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FLOOD RISK – OPTIMIZING A NATIONAL PROGRAM

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Floods are a major natural hazard substantially impacting the developed and developing world. Recent floods have caused near-record natural hazards losses in regions as disparate as Mozambique, and central and eastern Europe. A comprehensive detailed analysis was performed for a Study Region in eastern Europe, with the goal of identifying an economically efficient insurance program appropriate for that region. A international review of national natural hazards insurance programs identified a range of options, which were analyzed for the protection they offered to the exposed capital, under two conditions of mitigation: embankments and no embankments. A Most Favored Option which combined insurance with mitigation in high hazard zones was identified via a Dynamic Financial Analysis, and demonstrated to be cost beneficial. Analysis for other regions will be greatly facilitated by emerging new technologies, which are exemplified by the HAZUS® ^{MH} software in the US.

Introduction

Natural hazards such as floods, earthquakes and windstorm have taken a terrible toll in this century, despite increasing capabilities to forecast these events and mitigate their consequences. Figure 1 shows the increasing trend in economic losses due to natural hazards in general, while Table 1 shows relative flooding losses for the second half of the 20th century. Figure 2 indicates that earthquake, windstorm and flood contribute about equally to economic losses, although windstorm is the leader for insured losses. These economic losses are not inconsequential - in year 2000, the worldwide economic losses amounted to $31 Billions with the insured losses being $8.3 Billions.

Table 1 Great Flood Disasters: decade comparison
(after Loster, 1999)

	Decade 1950-59	Decade 1960-69	Decade 1970-79	Decade 1980-89	last 10 1989-98	Factor last 10:50	Factor last 10:60
Number	7	7	9	20	34	4.9	4.9
Economic losses	27.9	20.2	19.2	25.5	199.6	7.2	9.9
Insured losses	---	0.2	0.4	1.4	7.4	---	37

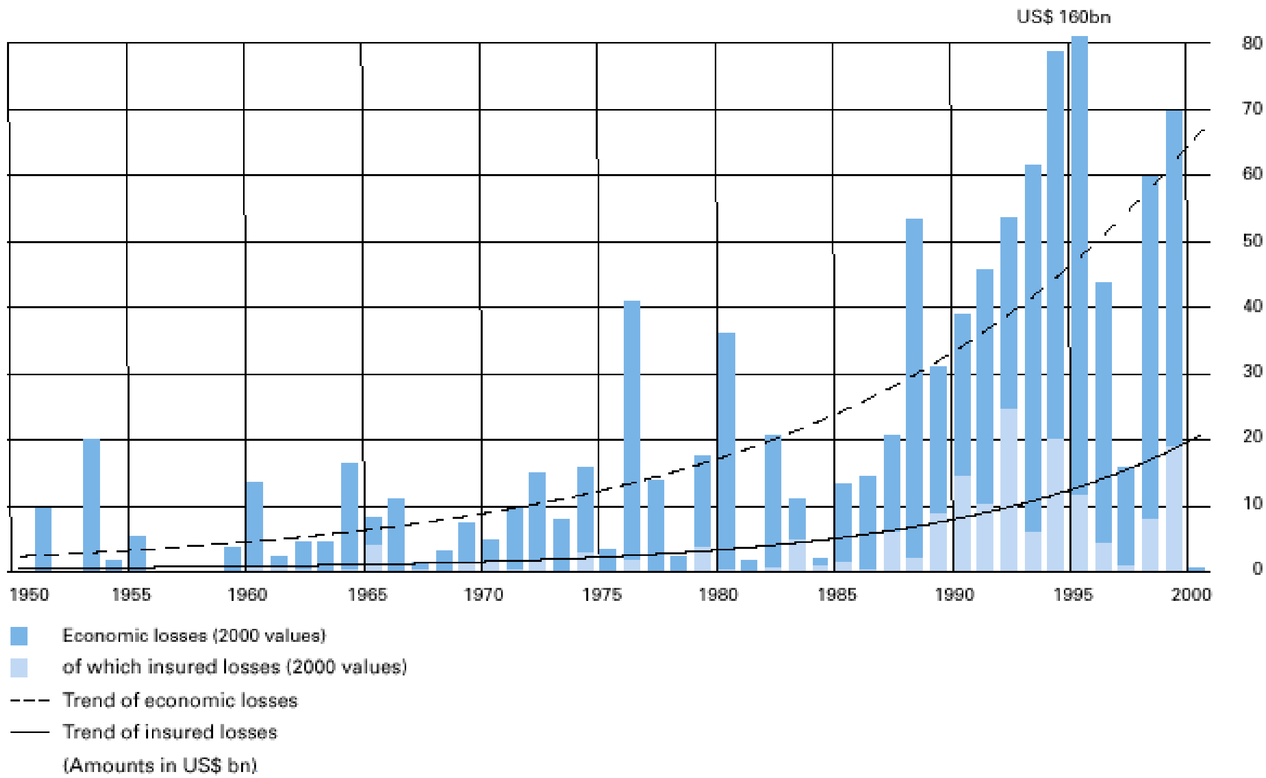


Figure 1 Trends of Economic and Insured Losses Worldwide Over the Last 50 Years

(Source: Munich Re)

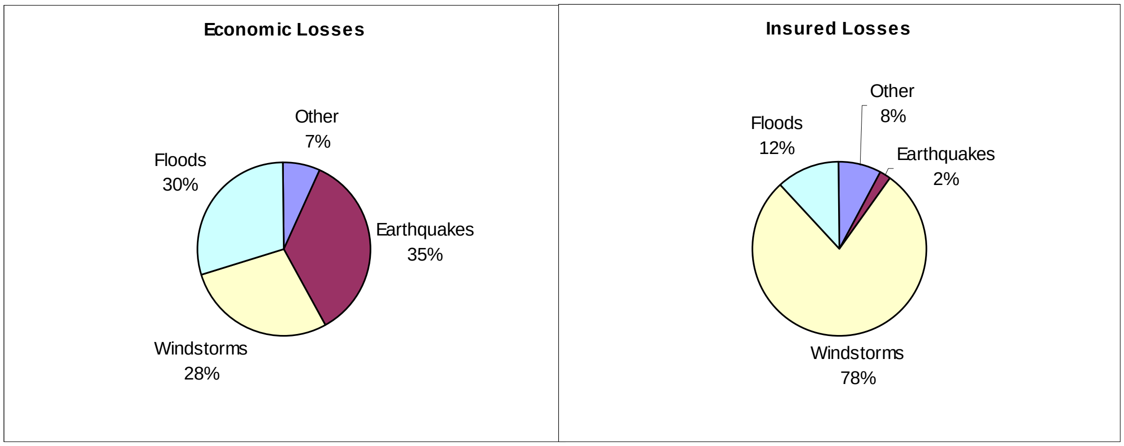


Figure 2 (a) Economic and Insured Losses in the Last 50 Years (Ref. 2)

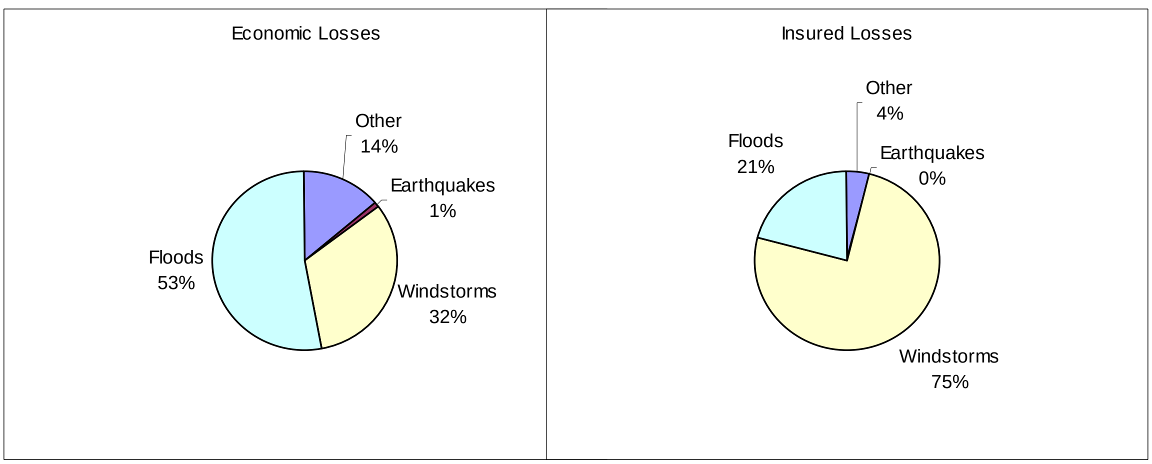


Figure 2 (b) Economic and Insured Losses in Year 2000 (Ref. 1).

Central and eastern Europe has been a region repeatedly and severely impacted by floods in recent decades. Recent examples include:

- Poland had severe flooding in 1997, in which torrential rains drenched south-western Poland, causing the rivers Oder, Nyza, and Mozara to overflow their banks and break through flood dikes, resulting in (Stripple, 1998):
  - 5 confirmed deaths
  - at least 150.000 people evacuated
  - 6 cities, 875 villages, 40.000 farms and 450.000 hectares of agricultural land inundated
  - 10 medical facilities, 250 schools damaged or destroyed
  - 40 bridges, 1600 km of roads destroyed
  - 200 small and medium sized factories destroyed
  - estimates showing that the economic cost amounted to 2.9 billion US dollars or approximately 3% of Poland's GDP.
- Flooding throughout central Europe in 2002 caused widespread damage and destruction in Austria, Germany and the Czech Republic, on an unprecedented scale. The total economic losses were estimated at approximately 55 billion euros. However, total insured losses were only in the range of 1.5 billion to 3 billion euros. Thus, there were many uninsured losses leading to large-scale government assistance. As a result, the European Union agreed to set up a permanent fund for future natural disasters. (Maggs, 2002)

Note that these losses are only exceeded in modern times, for a natural hazard, by the 1995 Kobe earthquake. The 2002 floods led a leading global reinsurer to state:

> *"The greatest distress was mitigated by remarkably generous donations and government aid. Even so, it will take years to telimate the hardship completely…voluntary donations and taxpayers' money is only the second-best solution…there is no reason why comprehensive cover for flood damage should not be available…presupposes a close partnership among the insurance industry, policyholders and governments."* (Swiss Re, 2002)

As a result of the 1997 floods, a central European nation received World Bank loans for a variety of flood-related projects, including:

- Study of options to implement a flood insurance system
- Delineation of expected stimulating effects resulting from a flood insurance system such as on spatial planning, building codes or legal requisites
- Preparation of a flood insurance system proposal for the governmental authorities.

The next section of this paper describes the study of options.

Options to implement a flood insurance system

An analysis was performed to identify the most favored insurance option that would stimulate appropriate land management in inundation areas, and preparation for floods. In outline, the analysis consisted of the following major tasks:

- A review of International natural hazards insurance practice and the situation in the subject country,
- An examination of the range of options for a flood insurance scheme the subject country,
- Selection of eight (8) options that cover a broad range of the feasible set. These eight options actually constitute 16 cases for analysis, since each option is analyzed under the case of No Mitigation, and Mitigation. The analyses results in estimates of the damage occurring under the two mitigation scenarios, and the losses covered under the 16 insurance-mitigation cases, and were performed for a Study Region representing approximately 0.8% of the total population of the subject country. Geographic Information System (GIS) data and methods were used extensively in these analyses, which probabilistically account for damage to buildings and contents under various levels of flooding.
- Based on the analytical results, a Dynamic Financial Analysis (DFA) was performed to examine the potential solvency of each insurance scheme.
- Based on the DFA, the arguments for and against each of the options were reviewed, to determine the most favored insurance scheme.

Each of these steps is discussed next.

Review of International and Subject Country insurance practices

The analysis began with a review of leading flood insurance solutions in other countries, together with the situation in the subject countr, in order to develop the insurance scheme options for analysis. Increasing economic losses since the 1960’s caused by natural hazards such as floods and earthquakes has spurred the formation of a number of national or regional insurance programs focused on natural hazards. Notable among these is the FONDEN in Mexicio, the US national flood insurance program (NFIP), France’s Nat Cat (multi-peril) and Japan’s and New Zealand’s earthquake-focused programs. These programs were analyzed according to a broad set of variables, indicated in Table 2.

Table 2 Insurance Program Variables

PARAMETER		CRITERION
1	**MANAGEMENT**	Privately managed
		Publicly managed
2	**FUNDING**	Privately funded
		Publicly funded
3	**INSURANCE SCHEME**	Insurance pool
		Reinsurance pool
		Private insurance companies
4	**COVERAGES**	Building
		Contents
		Time Element (Additional Living Expense, Business Interruption)
		Livestock
		Crop
		Agricultural motor vehicles
5	**LINES OF BUSINESS**	Residential Urban
		Residential Rural
		Agricultural
		Commercial & Industrial
		Government and Non-Profit
		Infrastructure/Roads, Rails and Bridges
6	**RATE BASIS**	Risk based
		Flat rate
		Mitigation incentives
7	**GEOGRAPHICAL**	Regional
		National
8	**PARTICIPATION**	Voluntary program
		Compulsory program
		Universal program

Using the variables in Table 2, a survey of 15 major national and regional programs found the following general tendencies (Scawthorn, 2001):

- Most programs focus on the natural hazard of greatest concern, often ignoring lesser natural hazards. A program can be regional, or national, depending on the relative risk across the nation.

- Residential building and contents risk is the primary concern, with relatively low deductibles and high limits. Rates vary significantly but are usually tied to the risk, and are not subsidized. Homeowners and tenants are free to participate or not, and a significant fraction choose to be uninsured. Mitigation is not typically a major focus.

- Management typically has a public dimension although it may be quasi-independent of the government. Sales and servicing are typically through the established distribution networks of private primary insurance companies and agents. Policies are often tied to the basic fire policy (ie, via an endorsement), with the natural hazard risk 'passed through' to an industry-wide insurance or reinsurance pool.

The subject country for the project has a long history of flooding, usually due to unusual meteorological conditions causing episodes of heavy rainfall. In the subject country, insurance for flood losses is available via the traditional insurance markets, and it is estimated approximately 12% of homeowners purchase flood insurance. Purchase of flood insurance in the commercial sector is more difficult to determine, but estimates ranged from 8% to 20%, although under-insurance appeared prevalent. National legislation affecting flood emergency response and insurance generally came under numerous more general measures for emergencies and natural disasters, so that a cohesive approach to flood mitigation or insurance had not been achieved. Specifically, ordinary insurance regulations governed current and prospective flood insurance. A number of special regulations resulted from recent flooding did not change this.

Range of options for a flood insurance

There are an infinite number of possible options for any insurance scheme, due to the large number of parameters involved in the definition of what constitutes insurance. A presentation of some key parameters defining an insurance program is provided in Table 2. In this study only a select number of major parameters were considered, consisting of:

- Line(s) of business to be covered by the flood insurance.
- Coverage(s) to be included for each of the line of business.
- Estimate of the market penetration[1] for each line of business for risks located within the 100-year flood zone[2].
- Estimate of the market penetration for each line of business for risks located outside the 100-year flood zone.
- Deductible[3] expressed as a percentage of the building insured value.
- Deductible expressed as a percentage of the building damage.

1 The market penetration, also known as the buy rate, is defined as the percentage of insured to the maximum number of possible insured.

2 In most flood insurance programs, this zone is considered with special attention because of its high hazard potential. Therefore, in this study we will distinguish between this flood zone and the lesser flood prone zone outside of it.

3 There are several ways to define the deductible. For simplicity, in this study we have considered only two types, one defined as a function of the building insured value and the other as a function of the building damage.

- The limit considered for any policy, for any line of business, and for any insurance option is the total insured value (TIV) that is assumed to be equal to the replacement cost.

In the analysis of the insurance options, no reinsurance was considered. This assumption was made not only for simplicity, but also to make all options normalized at the primary insurance level. Reinsurance, if desired, could be purchased by the management agency in charge of the pool.

Based on the parameters as defined above, the review of international natural hazards insurance practice, and the review of the insurance industry in the subject country, eight different insurance options were identified for analysis, as representative of the possible options for a flood insurance program in Poland. The options included

- a Base Case representative of current flood insurance practice in Poland,
- a scheme compulsory for residential only,
- several other schemes involving combinations of public and private insurance, and
- schemes modeled after national programs in France, New Zealand and the USA.

These eight options are detailed in Table 3 and combined in varying degrees voluntary vs. compulsory insurance, residential vs. commercial vs. public property protection, etc.

Sixteen analytical cases representing all eight options, under conditions of No-mitigation (i.e., current embankment conditions, corresponding to approximately 50 year return period protection levels) and Mitigation (i.e., embankments providing protection against 100-year floods), were analyzed for the Study Region. The population of the Study Region representing approximately 0.8% of the total population of the subject country. Total assets at risk were estimated to be approximately USD 3 billion.

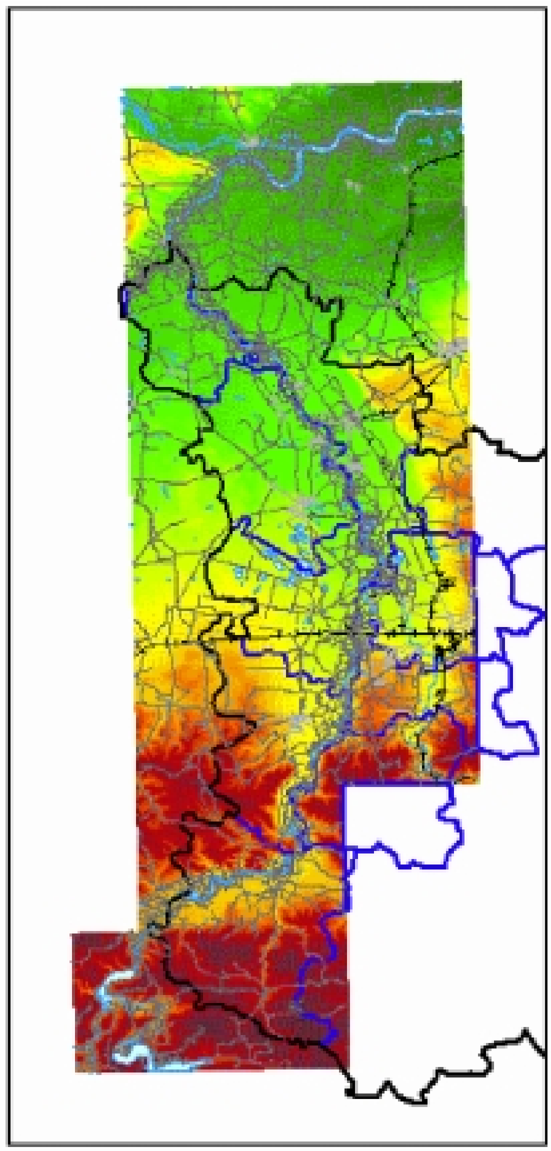


Figure 3 Study Region topography, stream reaches and roads

Table 3 Definition of Insurance Options

Option No.	Option Name	Line of Business	Building Coverage	Contents Coverage	Time Element Coverage	Market Penetration Outside 100-Year Flood Zone	Market Penetration Inside 100-Year Flood Zone	Deductible as % of Building (Asset) TIV	Deductible as % of Building (Asset) Damage
1	Base	Residential Urban	Yes	No	No	10%	20%	1.0%	0.0%
1	Base	Residential Rural	Yes	No	No	10%	20%	1.0%	0.0%
1	Base	Agricultural	Yes	No	No	30%	60%	1.0%	0.0%
1	Base	Commercial & Industrial	Yes	Yes	No	15%	30%	1.0%	0.0%
1	Base	Government and Non-Profit	No	No	No	0%	0%	0.0%	0.0%
1	Base	Infrastructure	No	No	No	0%	0%	0.0%	0.0%
2	Non-Commercial	Residential Urban	Yes	No	No	100%	100%	0.0%	0.0%
2	Non-Commercial	Residential Rural	Yes	No	No	100%	100%	0.0%	0.0%
2	Non-Commercial	Agricultural	Yes	Yes	Yes	100%	100%	0.0%	0.0%
2	Non-Commercial	Commercial & Industrial	No	No	No	0%	0%	0.0%	0.0%
2	Non-Commercial	Government and Non-Profit	Yes	No	No	100%	100%	0.0%	0.0%
2	Non-Commercial	Infrastructure	Yes	No	No	100%	100%	0.0%	0.0%
3	Non-Public	Residential Urban	Yes	Yes	Yes	15%	45%	1.0%	0.0%
3	Non-Public	Residential Rural	Yes	Yes	Yes	15%	45%	1.0%	0.0%
3	Non-Public	Agricultural	Yes	Yes	Yes	25%	75%	1.0%	0.0%
3	Non-Public	Commercial & Industrial	Yes	Yes	Yes	25%	75%	1.0%	0.0%
3	Non-Public	Government and Non-Profit	No	No	No	0%	0%	0.0%	0.0%
3	Non-Public	Infrastructure	No	No	No	0%	0%	0.0%	0.0%
4	High-Hazard	Residential Urban	Yes	Yes	Yes	15%	100%	5.0%	0.0%
4	High-Hazard	Residential Rural	Yes	Yes	Yes	15%	100%	5.0%	0.0%
4	High-Hazard	Agricultural	Yes	Yes	Yes	25%	100%	5.0%	0.0%
4	High-Hazard	Commercial & Industrial	Yes	Yes	Yes	25%	100%	5.0%	0.0%
4	High-Hazard	Government and Non-Profit	Yes	Yes	No	50%	100%	1.0%	0.0%
4	High-Hazard	Infrastructure	Yes	No	No	50%	100%	1.0%	0.0%

Table 3 Definition of Insurance Options (Continued)

Option No.	Option Name	Line of Business	Building Coverage	Contents Coverage	Time Element Coverage	Market Penetration Outside 100-Year Flood Zone	Market Penetration Inside 100-Year Flood Zone	Deductible as % of Building (Asset) TIV	Deductible as % of Building (Asset) Damage
5	Hybrid	Residential Urban	Yes	Yes	Yes	15%	45%	5.0%	0.0%
5	Hybrid	Residential Rural	Yes	Yes	Yes	15%	45%	5.0%	0.0%
5	Hybrid	Agricultural	Yes	Yes	Yes	25%	75%	5.0%	0.0%
5	Hybrid	Commercial & Industrial	Yes	Yes	Yes	100%	100%	5.0%	0.0%
5	Hybrid	Government and Non-Profit	Yes	Yes	Yes	100%	100%	5.0%	0.0%
5	Hybrid	Infrastructure	Yes	No	No	100%	100%	5.0%	0.0%
6	French	Residential Urban	Yes	Yes	Yes	20%	40%	1.0%	0.0%
6	French	Residential Rural	Yes	Yes	Yes	20%	40%	1.0%	0.0%
6	French	Agricultural	Yes	Yes	Yes	30%	60%	0.0%	10.0%
6	French	Commercial & Industrial	Yes	Yes	Yes	30%	60%	0.0%	10.0%
6	French	Government and Non-Profit	No	No	No	0%	0%	0.0%	0.0%
6	French	Infrastructure	No	No	No	0%	0%	0.0%	0.0%
7	New-Zealand	Residential Urban	Yes	Yes	No	20%	40%	0.0%	1.0%
7	New-Zealand	Residential Rural	Yes	Yes	No	20%	40%	0.0%	1.0%
7	New-Zealand	Agricultural	No	No	No	0%	0%	0.0%	0.0%
7	New-Zealand	Commercial & Industrial	No	No	No	0%	0%	0.0%	0.0%
7	New-Zealand	Government and Non-Profit	No	No	No	0%	0%	0.0%	0.0%
7	New-Zealand	Infrastructure	No	No	No	0%	0%	0.0%	0.0%
8	US	Residential Urban	Yes	Yes	No	15%	100%	1.0%	0.0%
8	US	Residential Rural	Yes	Yes	No	15%	100%	1.0%	0.0%
8	US	Agricultural	No	No	No	0%	0%	0.0%	0.0%
8	US	Commercial & Industrial	Yes	Yes	No	25%	100%	1.0%	0.0%
8	US	Government and Non-Profit	No	No	No	0%	0%	0.0%	0.0%
8	US	Infrastructure	No	No	No	0%	0%	0.0%	0.0%

Hydraulic, Damage and Loss Analysis

Available data was used to estimate flood discharges corresponding to return periods from 10 to 1,000 years, and is then employed in a hydrodynamic model within a Geographic Information System (GIS) framework to estimate damage to buildings and contents under various levels of flooding. The hydrodynamic modeling was performed by the firm of GEOMOR and the Danish Hydraulic Institute (DHI). Figure 4 shows an example of flooding expected with with and without levees or 'embankments'. That is, the "No Embankment case corresponded to current conditions, which are approximately equivalent to a 50 year return period discharge level of protection, and "With Embankment" corresponded to a level of protection equivalent to a '100 year' return period discharge.

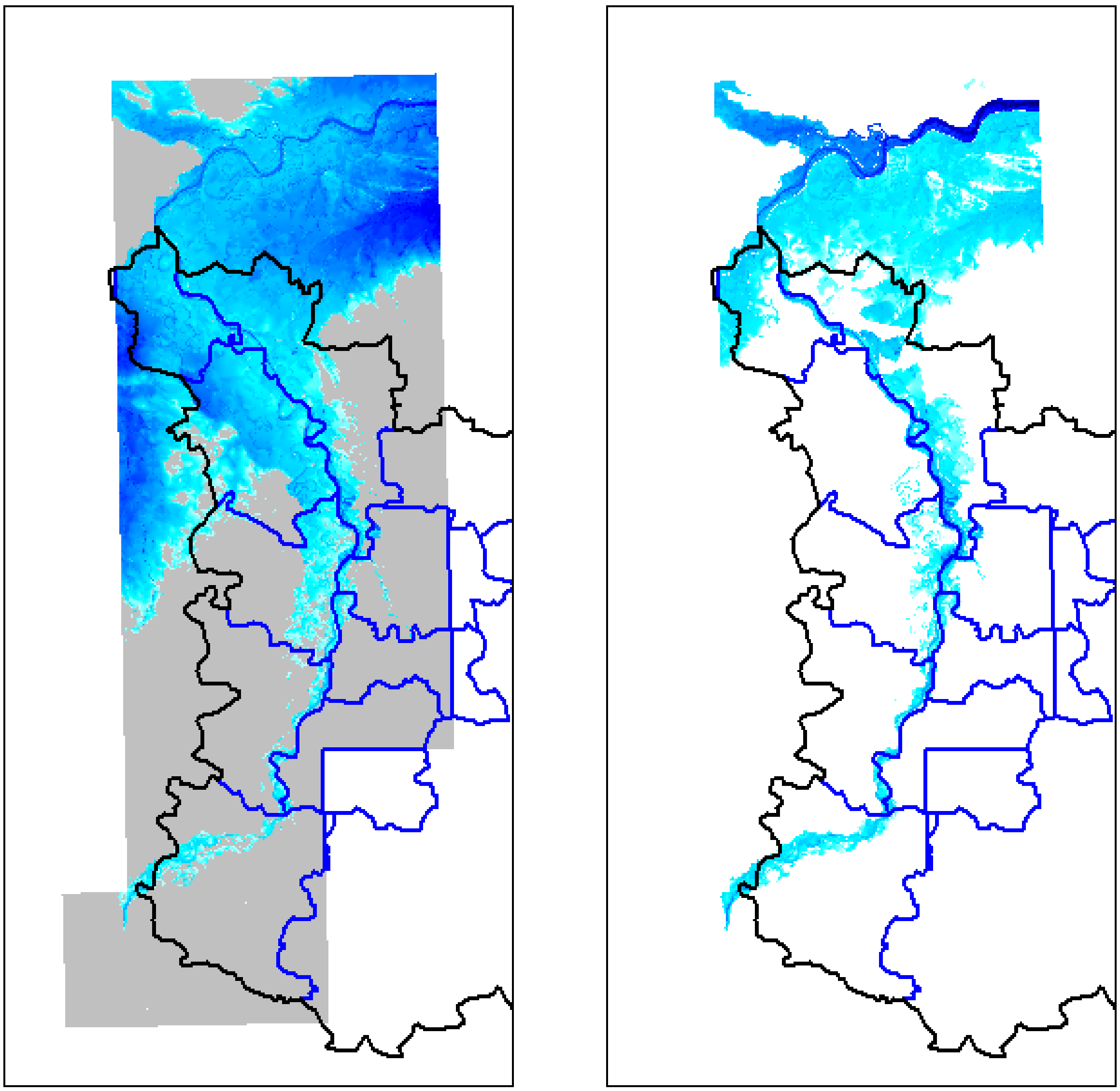


Figure 4 Study Region Subject to 100-Year Return Period Discharge (l) No Embankment (2) with Embankment

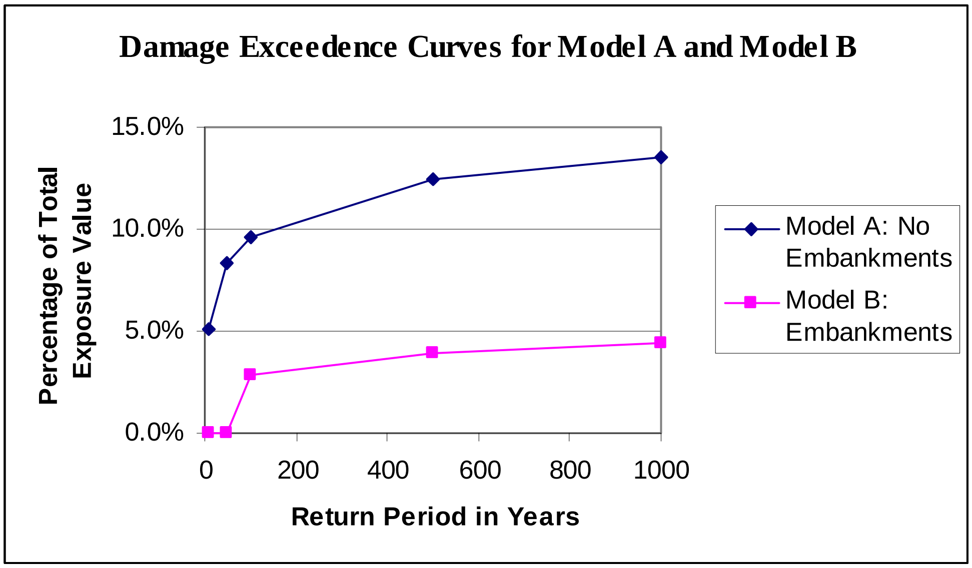
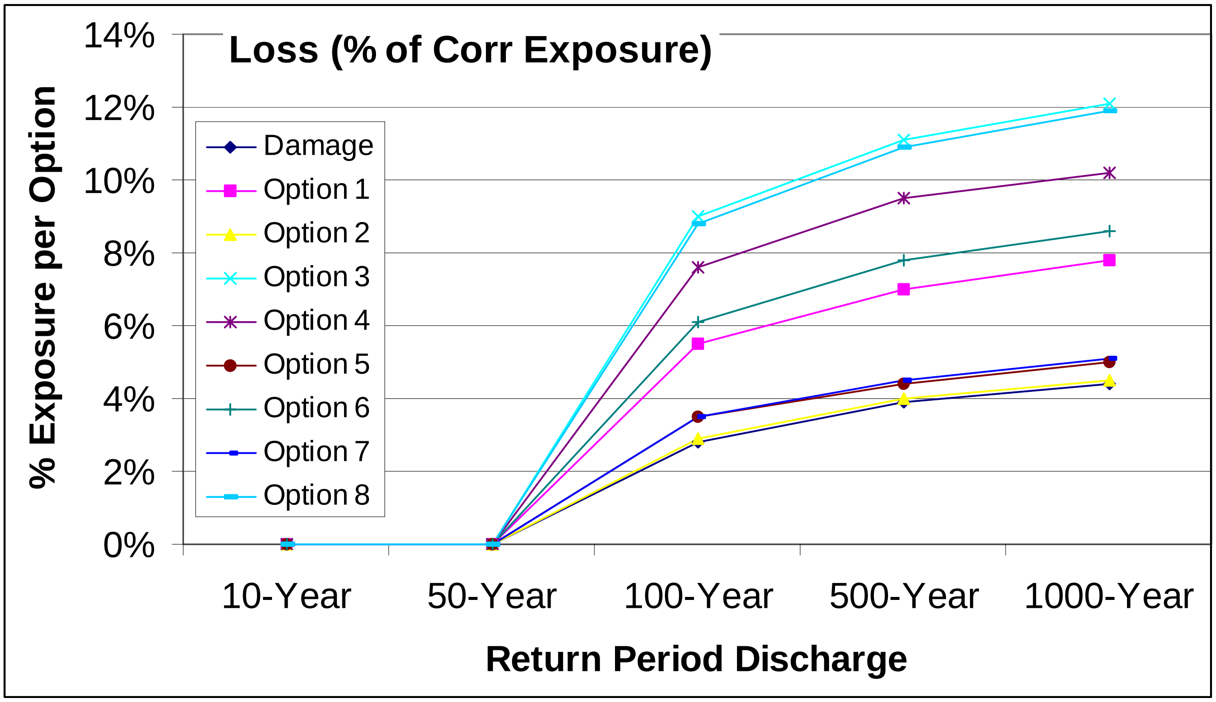


Figure 5 Damage Exceedence Curves for With and Without Embankments

Figure 5 presents the damage exceedance curves for the Study Region, for the With and Without Embankment scenarios (ie, with 50 year, and 100 year, return period discharge levels of protection). Note that under any insurance scheme, the damage exceedance curves do not change. However, insurance payments will vary dramatically, depending on the option. For example, for the 100-year flood, losses (i.e., insurance claims paid) range from 9% (Option 7) to a high of 92% (Option 4, High Hazard Case) of total 100 year flood damage, respectively.

Under the Mitigation scheme, damage and losses for floods of 100-year or more frequent return period are eliminated, and mitigation reduces annualized damage and losses by about 50%, in all cases.

Figure 6 shows losses for each insurance option (see Table 3 for details of each Option) as a function of the values insured in that Option (top, termed Corresponding Exposure), and as a function of the total values in the Study Region (ie, whether insured or not, termed Total Exposure), bottom. In both figures, Damage is indicated as % of Total Exposure. Thus, it can be seen that, for the 1000 year return period discharge, damage is 4.4% of total values in the Study Region. Option 1 pays 7.8% of the total value insured under that option, but only 0.9% of the total values in the region.



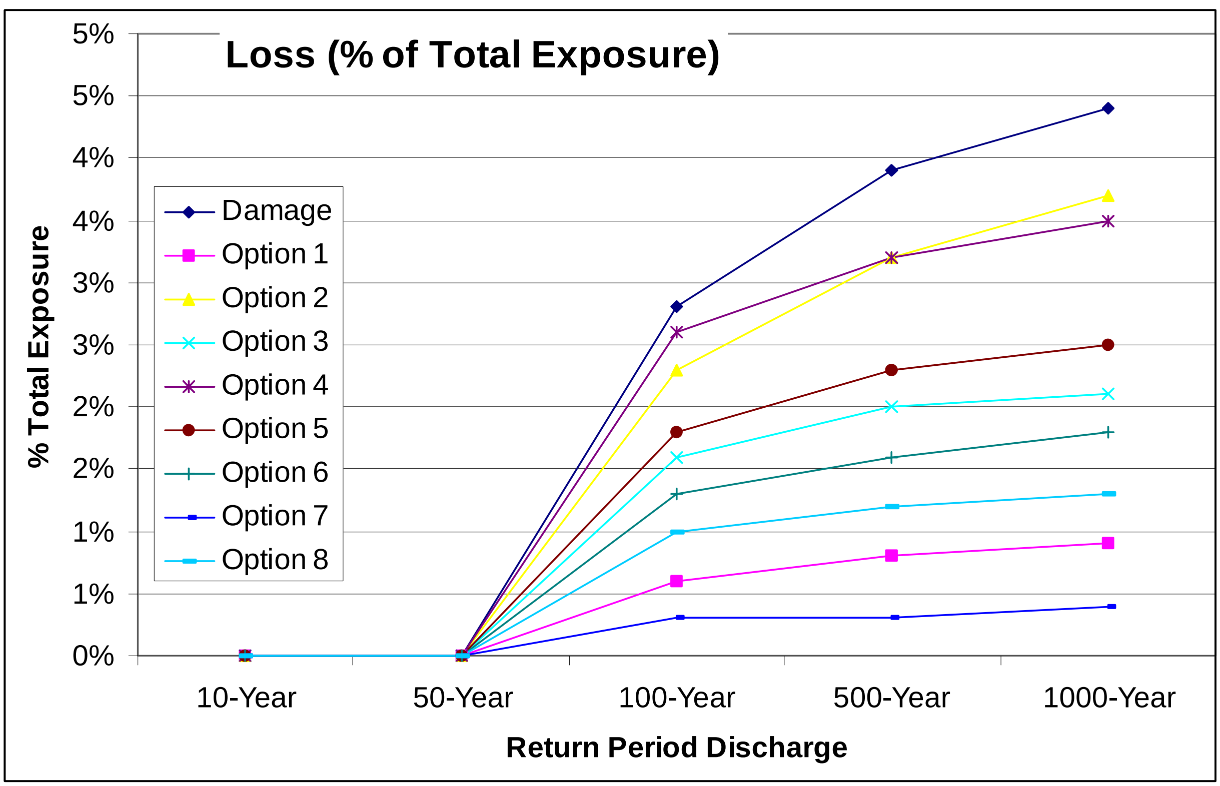


Figure 6 Loss vs. Insurance Options ((t) % of Exposure per the Option, (b) % of Total Exposure

Dynamic Financial Analysis

In order to assist in selecting the most appropriate insurance option among the eight options analyzed in the previous section, consideration must be given to the financial efficiency of each option. In order to assess financial efficiency, a technique known as Dynamic Financial Analysis (DFA) was employed. In this application, DFA was simply a forward-looking estimate of the financial condition of a postulated Flood Insurance Pool (FIP) over a period of time (in this case 50 years). A financial model applicable for each of the options under predetermined conditions was created, and analyzed using the DFA model to calculate the capital required for the insurance pool. In this analysis, two conditions were addressed:

1. where no mitigation plans are undertaken which means that flood management conditions are maintained in their current status and are limited to routine maintenance.
2. where mitigation plans are implemented. Flood mitigation plans include the strengthening of dikes (levees) so that they can withstand flood levels up to the 100-year levels, and the development of flood maps for the public, city planners and insurance underwriters.

DFA was employed for these two conditions to examine the interplay of each option's exposure and resulting claims, for the Study Region, to determine the initial capital requirements to assure a reasonable standard of solvency for the flood insurance pool, which was termed FIP (Flood Insurance Pool). The finding was that the Most Favored Option (MFO) was the High Hazard Option (No. 4). Key elements of the MFO were:

- ALL PROPERTY[4] located within a High Hazard Zone (i.e., the 100-Year flood zone) IS REQUIRED to purchase flood insurance at actuarially sound rates. The insurance premium is a surcharge to the property tax, and collection and enforcement be performed by the property tax system.

- Outside the High Hazard zone, purchase of insurance is voluntary, purchased from private insurers as an amendment to the fire policy, but endorsed by FIP.

- As compared to the capital required for the MFO but with no mitigation (ie, no embankments), the FIP required only 67% of the capital to assure solvency, plus 10% for cost of mitigation.

The decrease in capital required to assure solvency in the *with mitigation* case is due to mitigation (levees) reducing the probability of insolvency. <u>This decrease in capital required for the FIP is significantly greater than the cost of mitigation.</u> This demonstrates that mitigation in concert with the MFO insurance program is cost-beneficial.

It was concluded on the basis of the limited Study Region analysis that the MFO should be implemented through a newly created entity called the Flood Insurance Pool (FIP). While the study examined only one Study Region, the selection of the MFO was not anticipated to differ,

[4] By all property is meant residential, commercial and industrial private property, public property including public buildings, roads, bridges and other infrastructure, and agricultural property including crops and livestock.

when extended to a national program, due to parameters such as building vulnerability and inventory, insurance structure, insurance penetration, etc not varying greatly across the country. However, extension of the FIP to the entire subject country required additional analysis to determine the capital required for a national pool. At the time of the study, an analysis for the entire subject country would be data-intensive. Given that substantial amounts of the required data would have to be collected or even generated, the cost of the analysis was considered substantial. Recently, new technologies have emerged which offer the ability to reduce these costs – these new technologies are discussed in the next section.

HAZUS® MH Flood Loss Estimation Model

HAZUS® MH is a standardized methodology and software program for estimating potential losses from earthquakes, floods, and wind, being developed by the National Institute of Building Sciences (NIBS) under a Cooperative Agreement with the Federal Emergency Management Agency (FEMA). It is intended to be nationally applicable in the US. HAZUS® MH Flood operates at three Levels:

- Level 1 is the default level, in which analyses are performed using hazard and exposure data, together with algorithms, damage functions and software, all of which comes with the model. Level 1 has two kinds of users:
    - Local users, who wish to examine their risk or the potential benefits of a mitigation measure, without investing any time for data collection or processing. Local users, who might be floodplain managers, emergency responders, land use planners or others, are expected to understand that the default data furnished with the model may be inaccurate in detail, and are expected to go to Level 2, if the default Level 1 analysis is promising.
    - Non-local users, typically policy-makers, who are not local and are not expected to have local knowledge. Such users, who might be state emergency responders, legislative analysts or others, have a different perspective than local users, and the Level 1 analysis and results are anticipated to have sufficient accuracy (in the mean) for their needs.
- Level 2 is employed mainly by local users, and uses the HAZUS® MH software for all calculations, differing from Level 1 in the input data. Instead of employing default DEM, discharge-frequency and/or exposure data, in Level 2 more accurate data developed by or available to local users can be input.
- Level 3 is similar to Level 2 in that it is intended for local users only, but differs in that results of hydrologic or other analyses will be importable, via standardized format. An example of this would be importing rating curves from the HEC-RAS model, rather than generating them using the HAZUS® MH software.

The basic concept of the HAZUS® MH Flood Model is quite simple, and begins with digital elevation model (DEM) or equivalent topographic information. This is obtained from the USGS Elevation Database of North America (EDNA) and combined with stream discharge and other data in a hydraulic model of the stream to determine a flood surface elevation. The difference between the ground surface and the flood surface provides the areas and depth of flooding.

Concurrently, the geographic distribution of the population and properties at risk (the 'inventory' – note that a default inventory is furnished with HAZUS® MH) is determined. Depth-damage or equivalent flood vulnerability curves are then to at each location to the inventory to determine damage and resulting losses.
More specifically, HAZUS® MH provides the capability for a Level 1 analysis using national data, and a Level 2 with user-supplied hazard and inventory data for riverine and coastal flooding events. Damage and direct and indirect economic losses are modeled for:

- all occupancy classifications and general building types,
- essential facilities,
- transportation lifelines (bridges only),
- utility lifelines (potable water and wastewater components for treatment plants only - at Level 2 other utility components can be assessed),
- crop damage,
- vehicle damage,

Damage and losses to these assets are estimated for a typical study region, for riverine and coastal flooding, on the basis of scenario events defined by the user, and annualized losses. Debris generation and population shelter requirements are also estimated.

Results from the direct loss models are based on physical damage to structures (including building interiors) and contents. Additionally, the following capabilities are provided:

- Effects of flood warning on the degree of expected damage
- Effects of collateral damage from flow velocity (riverine flooding only)
- Casualty estimation, in a simplified manner

Depending on the expertise of the user, the Flood Model is designed to operate with minimal user interface and data (Level 1), or the user can pre-process higher quality data and perform more rigorous analyses (Level 2). Users are required to have ESRI's ArcGIS version 8.1.X or better and the associated extension Spatial Analyst in order to perform flood loss estimation. All users are required to supply a Digital Elevation Model (DEM) since floods are inherently dependent on the terrain. The Flood Model has been designed to ease the process of bringing in the DEM. Once a DEM is supplied, the user can then start developing estimates of damage and losses due to their flood hazard. A user who may have better terrain data and improved data that defines their flood hazard may decide to use the Flood Information Tool (FIT) to pre-process the data and import it into the Flood Model. The FIT requires the user to have the following data:

- Flood surface data such as Coastal Base Flood Elevations (BFE), digital stream cross sections attributed with flood elevation, or digitized BFE lines from the Flood Insurance Rate Map (FIRM). These need to be in the form of a polyline,
- Digitized floodplain boundaries such as those shown on a FIRM (i.e., a paper map digitized either in house or by a contractor), a Digital Flood Insurance Rate Map (DFIRM), a Q3 map, or any other floodplain map. This need to be in the form of a polygon,
- Ground elevation in a grid format. This may be built from contours, Triangular Irregular Networks (TINs) or other formats that the user may have.

The FIT has been designed to operate as an extension within ArcGIS. The FIT allows the user to produce depth grids for one or more return periods, skew angles, and other data required by the Flood Model.

The Inventory Collection and Survey Tool (InCAST) and the Building Import Tool (BIT) are tools that were developed to assist users in collecting and generating building inventory data for the HAZUS99 Earthquake Model. While every effort has been made to preserve and utilize fields and data from the existing Earthquake Model, the physical nature of the flood hazard and differences in damage functions cause differences in data requirements and detail.

The BIT is designed to take existing large format data and import the data into HAZUS. The user interface for the program is not complex and requires only moderate modifications to account for different fields necessary for flood loss estimation (such as foundation type and garage). The BIT itself has been modified to support the proposed HAZUS-MH Software Architecture and the Flood Model is the first model developed according to the proposed architecture.

The InCAST program is site specific in nature and is somewhat more suitable to the flood hazard. InCAST has features that make the collection of data regarding repetitive loss structures or structures within a particular census block fairly easy. The InCAST tool has several "tabs" that allow the user to enter data of ever increasing detail into a database file. While there was some effort during the creation of InCAST to account for the three hazard models, it turns out that there a level of modification was necessary for the tool to be user friendly and completely useful. It was determined that the InCAST would appear slightly different for each hazard so that only the data required for the hazard is collected. This does not preclude the user from selecting a different hazard and updating an existing database that might have been created for another hazard.

As noted above, depending on the level of analysis, the data employed in HAZUS® MH can range from relatively coarse (the 'default' data), to highly specific and detailed. A major part of the effort in development of the HAZUS® MH Flood Model was the development of this data. The next sections provide a summary of each aspect of the HAZUS® MH Flood Model (the reader is referred to the Flood Technical Manual [www.nibs.org] for more detailed information).

Concluding Remarks

Floods are a major natural hazard substantially impacting the developed and developing world. Recent floods have caused near-record natural hazards losses in central and eastern Europe. A comprehensive detailed analysis was performed for a Study Region in eastern Europe, with the goal of identifying an economically efficient insurance program appropriate for that region. A Most Favored Option which combined insurance in high hazard zones with mitigation in those zones was identified via a Dynamic Financial Analysis, and demonstrated to be cost beneficial. Analysis for other regions will be greatly facilitated by emerging new technologies, which are exemplified by the HAZUS® MH software in the US.

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