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FLOOD INSURANCE – FROM CLIENTS TO GLOBAL FINANCIAL MARKETS

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ABSTRACT: Weather-related natural catastrophes are increasing worldwide in number and intensity. Flood losses have reached a new level in terms of total and insured loss amounts, types of events, and places where they occur; this represents a challenge that must be faced by governments, the people concerned, and the financial sector, both nationally and globally. Flood insurance is still relatively rare in most countries, but the development of insurance products and solutions to make flood risk more insurable has gained momentum. There is no ideal flood insurance solution as each situation is influenced by such factors as risk-adequate premium structure, adverse selection, and general risk awareness. The solution must be found between the extremes of obligatory and fully voluntary insurance and must be tailored to the situation in each respective country. While rich countries have to find ways to handle record losses of US$ 100bn and more, poor countries need micro-insurance solutions to provide people with at least a minimum of financial security. The insurance industry has – through the reinsurance sector – established a system to pay local monetary losses globally. In the wake of extremely expensive catastrophes, a system involving the whole financial market has great potential. Additionally, governments must prepare for disasters that threaten their people's existence by building up national funds.

Key Words: flood catastrophes, flood losses, flood risk, risk transfer, flood insurance

1. INTRODUCTION: FLOOD LOSSES

In most parts of the world, flooding is the leading cause of losses due to natural phenomena and is responsible for a greater number of damaging events than any other type of natural hazard. Munich Re's Geo Risks Research unit has been collecting loss data on natural catastrophes for several decades. Some 25,000 loss events are stored in the world's largest database of its kind. Recent events have shown that we must reckon with more and more water-related catastrophes in the future (Munich Re, 2008a). Table 1 reveals that costly floods occur in all parts of the world. The development of total and insured flood losses in Europe since 1980 is shown in Figure 1. Both graphs show a strong positive trend, but also that the insured shares vary widely. In contrast to coverage for windstorm losses, flood insurance has only reached a very low average penetration. Typical insured percentages in developed countries are from 10–30%, with a few exceptions, such as the United Kingdom, where the majority of homeowners' policies include flood insurance. In the 2007 floods there, 75% of the losses were insured, in contrast to just 16% in the 2002 Elbe and Danube floods (c.f. Table 1). The dramatic rise in the number and size of costly floods has increased demand for flood insurance and prompted the insurance industry to develop appropriate solutions.

Table 1 The costliest floods in the 21st century
(original values, not adjusted for inflation, * including windstorm losses)

Year	Country/ies (mainly affected regions/river basins)		Total losses US$ m	Insured losses US$ m	Insured losses [%]
2000	Japan: Typhoon Saomai		1,400	1,050	75
2002	China (Yangtze)		8,200		<1
2003	China (Yangtze, Huai)		7,890		<1
2004	China (Yangtze, Yellow, Huai)		7,800		<1
2004	India, Bangladesh, Nepal		5,000		<1
2005	China (Pearl)		5,000		<1
2005	India (Mumbai)		5,000	770	15
2006	India (Gujarat, Orissa)		5,300	400	8
2007	Indonesia (Jakarta)		1,700	410	24
2007	Tajikistan		1,000		<1
2007	India		2,600		<1
2007	Oman: Tropical Cyclone Gonu		3,900	650	17
2007	China (Huai)		6,800		<1
2007	Pakistan: Tropical Cyclone Yemyin		990		<1
2007	Bangladesh: Tropical Cyclone Sidr	*	3,775		<1
2000	Italy (north), Switzerland (south)		8,500	470	6
2000	United Kingdom		1,500	1,100	73
2002	Central Europe (Elbe, Danube)		21,500	3,400	16
2003	France (Rhone)		1,600	900	56
2005	Romania, Bulgaria		2,440	15	<1
2005	Switzerland, Austria, Germany (Bavaria)		3,300	1,760	53
2007	United Kingdom		8,000	6,000	75
2001	USA: Tropical Storm Allison (Houston, TX)		6,000	3,500	58
2001	Argentina		750		<1
2005	Canada (Alberta)		860	190	22
2005	USA: Hurricane Katrina (Gulf Coast)	*	125,000	61,600	49
2007	Mexico (Tabasco)		2,500	350	14
2007	Australia (East Coast)	*	1,300	680	52
2000	Mozambique, Zimbabwe, South Africa		715	50	7
2007	Madagascar	*	240		<1
2007	Sudan		300		<1

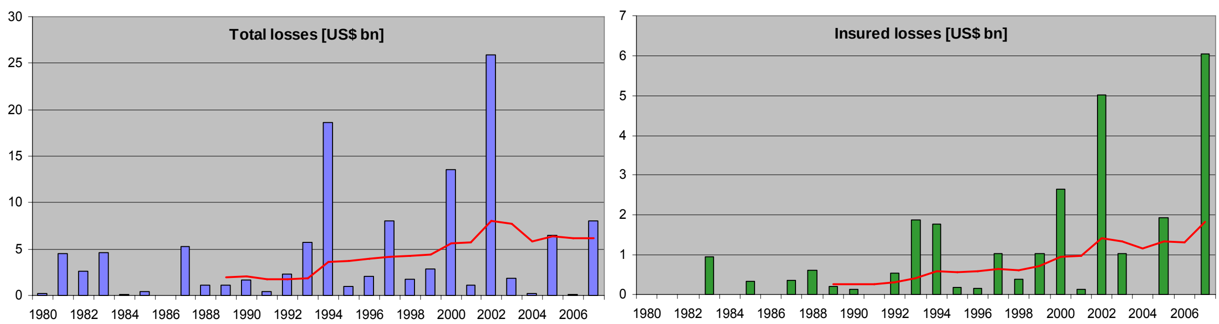

Figure 1: Flood losses in Europe 1980–2007; total and insured losses; 10-year running mean (---)
Note: the losses (2007 values) for the year Y refer to the period 1 April Y to 31 March Y+1

Rising sea levels, increased tropical cyclone frequencies and intensities (rain and wind), "new" flood experiences (as in 2007, when Cyclone Gonu caused flood losses of US$ 3.9bn in Oman), and coastal flood scenarios (e.g. New York) that could possibly produce losses far exceeding those caused by Hurricane Katrina call for new ways of coping with flood disasters. Large insured losses often arise from industrial losses rather than from damage to homeowners' property: in June 2005, almost 1,000 mm of rain fell in just one day on Mumbai, the most densely insured region of India, causing a total flood loss of US$ 5bn, of which US$ 770m was insured – practically all coming from industry covers. Large losses are also magnified by phenomena such as demand surge (many people need to have their houses repaired at the same time, which leads to an increase in prices), contingent business interruption losses (e.g. credit card and TV companies submit claims because credit cards and pay-per-view programs, respectively, are not or cannot be used in the disaster area anymore, or plants cannot operate because workers are prevented from coming to work), and law firms profiting from the many disputes that always follow such events. Hence, catastrophes tend to become more and more costly. They cannot be borne by a national insurance industry alone, so that the financial burden must be distributed globally and among different potential carriers of risk.

2. COPING WITH THE FLOOD RISK

Risk and loss minimisation call for an integrated course of action. The flood risk must be carried on several shoulders: the state, the people and enterprises affected, and the financial sector, in particular the insurance industry. Only when they all cooperate with each other in a fine-tuned relationship, in the spirit of a risk partnership, is disaster prevention really effective.

2.1 Definition of "risk"

The term "risk" is used in different ways in different situations. For scientific discussions, it should be defined in an unambiguous and consistent way. Here, risk is understood – in a qualitative way – as the product of a hazard and its consequences and is hence determined by three components (Kron, 2005):

1. the hazard *H*, i.e. the probability of occurrence of the threatening natural event;
2. the exposed values or values at risk *E*, i.e. the objects that are present at the location involved;
3. the vulnerability *V*, i.e. the lack of resistance to damaging/destructive forces.

In its most simple form, the risk is calculated by multiplying these three components.

[1] $R = H \times E \times V$

Where there are no people or values that can be affected by a natural phenomenon, there is no risk. Vulnerability can refer to human health (human vulnerability), structural integrity (physical vulnerability) or personal wealth (financial vulnerability). Insurance's contribution to risk control addresses the last of these factors; this aspect of risk reduction will be the focus of the following discussion.

2.2 Public authorities

The job of the state or the government is primarily to reduce the underlying risk for society as a whole. It provides access to observation and early-warning systems, builds dykes, deploys flood retention areas, determines the framework for the use of exposed areas by enacting statutory provisions, and prepares emergency plans, including programs to alleviate recovery (temporary housing, financial assistance, tax relief, etc.). In some countries, insurance programs are state-run. Unlike in the case of earthquake and windstorm, where homeowners themselves are responsible for ensuring their houses are properly protected, the responsibility for protection from flooding is largely shifted to public authorities.

The most visible governmental action relates to structural flood control measures. These are aimed at reducing the probability of inundation and thus lowering the hazard. Much can be done along rivers, but it is very difficult to influence the hazard resulting from local torrential rain and flash flooding because the source of the flooding cannot be located as in the case of a river flood (c.f. chapter 3.1).

2.3 Those immediately affected: individuals, companies, communities

Those immediately affected (individuals, companies, communities) have a great potential for loss reduction. The crucial point is whether they keep their risk awareness alive. Even those people who do not neglect the danger of flood from the very beginning often quickly forget about it, especially if nothing happens for some time. They rely on flood control systems and at the same time make their property more and more valuable by adding additional items – that are often susceptible to water. These people must be informed and educated to build in an appropriate manner, control the exposure of their values, and be ready to take action in an emergency. This includes preparing for catastrophic losses by taking financial precautions, e.g. buying insurance. The main parameters of Equation 1 they can influence are values at risk and vulnerability, both physical and financial.

2.4 The insurance industry

The true task of insurance companies is to compensate financial losses that would have a substantial impact on insureds or even constitute their ruin. They carry the financial risk from events that have such a low probability that they cannot be considered foreseeable. Insurance redistributes the burden borne by individuals among the entire community of insureds, which is ideally composed in such a way that they all have a chance of being affected – even if the degrees of probability differ. Furthermore, they perform educational and public relations services, e.g. by publishing brochures in which they draw attention to hazards and explain ways of dealing with them (e.g. Munich Re, 2008b).

2.5 The reinsurance industry

In the same way as private individuals, insurance companies try to avoid volatility in their payments. Natural peril insurance is highly volatile. Large single losses (from one event) can be reduced by transferring part of the risk to the reinsurance sector, in which companies often do business worldwide. When catastrophic losses occur in one country, they are distributed all over the world, thus relieving the local insurance market and possibly even preventing its collapse.

Insurance and especially reinsurance companies must be prepared to pay large amounts of money after major events. One example: Munich Re faced claims in the order of US$ 2bn after both the attack on the World Trade Center in 2001 and Hurricane Katrina in 2005. The company is not threatened in its existence even by such enormous amounts. However, volatility is expensive. Money for payments must be made available very quickly and cannot be placed in long-term – and thus profitable – investments. With increasing single losses, the whole financial market including banks, loan institutions, and investors is becoming more and more involved in covering risks.

3. FLOOD INSURANCE TECHNIQUES

3.1 Types of floods, adverse selection, insurability

In insurance contracts, flooding is defined as a "temporary covering of land by water as a result of surface waters escaping from their normal confines or as a result of heavy precipitation". There are three main types of flood: storm surge, river flood, and flash flood, each requiring quite different approaches when it comes to insuring them.

Storm surges occur along the coasts of seas and big lakes. Along with tsunamis, they have the highest loss potential of water-related natural events, both for lives and for property, but coastal defence works prevent frequent losses.

River floods are usually the result of intense and/or persistent rain for several days or even weeks over large areas. A flood wave builds up gradually in the river, propagates downstream, and can affect many reaches along the course of the river. Inundation emanates from the river channel, and the size of the flooded area is usually a function of peak discharge and flood volume. Flood control systems, in particular dykes, have a significant impact.

Flash floods are produced by intense rainfall; they are mostly local events relatively independent of each other and scattered in time and space. Flash floods have a sudden onset and last from a few hours to perhaps a day or two. In sloped terrain, the water flows at high speed and has an incredible potential for destruction, whereas in flat areas, the water accumulates on the surface or in depressions. This type of flood resulted in losses of up to several billion dollars in Houston/USA, 2001, Mumbai/India, 2005 and Oman, 2007 (c.f. Table 1).

Only a relatively small proportion of buildings are exposed to river floods: the areas affected are always the same and flooding occurs at almost regular intervals. People in these areas seek insurance, while those who live some distance from a river are not interested in buying cover. Hence, if an insurance company planned to sell individual policies as part of a voluntary insurance scheme, the premiums would have to be so high that prospective policyholders would normally find them prohibitive. This phenomenon is called adverse selection or anti-selection. It makes flood-only insurance on a free-market basis practically impossible.

The effect of adverse selection is even more distinct in the case of the storm surge hazard. Furthermore, the extremely high loss potential ($\rightarrow \infty$) from one single event coupled with the very low occurrence probability ($\rightarrow 0$) makes it difficult to calculate the risk and thus the premium, and leads to a highly uncertain result.

Flash floods have a relatively uniform probability in time and space. The necessary geographical spread of objects at risk is given and the community of insureds is large, i.e. the frequency of someone being hit by an extreme event is low. As a consequence, the premiums can be kept low, too. Consumer demand for insurance protection could be developed on a broad front, and adequate premiums can be calculated with a relatively high degree of reliability. Flood damage caused by flash floods is insurable without any problem.

3.2 Multi-risk policies, hazard zonation, premiums

Flooding typically affects certain parts of a country with a higher frequency than others. While the identification of the site-specific flood risk is indispensable, insurance packages, risk-adequate premiums and deductibles, and – to some extent – cross-subsidisation are necessary to achieve a viable portfolio. In practice, only obligatory insurance schemes seem capable of establishing a successfully functioning community of insureds with the necessary critical mass and adequate geographical spread of risks. However, there is no one best or ideal flood insurance solution. Rather, it has to be tailored to the specific hazard situation in a country and is to a large extent dependent on the long-term situation there. Although attempts have been made at political level to introduce obligatory flood insurance in a number of countries, voluntary covers are still widespread. In some countries, there are also legal problems in forcing people to insure themselves against their own free will.

Adverse selection can be avoided by offering multi-risk insurance packages. The portfolio is then composed of all kinds of clients: those that live close to a river (flood risk), those in a geologically active region (earthquake risk), those on a mountain slope (landslide and avalanche risk), etc. Nevertheless, premiums for the various hazards should reflect the individual exposure. In mass business – i.e. for private homes and small businesses and their contents – the effort required to assess the exposure of a certain building must be seen in the context of the annual premium income for one such object, which starts at roughly US$ 50 in low-risk areas. Since an individual assessment of the risk and the calculation of an individual premium for these objects are impossible, the premium must be fixed on the basis of a flat-rate assumption. For this, zones with a similar flood (earthquake, landslide) hazard must be identified and/or defined, within which the premiums are constant.

In recent years, national insurance associations and large companies in several countries have put a lot of effort into countrywide flood zoning systems (ZÜRS in Germany, HORA in Austria, SIGRA in Italy). In most cases, this was done in close cooperation with government agencies. Governments also see the advantage of having "no-go" zones or "high-price" zones set by the insurance industry to help them in their effort to keep high-risk areas free from residential and commercial development.

Insurance contracts are based on the status quo. If the hazard is high and the precautions taken minimal, the premium charged will be high (if the object is insurable at all); if the hazard is low or protection standards are high, premiums can be low. In practice, insurers often recommend (or require) precautionary measures (structural, emergency plans, etc.) to reduce the risk and also to make it more calculable.

The annual net premium reflects the average annual loss of an object at risk, which is the same as the annual risk, *R*. With flood discharges *Q* being the hazard, the risk is determined by

[2] $$R = \int_{Q_a}^{\infty} C(Q) \cdot f(Q) \; dQ$$

where *C(Q)* are the costs/losses caused by a given discharge *Q*, and *f(Q)* is the probability density function of the discharge. The integration must be performed for the whole range above the flood value Q_a, from which losses start to occur (for details, see Kron 2005).

Pricing must also take into consideration the cost of reserves being kept at hand for large losses (c.f. chapter 3.4). The probability of a single home (e.g. in the Netherlands just behind the sea dyke) being flooded is very small ($< 10^{-3}$), but if that occurs, thousands of other houses will be damaged at the same time and the overall loss will be enormous. Maintaining reserves for such a contingency costs a multiple of the amount calculated by Equation 2 that reflects the individual risk; it thus constitutes another component of the premium. The required annual premium is therefore not around 1‰ but maybe 1% of the insured value, which makes the insurance cover practically unaffordable.

3.3 Structure of insurance contracts: Self-participation

Insurance terms and conditions, if wisely applied, can support the implementation of land-use policies and building codes. If risks are not insurable – or only at great cost – hazard-prone areas will not be developed and hence new risks will not be created. In this respect, legal provisions must address insurance issues before development and construction commence rather than treating insurance as a universal remedy for all kinds of misconduct.

There is no reasonable insurance solution that can possibly make insurance companies pay for all the losses that may be incurred. Instead, a certain amount has to be borne by the insureds before the insurance becomes effective, i.e. deductibles must be introduced. Such a structure has advantages for both the insurer and the insured. The insurer does not have to settle masses of small losses and saves on both loss compensation payments and administrative costs. The client profits from that in the form of lower premiums. In a similar way, insurance contracts, especially in industrial business, often define a limit, i.e. a maximum payout sum.

An important consequence of deductibles is the motivation of policyholders "to do something" in order to reduce or limit losses. If people have to pay part of the loss themselves, this should act as an incentive to install precautionary measures or to rescue items in the event of a flood. With proper preparedness and freedom from the responsibility to pay for small losses (which may be extremely frequent), the insurance company only has to cover a reduced risk – so that the premium will be reduced, too. People whose exposure is so high that they cannot be granted insurance may only become eligible for cover by accepting a deductible.

Every insurance contract includes specifications concerning the scope of cover. Insurance conditions usually name the perils covered ("windstorm", "flooding", etc.) and, at the same time, define what is meant by "flooding". Sometimes exclusions are added, such as "Cover does not extend to losses resulting from storm surge, groundwater, dam break." The conditions (the wording) vary from country to country and from insurance company to insurance company, though sometimes only with regard to the details.

The insurance industry needs to distinguish between losses caused by wind and those caused by water (storm surge, rainfall), because as a rule (except in East Asia) they are covered by different policies. After tropical cyclones, which always bring a mixture of wind, rainwater, and storm surge, this separation is very difficult, if not impossible. The best known example is Hurricane Katrina, after which there were major arguments as to whether shoreline houses had been washed away by the storm surge (not insured in a typical US homeowner's storm insurance) or blown away by the storm (insured). Some markets avoid these problems to a large extent by offering "all risks insurance" or, as in East Asia, an STF cover, which stands for Storm-Tempest-Flood. Here, the wind-water problem does not arise. While this form of cover is ideal in that it provides clear conditions, the problem – for the insurer – lies in calculating the premium. Storm and tempest losses threaten homeowners quite uniformly, whereas the flood risk is heavily dependent on the location of the insured object. Therefore, risk-adequate premiums must be calculated as the sum of the premiums for the individual hazards. As soon as this is done, market opportunities evolve for single risk products, which are then promoted and eventually purchased. As a consequence, the all risk product may cease to be competitive.

3.4 PML calculations

For a company's balance sheet and even for its survival, knowledge of its possible maximum losses is crucial. Typically, scenarios are identified that can produce large losses, for example "Hurricane Florida", "Earthquake S.F. Bay Area", "Winter Storm Europe", or "Flood Rhine River". As theoretically possible maximum losses are not realistically encountered, "probable maximum losses (PML)" are assessed. "Probable" is specified by a company's business policy, ranging – as a rule – from 1 in 200 to 1 in 1,000 years. The losses are modelled stochastically by computing losses from a large number of artificially generated single events, where the statistics of frequency, intensity, and the spatial extent of the various events are based on observations in history. The damage ratio (e.g. for a single house) is derived from empirical loss data and usually applied as an average value. These models only look at large-scale events so that the high variability from building to building is averaged out (Kron and Willems 2002). Flood PML models require a far more sophisticated approach than models for windstorm and earthquake as the affected areas depend very much on a small-scale, detailed description of the particular conditions there. This is why flood models have only been in use for a few years. However, a number of stochastic models were developed recently, e.g. for Germany and Austria.

4. THE ROLE OF THE GLOBAL FINANCIAL MARKETS

Today, the availability of huge amounts of money in the international financial markets, the potential of record losses from single natural catastrophes, and the need for special products have led to the dawning of new financial instruments, which supplement the classical distribution of risk via the reinsurance market: these are called catastrophe bonds (cat bonds). Through a cat bond, a specified risk (e.g. losses from a hurricane in Florida) is transferred from a risk carrier (sponsor) to investors. The sponsor is usually a member of the (re-)insurance industry, but may also be a large company (such as a national railroad company). The investor buys a share of the bond and earns interest on the purchased notes. If the catastrophic event for which the bond is issued does not occur during its lifetime, the invested capital is paid back to the investor at maturity. If it does occur, however, the investor loses its principal or a portion of it. The definition of the "occurrence", i.e. the trigger of the cat bond, can be defined in different ways: a) by a certain loss to the sponsor (indemnity trigger), b) by a market loss (industry loss index trigger), or c) if a set of certain defined physical threshold values (e.g. wind speeds at certain points or discharges) are exceeded (parametric trigger). Munich Re issued a bond in 2007 that covers hurricane losses in 26 US states until 2010. The investors of that note will lose their invested capital if the market loss (total insured losses) in any one event exceeds US$ 35bn.

Cat bonds are usually high-interest, but also high-risk investments and are practically only purchased by professional investors. Investors choose to invest in catastrophe bonds because their return is largely uncorrelated with the return on other investments, so cat bonds help investors achieve diversification. Investors who participate in this market include hedge funds, specialised catastrophe-oriented funds, asset managers, life insurers, reinsurers, banks, and pension funds. Only one cat bond has been triggered so far (by Hurricane Katrina), because the trigger points were set quite high in the past. Over the coming years, increasing experience with cat bonds on the part of both investors and sponsors could reduce prices and thereby enhance the competitiveness of these financial instruments. Furthermore, it is also possible that the diversity of cat bonds in terms of expected loss levels, trigger types, and underlying perils will grow in the future.

Cat bonds are geared to very large potential losses and are therefore an instrument exclusively used in developed countries. Another instrument used in a similar way is a swap. Here, an identical portion of risk from two independent (and distant) events is exchanged between two partners who are thus both sponsor and investor. For example, a portion of the "Flood Europe" risk is transferred in exchange for the same portion of the "Hurricane Florida" risk.

5. INSURANCE IN POOR COUNTRIES

While flood insurance penetration is low in developed countries mainly because people lack risk awareness, people and businesses in poor countries often just cannot afford to pay insurance premiums, if the cover is available at all. In the aftermath of floods, it is most often the poor that have to rebuild their lives without the financial cushion of insurance.

Micro-insurance schemes are a key to helping them manage their risk better and maintain their standard of living. Micro-insurance is specially designed for low-income people and covers them against specific perils in exchange for regular premium payments proportionate to the likelihood and cost of the risk involved. Generally, micro-insurance is for people ignored by mainstream commercial and social insurance schemes, people who do not have access to regular products. Basically, it works like any other insurance scheme, but there are some aspects that make it different. Firstly, it does not cover a single client under one contract, but rather thousands of clients. Secondly, micro-insurance requires an intermediary between the client and the insurance company, a (local) non-governmental organisation, for instance, or a rural bank that can handle the distribution and administration. Furthermore, it involves a variety of problems such as low premiums and high transaction costs per client, lack of infrastructure, lack of insurance knowledge, insurance illiteracy (clients do not understand the concept of insurance), low and irregular income, and lack of data. Therefore, the first and most important prerequisite for an effective micro-insurance scheme is raising awareness and educating the people concerned.

Micro-insurance covers for risks related to natural disasters are still hardly available. A scheme is currently being set up for underprivileged residents of Jakarta, Indonesia, who suffer from flooding practically every year. As fewer than 100 million people (or 3%) of the world's poor have access to insurance, the micro-insurance market has a huge development potential. One long-term objective, of course, is also to help people develop a stable life situation that allows them to choose regular insurance products and thus become normal clients of the insurance industry.

6. FINAL REMARKS

Flood insurance has become a top issue in many countries in the aftermath of the large flood catastrophes that have occurred all over the world in recent years. At first sight, flood insurance that is obligatory for everybody seems the best solution to bypass the necessity of spending huge amounts of public money on financial relief and reconstruction of damaged private property. The problem is that the potential insureds are generally not happy about subsidising those who are exposed to a risk much higher than their own. On the other hand, the loss-bearing capacity of the insurance industry and the financial sector is limited. The state must always serve as a reinsurer of the last resort, stepping in when losses exceed this capacity. However, governments are reluctant to guarantee the assumption of potential record losses. This would require them to build up funds, with money that would then not be available for other purposes such as healthcare, pensions, and traffic projects.

A purely voluntary insurance scheme would fail to reach large parts of society due to adverse selection or lack of risk awareness. These people would rely on and seek help from the state in the event of a disaster. A system should be set up that finds a compromise between the extremes of fully obligatory and fully voluntary covers: it must be based on risk-adequate premiums which are cross-subsidised to some extent to make them affordable but are nevertheless acceptable to a vast majority. Society must understand that using tax revenue for the purposes of relief is nothing but subsidisation – and of the more expensive kind, because losses always cost more than precautions. At the same time, loss prevention measures must be enforced, the most important being the strict prohibition of building in high-risk areas. In this context, requiring insurance is a wise way to impede unchecked development. The state should also restrict post-disaster relief payments to those who are not insurable but have otherwise contributed to their own protection. At the lower end of the scale, it must be acknowledged that insurance should not be simply a band-aid that takes care of any little financial injury but is meant for substantial and catastrophic incidents that could ruin an insured.

It is without doubt possible to establish an insurance system that is compatible with the needs of the whole society, if certain conditions are accepted and the various aspects are considered within a long-term perspective, and not on a day-to-day basis. It is also unquestionable that we will never be able to prevent huge floods and huge flood losses. But we can prevent great flood catastrophes – if we are willing to tackle the risk from frequent events in a joint effort involving governments and the people, and if we are sufficiently prepared for the residual risk from rare events by involving the finance industry.

7. REFERENCES

Kron, W. 2005. Flood Risk = Hazard · Values · Vulnerability. *Water International* Vol. 30, No.1, March 2005: pp. 58–68.

Kron, W. and Willems, W. 2002. Flood risk zoning and loss accumulation analysis for Germany. Proc. of the International Conference on Flood Estimation, 6–8 March 2002, Berne, Switzerland, pp. 549–558.

Munich Re 2008a. *Topics Geo – Natural catastrophes 2007*. Munich Reinsurance Company. Munich, Germany.

Munich Re 2008b. *Highs and lows - Weather risks in central Europe.* Munich Reinsurance Company. Munich, Germany.

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