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# Economic Efficiency of Flood Protection Measures

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# Introduction

## **Main goal of the paper**

- The paper presents the results of long-term development of the methodology oriented on the flood protection measures economic efficiency evaluation

## **Schedule of presentation**

- Flood protection measures
- Principles of the economic efficiency assessment
- Costs and benefits for valuation
- Economic efficiency of the flood protection measures assessment
- Conclusions

# Flood Protection

## **Nonstructural flood protection measures**

- definition of flooding areas
- legislative assurance of flooding areas
- forecasting system
- early warning systems
- information of public

## **Structural flood protection measures**

- retention
- increasing of watercourses capacity
- protection walls
- stabilization of watercourses
- regulation of forestry
- regulation of activities in agriculture

# Economic Efficiency - Principles

$$NPV_E = \sum_{i=1}^n \frac{B - C}{(1 + r)^i}$$

where:

$NPV_E$  Economic Net Present Value

B in monetary units expressed benefits of the project

C in monetary units expressed costs of the project

r discount rate

n lifetime of the project, the duration of the valuated period in years

# Costs Connected With Flood Protection Measures

## Costs for economic valuation

- Investment costs
- Appreciable operating costs
- Appreciable costs caused by flood
- Other impacts

# Appreciable Costs Caused by Flood – Loss Savings

Basic steps for the appreciable costs caused by flood assessment:

- Assessment of value of the property in the territory threaten by flood
- Assessment of expected damages on buildings caused by flood – damage curves
- Flood losses prediction

# Territory Categories

- Determination of the average value of the property per square unit of the **territory**
- Territory categories come out from the territory planning documentation

Color	Mar king	Territory Category
Red	A	Residential areas
Orange	B	Recreational areas
Yellow	C	Areas of Civil Infrastructures
Light Orange	D	Green Areas
Red with vertical stripes	E	Mixed residential areas
Grey	F	Transport infrastructure areas
Blue	G	Technical infrastructure areas
Light Grey	H	Areas for production and storage
Pink with vertical stripes	I	Mixed production areas
Light Blue	J	Water and water-management areas
Light Orange	K	Agricultural areas
Light Green	L	Woodland areas
Green with vertical stripes	M	Natural areas
Pink	N	Mixed parts of unbuilt-up area
Black	O	Mixed parts of unbuilt-up area
Brown	P	Specific areas

# Assessment of Value of the Property in the Territory

- Territorial Property Index (TPI) for the category of the territory
- Expressing the value of the property per the square meter

$$TPI = \frac{VPT}{TRA}$$

TPI      Territorial Property Index

VPT      Value of Property in Territory

TRA      Total Residential Area

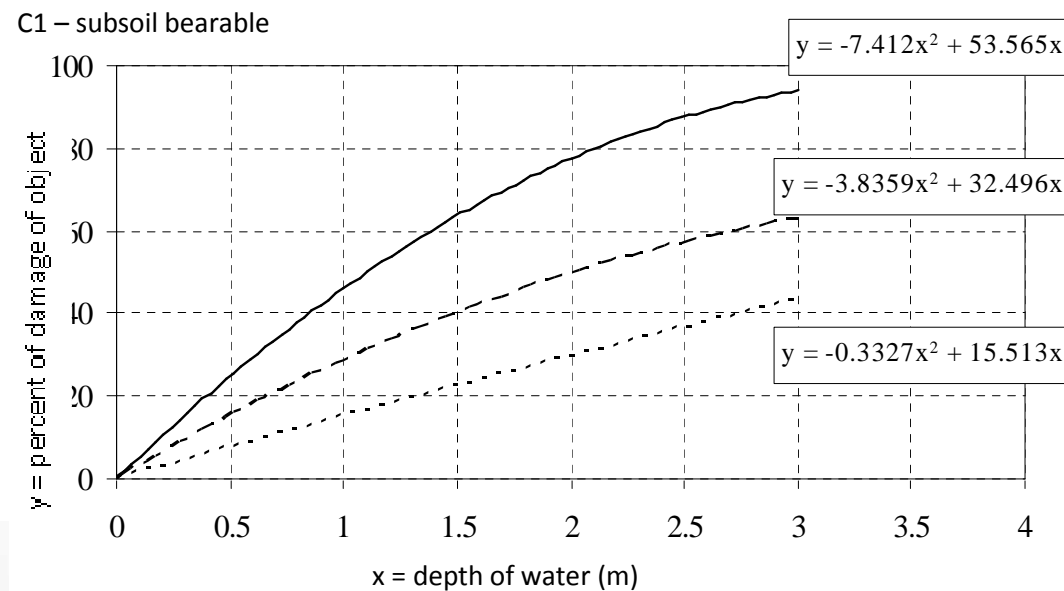


<b>Code</b>	<b>Name of representative</b>	<b>Built-up area (m<sup>2</sup>)</b>	<b>Land acreage (m<sup>2</sup>)</b>	<b>Techno-economic index (CZK/m<sup>2</sup>)</b>	<b>Total value (CZK)</b>
803 3	Apartment buildings till 4 floor	120.0	362	77,426	9,293,112
803 5	Apartment buildings over 4 floor	6.2	37	65,604	406,194
803 6	Family houses	1,988.6	7,983	31,377	62,397,011
801 1	Buildings for health care and services	17.3	45	120,508	2,087,356
801 2	Buildings for municipal services and hygiene	0.6	4	120,508	77,670
801 3	Buildings for education and training	58.7	646	84,177	4,940,951
801 4	Buildings for science, culture and education	4.5	18	134,833	600,175
801 5	Buildings for physical education	11.5	19	44,239	510,705
801 6	Buildings for administration	4.4	16	79,085	344,717
801 8	Buildings for commerce and public catering	24.5	130	88,282	2,159,358
801 9	Buildings social care	8.3	23	52,948	438,515
812 1	Buildings manufacturing industry, special	0.5	1	90,614	44,114
823 3	Areas for Physical Education uncovered	485.0	485	1,537	745,526
812 6	Additional objects	185.7	186	26,671	4,953,052
822 5	Objects of technical equipment	43.1	45	2,093	90,226
	<b>Totally</b>	<b>2,959</b>	<b>10,000</b>		<b>3 563 547 EUR</b>

# Expected Losses Caused by Flood – Damage Curves

Dependence of damage of the property on:

- depth of water
- duration of the flood
- influence of subsoil



# Flood Losses Prediction

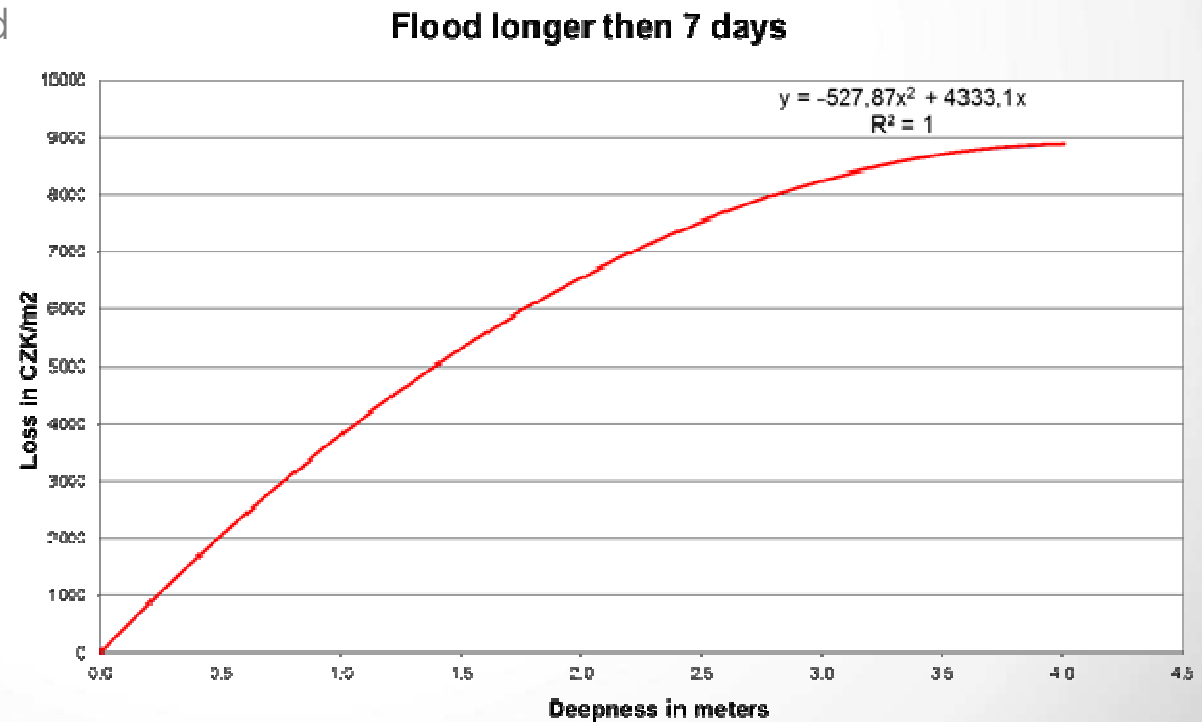
For **derivation** possible to carry out following steps:

- The assessment of the damage (in %) for particular property representatives in dependence on quality of subsoil, duration of flood and depth of water
- The assessment of the loss on particular representatives caused by flood
- The derivation of the dependence of the total loss on property in the territory on the quality of subsoil, duration of the flood and the depth of water

<b>Name of representative</b>	<b>Damage %</b>	<b>Reproduction price CZK/ha</b>	<b>Loss totally CZK/ha</b>
Apartment buildings till 4 floor	17,0192	9 293 112	1 581 613
Apartment buildings over 4 floor	17,0192	406 194	69 131
family houses	56,7288	62 397 011	35 397 076
Buildings for health care and services	51,5440	2 087 356	1 075 907
Buildings for municipal services and hygiene	51,5440	77 670	40 034
Buildings for education and training	51,5440	4 940 951	2 546 764
Buildings for science, culture and education	51,5440	600 175	309 354
Buildings for physical education	51,5440	510 705	263 238
Buildings for administration	51,5440	344 717	177 681
Buildings for commerce and public ery	51,5440	2 159 358	1 113 020
Buildings social care	51,5440	438 515	226 028
Buildings manufacturing industry, special	59,4568	44 114	26 229
Areas for Physical Education uncovered	29,1792	745 526	217 538
Additional objects	59,4568	4 953 052	2 944 926
Objects of technical equipment	50,7528	90 226	45 792
<b>Total loss of territory representative</b>			<b>1 841 373 EUR</b>

# Derivation of the Dependence of the Total Loss

- Usage of regression analysis
- Dependence on:
  - Quality of subsoil
  - Depth of water
  - Duration of the flood



# Economic Efficiency of the Flood Protection

- Main index is the Economic Net Present Value (NPVE)

$$NPV_E = \sum_{i=1}^n \frac{1}{(1+r)^i} \left[ \sum_{j=1}^m p_j (C_{ij}^0 - C_{ij}^I) \right] - IC$$

where

$NPV_E$  Economic Net Present Value

$IC$  Investment costs

$C_{0ij}$  j - kind of costs in zero option in i - time period

$C_{lij}$  j - kind of costs in investment option in i - time period

$r$  Discount rate

$n$  Life time of the investment project, event. duration of the valuated project's time period (in years)

$m$  Number of costs identified in the frame of the projects

$p_j$  Probability of j - cost, it must be  $\sum p_j = 1$

# Conclusions

Basic problems to solve

- Prediction of flood intensity and frequency
- Prediction of damages caused by flood
- Prediction of prices development
- Possibilities of usage for general kind of the territory