Business from technology

Vulnerability and adaptation assessment of flood prone areas

Test case: City of Pori

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Content

- Backgroud
- Event-tree modelling of direct costs
- VERM-simulations of full costs
- Preliminary conclusions

EU ‘Floods Directive’

Entered into force 2007

- ✓ Preliminary flood risk assessment 2011
- ✓ Flood hazard and risk maps 2013
- ✓ Flood risk management plans 2015

Consequences from floods (Flood Directive Article 4-2b)

- ➢ Human Health
- ➢ Environment
- ➢ Cultural heritage
- ➢ Economic Activity

Law on flood risk management 30.6.2010 (Finland)

Regulation on flood risk management 7.7.2010 (Finland)

Flood risk areas in Finland

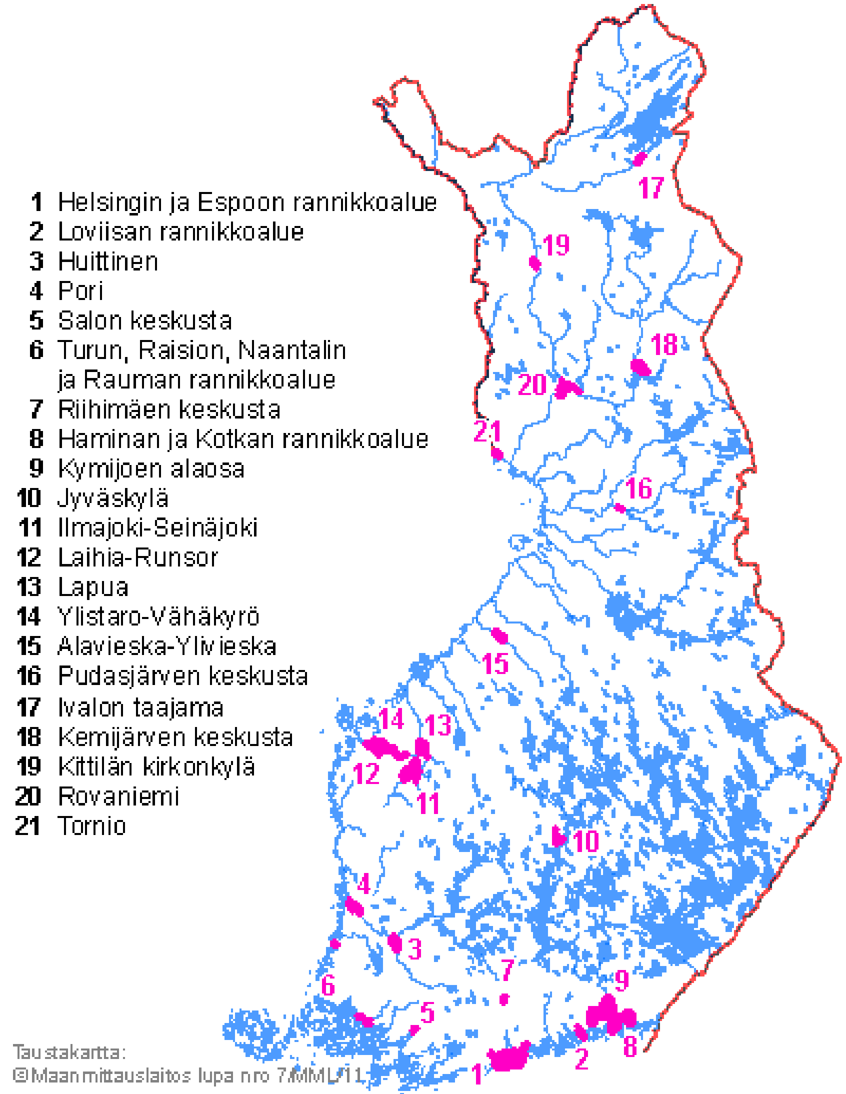
Ministry of Agriculture and Forestry (2011):

21 Flood risk areas

Consequences combined with the annual probability of a flood gives the **annual flood risk** in a region

Merkittävien tulvariskialueiden sijaintikartta 20.12.2011

- vesistöjen tai merenpinnan noususta aiheutuvat tulvat



IrtoRiski-project*:
Modelling extreme event impact pathways in terms of direct and indirect costs

- Direct costs (repair costs, loss of production time, loss of stock, ….)

Event-tree model

- Full costs accrued in the local economy as a function of restoration time (building material costs, insurance costs, labour costs, regional GDP downswing , …)

VERM model (CGE)

- How do these models supplement each other?

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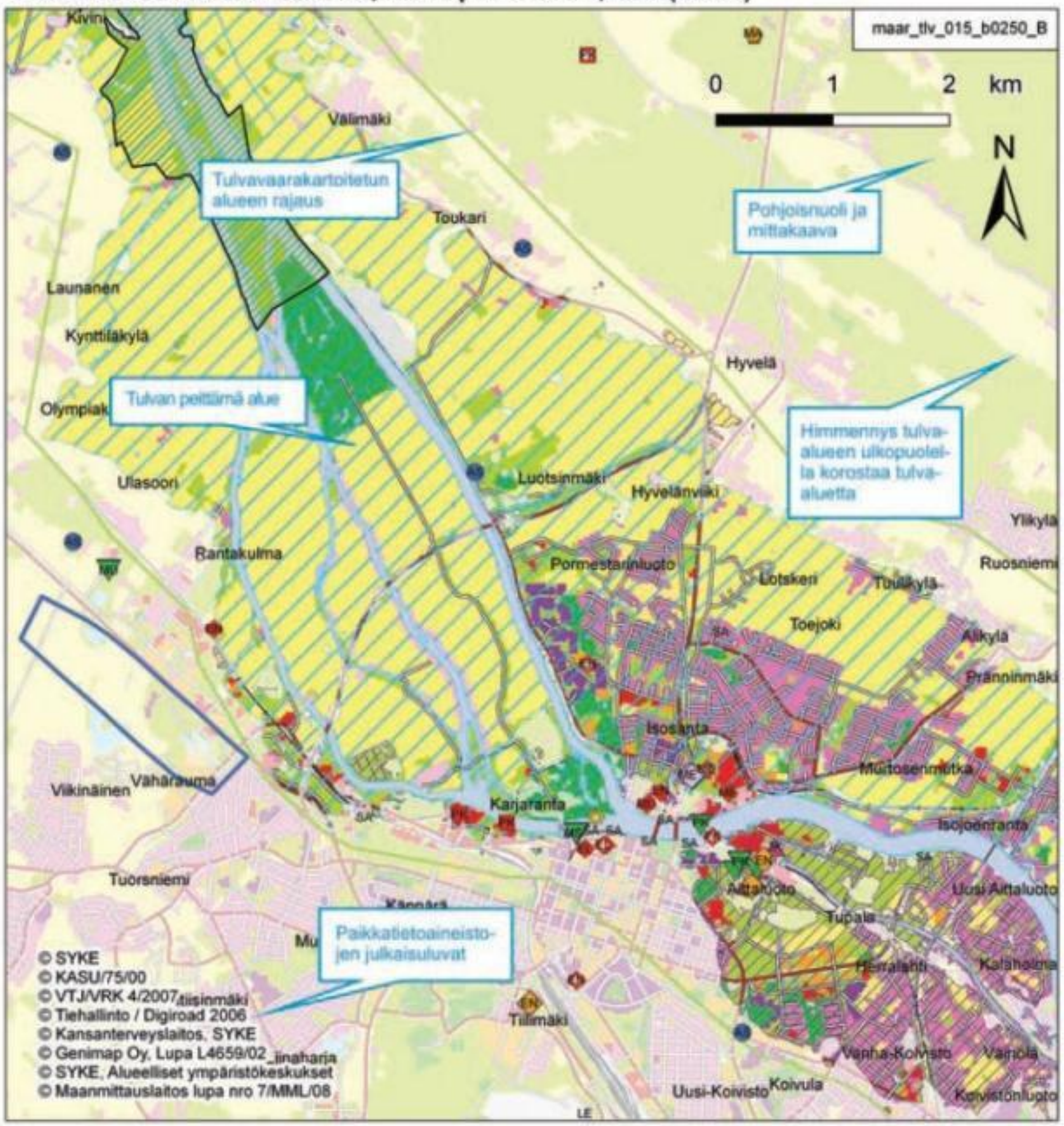
Test case:
City of Pori

- Pori is the only larger urban settlement in Finland with significant river flooding risks in the short term
- The current R50 and R250 sized floods will have decreased return times by 2050 compared to the current situation
- Test case is based on current climate flood data (design flood mainly R100)
- Direct cost for the R50 flood is ~ 115 M€ and for R250 ~ 335 M€ (mainly impacts on building stock)
- Damage is expected to increase due to climate change (water mass in extreme floods could grow by15% ~ 20% up to 2050)

Porin tulvariskikartta HQ 1/250, merenpinta N60+1,40 m (osa B)



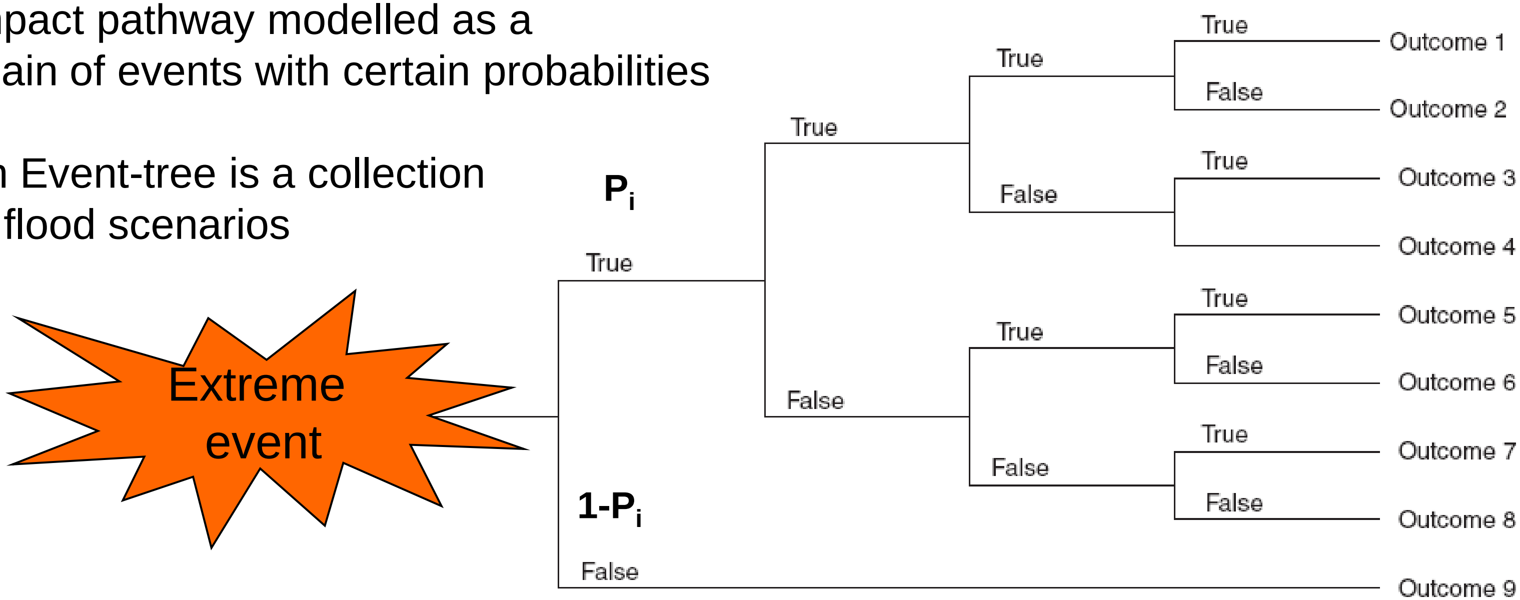
Modeling of impact pathways
- an Event-tree model

Flood barriers

	B_1	B_2	B_3	B_4	
Accidental event	Additional event I occurs	Barrier I does not function	Barrier II does not function	Additional event II occurs	Outcome / consequence

Impact pathway modelled as a chain of events with certain probabilities

An Event-tree is a collection of flood scenarios

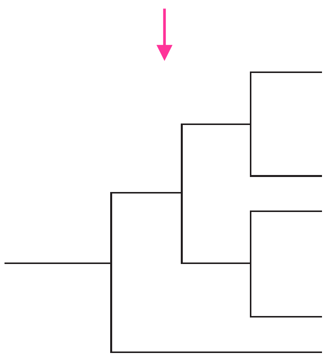


Elicit:

- Branching probabilities for failure Pr{barrier B_i fails | events E_{i-} } = P_i
- Conditional probabilities (conditional on the previous events)!

Modeling of direct impacts

Regional investments in flood barriers change probabilities



Scenario probability	Loss of lives					Material damage				Environmental damage			
	0	1-2	3-5	6 - 20	> 20	N	L	M	H	N	L	M	H

Cost [M€]

0.1 | 1 | 10 | 100

Consequence *X* related to each flood scenario can be specified by a <u>category estimate</u> (most probable consequence category) or by providing a probability distribution over the categories

FLOOD EVENT (PRECURSOR)	IMPACT PATHWAYS					CONSEQUENCE ANALYSIS				CONTROL OPTIONS		
Flood event (downpour, sea flood, river flood, ..) Flood scenarios Sc1-Sc3	Flood containment succeeds B1	Structure exposure negligible B2	Protection of structure succeeds B3	Emergency response succeeds B4	Service/supply chain undisrupted B5	Direct costs (million euros)	Health effects	Social effects	Risk shares and residual risk	Additional counter-measures	Investments (life cycle cost; million euros)	Benefit/cost
Flood protection is based on the hydrological parameters of the design flood	flood banks, dam, reservoir, ditch network	infrastructure, residential buildings	structural engineering conceptions	rescue equipment availability and capacity	flexibility & redundancy of production		not assessed in the demo	not assessed in the demo				
$P(Q > q_R)$	p_1	p_2	p_3	p_4	p_5							
Sc1:Present climate:	**0,8**	**0,8**	**0**	**0,8**	**0,8**					construction of two additional ditches and an absorption area	2	
Sc2: Futrure climate:	*0,2*	*0,5*	*0*	*0,3*	*0,3*							
Sc3: Future climate + new control	0,8	0,8	0	0,8	0,8							
R50: 0,02					**1,60E-02**	**0**			0,00E+00			
R30: 0,03	+				*6,67E-03*	*0*			0,00E+00			
	-				2,67E-02	0			0,00E+00			
					3,20E-03	**0**			0,00E+00			
		+			*1,33E-02*	*0*			0,00E+00			
					5,33E-03	0			0,00E+00			
		-			**0,00E+00**	**0**			0,00E+00			
					0,00E+00	*0*			0,00E+00			
					0,00E+00	0			0,00E+00			
			+									
			-		**6,40E-04**	**5**			3,20E-03			
				+	*4,00E-03*	*5*			2,00E-02			
				-	1,07E-03	5			5,33E-03			
					1,28E-04	**25**			3,20E-03			
					2,80E-03	*25*			7,00E-02			
					2,13E-04	25			5,33E-03			
					3,20E-05	**115**			3,68E-03			
					6,53E-03	*115*			7,51E-01			
					5,33E-05	115			6,13E-03			
Annual risk (present climate)									**0,010080**	No discounting		**8,25**
Annual risk (climate in 2025)									*0,841333*	Discount rate	5 %	**5,39**
Annual risk (climate in 2025 with investment)									0,016800			

Event tree pathways describe different flood scenarios

The object will suffer flood damages

Expected annual loss (residual risk)

Benefit/cost ratio over investment lifetime

Benefit/cost ratio for an investment with a 20-year lifetime: **T = 20**

Modelling of full costs

A dynamic CGE model VERM (20 regions, 46 sectors) modules was used (VERM is operated by the Government Institute for Economic Research VATT).

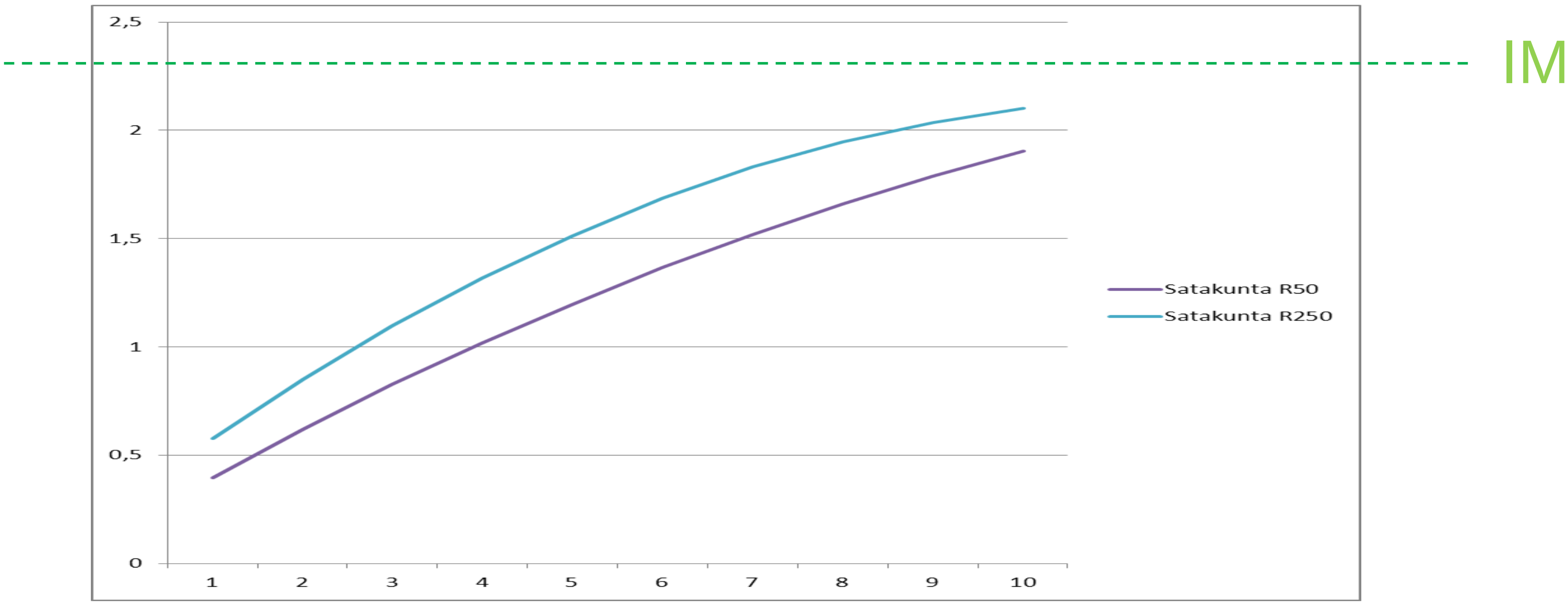
A reference level for the full costs, depicting ’no state compensation’ to the affected area was computed.

Based on VATT simulations an induced impact multiplier (IM) was then approximated. The IM is the Net Present Value of difference between shock induced growth curve and the baseline GDP for a 10 year period (= full costs = reduction in GDP), divided by the original direct costs in terms of capital stock reduction

Full costs ≈ IM * Direct costs

Deduced impact multiplier IM ….

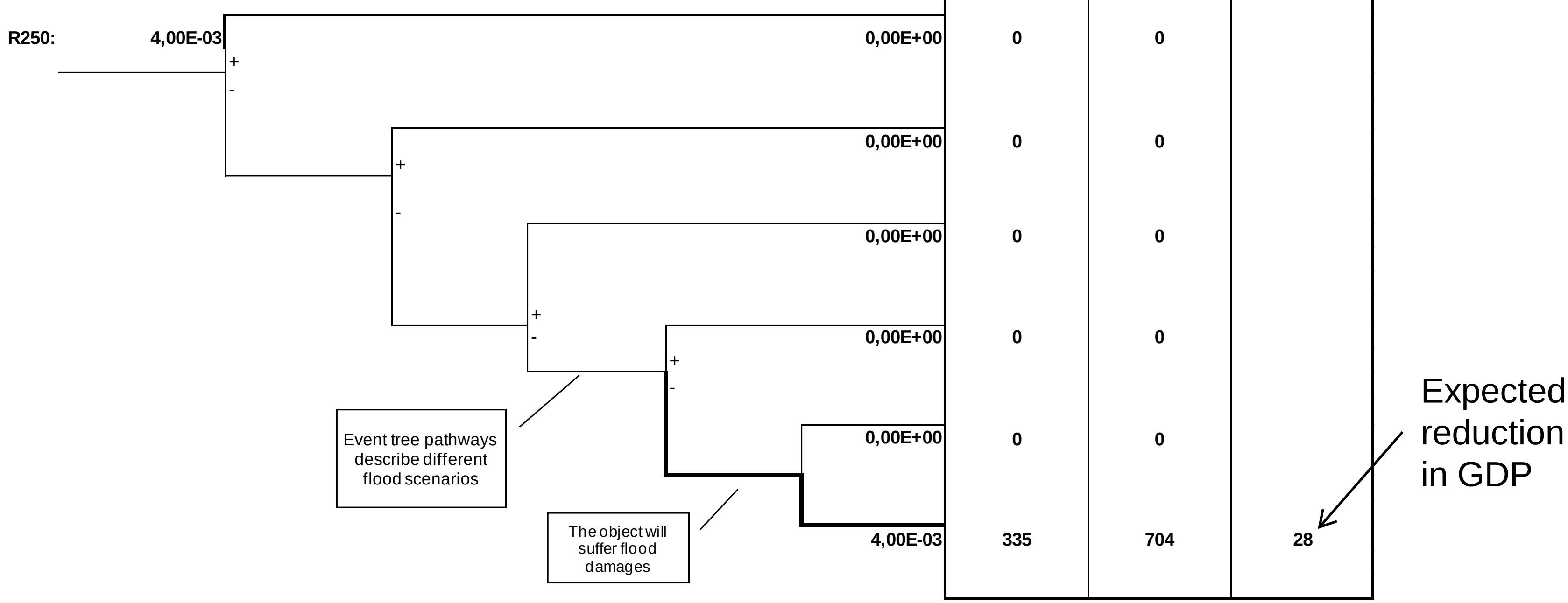
Approximated impact multiplier for Pori (Satakunta province) with regard to the default policy ’no compensation, no insurance’ (discounting factor 5%). GDP at state level.



Extended Event-tree …

VERM simulation for 'worst flood scenario' R250 in current climate, no compensation
→ approximate expected full cost during next 10 years (with possibly similar floods recurring)

FLOOD EVENT (PRECURSOR)	IMPACT PATHWAYS					CONSEQUENCE ANALYSIS (default case)		
Flood event (downpour, sea flood, river flood, ..) Flood scenarios Sc1-Sc3	Flood containment succeeds B1	Structure exposure negligible B2	Protection of structure succeeds B3	Emergency response succeeds B4	Service/supply chain undisrupted B5	Direct costs, Meuros	Indirect cost (after 10 years), Meuros	Expected value of net costs, Meuros
Flood protection is based on the hydrological parameters of the design flood	flood banks, dam, reservoir, ditch network	infrastructure, residential buildings	structural engineering conceptions	rescue equipment availability and capacity	flexibility & redundancy of production			
Annual probability $P(Q > q_R)$	p_1	p_2	p_3	p_4	p_5			
	0	**0**	**0**	**0**	**0**			



First results raise first questions …

- Which results reflect vulnerability better: direct costs or full cost?
- Which investment criteria to follow: cost/benefit (where 'benefit' is equal to the reduction of direct costs), or the reduction of expected full cost?
- Are expected values ok? This would asume that adaptation decision-making is risk-neutral. Hard to believe….
- Recurring flood? For R250 full cost computations assume very small contribution from additional floods due to the small occurrence probability of more than one flood. Needs further work…

# floods in 10 years	# ~ BINOM(0.004,#,10)
1	0,038583
2	0,000697
3	0,000007
4	0,000000
5	0,000000

Conclusions (so far)

- Basic Event-tree modelling and dynamic CGE simulation can supplement each other for a comprehensive cost assessment …
- …but who needs this type of integrated assessment as key actors (ministries → municipalities → public and private sectors / asset owners) have different responsibilities and means, and thus different assessment needs for advancing adaptation
- A extended Event-tree approach gives, however, a common framework for discussing and checking the consistency of assumptions underlying cost modelling

- *Further arguments and conclusions related to the IrtoRiski-projects will be provided in the presentation 3.4.4. 'Interpreting wellfare effects in induced economic impact evaluation of extreme events' (Hanna Virta)*

References

- Virta, H., Rosqvist, T., Simola, A., Perrels, A., Molarius, R., Luomaranta, A. & Honkatukia, J. (2011), Cost-benefit analysis of climate change induced extreme events as part of public decision making. Final project report of IRTORISKI. (In Finnish, with extended English summary), Finnish Meteorological Institute, Helsinki. 97 p.
- Perrels, A., Simola, A., Rosqvist, T., Virta, H., Honkatukia, J. (2011), Quantifying direct and induced economic costs of climate change, presented at NCCR Climate Economics and Law Conference, Bern, 16-17 June 2011