person, permanently present at a certain location, is killed due to an accident resulting from a hazardous activity.
- Not feasible to model=> look at accident statistics
- Dutch Safety Standards:

$$IR < \beta_i \cdot 10^{-4} \ (1/\text{year})$$

Policy factor

β=100, in the case of complete freedom of choice (e.g. mountaineering)
…
β=0.01, in the case of an imposed risk without any perceived direct benefit (e.g flood)

Societal risk

- "The relation between frequency and the number of people suffering from a specified level of harm in a given population from the realisation of specified hazards"
- If the specified level of harm is limited to loss of life

=>The societal risk can be modelled by FN-curve:

$$1 - F_N(x) = P(N > x) = \int_x^{\infty} f_N(x) \cdot dx$$

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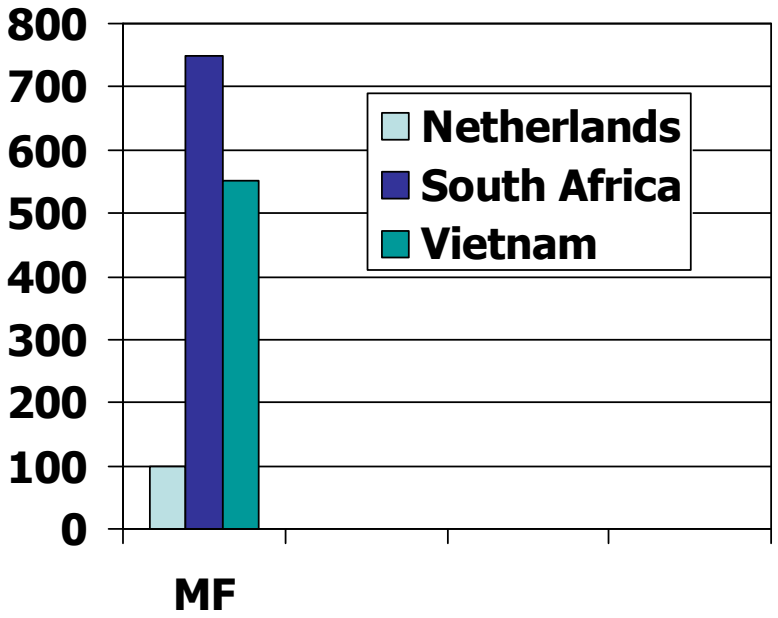
Societal risk

Acceptable level: $E(N_{di}) + k * \sigma(N_{di}) < \beta_i * MF$

where k: risk aversion index, in range of 1 to 3

MF: multification factor, depends on:

- the averaged death rate;
- the number of hazardous activities
- the size of the population



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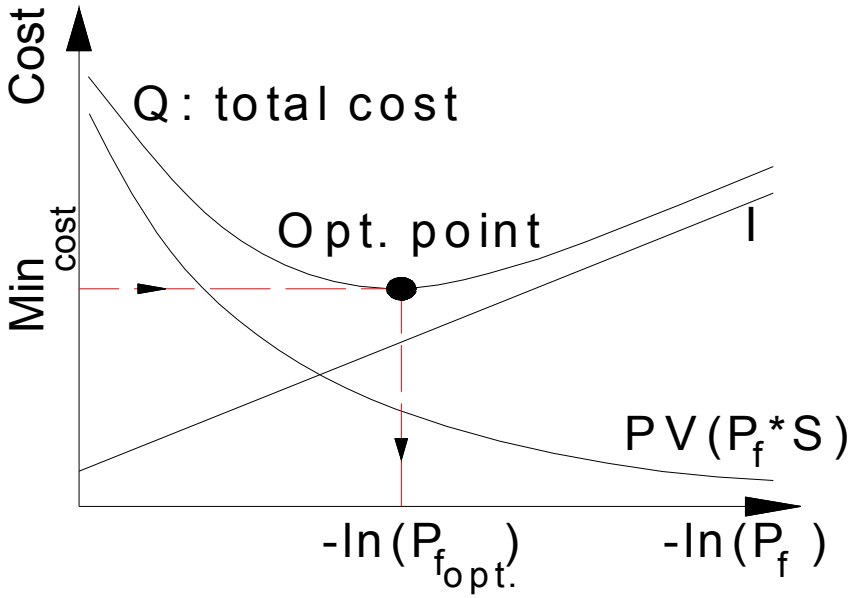
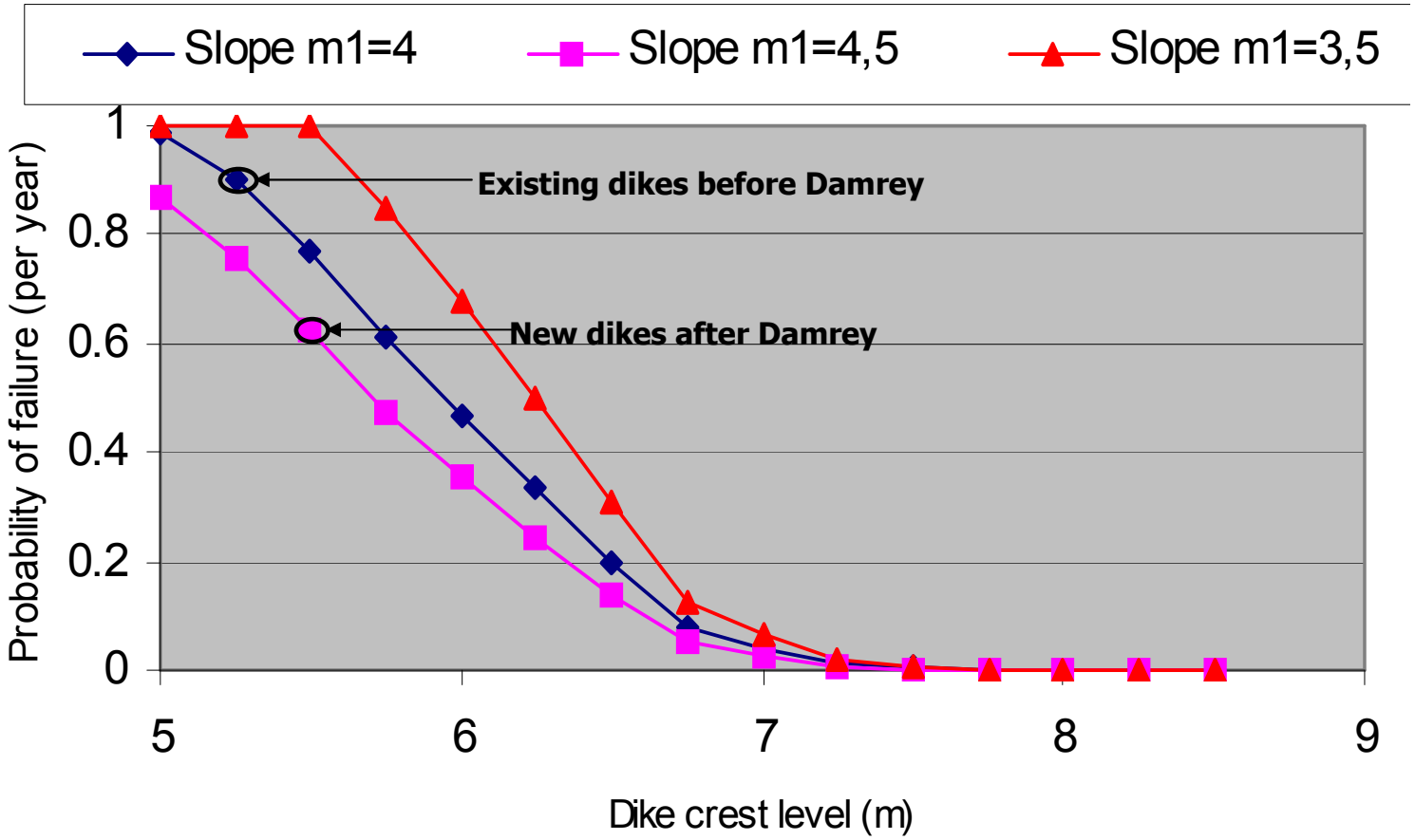
Economic risk

- The total costs=Sum of the expenditure for a safer system + the expected value of the economic damage.
- Search for minimum point



Application to the case of Vietnam(1)
Safety assessment



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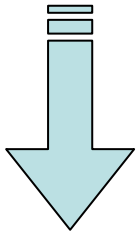
Application to the case of Vietnam(2)
Accident statistics

- Total population: 85 million
- Road traffic accident statistics: $P_f=1.45\text{x}10^{-4}$
- Averaged death rate: $r=6\text{x}10^{-3}$ per year



$$MF_{VN} = 550$$

=>Acceptable level: $$E(N_{di}) + k * \sigma(N_{di}) < \beta_i * 550$$

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Application to the case of Vietnam(3)
Societal risk

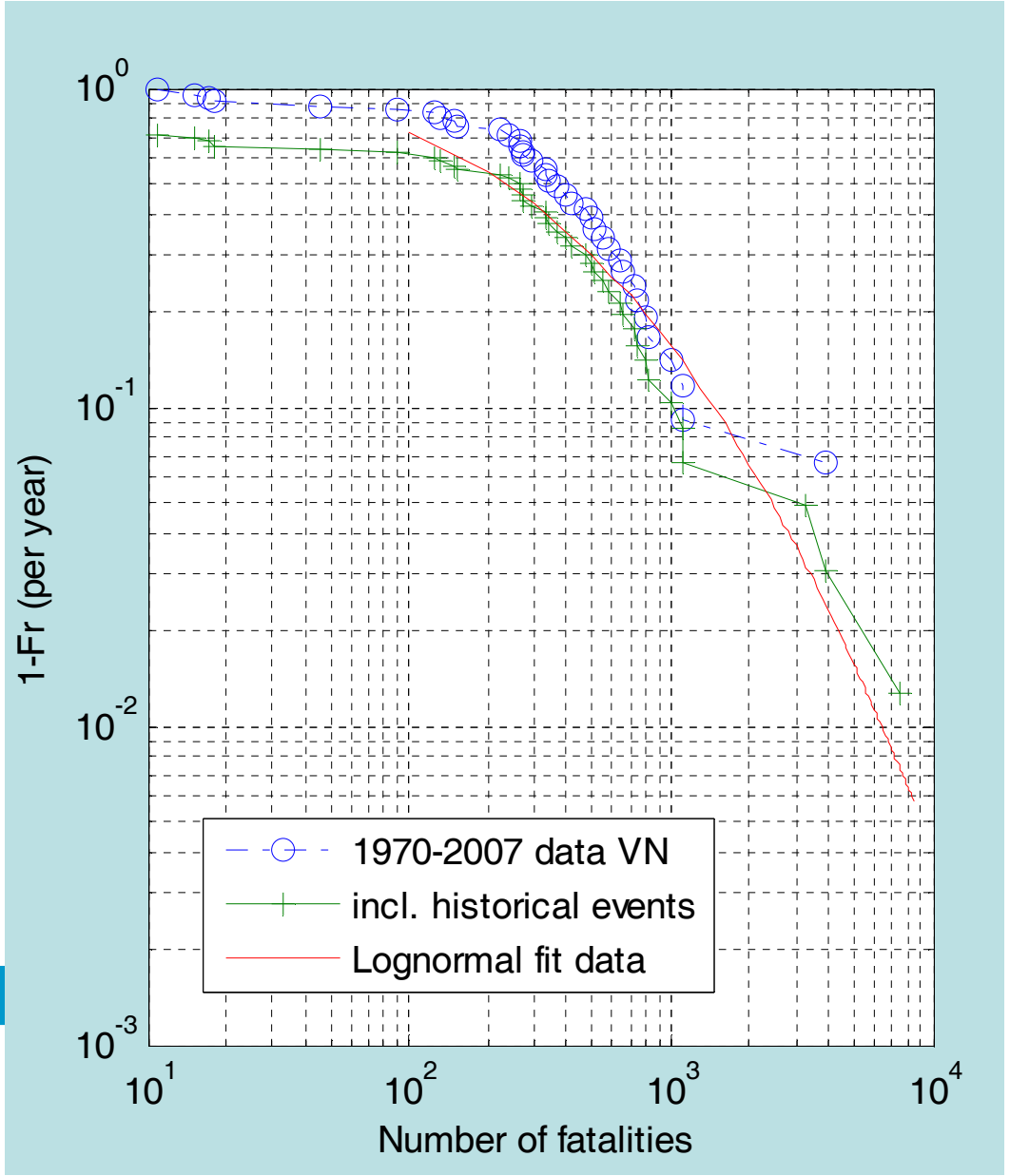
FN-Curve

Data from DDMFC of Vietnam &

ADRC in Japan;

E(N)=541 fat;

σ(N)=1169.7 fat;



Application to the case of Vietnam(4)
Societal risk

k	TR	β	β_{Dutch}
1	1710.7	3.1	0.01
2	2880.4	5.2	0.1
3	4050.1	7.4	1.0
Safety Standard		???	1/10000

Factor 10 to 100 is found comparing to the Dutch case

Safety level of 1/100 per year can be set for Vietnam

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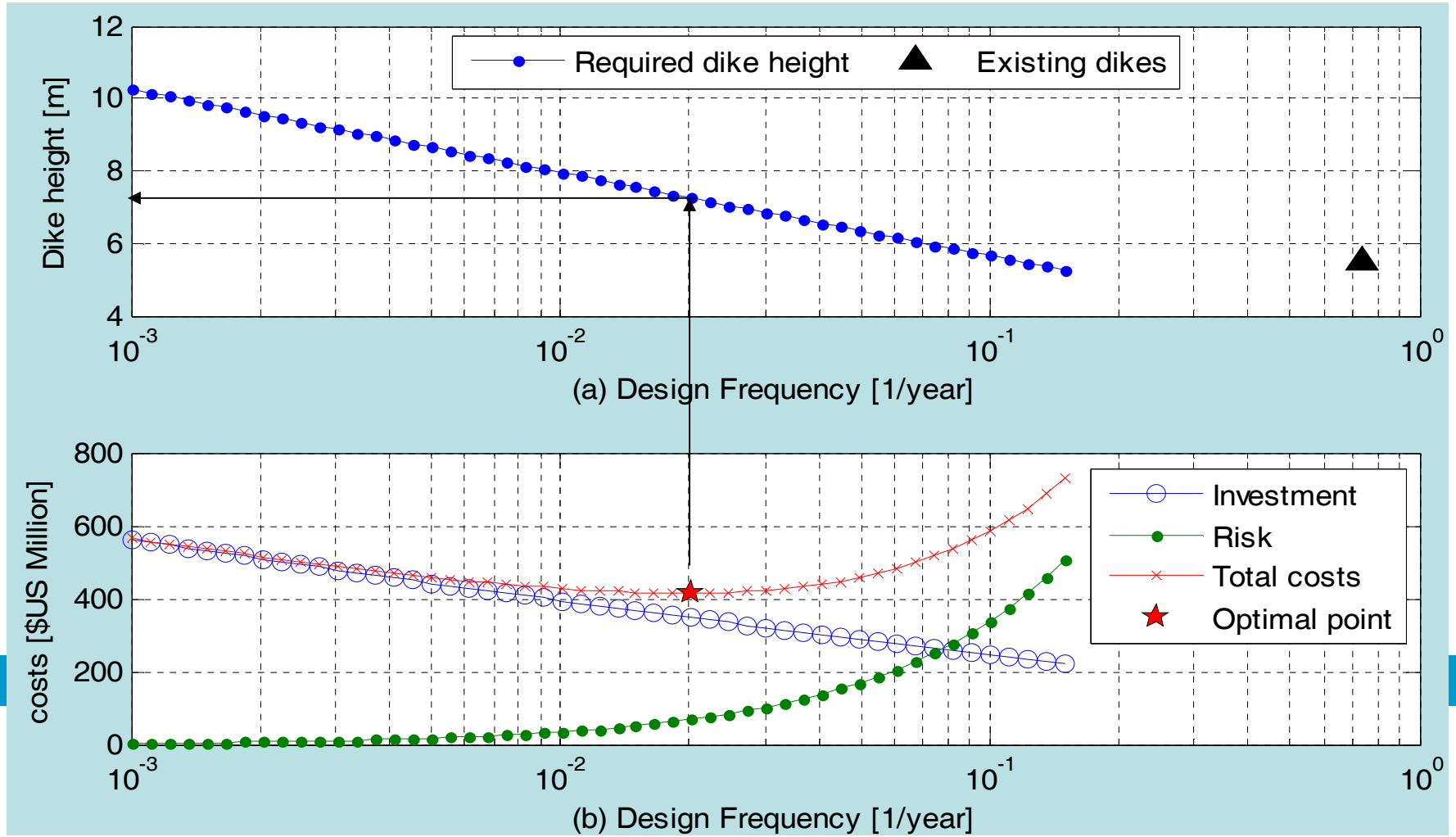
Application to the case of Vietnam(5)
Economic risk analysis: Nam Dinh case

Economic risk based optimal of satety level



Conclusions

- Existing coastal flood defences is not safe, P_f^{system}=0.63 per year
- The policy factor β of Vietnam was found in the range of 3 to 7.5 => Flood safety standards should be set at 1/100 per year;
- The current safety standard of flood defences of the case study in Vietnam (1/20 years) is not safe enough;
- An optimal choice of the acceptable risk level is recommended at 1/100 years

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Application to the case of Vietnam(5)
Economic risk analysis: Nam Dinh case

FD-Curve

E(D)=$181.3 Mil;

σ(D)=$309.5 Mil;