Contrasting the Costs and Benefits of Hard and Soft Approaches to Disaster Risk Reduction under Changing Climatic Conditions

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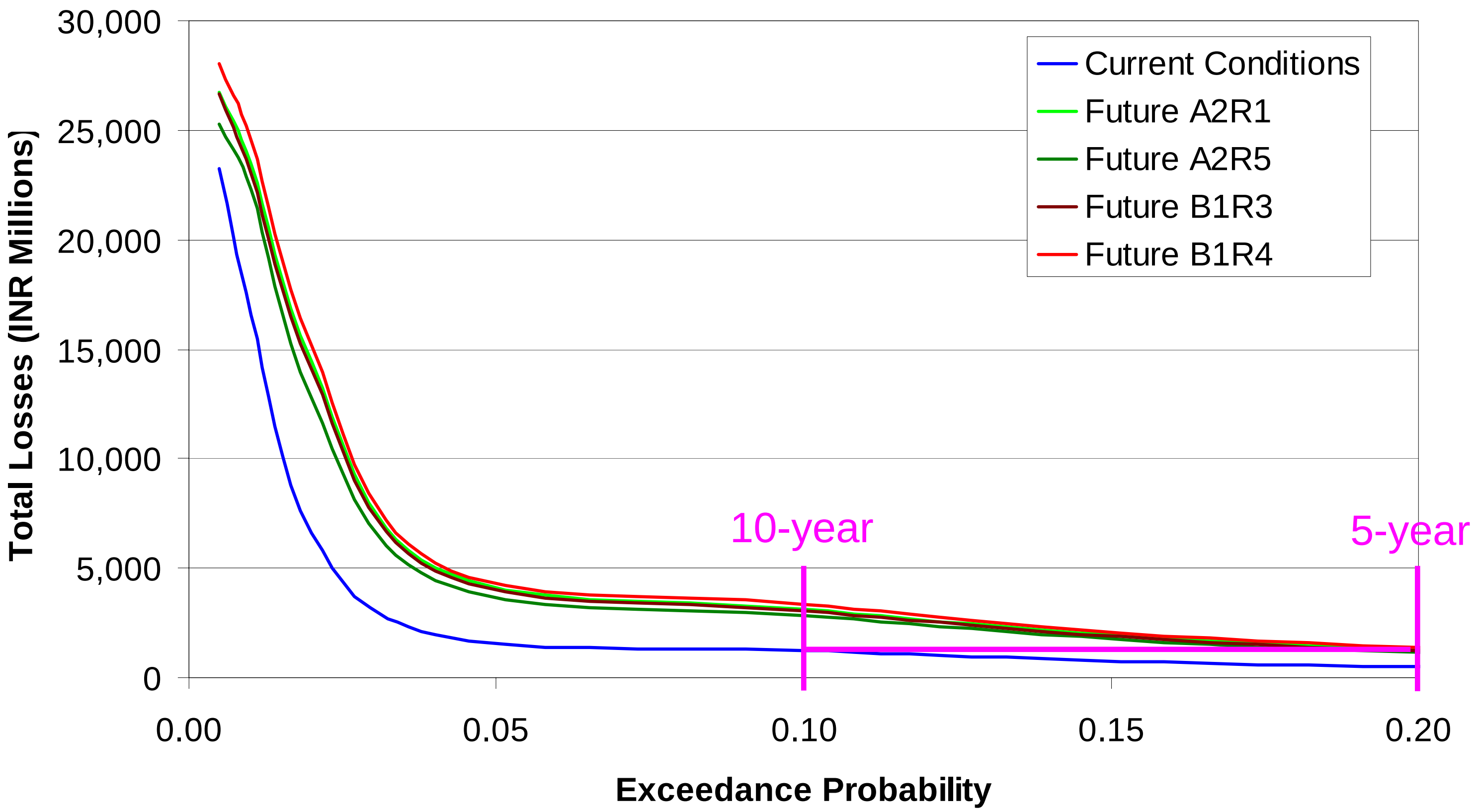
Quantitative Data Issues

Key Data Required	Issues
Past flood losses	Secondary data incomplete, survey data likely not representative of full basin. Only two events available.
Maps of flooded areas	Some satellite photos available, insufficient resolution for analysis.
Basin topography	Topographical maps of insufficient and mismatched resolution. Only one cross-section available for the entire river.
Hydrometeorologic time-series	Rainfall data was available only for the Nepali side of the Rohini Basin, but its validity was unknown. Significant gaps exist in the streamflow data of the Rohini River and the record is short. Both rainfall and streamflow datasets had to be corrected and estimates used to fill significant gaps.
Embankment details including past performance	Failure data limited, specific maintenance information not available.
Demographic information	Recent census at village level but projected future trends only available at state level.
On-going flood risk reduction activities (explicit and/or autonomous)	Very limited information, some trends on autonomous risk reduction could be inferred from surveys (primarily housing dynamics).
Climate change projections	Downscaling of regional climate model results and transformation into changes in flood regime highly uncertain.

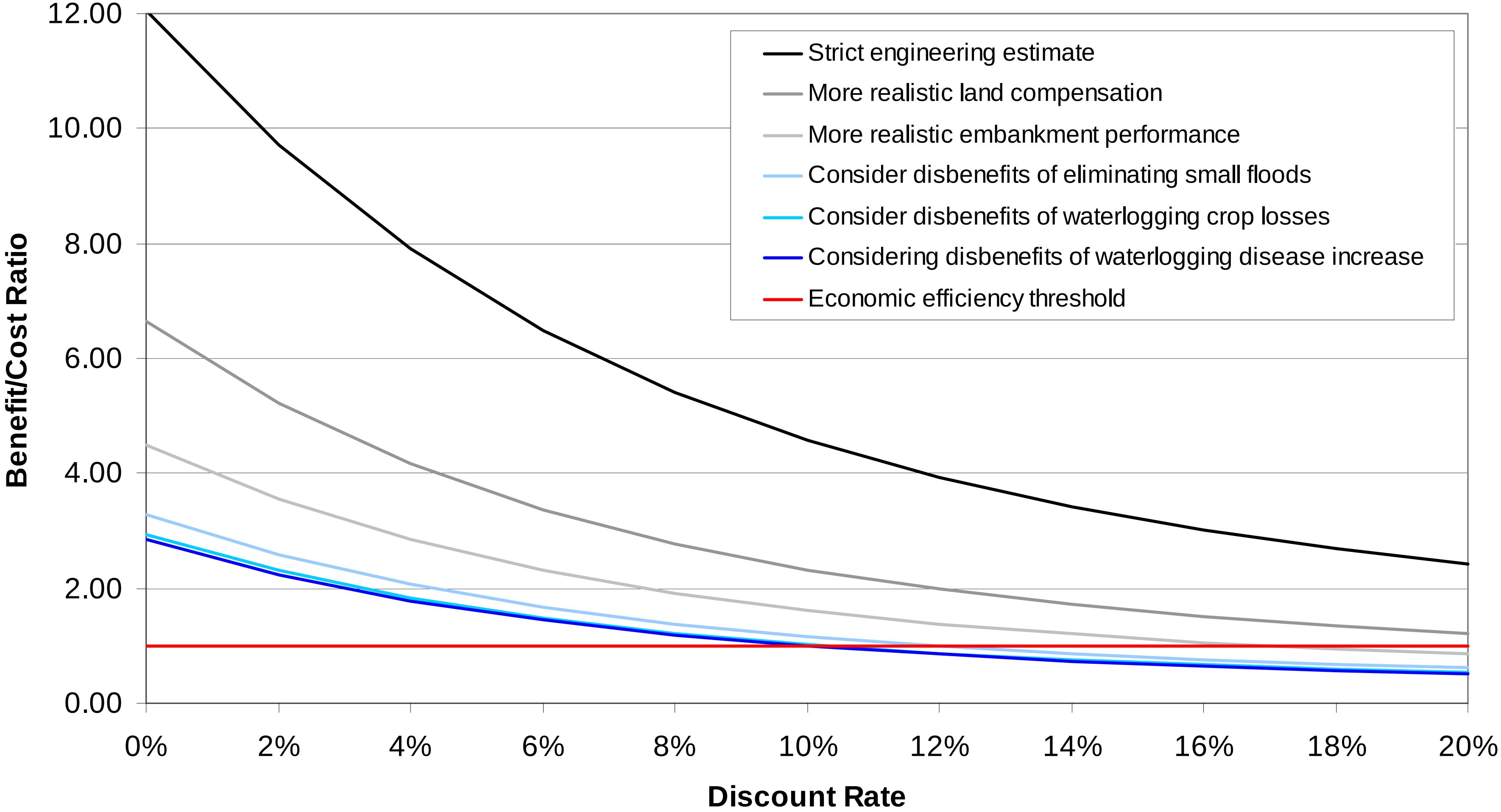
Rohini Basin Direct Losses



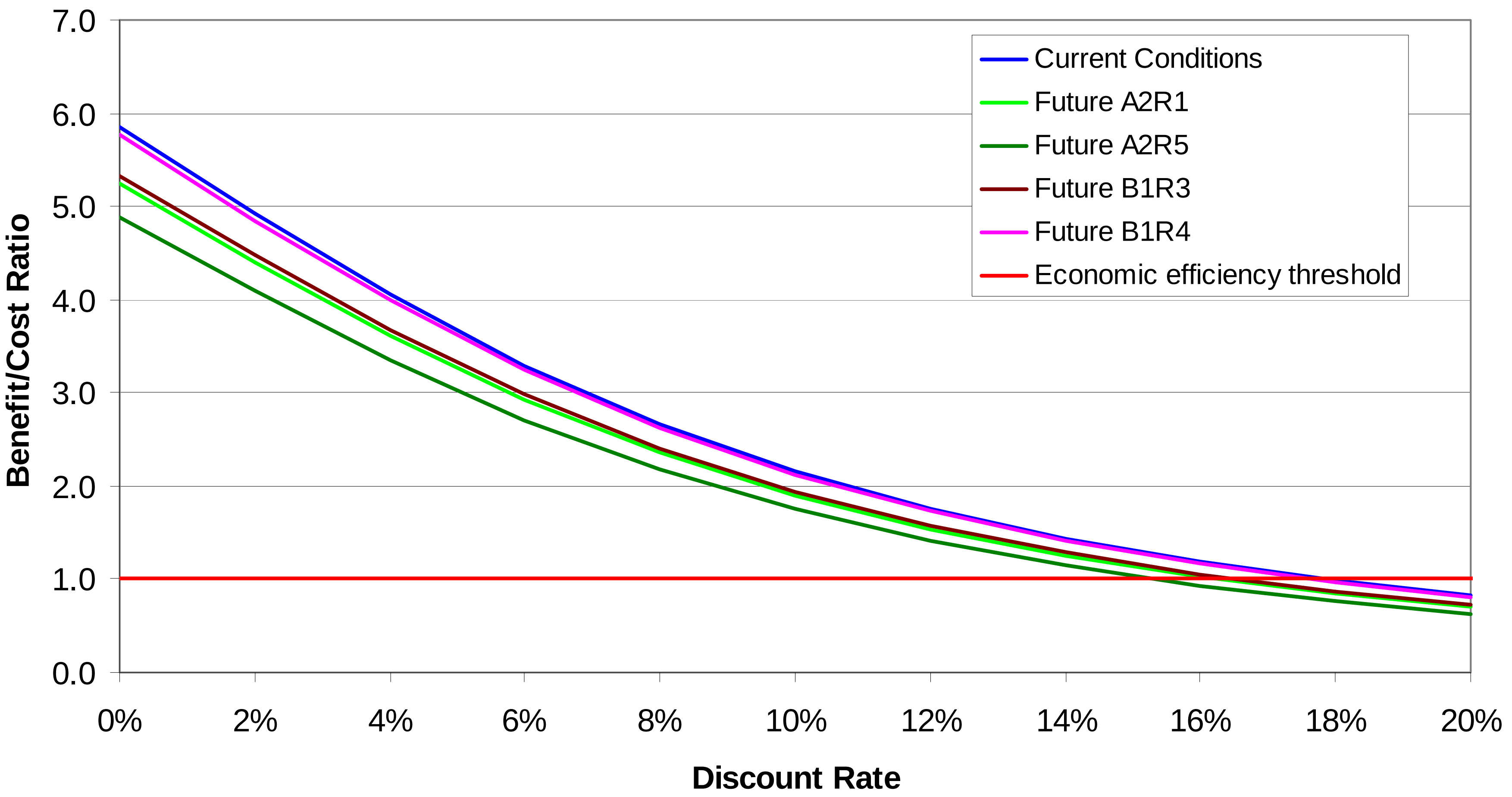
<u>Expected Average Annual Losses (INR)</u>

Current conditions	**570 million**
Projected climate change scenarios	**1050-1230 million**

Embankments: Past Performance (1973-2007)



Embankments: Future Maintenance



People-Centered Strategy Performance


Trapa (water chestnut) deep-water cultivation.
GEAG, 2007

Current and projected future conditions:

B/C Ratio = 2.0 – 2.5

If all benefits reduced by 50%:

B/C Ratio = 1.0 – 1.3

If non-flood benefits NOT considered:

B/C Ratio = 0.5 – 1.0

B/C ratios computed over 0-20% discount rates

- Capital costs only 40% greater than annual costs
- Annual costs high (INR 2850/household), comparable to average annual flood losses (INR 2350-5000/household)
- Annual benefits (flood & non-flood) still higher than costs
- B/C ratio not very sensitive to discount rate, but Net Present Value is (INR 5 - 66 billion)

Driving Assumptions

Assumption	Basis	Issues
District level secondary data representative of basin	Can pro-rate based on % of area in basin	District outside basin includes other rivers, regional major city.
Survey data representative of entire basin	Secondary data incomplete, no other choice	Although up-scaling considered risk profiles, could still misrepresent basin.
Return periods of past events	Anectodal, overall monsoon descriptors and general loss trends	Inconsistent with hydrologic analysis, has major impact on estimated loss frequencies.
Pareto distribution best represents loss frequencies	Commonly used extreme value distribution, based on two loss events and no loss below 2-year event	Statistical fit based on 3 points is weak, has major impact on estimated loss frequencies. Estimates of high frequency flood losses a driving factor.
Rainfall and large-scale climate data are valid and accurate	Standard practice – no other choice.	Significant gaps and uncertainty in the geographically limited historic rainfall data adds uncertainty.
Relationships between rainfall and large-scale climate will remain valid in future	Standard practice – no other choice.	Monsoon rainfall has historically been linked to ENSO (El Niño) and other large-scale climate features. These relationships are changing and breaking down.
GCM (General Circulation Models) climate change projections are sufficiently dependable	Standard practice – no other choice.	Climate change appears to be happening much faster than the GCMs predict, e.g. the melting of Artic and Greenland icesheets is faster than predicted. Actual climate change could actually be much different than model projections.
Basic hydrologic and hydraulic analysis sufficiently dependable.	Data limitations and desire to keep analysis simple.	In relatively flat basins with large anthropogenic alterations like the Rohini (embankments, land use changes, etc.), hydrology and hydraulics become dynamic and multi-dimensional.
Flood losses linearly related to flooded area	Simplification of modeling	Over-simplifies a complex issue, particularly for small events and economic flow (verses stock) losses.
Future exposure represented by projected populations	Nothing else available	Does not consider all autonomous adaption.
Shifting of larger loss frequencies to reflect embankment failures	1998 and 2007 floods	Not calibrated with observations of flooded areas.
Intervention costs	Field experience	May not be appropriate for basin/program specifics.
Intervention benefits	Modeling, field experience, expert judgment	Monetized values generally unproven, based on multiple small assumptions.
Intervention disbenefits	Modeling, field experience, expert judgment	Monetized values often unproven.
Discount rate	Standard "best practice"	Has major impact on results.

Conclusions & Lessons Learned

- Past embankment performance cannot be concluded to have been economically efficient
- Projected climate change negatively impacts future embankment performance
- People-centered strategy economically efficient, more robust in terms of projected climate change impacts (does not depend on specific flood magnitudes)
- Some people-centered benefits accrue regardless of flood patterns (discount rate less important)
- Vast uncertainties in data and assumptions – results only in orders of magnitude
- Distributional aspects not captured
- Data acquisition effort likely not worth it for quantitative CBA (but for other insights)

Quantitative Analysis of the Economics of Flood Risk Reduction in an Urban Context: The Case of the Leh Basin in Rawalpindi

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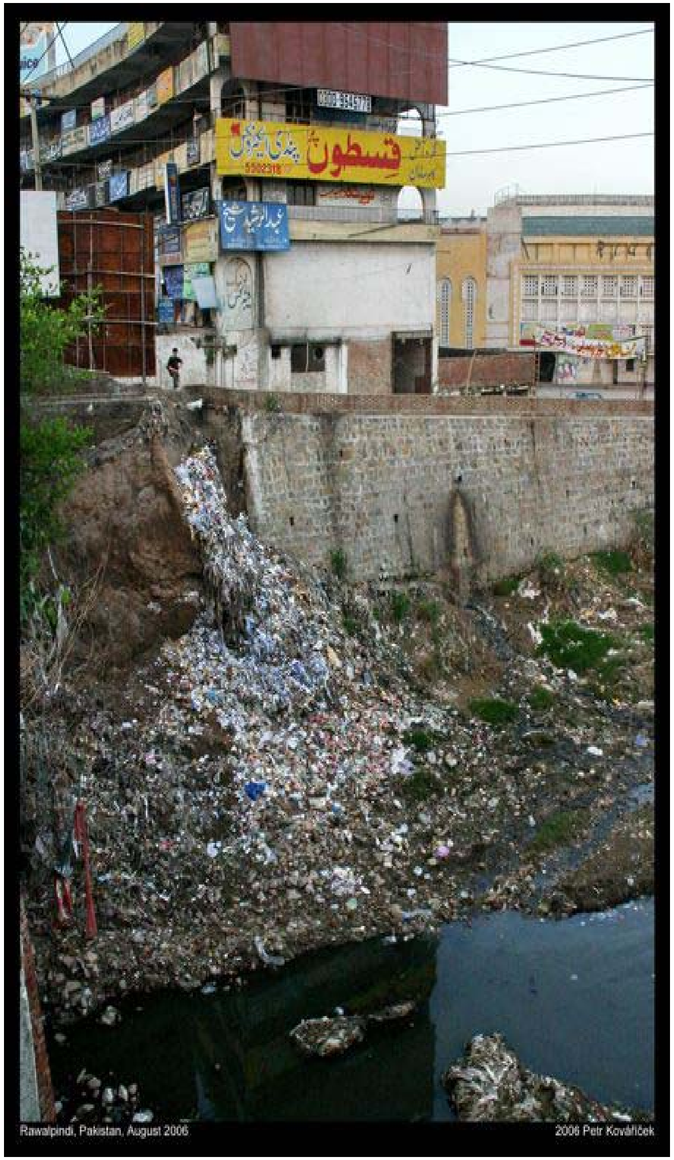
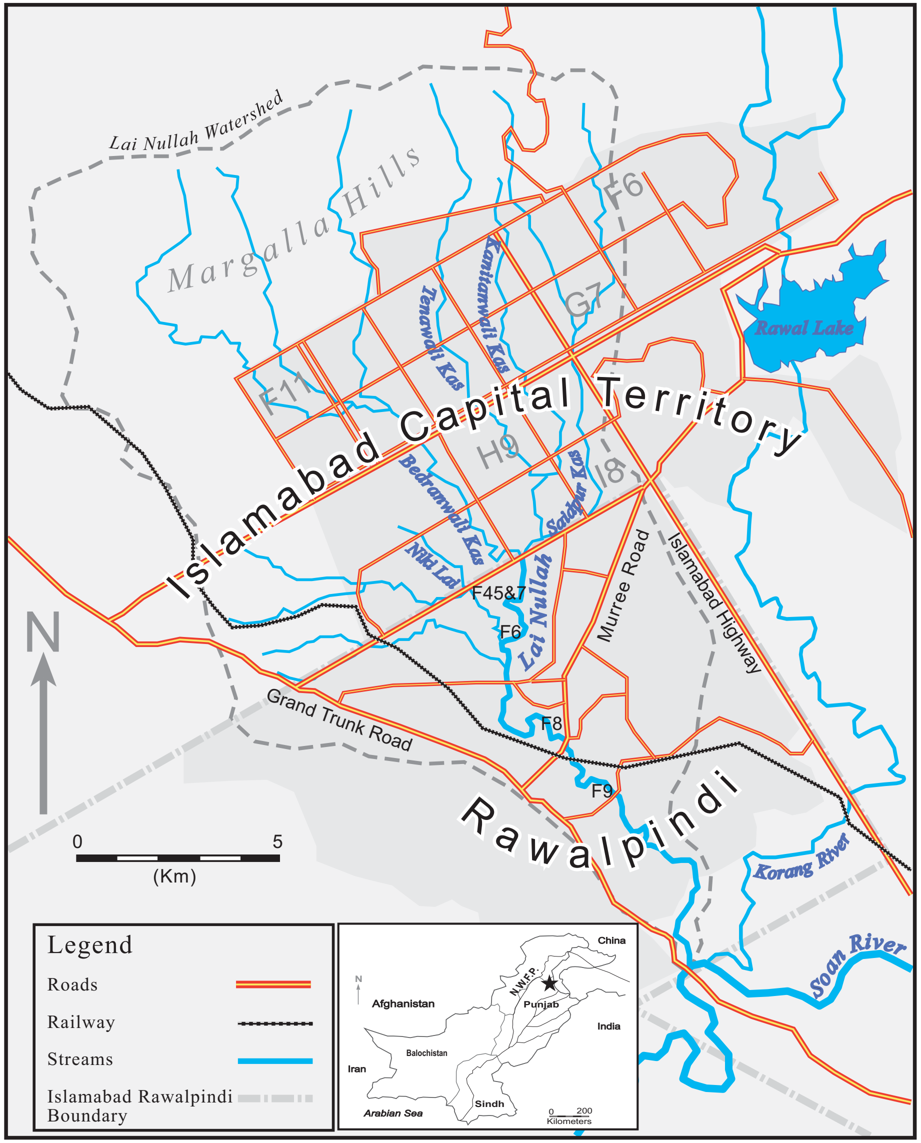
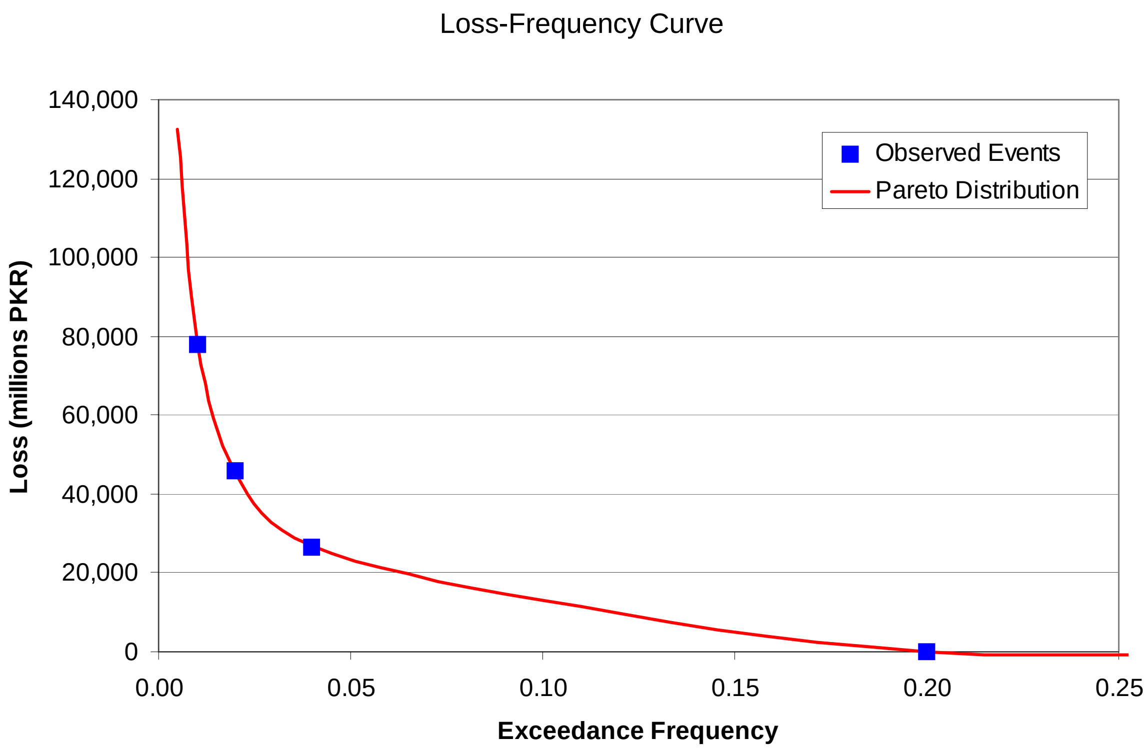
Urban Setting



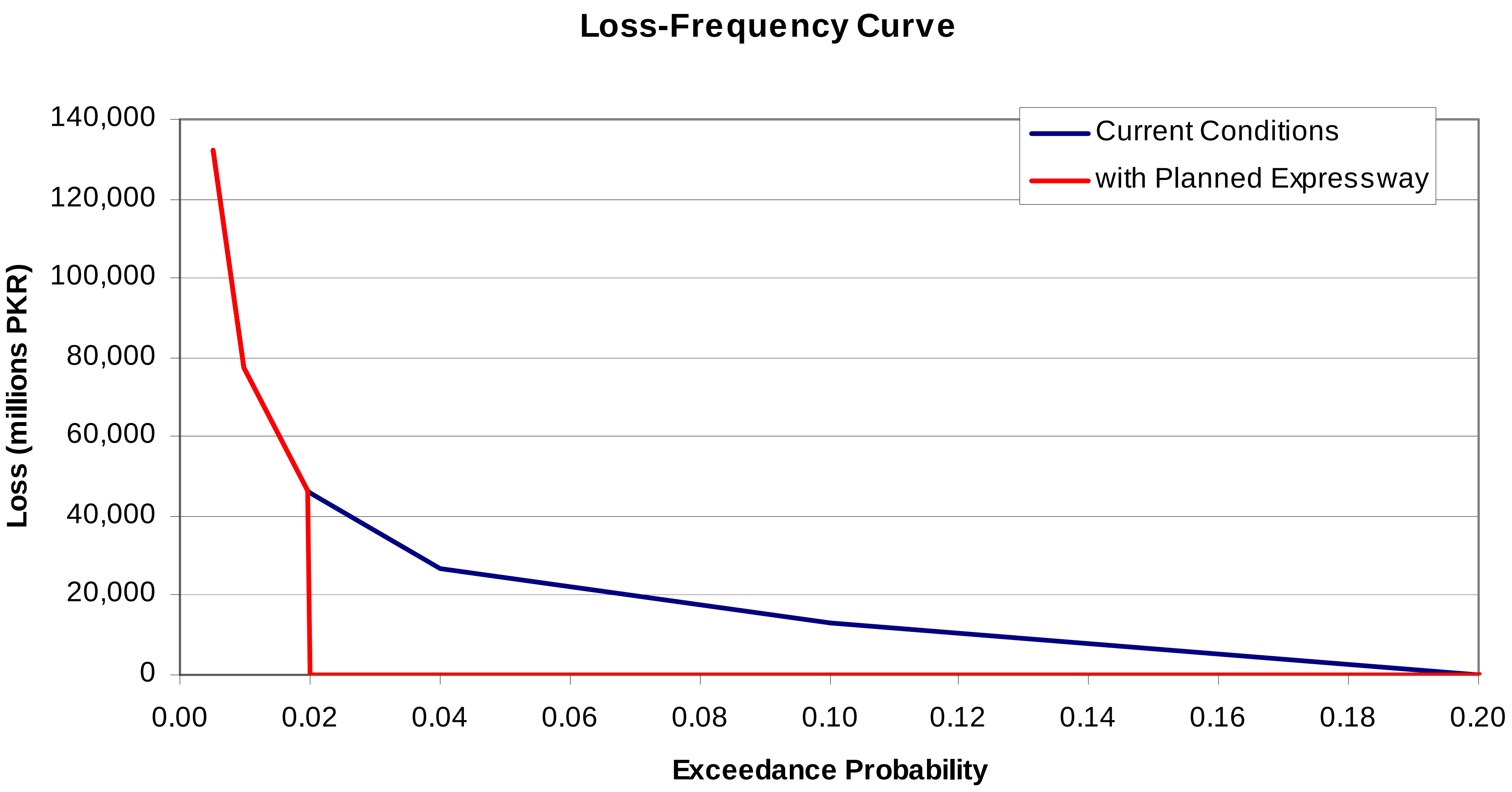


Flood Risk Reduction Options

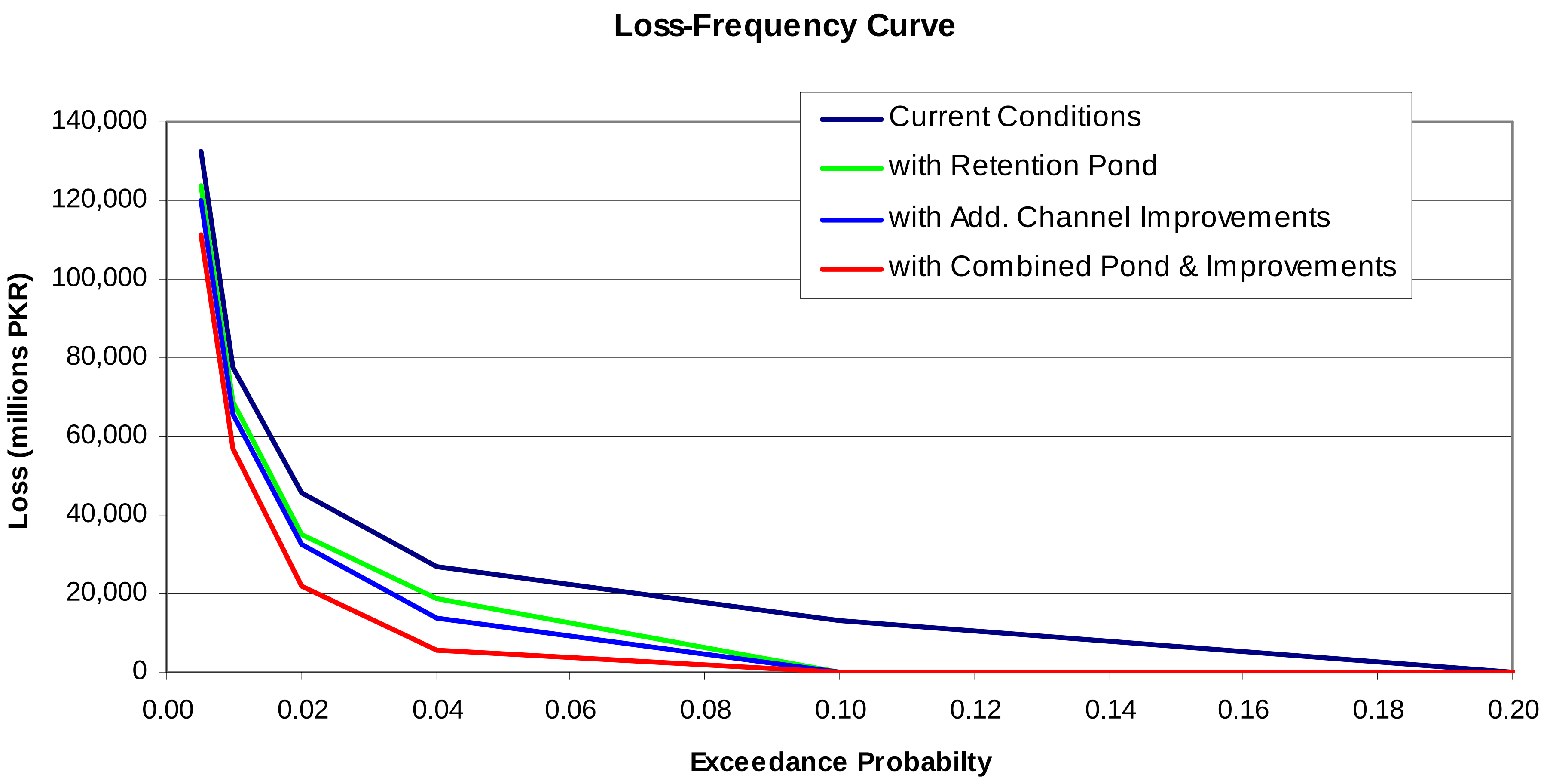


1. Expressway & flood control project (government)
2. River engineering options (donor)
3. Early warning system (government & donor)
4. Floodplain relocation (conservationists, civil society)

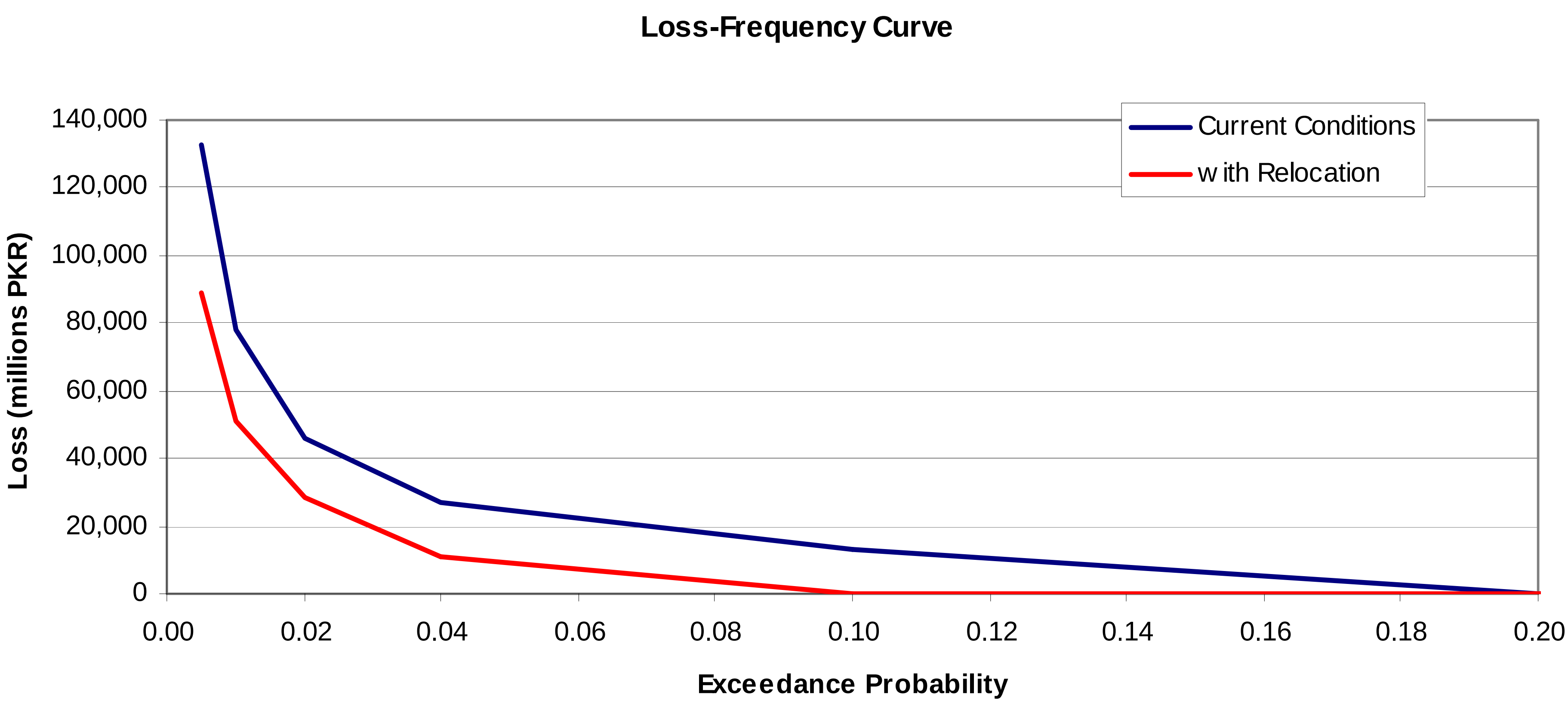
Expressway Risk Reduction



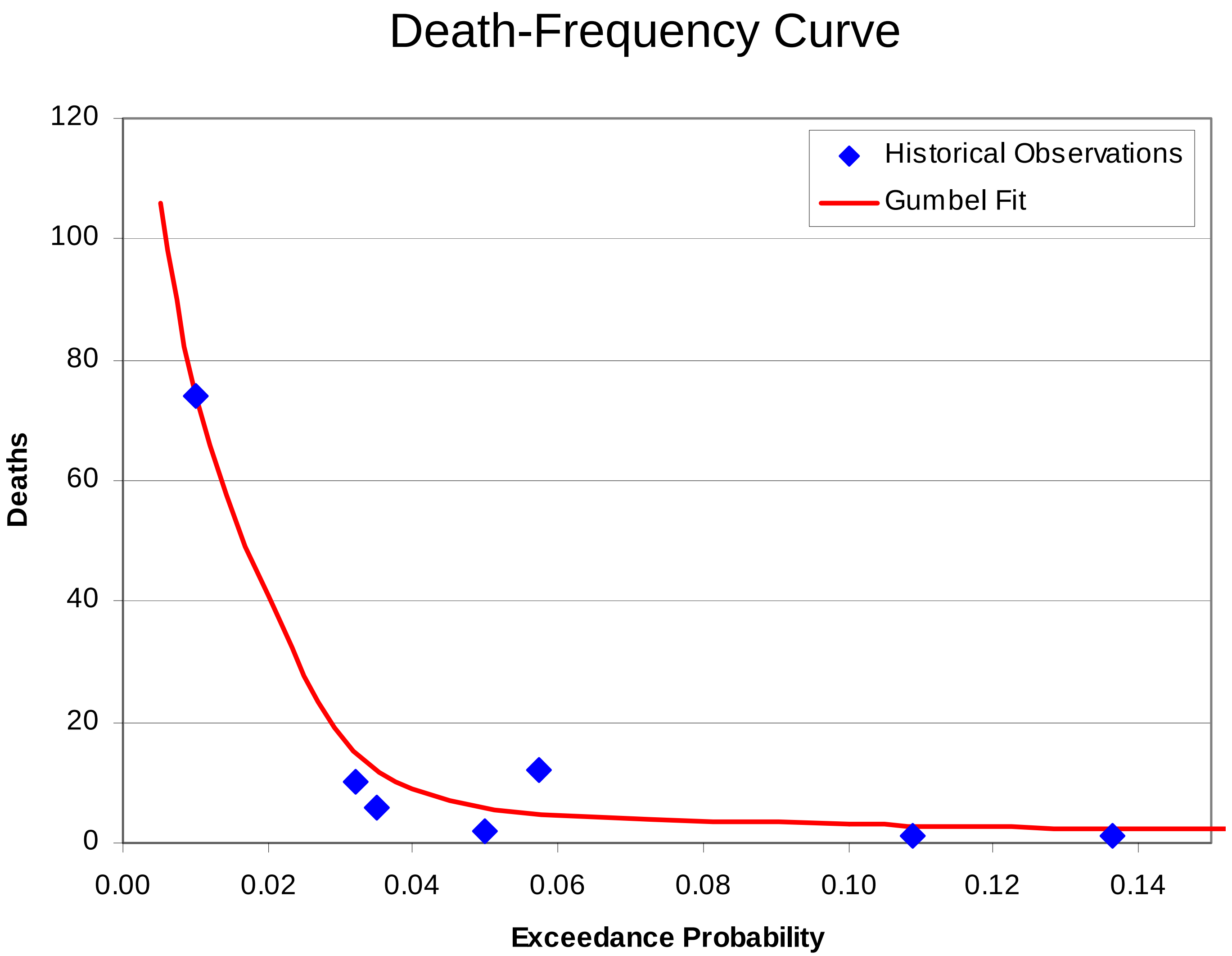
River Engineering Risk Reduction



Floodplain Relocation Risk Reduction



Early Warning System



CBA Results

- Expressway B/C ratio = 1.3 – 3.9
- Engineering options (B/C ratios)
  - Retention pond > 5
  - Opening of hydraulic bottleneck > 17
  - Combination of both > 6
- Relocation B/C ratio = 0.8 – 5.5
- Early warning system:
  - Considering moveable assets saved B/C ratio ~ 1.6
  - Cost per live saved > PKR 3 million (USD 44,000)

B/C ratios computed over 0-20% discount rates

Conclusions & Lessons Learned

- Flood risk reduction in an urban setting generally economically efficient
- Some options more cost effective than others: “opening” the river channel and floodplain at bottleneck more cost effective than re-engineering entire river reach
- Proper relocation expensive in an urban setting and requires appropriate legislative framework
- Cost per life saved with current early warning system much higher than saving lives through improvement of basic services (health, watsan)
- Despite good data availability, some issues not captured:
  - Indirect (economic) risk
  - Potential climate change impacts
  - Solid waste & sewage issues leading to disease