Assessment of the flood damages on the real estate property in the Czech Republic area

Zjišťování povodňových škod na nemovitém majetku na území České republiky

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Abstract: The problem of floods can be solved by investment activities in the form of the flood protection measures or by the potential liquidation of damages after the flood. In the frame of the solved grant projects, there was developed the basic methodology for the losses on the immovable property in the territory assessment and consequently the database of input data for its use. The output of the described methodology enables the comparison of the potential losses on immovable property with the investment costs for the flood protection measures. In order to be able to estimate the occurred losses, the own method has been developed by the members of the research team. This method consists of the specification of the territorial property valuation and the evaluation of the damage on the territorial property caused by floods. The basic quality of the Territorial Property Index is that it respects the generally defined structure of the real estate property in the given area. The Territorial Property Index is then calculated for the individual area categories. While evaluating the damage, first the measure of the damages of the property representatives depending on the hydrological situation defined in advance must be investigated. The damages are then estimated based on three defined primary parameters.

Key words: flood, property, flood protection measure, loss, damage

Abstrakt: Problém povodní lze řešit investičními aktivitami v podobě realizace protipovodňových opatření nebo potenciální likvidací škod po povodni. V rámci řešeného grantového projektu byla vytvořena základní metodika pro stanovení škod na nemovitém majetku v území a následně databáze vstupních informací pro její užívání. Výstup popsané metodiky umožňuje porovnání potenciálních ztrát na nemovitém majetku s investičními náklady na realizaci protipovodňových opatření. Pro možnost ocenění potenciálních škod byla členy řešitelského kolektivu vyvinuta metoda ocenění škod, která se skládá ze specifikace hodnocení majetku v území a ohodnocení poškození majetku v území v důsledku povodně. Základní význam Územního majetkového ukazatele spočívá v respektování obecně definované struktury nemovitého majetku v posuzované oblasti. Územní majetkový ukazatel je následně stanoven pro jednotlivé kategorie území. Pro možnost ohodnocení škod na majetku způsobených povodní musí být nejdříve odhadnuto poškození reprezentantů majetku v závislosti na hydrologické situaci v území. Poškození je odhadováno v závislosti na třech definovaných parametrech.

Klíčová slova: povodeň, majetek, protipovodňové opatření, škoda, poškození

The value of the potential flood loss, which was determined according to the methodology, is continuously compared with the real situation that means with the consequence of the real flood. The problem of floods can be solved by investment activities in the form of the flood protection measures or by the potential liquidation of damages after the flood. The decision about the realization of flood protection measures should be in the frame of the sustainable development of the territory researched in the wide

Supported by the Czech Science Foundation (Project No. 103/05/0160) and by the Institute of Structural Economics and Management, Faculty of Civil Engineering, Brno University of Technology.

context of the area of public investments and the general social utility. The realized flood damages ask for the expensive regeneration of the territory. In the frame of the solved grants projects, there was developed a basic methodology for the losses on the immovable property in the territory assessment and consequently the database of input data for its use. It concerns the database of the property losses that was created based on the directly defined parameters of the flood and the database of the representatives of the immovable property. The database of representatives of the immovable property and the next territory-planning groundwork and experiences were used for the creation of the database of the territorial and property indexes classified according to the functional usage of the territory (territory for living, territory for production and storing etc.) and based on that, it is possible to find out the potential damage in the locality of interest.

The output of described methodology enables the comparison of the potential losses on the immovable property with the investment costs for the flood protection measures. The potential flood losses that were set in the model for a certain hydrologic situation according to the cited methodology are continuously compared with the real state that means with the consequences of the real floods. The data matching moves from 80% to 95%.

MATERIALS AND METHODS

This methodology was developed in the frame of the solution of the project Czech Science Foundation (and was published in Korytárová et al. 2007a). The thesis and the studies were supported by the Institute of Structural Economics and Management at FCE Brno University of Technology.

RESULTS

Flood effects are increasing the annual financial cost load of the public and private budgets in recent years in the Czech Republic. The floods affected the Czech Republic in the years 1997 (around 5% of our area), 2002, 2005, 2006, and also in the year 2009 the swollen rivers flooded hundreds of houses and some road sections in the Vsetin, Novy Jicin and Olomouc areas.

The damage on property caused by floods has been relatively very high. Since the flood protection measures are capital-intensive, their economical efficiency must be judged with regard to the context of the potential flood damage, which can be avoided or which at least can be reduced. In order to be able to estimate the occurred loss, own method has been developed by the members of the research team; this method consists of the following steps (Korytárová et al. 2007a):

Specification of the territorial property valuation:

- Specification of property representatives in the territory.
- Estimation of the property representatives.
- Specification of the territorial category.
- Specification of the territorial representative.
- Estimation of the territorial property index on the reproduction price level.

Evaluation of the damage on the territorial property caused by floods:

- Specification of the damage to the property representatives.
- Evaluation of the damage ratio of the territorial representative formulated in%.
- Specification of the damage on the territorial representative on the reproduction price level.
- Specification of the damage in the monitored territory on the reproduction price level.

Specification of the territorial property valuation

The basic quality of the Territorial Property Index is that it respects the generally defined structure of the real estate property in the given area. Thus the entire real estate property, which is usually present in the given area expressed by the value of the Representatives of Property in the area in the reproduction price, contributes to its value. However, many different kinds of property can exist in an area. Because of this, it is practical to split up the whole area surface into different area categories, which can be defined from the planning point of view by the prevalent functional utilization of the individual areas. The Territorial Property Index is then calculated for the individual area categories. The area categories are specified in relation to the Regulation No. 501/2006 Coll. on general requirements for the area utilization. A basic overview is presented in the Table 1.

The values of the Territorial Property Index are calculated for the individual area categories, as it is necessary to describe the individual area categories from the viewpoint of their functional utilization.

The functional utilization of the individual area categories (as given in Table 1) is generally defined by

the Regulation No. 501/2006 Coll. on general requirements for the area utilization (Regulation only in the following text). The Regulation states, what kinds of land occur usually in the given category. By the way of example, the characteristic of the A area category – residential areas – can be given (Table 2).

The Regulation does not deal with the usual shares of lands occurring in the given category. These shares have been determined by the means of an expert estimate supported by a statistical survey. Within the framework of the survey, the shares of the land in the areas regarding the individual area categories in the selected parts (e.g. municipalities) have been monitored and the mean values of these shares have been determined subsequently. This method is very precise but rather demanding on time and the necessary data.

Table 1. Area categories

Marking	Area category
A	residential areas
B	recreational areas
C	areas of civil infrastructures
D	green areas
E	mixed residential areas
F	transport infrastructure areas
G	technical infrastructure areas
H	areas for production and storage
I	mixed production areas
J	water and water-management areas
K	agricultural areas
L	woodland areas
M	natural areas
N	mixed parts of non-built area
O	mineral working areas
P	specific areas

Table 2. Functional utilization of A area category – residential areas

Functional utilization of area (A – residential area)
One-family house lands
Block of flats lands
Related transport infrastructure lands
Related technical infrastructure lands
Public space lands
Related amenity lands (with the exception of business areas over 1000 m^2)
Other buildings and facilities not impairing the level of the environment
Other non-built-on lands

The manner how to determine the Representative of the Area can be demonstrated on the example of the A category – residential areas. The outputs of the statistical survey carried out on a sample of 139 South Moravian municipalities with up to 50 thousand inhabitants have been used for the calculation.

In accordance with the Regulation, the total residential area has been split up into two basic groups of areas, namely built-up areas and non-built-on areas. Based on the established data, the ratio of these areas has been set as 30 per cent to 70 per cent. The total built-up area has been further broken down into the following four parts:

- housing areas, areas including land of objects designed for habitation and open spaces – hard or unpaved surfaces
- auxiliary objects areas
- amenity objects areas
- areas of objects of technical facilities

The area of the land of an object (e.g. of a block of flats) depends to a certain extent not only on the size of the object itself, but also on the type of development where it occurs within the framework of the given residential area. Because of this, the three following types of development have been defined (Korytárová and Šlezingr 2007):

- Residential areas with open (Korytárová et al. 2007b) layout (living floor spaces, amenities and technical facilities, possibly also garages and other auxiliary objects that are located in independent, freely standing objects);
- Residential areas with closed layout (living floor spaces that are located in spatially connected objects of terraces houses, possibly also in objects forming blocks, amenities and technical facilities that are located in functionally independent but structurally and really concentrated objects);
- Residential areas with integrated layout (living floor spaces, areas of amenities and other functions that are united in common objects, usually one on top of the other).

Residential areas

Each of the above-mentioned types of development can consist of different kinds of houses designed for habitation, therefore, the following three kinds of

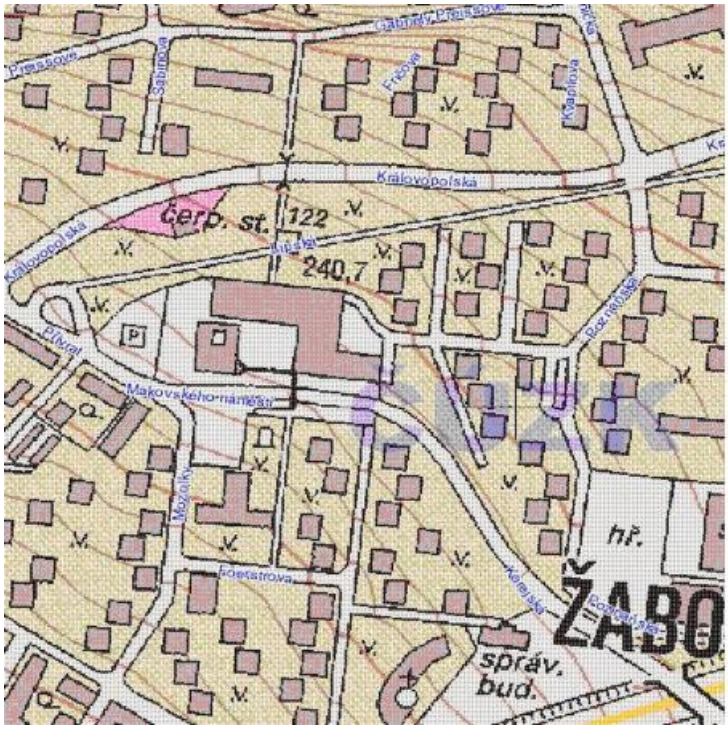

Figure 1. Open type of development, dwelling houses up to four storeys

development have been considered in the calculations:
– dwelling houses up to four storeys
– dwelling houses with more than four storeys
– one-family houses

One of the possible combinations of the type and kind of development is shown in Figure 1.

The average size of the area of the development designed for habitation should respect the type of the development (open, closed and integrated layout), kinds of development (dwelling houses up to four storeys, dwelling houses with more than four storeys and one-family houses) and their shares in the total development designed for habitation.

The weights for the type of development (a_i) and kind of development (b_{ij}) have been established for the determination of the Representative of Area of the A category – residential areas – by the means of the statistical survey mentioned in the preceding text. After transforming the outputs of the formulas defined above, it was possible to describe the Representative of Area of the A category – residential areas – by the proportional representation of the partial units in the total residential area. The structure of the representative is given in Table 3.

Table 3. Structure of the representative of the area of the A category – residential areas

Area	Share (%)
Residential area (CPB)	100.00
Built-up residential area out of it	30.00
Area of the development designed for habitation (PZB)	83.83
Area of the auxiliary objects (PDO)	1.86
Area of the technical facility objects (PTV)	0.45
Area of the amenity objects (POV)	13.86
Non-built-on area (PN)	70.00

Determination of Territorial Property Index

The individual areas of the development are determined by a certain number of the representatives of one type of the real property – building objects. To determine the Representatives of the Real Estate Property, the budget index cards collected during the last five years for teaching as well as research purposes in the Institute of Structural Economy and Management of the Faculty of Civil Engineering of the University of Technology in Brno have been used. From the viewpoint of the methodology of the determination of the Territorial Property Index, the technical characteristics of building volume (OP) and the built-over surface (ZP) are decisive with the individual Representatives of Property. Then the set of the quantified characteristics of the individual building objects has made it possible to evaluate statistically the data occurring most often. Based on them, the representative of a certain kind of real estate property has been specified by the means of the

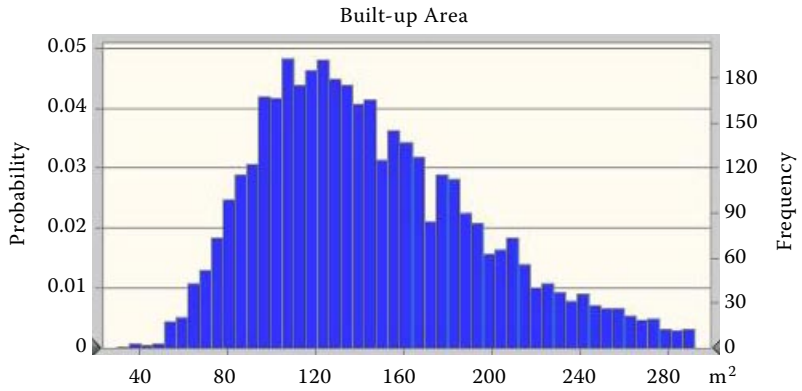

Figure 2. Probabilistic configuration of the build up-area of one-family house

Source: Korytárová et al. (2007a)

technical characteristics. The Crystal Ball software has been used for evaluation of the data.

The Representative of Property of one-family house, which forms one kind of the development in the residential area, has been selected for the example in Figure 3 (Uhmannová and Šlezingr 2003).

Table 4. Probabilistic characteristics of the built up area of one-family house

Statistics	Forecast values
Trials	4 000
Mean	146.63
Median	137.55
Mode	–
Standard deviation	51.96
Variance	2 699.77
Skewness	0.7908
Kurtosis	3.41
Coeff. of variability	0.3544
Minimum	30.11
Maximum	344.67
Range width	314.56
Mean std. error	0.82

Source: Korytárová et al. (2007a)

The values of the built-up area and building volume have been processed by the program to clearly arranged charts and tables. Figure 2 and Table 4 demonstrate the outputs of the built-up area values. The horizontal axis of the chart represents the values of the built-up area in m^2 and the vertical axis shows the number of the possible occurrences. The median value, which has been gained from the variant models, has the size of 138 m^2.

The desired Territorial Property Index is determined by the means of the methodology mentioned above as the quotient of the total value of the real estate property in the area and its area using the following formula (Korytárová and Šlezingr 2007):

$$TPI = \frac{VPA}{TRA} \quad (1)$$

where:

TPI = Territorial Property Index
VPA = Value of Property in the Area
TRA = Total Residential Area

The value of the Territorial Property Index represents the value of the real estate property in the area in CZK per 1 m^2 of the given area category. The example demonstrates the TPI value for the A area category in Table 5 – residential areas.

A number of European countries work at determination of the Territorial Property Indexes. The values

Figure 3. Card of the representative of the area of the A category – residential areas

Table 5. Territorial property index – A area category – residential areas

Total value of the real property	11 108 900 CZK
Total land area A	10 000 m^2
Territorial Property Index	11 109 CZK/m^2

determined by the research are compared with the foreign sources (Tichá et al. 2003). The values given in EUR/m^2 have been converted on the basis of the current exchange rate (Table 6). The comparable 2010 price level has been determined by the means of the inflation index (Tichá et al. 2003).

Evaluation of the damage on the Territorial Property after the Flood, Specification of Damage of Property Representatives

While evaluating the damage, first the measure of damages of the property representatives depending on the hydrological situation defined in advance must be investigated. This status has been simulated in the methodology on the basis of three primary parameters, namely of: water depth (h), duration of the flood (t) and the bear load sub-grade. The selected criteria for own evaluations of the potential damage are as follow:

h – Depth of Water (Elevation of the Water Column within the Structure or in the Terrain Level)
- h_1 – to 0.5 m
- h_2 – to 3.0 m (Average Elevation of the Ground Floor)
- h_3 – above 3.0 m

t – Duration (Water on the Surface of the Structure)
- t_1 – within 1 day
- t_2 – from 2 to 7 days
- t_3 – more than 7 days

The combination of the above described criteria has been elaborated on the assumption of both flowing water reaching the speed up to 1.0 m/s and the bear load sub-grade.

The table data have been transferred into a detailed chart which enables to determine the percentage of damage occurred for the particular real estate property representatives. The curves in the particular charts shall be subsequently specified in a more detailed manner upon the data acquired from the case studies within the scope of the research grant.

The Figure 4 shows the damage curve for a real estate property representative of a family house.

Evaluation of the damage ratio of the territorial representative

The territorial representative is formed through built-up areas of a specific number of real estate property representatives. For each type of the real estate property representative, the percentages of damage have been determined by the help of the damage curves. Further, the number of the real estate property representatives within the location of interest has been determined and by the means of their reproduction price level as well as the percentage of damage, the average percentage damage in the determined territorial category has been specified (Table 7).

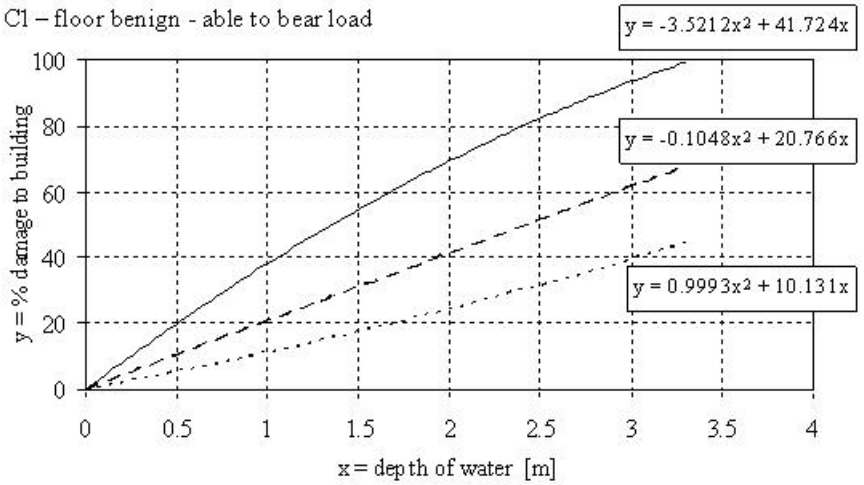

Figure 4. Damage curves for the representative of the family house property, contiguous terraced development

Table 6. International comparison of the Land Property Indexes

	Area category	Value of the Land Property Index (CZK/m^2)*				
		Germany	Switzerland	France	Netherlands	Czech Republic
A	Residential areas	10 382	10 827	8 894	10 370	10 099

*Price level 2007

Table 7. Categories of developed areas

Code of territorial category	Name of territorial category	Value of the real property (1 000 €)	Damage ratio (%)	Damage (1 000 €)
A	residential areas	12 216	0.168	2 050
B	recreational areas	360	0.598	183
C	areas of civil infrastructure	43 456	0.170	830
D	green areas			
E	miscellaneous areas			
F	production and logistics areas	5 962	0.12	715
G	areas of transportation infrastructure			
H	areas of technical infrastructure	64	0.05	3
I	specific areas			
Total sum of the potential damage				3 782

CONCLUSION

The estimated damage on the real estate property located in the flood area of Šumický Stream in the city of Pohořelice amounting to 3 782 thousand € does not include the internal equipment of structures, the operational technology, stocks, the vehicles located inside of the structures etc.

Further, no damages on agricultural production, on the river-basin of the Šumický Stream, on the transportation infrastructure, on the dams of the Šumický as well as Pohořelický Pond (these ponds would be overfilled if no dam failure occurred) are included.

Providing the existing status of land management in the basin of the Šumický Stream, we have to take into consideration, while evaluating the damage, the transport of a large quantity of earth material which would subsequently be sedimented at the places where the speed of the stream is lower, namely everywhere at the places of the potential effusion. All those damages are referred to as "the miscellaneous damages".

Based on the experience from solving the consequences of flood events in 1997 and 2002 (in particular we relied on the situation in the City of Olešnice and in the local part Roudná in České Budějovice where lots of useful data is available) we can claim that the level of miscellaneous damages reaches at least the level of damage on structures or it is even higher than that.

The total evaluation of damage on the structures plus the "miscellaneous damages" can be evaluated with regard to the aforesaid information to the price level of minimally a double of the structural damage, namely to the sum total of CZK 211 800 thousand.

This paper deals with the methodology of the potential flood loss assessment which was developed in the frame of solution of flood protection measures in the Czech Republic area. The potential flood losses are set in model for certain hydrologic situation. On the base of the flood parameters (speed of water, depth of water and duration of flood) and the property representative (building objects), there were created the loss curves. These loss curves are created in a graph form that is used for the determination of the percent damage on the property representative for various combinations of the above cited flood parameters.

As a next step of this methodology, there were created the territorial property indexes for the separate territorial categories (according to their functional

usage) which are defined by the quantity and reproduction price of the real estate property representative. These territorial property indexes in monetary unit/m^2 make it possible to quickly assess the value of the immovable property in the inundation area. Consequently, by the help of loss curves, it is possible to determine the value of the potential flood loss in this area.

Acknowledgment

This result has been achieved with the financial support of the Czech Science Foundation, Project No. 103/05/0160 "The procedures of support of the decision-making in the field of structural investments in order to safeguard the territorial stability against floods".

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Arrived on 18th May 2010

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