Scenario Simulations: Modelling of Flood Management Strategies

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Abstract

Flood risk management policies is the subject of an international joint research project with the Upper Tisza in Hungary as its pilot study area. Within this project, a geographically explicit flood simulation tool has been designed and implemented. The model integrates aspects of the geographical, the hydrological, the economical, and the social. The perspectives of different stakeholders are represented as agents who make decisions on whether to buy flood insurance or not. Two different flood management policy scenarios were implemented and evaluated. Some policy experiments are also reported on, where two different policy strategies are simulated. The major lesson learned from the experiments, is that individual based models are important in policy settings. A flood-risk policy strategy that seems fair on the average can hide large inequalities. To be able to analyse these features of potential policy strategies, the model must be spatially explicit and fine grained enough to represent individual properties.

Key words: Flood-risk management, Insurance, Agent-based modelling

1 Introduction

The aim of this paper is to design and implement a geographically explicit flood-risk policy model that is capable of simulating flood failures in the Palad-Csecsei basin in Hungary, and to estimate the consequences of different financial flood-risk management strategies from different stakeholder perspectives.

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Agent-based social simulation is becoming increasingly popular for policy making, see for instance (Boman and Holm, 2002; Gilbert and Terna, 2000; Polhill et al., 2001).

During the last century the number of natural disasters has increased significantly, it was five times greater in the decade 1988–1997 than in 1960–1969. As the number of catastrophes increases, human and financial losses escalate. In the period 1988–1997, the cost for major natural disasters was 700 billion USD, according to figures from Munich Re (1998). Floods played an important role, causing around 50 per cent of the economic losses (Abramovitz, 2001). Policy makers on a national level are concerned with increasing costs for compensation and mitigation. Most countries have a disaster compensation policy based on solidarity; the government compensates for the losses that individual property owners suffer. A higher degree of private responsibility is a distinguishing feature for compensation policies in only a few countries, such as the UK and Australia (THRD, 1999b).

Within a joint international research project between the International Institute of Applied System Analysis (IIASA) in Austria, the Computer and System Science Department (DSV) in Sweden, and the Hungarian Academy of Science, an executable simulation model has been developed by the authors. For more information on the flood-risk management project, consult Linnerooth-Bayer and Vári (2000); Linnerooth-Bayer (2001); Ekenberg et al. (2002). The simulation model estimates the economical consequences of different flood-risk management policy strategies. As a case, the Palad-Csecsei basin of the Upper Tisza in Hungary has been investigated. The focus has been on the use of financial mitigation measures, mainly insurance. For such a model to be useful, it must integrate data from different systems; the geographical, the hydrological, the economical, and the social system. The simulation model consists of six modules; the Monte Carlo module, the Catastrophe module, the Policy module, the Consequence module, the Spatial module, and the Agent module.

A flood simulation is run over a number of years, 50 for instance. An initial policy strategy is decided upon before the start. A policy strategy could for instance be to subsidy insurance premiums for all poor households and to set the compensation level from government to 50 per cent of property losses. Each simulation round, a flood event might or might not occur. A flood event is either a levee failure or seepage. The financial consequences for the incorporated stakeholders are estimated at the end of each simulation round. In the model, following stakeholders are represented: the government agent, the insurer agents, and the property owner agents. The property owner agents are the only situated agents, their properties have specific locations in the geographical representation of the basin. They react in respect to their location. The property owner agent makes a decision on whether to buy insurance or not, the decision is influenced by the local environment. After the last simulation round, the economical consequences are compiled and presented for the different agents. A detailed description of the model is given in Section 2.

2 The Model

The development of the flood simulation model was an iterative process. Initially, an executable prototype model was implemented, using fictive data. The prototype was based on an existing cyclone model developed by Ermolieva (1997). Some experiments were performed on the prototype model and made the basis for the sharp version of the model, see (Brouwers, 2002; Hansson, 2000). The catastrophe simulation model consists of several modules. Each module is thoroughly described in its own subsection.

2.1 The Monte Carlo module

At the beginning of each simulation round, three stochastic variables are used to simulate flood events of two types: levee failures and seepage. The variables are assigned random numbers in the interval 0–1 from a uniform distribution. The term flood is used to describe that the water level in the river is higher than normal. In an unprotected river, all floods would overflow the embankments. However, the part of the river that is investigated is protected by levees designed to hold back most floods. Hydrological data is used to calculate the probabilities for floods of different magnitudes to occur. The different magnitudes used in the flood simulations are 100-year floods (minor), 150-year (medium), and 1000-year (extreme). A 100-year flood denotes a flood of such a magnitude, that in a long time perspective, the average time between floods of that magnitude or greater, is 100 years. The probability concerns one single year and tells nothing about the accumulated risk during a longer period. The probability distribution for a floods is:

- no flood: 0.9823
- minor flood (100-year): 0.01
- medium flood (150-year): 0.0667
- extreme flood (1000-year): 0.001

The value of the variable $Magnitude$ is tested, if it is less than or equal to the threshold for the three floods 0.01, 0.0167 (0.01+0.667), and 0.0177 (0.01+0.667+0.001) the corresponding flood occurs. If the value is larger than 0.0177 no flood occurs. If a flood occurs (minor, medium, or extreme), then one of three possible things can happen:

(1) flood event 1, levee failure: a levee fails, it is either overtopped or it bursts
(2) flood event 2, seepage: water finds its way under a levee
(3) no flood event: the levee holds back the water

If *Magnitude* tells that there is a flood, then the values of the variables *Failure* and *Seepage* are checked to see if the flood inundates the neighbouring land. The variable *Failure* tells if the flood, (minor, medium ore extreme), will cause a levee failure at one of three possible locations. Most floods do not cause levee failures, or seepage (since the embankments hold back the water). The probabilities for the failure events at the three locations are presented in Table 1, the figures are provided by Hungarian hydrologists THRD (1999a).

Location.:	1	2	3
Levee failure: from minor flood (100-year)	0.12	0.20	0.28
Levee failure: from medium flood (150-year)	0.18	0.22	0.40
Levee failure: from extreme flood (1000-year)	0.19	0.33	0.45

Table 1
Levee failure probabilities

Seepage occurs when river water inundates neighbouring land by finding its way under the levee. We estimate that seepage occurs twice as often as levee failures, the probabilities for seepage events are fictive but realistic. The probability distribution for *Seepage* are presented in Table 2.

Location:	1	2	3
Seepage: minor flood (100-year)	0.24	0.40	0.56
Seepage: medium flood (150-year)	0.36	0.44	0.80
Seepage: extreme flood (1000-year)	0.38	0.66	0.90

Table 2
Seepage probabilities

Note that the probability for a levee failure at location 3 to occur from a 1000-year flood is 0.001×0.45. The probability for any flood event to occur during a single year (failure or seepage) is 0.04 and the probability that no flood event occurs during one year is 0.96. The probability that no flood events occur during an entire 50-year period is only 0.15.

2.2 Catastrophe Module

The Catastrophe module is consulted when a flood event has occurred. It calculates the effects of failure and seepage events: what land areas are inundated, for how long, and by how deep water. The simulations are performed with 18 pre-compiled flood event scenarios, 9 failure events and 9 seepage events. Each scenario is provided with a specific loss distribution, the methods for designing loss functions are described in (THRD, 1999a). The loss functions only consider direct damages to private properties, using spatial data such as soil type, material of building, and elevation.

2.3 Spatial Module

The Palad-Csecsei basin is geographically represented in form of a grid, consisting of 1551 × 1551 cells, measuring 100 m^2. For each cell, there is rich geographical information system (GIS) data available: digital elevation, current land-use, asset value, and soil type. Each cell belongs to one of 11 municipalities. Example on values for the GIS variables are: swamp, area for sport/recreation, broad-leaved forest and urban parks, for the variable land-use. If the land is cultivated, data on the type of crop is also included.

2.4 Agent Module

The stakeholders relevant for the flood-risk management problem are represented in the model as agents: the government, the insurers, and the property owners. Other agents could have been chosen, but these were considered most important for investigating potential financial flood risk-management strategies.

The insurer agent is an aggregated agent represented by the wealth and the insurance contracts. The insurer agent is not situated, but the insurance contracts regard specific locations. The initial wealth of the insurer agent is 1 000 000 HUF, the size is based on own assumptions, but corresponds roughly to 10 per cent of the expected damage for all properties in the basin (9 939 623 HUF, only levee failures are concerned). An insurance contract has a coverage, a premium size, and a deductible. The terms of the contracts are decided in the policy strategy. The insurance agents do not offer insurance against seepage events, this reflects the real situation in Hungary. The flood insurance is a bundled part of the normal property insurance, and approximately 2 per cent of the total claims from private property insurance, account for flood damages.

The property owner agents can be seen as a combination of the property itself and the human owner of that property. The property owner agents have following attributes: location, wealth, income, expenditures, and insurance. The location is the cell where the (mid-point of the) property is situated. Each property agent is assigned an initial random wealth, using a uniform distribution in the range 0–10 000 HUF. The 2 580 property owner agents have a yearly net income, which is a random value in the range 0–100 000 HUF from a normal distribution with the mean 36 900 and the standard deviation 10 000. The figure 36 900 was the average net earning/month of 1998 in the Szabolcs-Szatmár-Bereg county, regarding employed persons working in enterprises with more than 20 employees, and the public sector. The figures are collected from (KSH, 2000). The expenditures are assumed to be high, 90 per cent of the incomes. The Palad-Csecsei basin is a very poor area, with a high degree of unemployment. Property owner agents make insurance decisions, to buy insurance or not. Their decisions depend on their risk-willingness and the current wealth. A random value from a uniform distribution is compared with the $InsuranceRate$. In Hungary, 60 per cent of the property owners have property insurance with flood protection included. When the property agents consider to buy the more expensive top-insurance, with a risk-based premium, their economic situation decides if they can afford it or not.

The government is represented as a single, or aggregated, agent. Only the part of the governmental budget that concerns flood management is taken into consideration in the model, and only the financial load is considered, i.e., no incomes are included in the model. This is mainly because of the small size of the pilot basin and also due to lack of data. The governmental agent has the following attributes: compensation level, and a yearly maintenance cost. The size of the compensation level is set in the current policy strategy. Maintenance costs for structural mitigation is also considered a policy parameter, the maintenance of levees is costly and the degree to which it is attended upon, vary with the financial climate.

2.5 Consequence Module

At the end of each round, the Consequence module calculates the changes in wealth for all involved agents. The wealth transformation functions for the different agents are described in Section 3. Information used in this module is gathered from most other modules.

3 Numerical Representation

The policy vector X contains possible policy strategies. An instance of the vector, x describes a specific policy strategy. A policy strategy consists of a number of policy parameters, that all can take different values. Policy parameters are for instance, level of governmental compensation, premium size and size of deductible. An example policy strategy could be: governmental compensation set to 40 per cent, premium size 1 per cent of property value, and size of deductibles set to 100 000 HUF.

The uncertainty is treated explicitly in the model, the vector Ω contains all stochastic variables. The modelled system can be in different states, a state can be thought of as a snap-shot of the model with the values of all variables visible. The values of some of the variables are impossible to predict with certainty, these are referred to as the random variables. Stochastic variables can for instance be: wind-speed, precipitation, water-level, discharge. In the performed experiments, the vector Ω contains only three variables: $Magnitude$, $Failure$, and $Seepage$.

3.0.1 Wealth transformation function for property agent

$$W^{\mathrm{prA}}(x,\omega) = W + G(x,\omega) - D(\omega) + I - E(I) + \sum_{\mathrm{Ins}=1}^{\mathrm{n}} H_{\mathrm{Ins}}(x,\omega) - \Pi_{\mathrm{Ins}}(x) \tag{1}$$

Let W be the wealth of the property agent prA. The wealth is transformed over time as a function of the compensation received from the government G, the size depends on the severity of the flood ω, and the degree of compensation which is decided by the policy parameter x. Cost for flood damages D on the property is deducted, the income I is added to the wealth and the expenditures E are deducted. The wealth is finally updated according to the collected claims H and the paid premiums Π for all insurance companies Ins.

How much insurance compensation H the property owner receives from each insurer depends on two things:

(1) the current policy strategy x which decides
size of the deductible, and the coverage, that is, the proportion of the property insured
For instance, a 70 per cent coverage of a building worth 1 million HUF means that the building is only insured up to 700 000 HUF
(2) the severity of the flood ω
the losses are a function of the severity of the flood

For example, a building worth 1 million HUF has an insurance contract with the following features: coverage = 70 per cent, and deductible = 10 per cent (the first 10 per cent of the losses are not covered by the insurance, this is a policy parameter). If a flood occurs that destroys 50 per cent of property, the property owner would receive 315 000 HUF from the insurance company (losses: 500 000, deductibles: 50 000). Compensation from the government G

is added to the wealth, the government decides to what degree the victims should be compensated; this is decided by the policy parameter x, the size depends on the severity of the flood ω. The cost for insurance premiums are deducted from the wealth. The premium is considered a policy parameter, which is dependent on the size of the coverage and can vary among the insurer agents. For example, if premium is set to 5 per cent of the property value, and coverage to 50 per cent, then a million HUF building would cost 25 000 HUF (per year) in insurance premiums.

3.0.2 Wealth transformation function for government agent

$$W^{\mathrm{Gov}}(x,\omega) = W - \sum_{\mathrm{prA}=1}^{\mathrm{n}} G_{\mathrm{prA}}(x,\omega) - M(x) \tag{2}$$

The wealth of the government is reduced by flood compensation G paid to the property agents prA, where x is the policy parameter deciding the compensation level. The size of compensation also depends on the severity of the flood, decided by ω. M represents the costs for flood mitigation and the cost for maintenance of the structural flood mitigation measures.

3.0.3 Wealth transformation function for insurer agent

$$W^{\mathrm{Ins}}(x,\omega) = W + \sum_{\mathrm{prA}=1}^{\mathrm{n}} \mathrm{FP}_{\mathrm{prA}} \times \Pi_{\mathrm{prA}}(x) - H_{\mathrm{prA}}(x,\omega) \tag{3}$$

The wealth of the insurer agent Ins is increased by the flood part FP of the premiums Π that is received from the property agents prA, were coverage is included in the current policy strategy X. The compensation H is deducted from the wealth according to the policy strategy, and the severity of the flood ω.

3.0.4 Calculation of risk-based premiums, per location

$$Prem_{\mathrm{Loc}} = z + \sum_{\mathrm{LFS}=1}^{\mathrm{n}} P_{\mathrm{Loc}}(\mathrm{LFS}) \times D_{\mathrm{Loc}}(\mathrm{LFS}) \tag{4}$$

The expected damages for each specific location Loc are calculated; for each levee failure scenario LFS, the damages D are multiplied by the probability

P for that scenario to occur, the expected damages for all scenarios are summarised. A safety load z, accounting for the margins (profit, risk, etc.) that are added to the premium.

4 Policy Scenarios

Policy strategies for coping with losses vary from country to country, and several grounds for choosing a policy can be identified Green (1999). The capacity of the insurance industry in a country may affect the degree to which a local government becomes involved. In Hungary, an increased use of private catastrophe insurance is a goal in the political agenda. The history and the tradition of how the government acts have had a significant influence on the prevailing flood management policies. In (Vári, 1999) interviews with the stakeholders in the Upper Tisza are presented, most respondents agreed that it is right to protect the high-risk settlements at all costs, only a minority of the respondents would support, even partial, relocation of the local population. With regard to strategies for sharing economical responsibility, most respondents thought that the government should compensate the victims. However, many would accept a policy combining government compensation with private/community self-insurance schemes. As much as 46 per cent of the respondents were of the opinion that taxes should be used as a means to compensate victims.

Linnerooth-Bayer (2001) has designed three possible flood risk management policy scenarios for Hungary, based on interviews and surveys of the views of the stakeholders. A crucial interest has been to find a balance between social solidarity, private responsibility and the community responsibility. Two of the three scenarios are implemented and used within the simulation experiments run on the flood-risk model. There are of course many other possible scenarios, such as renaturalization for instance. The different policy scenarios are presented below.

4.0.5 Scenario 1, Business as Usual

Scenario number one, represents the current flood management strategy in Hungary, why this scenario is called Business as usual. The government continues to compensate the property owners from floods caused by levee failures, as this is considered the responsibility of the government. The government also compensates for seepage, but the compensation is smaller than for levee failures. The government finances the costs for mitigation and compensation from its catastrophe budget, meaning that all taxpayers contribute through their taxes. The insurance is a bundled property insurance, where the all-hazard insurance part accounts for two per cent or the total premiums, according to estimations by (Mitchell, 2000). The size of the premium is based on the property value alone, which implies a cross-subsidation of premiums from low-risk locations to high-risk locations.

4.0.6 Scenario 2, Market Model

In the second scenario, part of the responsibility is shifted from the government to the individual property owner, why the compensation from the government is reduced. The seepage events are still compensated for, but only to a low level. The property owner agents also receive less compensation than in scenario 1 from the normal insurance, the intention behind this is to reduce the level of cross-subsidation. The gap in insurance coverage can be filled by buying a risk-based insurance, the premiums are based on the local flood-risks, see Section 3.0.4. The expected damage for a property is the base for calculating the size of the premium, in the experiments 545 properties were affected by levee failures. The expected damages are multiplied by a safety load. In Figure 1 the expected damages for the properties are presented.

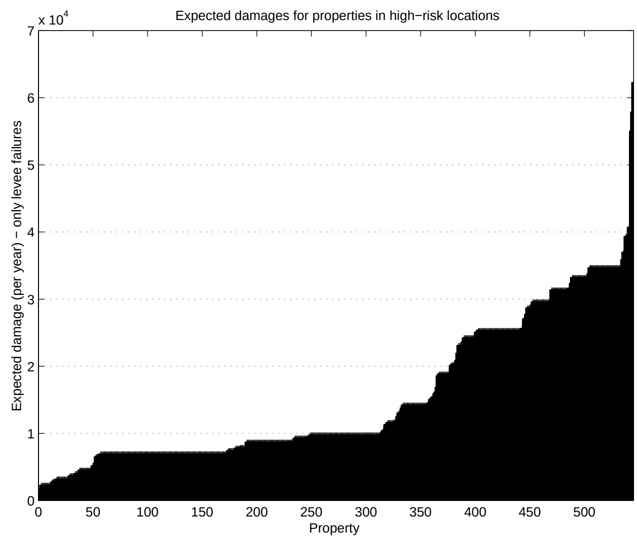

Fig. 1. Expected damages for properties, levee failures.

5 Experiments

Some experiments were performed with the flood-risk simulation model, where the two policy strategies described in sections 4.0.5 and 4.0.6, were tested.

The following settings were used for the simulations of the scenario 1, Business as Usual.

- Maintenance cost: 100 000 HUF per year (for the levees in the basin)

- Compensation from government (levee failure): 100 per cent of damages
- Compensation from government (seepage): 50 per cent of damages
- Deductible: the first 5 per cent of the damages
- Coverage: 100 per cent
- Insurance rate: 60 per cent of the households have property insurance
- Insurance premium: cross-subsidised, 0.2 per cent of property value/year

It might seem strange that property owners are compensated from the government even if they hold private insurance. There was an outcry from the public when this happened recently, as many people thought it was deeply unfair (Linnerooth-Bayer and Amendola, 1998). The rationale for this policy of double compensation is to encourage house owners to buy insurance. If insurance holders were punished by not being compensated by the government, the incentive to buy private insurance would be reduced.

The following settings were used for the simulations of the scenario Market Model.

- Maintenance cost: 100 000 HUF per year (for the basin)
- Compensation from government (levee failure): 75 per cent of damages
- Compensation from government (seepage): 30 per cent of damages
- Deductible for cross-subsidised insurance: the first 5 per cent of the damages
- Coverage for cross-subsidised insurance: 60 per cent
- Insurance rate for cross-subsidised insurance: 60 per cent
- Premiums for cross-subsidised insurance: 0.1 per cent of property value/year
- Coverage for risk-based top-insurance: 100 per cent
- Insurance premium for top-insurance: risk-based, see section 3.0.4
- Insurance rate for top-insurance: around 10 per cent, first decided by economical situation then risk-willingness
- Deductible for risk-based premium: 0 per cent

The same distribution on flood events, and base-insurance was used for both scenarios.

Each scenario was first simulated only once, for a time-period of 50 years. The goal of these initial experiments was to investigate how the consequences for individual property owners vary. Results of simulations including many agents are normally aggregated and presented in tables or histograms. The result on the micro-level can therefore be hard to extract. The statistical significance of these single-run simulations run, is of course insignificant. The figures presented in this section are merely included to show the variety of consequences among the property owner agents.

The wealth of the property agents grows steadily during the simulated 50-year period, as the expenditures are less than the incomes. During this time-period, 4 flood events occurred: 2 failures in years 8 and 41 and 2 seepage events years

32 and 34. By looking carefully at the dynamic wealth trajectory, see Figure 2, the effects of the double compensation is viable at the years when the failures occurred. No property owners show a negative balance during the time period, when the seepage events occurred the changes in wealth are too small to show, by inspecting the wealth of a single property agent we can however, see that the wealth is affected, see Figure 3. Not all property owners are affected by all flood events, this example property owner was not affected by the failure event that occurred year 41.

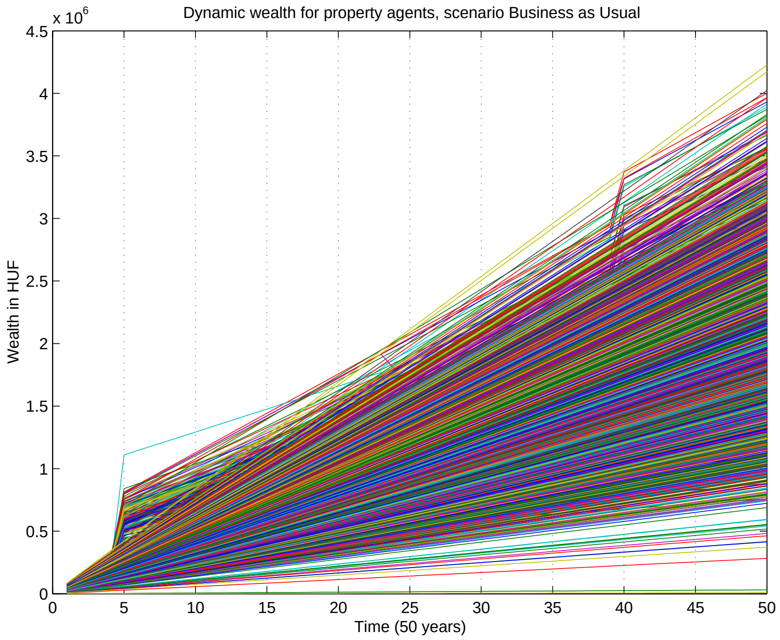

Fig. 2. Dynamic wealth of Property agents, scenario Business as usual.

The scenario Market Model was also simulated for a 50-year period, in Figure 4 the trajectory is presented.

A second set of simulations was performed, in which the number of simulations was increased to 1 000. The time period was still 50 years and both scenarios use the same distributions of flood events and cross-subsidised insurance contracts. In the tables presented in the Appendices A and **??**, the load for the government and the balance for the insurer agent are presented. The results of an example individual are also presented, to indicate the consequences for a property owner in a high-risk area who has insurance. The table is sorted in descending order, based on the governmental load. The results for the property agents were not further analysed, as they followed the trends shown in the single-run experiment quite much, that is the wealth of the agents increased steadily and a number of property owners gained economically from levee failures.

6 Conclusions

The experiments showed that the difference between the two policy scenarios mainly affect the property owners. The property owners who experienced seepage failures suffered severe losses, since the government only compensated 30 per cent. The property owners in high-risk areas, who had much insurance

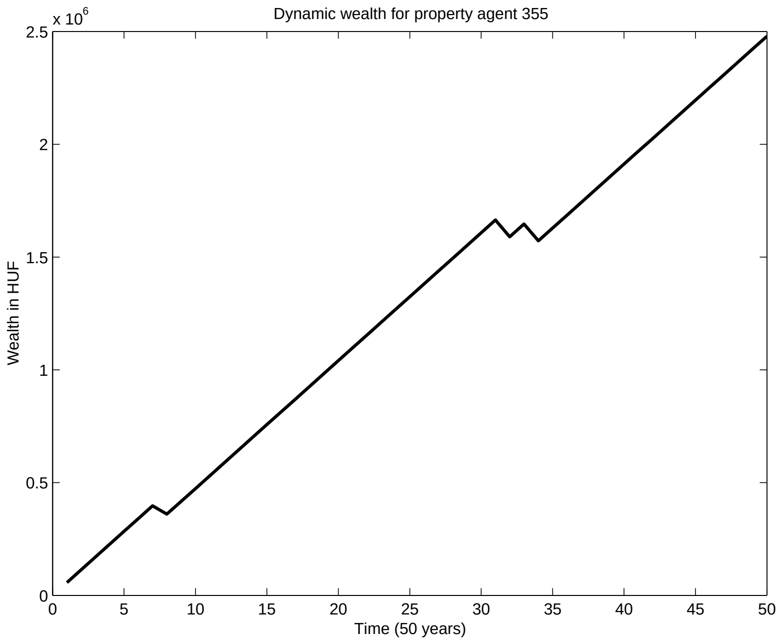

Fig. 3. Dynamic wealth of single Property agent, scenario Business as usual.

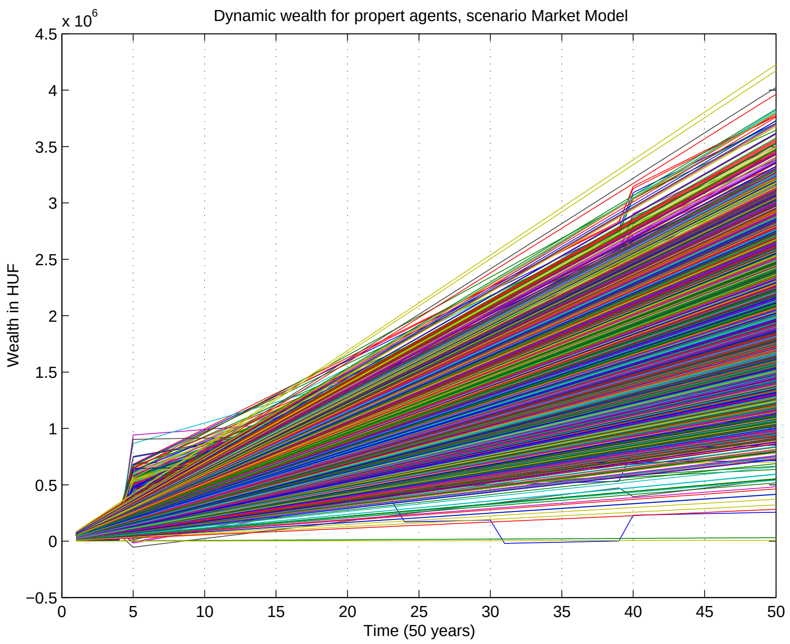

Fig. 4. Dynamic wealth of Property agents, scenario Business as usual.

gained economically from levee failures. The majority of the property owners who most needed the top-insurance could not afford one, this reflects the real situation in the Palad-Csecsei basin. The experiments further indicate that the reduction in governmental compensation (in scenario Market Model) was too small to bring any significant changes for the governmental flood management budget. If the compensation is reduced further, a market approach is likely to be very efficient for the government, since the responsibility of the loss lies more on the individual. This strategy also forces both industry and individuals to reduce risk, e.g., through constructing measures of their own. Governments carry a large responsibility for the infrastructure in the countries and they may wish to reduce catastrophic losses by diversifying with insurance or other risk transfer instruments see for instance (Doherty, 1997). On the other hand the pressure of people living in risk prone areas might be high since they may not be unable to afford insurance. However, is it fair not to share the burdens of these people?

Because purchasers of insurance in high-risk areas are subsidised in policy scenario 1, Business as Usual, people will not be discouraged from building in high-risk areas. In the long term, this might lead to an increased concentration of properties in high-risk areas with higher costs for flood compensation as a likely effect.

The deductible can be used as a policy tool for reducing the concentration of people and properties in high-risk ares. A high deductible, or a upper limit on the insurance contract, puts a larger financial responsibility on the individuals. The fairness of subsidation of insurance premiums can be discussed. It is not evident that insurance should be cross-subsidised; should the persons living in safe areas subsidy the premiums for those living in high-risk areas?

It seems likely that a flood-risk management model like this one, can be useful as a base for discussions on the pros and cons with different alternative policy strategies, in settings where policy makers and stakeholders work together. For a model to be useful it is important that the results are presented for the individuals as well as in a more aggregated way. The model can contribute in stakeholder meetings on catastrophe management questions, on both mitigation strategies and issues of fairness.

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A Appendices

No failures	No seepage	Gov load	Ins balance	Prop balance	Frequency
0	0	-5 000 000	218 158 608	3 076 300	16
1	0	-6 950 000	216 472 358	3 076 300	4
0	1	-7 272 500	218 158 608	2 888 800	28
1	1	-9 222 500	216 472 358	2 888 800	2
1	0	-9 545 000	214 410 858	3 432 550	1
0	2	-9 545 000	218 158 608	2 701 300	10
1	2	-11 495 000	216 472 358	2 701 300	1
2	0	-11 495 000	212 724 608	3 432 550	1
1	2	-11 495 000	216 472 358	2 701 300	1
0	3	-11 817 500	218 158 608	2 513 800	2
1	1	-11 817 500	214 410 858	3 245 050	1
0	3	-11 817 500	218 158 608	2 513 800	2
3	1	-13 122 500	213 099 858	2 888 800	1
2	1	-13 767 500	212 724 608	3 245 050	1
1	3	-13 767 500	216 472 358	2 513 800	1
0	4	-14 090 000	218 158 608	2 326 300	2
1	2	-14 090 000	214 410 858	3 057 550	1
0	6	-18 635 000	218 158 608	1 951 300	1
1	0	-45 565 000	194 555 858	3 432 550	3
1	1	-47 837 500	194 555 858	3 245 050	4
2	0	-50 110 000	190 808 108	3 788 800	1
1	0	-76 175 000	177 745 608	3 575 050	5
1	1	-78 447 500	177 745 608	3 387 550	3
1	2	-80 720 000	177 745 608	3 200 050	1
2	1	-82 992 500	173 997 858	3 743 800	1
1	1	-87 167 500	173 309 108	3 387 550	1
2	3	-92 947 500	170 953 108	3 226 300	1
1	1	-100 062 500	167 224 358	3 387 550	1
1	0	-266 120 000	71 483 358	3 717 550	1
1	2	-270 665 000	71 483 358	3 342 550	1
2	2	-272 615 000	69 797 108	3 342 550	1

Table A.1
Scenario Business as Usual

No failures	No seepage	Gov load	Ins balance	Prop balance	Frequency
0	0	-5 000 000	264 830 476	487 864	16
0	1	-6 363 500	264 830 476	225 364	28
1	0	-6 462 500	262 969 226	487 864	4
0	2	-7 727 000	264 830 476	-37 136	10
1	1	-7 826 000	262 969 226	225 364	2
1	0	-8 408 750	260 532 726	1 125 364	1
0	3	-9 090 500	264 830 476	-299 636	4
1	2	-9 189 500	262 969 226	-37 136	2
1	1	-9 772 250	260 532 726	862 864	1
2	0	-9 871 250	258 671 476	1 125 364	1
0	4	-10 454 000	264 830 476	-562 136	2
1	3	-10 553 000	262 969 226	-299 636	1
3	1	-10 751 000	259 246 726	225 364	1
1	2	-11 135 750	260 532 726	600 364	1
2	1	-11 234 750	258 671 476	862 864	1
0	6	-13 181 000	264 830 476	-1 087 136	1
1	0	-35 423 750	239 357 726	1 125 364	3
1	1	-36 787 250	239 357 726	862 864	4
2	0	-38 832 500	235 059 976	1 762 864	1
1	0	-58 381 250	220 422 476	1 380 364	5
1	1	-59 744 750	220 422 476	1 117 864	3
1	2	-61 108 250	220 422 476	855 364	1
2	1	-63 153 500	216 124 726	1 755 364	1
1	1	-66 284 750	214 710 976	1 117 864	1
2	3	-69 938 000	213 884 976	975 364	1
1	1	-75 956 000	207 226 226	1 117 864	1
1	0	-200 840 000	95 050 226	1 635 364	1
1	2	-203 567 000	95 050 226	1 110 364	1
2	2	-205 029 500	93 188 976	1 110 364	1

Table A.2
Scenario Market Model