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Asian Development Bank

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George Walker, Tun Lin, Yoshiaki Kobayashi

No. 5 | April 2009



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Contents

1	Introduction	1
2	Catastrophe Insurance – General Principles	3
	2.1 Indemnity versus Parametric	6
	2.2 Requirements for Insurability	7
3	Flood Insurance	8
	3.1 Nature of Flood Damage	8
	3.2 Types of Floods	9
	3.3 Insurability of Flood	9
	3.4 Categorization of Flood Risk for Riverine Flooding	11
4	Xinhua Pilot Study	12
	4.1 How Vulnerable are Buildings in Xinhua to Flood Risk?.....	13
	4.2 How Much Would Flood Insurance Cost in Xinhua?.....	18
	4.3 Can Xinhua Afford the Flood Insurance?	20
	4.4 How to Manage the Flood Insurance?.....	22
5	Conclusions of the Study	25
6	Policy Implications	28

Acronyms

ADB	Asian Development Bank
CNY	yuan
FIC	Flood Insurance Categories
PICC	People's Insurance Company of China
PMF	probable maximum flood
PRC	People's Republic of China

1. Introduction

Disasters have the potential to seriously disrupt economic development, especially in developing countries. By creating communities more resilient to the impact of major hazards, disaster management is an important component of sustainable development. An important part of the recovery aspect of disaster management is its funding. In the developed economies an important component of recovery funding is insurance.

Insurance itself does not reduce damage and consequent financial losses, but providing a previously agreed level of compensation in response to premium payments, it delivers cash quickly to fund recovery when it is most needed. Insurance relieves governments of pressures for relief money at such times, and also hastens an otherwise slow and frustration recovery process because of bureaucratic procedures.

In developed countries, the success of catastrophe insurance relates strongly to high mitigation levels, particularly regarding building regulations and land controls. Such measures keep the risk of insurance losses low and thus make catastrophe insurance affordable. Therefore, catastrophe insurance and mitigation can be regarded as partnership activities in the provision of effective disaster management within the framework of sustainable development¹ as shown in Figure 1.²

Flood insurance, only one component of catastrophe insurance, is universally available in only a few countries worldwide, but it is available in a restricted form in most countries. Its conditions of availability vary greatly, from being part of standard fire insurance coverage to being only available through special-purpose government schemes. The most common form of flood insurance is an optional addition to a normal fire insurance policy, provided at the discretion of the insurance company and based on an assessment of the likely flood risk. Coverage is usually denied to those regarded as relatively high risk for flooding.³

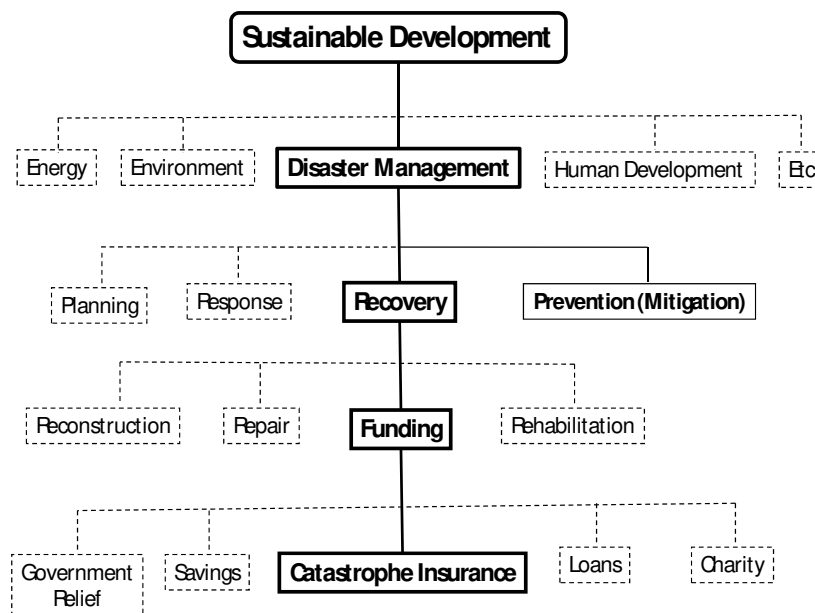
Flood insurance for property is available in the People's Republic of China (PRC) through normal insurance channels, usually as an addition to fire insurance policies, but the number of policies purchased appears to be relatively small. About 80% of property flood insurance purchased through normal channels is by large and medium-sized enterprises, although some appear to provide employees with household insurance. The general level of property insurance is relatively small at the household and small business levels, and the level of flood insurance is even less, likely due to a combination of cost and relatively high risk tolerance.

¹ Clarke, C., and N. A. Doherty 2004. Development-enhancing risk management. In *Catastrophe Risk and Reinsurance: A Country Risk Management Perspective*. Edited by E. N. Gurenko, London: Risk Books. 135–155.

² Walker, G.R. 2008. A proposed framework and approach to earthquake micro-insurance. Proc 14th World Conference on Earthquake Engineering, CD-Rom. Available: www.14wcee.com/

³ Lin, T., F. De Guzman, and M. Cuevas. 2007. *Flood Insurance as a Flood Management Tool: An Economic Perspective*. Manila: ADB.

Figure 1: Catastrophe Insurance in Sustainable Development Framework



.A limited number of agricultural insurance schemes operate commercially in the PRC and only in specific localities. These policies generally include flood insurance. They cover high-yield crops in areas where risks are well understood by the insurance companies.

The PRC has had several experiments with flood insurance coverage in situations currently largely uninsured for flood. None of these experiments appear to have led to established flood insurance schemes.

- (i) A pilot flood insurance scheme was implemented by People's Insurance Company of China (PICC) in 1992 in a rural area of Jianxi, following the 1991 flood in the Huai River Basin. This compulsory scheme covered storm and flood damage up to a specified limit. It was curtailed after experiencing extensive claims following a catastrophic flood in 1998 and has since been curtailed.
- (ii) A two-phase pilot agricultural flood insurance scheme was undertaken in the Huaihe River Basin between 1986 and 1996. The compulsory plan was sponsored jointly by the Ministry of Water Resources, Ministry of Treasury and Civil Affairs, and PICC phase resulted in disbursement of approximately 4 million yuan (CNY). Although the experiment was successful, it has been discontinued.
- (iii) In 1992 a seawall insurance scheme was implemented in Zhejiang province. The premium is shared by the Ministry of Water Resources, the provincial government, the local municipality or county government, and beneficiaries protected by the seawall.

- (iv) In 2007, several provinces instituted pilot schemes for agricultural insurance, including flood insurance, under a national Agricultural Insurance Program. The schemes used experience gained from the Huaihe River Basin pilot studies, and participating insurance companies provided insurance for specific crops. Premiums are shared by the national government, the provincial government, and the farmers.

1.1 The Study

With the aid of a loan from the Asian Development Bank (ADB), the Hunan government has embarked on a major upgrading of flood defense systems through the Hunan Hilly Regions Flood Management Project. One major objective of the project involves providing protection by 2010 against a 20-year average return in 27 county-level cities, against a 50-year average return in 6 municipal-level cities, and against a 100-year average return in 3 larger municipal-level cities.

In partnership with this major project, ADB funded the study as part of the technical assistance project. The study was intended to provide advice to the Hunan government and help it in making policy decisions on the provision of flood insurance after completion of the Hunan Hilly Regions Flood Management Sector Project in the different municipalities and counties. As discussed above, the existing agricultural insurance schemes generally cover flood risk for certain high-yield crops in areas where the risks are well understood. The study focused on the feasibility of flood insurance.

Xinhua County Town was the subject of a pilot study on the feasibility of flood insurance. Based on a sample building survey of Xinhua, a technical analysis of flood insurance risk in terms of location, construction type, and occupancy at each floor level was conducted, and the study determined premium rates based on both indemnity insurance and parametric insurance approach. A survey of affordability, undertaken in conjunction with the building survey, enabled an assessment of the technical feasibility of flood insurance. Operational feasibility was investigated by examining several alternative systems, ranging from a fully reinsured self-supporting commercial approach to a system subsidized, managed, and guaranteed by the government. This working paper is based on the report of that study.⁵

2. Catastrophe Insurance: General Principles

Catastrophe insurance is closely associated with property insurance, but has its own characteristics. Normal property insurance began several hundred years ago as insurance against individual building fires, and it is still commonly referred to as fire insurance, despite the much larger range of perils usually covered by it. It began following recognition that a

⁵ GHD. 2008. *Flood Insurability Feasibility Report*, Vol.2, Report on ADB TA4813-PRC, Strengthening Flood Management Sustainability in Hunan Province.

property owner's risk of a large individual loss caused by fire could be lessened if owners of similar properties joined together and subscribed annually to a pool that would approximately cover the group's annual total losses from fire. Modern catastrophe insurance largely has its origins in the aftermath of the San Francisco earthquake, when the large number of buildings destroyed by fire created a catastrophic event for the insurers. Catastrophe insurance may be combined with ordinary fire insurance as either standard inclusion or supplementary coverage, or may be provided separately through a special disaster insurance fund usually government controlled.

All insurance depends on a characteristic property of probability and statistics known as the Central Limit Theorem, which essentially states that the mean aggregate of similar combined but independent risks will equal the sum of the means, but the variance of the aggregate will be the square root of the sum of the variances.⁶ This means that the level of uncertainty relative to the mean, described statistically by the coefficient of variation (i.e., the ratio of the standard deviation to the mean in mathematical terms) is less for the aggregated risks than for the individual risks. The greater the number of individual risks combined, the greater the reduction in uncertainty of the aggregated losses. The less the similarity of the individual combined risks, the less the reduction in uncertainty. Insurance works by aggregating sufficient independent risks to reduce the uncertainty of annual total aggregated losses to a level that the company can manage in a sustainable manner.

An insurance company must collect total premiums sufficient to cover the estimated average annual total loss, plus an additional amount for managing the retained uncertainty and paying administrative costs; in the case of commercial insurance companies, they must also provide a return to their shareholders. Therefore, premiums normally will be greater than the estimated average annual loss insured. Consequently, there is usually a level of uncertainty below which it is more worthwhile for the property holder to retain the risk; this is usually undertaken through deductibles.

Several ways to reduce premiums include

- increasing the number of similar risks that are accumulated (i.e., getting larger);
- decreasing the differences between risks, accomplished by transferring a proportion of larger individual risks to other companies through various forms of reinsurance;
- reducing the mean risk by mitigation;
- reducing administrative costs;
- optimizing the management of reserves; and

⁶ Ang, A.H-S., and W. H. Tang. 1975. *Probability Concepts in Engineering Planning and Design*, Vol. 1, Basic Principles. New York: John Wiley & Sons.

- reducing risk to the insurance company through policy conditions, resulting in the property owner retaining a portion of the risk.

Mitigation has always been a major factor. Modern firefighting services originated in (i) fire brigades, owned and operated by insurance company to protect their own policyholders; and (ii) modern building codes as policy conditions developed by the fire insurance industry to encourage mitigation of losses from building fires through fire-resistant buildings and other forms of fire protection.

Losses from catastrophe insurance perils fail the test of independence for individual losses. If a large number of major losses from a single event is possible—a characteristic feature of most catastrophe insurance perils—uncertainties increase (i.e., the variance associated with annual total losses experienced by an insurance company to levels above those that can be tolerated, making perils uninsurable. However, in many cases, these uncertainties can be reduced to an acceptable level through catastrophe reinsurance. This can be done by either ceding a proportion of their overall portfolio to reinsurance companies through proportional reinsurance treaties, or more commonly for the larger companies, by ceding only catastrophe losses between various upper and lower limits to reinsurance companies through nonproportional reinsurance treaties, known as catastrophe excess of loss reinsurance.

Catastrophe reinsurance depends on reinsurance companies accepting only as much risk as they can afford from a single event, and then diversifying it with other separately reinsured independent event risks of a similar magnitude around the world. There is a maximum amount of diversification because of a limited number of globally insured event risks. This remains a major limitation, but there has been some easing of the problems created by this at the large event risk level by diversification with other large risks in the capital markets, perceived as independent from insured catastrophe risks. These limitations mean that the reduction in variance is generally less than that for fire risks by individual insurance companies' level, resulting in annual premiums frequently at significantly higher multiples of the average annual risks, especially for insurance of events with relatively large potential losses.⁷

Importantly, the total event loss risk ceded to a reinsurance company for a single event is critical irrespective of its source (i.e., it is the aggregate of all coverage provided for a particular event to different insurance companies, and includes coverage provided for other types of insurance that may be triggered by the event, such as automobile, life, accident, workers compensation, and liability claims.

⁷ Walker, G.R. 2003b. Pricing catastrophe risk. In *Catastrophic Risk and its Insurability*. Edited by N. R. Britton. Sydney: Aon Re Australia, 73–86.

Catastrophe insurance can be delivered as part of ordinary property insurance, through a common pool managed by insurance companies, through a government-managed disaster fund, or through catastrophe microinsurance. All these forms may use traditional reinsurance, capital market alternatives such as catastrophe bonds and contingent debt, or government assistance such as guarantees to reduce their risk of insolvency.

2.1 Indemnity versus Parametric

A characteristic feature of normal fire insurance is that it is indemnity based (i.e., the sum insured is based on the loss sustained by the policyholder). Initially the sum insured was the actual assessed value of the property during the period of the insurance—the indemnity value. Automobile insurance and many contents policies are still based on this approach but many building policies changed to replacement value during the 20th century (i.e., the cost of a new building to replace the old building irrespective of the building's actual indemnity value. This recognized that there was no alternative to replacement of old by new if a building was destroyed.

Where catastrophe insurance is provided in association with fire insurance, either as part of a standard policy or as supplementary coverage, it is usually indemnity based. However, an alternative form used widely for weather insurance potentially can be used more widely in catastrophe insurance. This is commonly described as parametric insurance, one particular form of index-based insurance. The most common form of parametric insurance is rain event cancellation insurance, where the organizer of an outdoor event takes out insurance for a specified amount that can be claimed if recorded rainfall in the vicinity of the event location exceeds a specified amount within a specified time period up to and possibly including part of the event. In this system, claims are not related to the loss sustained by the policyholder but fixed by the amount of coverage specified by the policyholder.

The main advantage of indemnity insurance is that the policyholder is compensated for the actual assessed loss sustained. The main disadvantages of indemnity insurance are that it depends on an assessment of damage post-event, which can take time and become a source of dispute; risk assessment for premium setting and catastrophe reinsurance purposes depends on an estimate of the property's pre-event vulnerability; and premiums are effectively fixed by the indemnity or replacement value of the property.

The main advantages of parametric insurance are that the general assessment of claims depends only on a measured parameter relating to the physical magnitude of the event; claims can be rapidly processed, with only a small risk of disputation; risk assessment is restricted to the specified event parameter, about which more is generally known than about vulnerability; and policyholders can limit amount insured to the level of premium they can afford. The main disadvantage is that the actual loss sustained in a particular event may differ significantly from the claim that can be made, if any. This is known as basis risk. For parametric risk to be acceptable, the basis risk must be manageable.

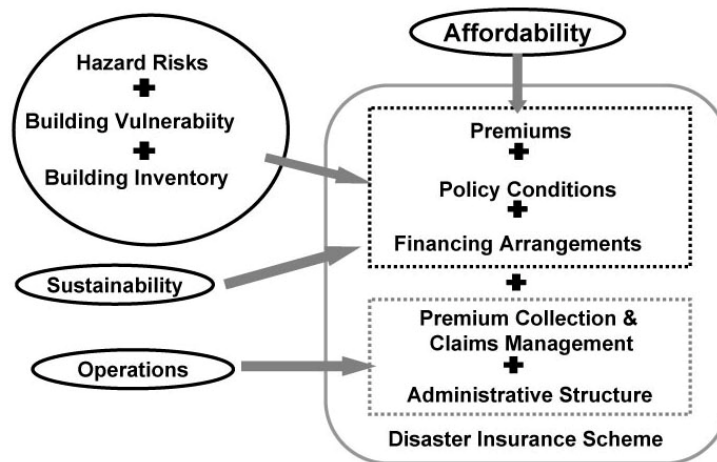
2.2 Insurability Requirements

An insurable catastrophe risk must satisfy at least the following conditions:

- The insured risk must be reasonably assessable at both the individual property level (for premium determination) and at the overall total loss level (for reinsurance purposes).
- The premiums must be affordable.
- The scheme that provides insurance must be sustainable in the long term.
- An efficient system for managing the catastrophe insurance must exist, including the collection of premiums, assessment and payment of claims, and management of reinsurance.

Figure 2 shows the interaction between conditions and outlines the process involved in the design of a disaster insurance scheme.⁸

Figure 2: Schematic of Disaster Insurance Design Process



The technical feasibility of a catastrophe insurance scheme depends on finding a combination of premium structure, policy conditions, and financing arrangements (which may include government subsidies) that is affordable and actuarially sustainable for the given portfolio of property and its vulnerability to the hazards covered. Overall feasibility requires operational feasibility.

⁸ Walker, G.R. 2004. Catastrophe risk models for Asia – A user perspective. In *Catastrophe Risk and Reinsurance: A Country Risk Management Perspective*. Edited by E. Gurenko London: Risk Books.

In addition, the risk of moral hazard—the risk that the policyholder will influence the magnitude and frequency of claims—must very small. In the case of indemnity insurance, the occurrence of event loss must be random in time and uninfluenced by deliberate human action; the amount of the insured loss must be a direct consequence of the event, caused only by vulnerability factors related to the property known to both the insurer and the insured; and the policy conditions must be unambiguous, clearly indicating the method of claim assessment. Using replacement value as insured value increases the risk of moral hazard from arson and human-inflicted damage on contents needing replacement. Underinsurance is a moral hazard that can significantly affect partial losses.

3. Flood Insurance

Flood is a peril that has proven particularly difficult for insurance companies in many countries because of several factors including (i) the wide range of events covered by the generic term of flood; (ii) the wide range of risk levels associated with flood, which depend on relatively small-scale geographic features and thus require very detailed risk-assessment procedures to delineate them; (iii) the greater vulnerability of contents and building finishes relative to building structure; and (iv) the large variation of risk in terms of floor level in multistory buildings.

3.1 Nature of Flood Damage

Flood damage has three primary forms. The most common is water damage to building contents, building finishes, and some building materials resulting from immersion in flood water and generally associated with fouling of immersed surfaces with mud and slime suspended in the flood waters. All types of flooding cause this type of damage and it can occur in all types of buildings. At any particular level of a building, damage will generally dependent on the depth of inundation above floor level. Floor coverings, electronic equipment, electrical white goods, and bed mattresses are particularly vulnerable to this type of damage if the depth of inundation is a half-meter or more. Some common building materials used for wall linings and the manufacture of low-cost furniture are also very susceptible to this form of damage.

The second most common form is structural damage to buildings resulting from force exerted on the walls and other building components by flowing, debris-laden water, or from weakened building materials because of immersion in water. Fast-flowing floods in relatively narrow valleys with a relatively large stream gradient are likely to experience this type of damage, particularly if they impact on low-rise, lightweight, single-family houses and small commercial buildings. Because it often leads to total loss of buildings, this type of flood contributes significantly to total losses.

Another form of damage associated with fast-flowing flooded streams and rivers involves building damage arising from the eroded foundations of adjacent buildings. Since the foundations of larger buildings are generally much deeper and therefore more resistant to erosion, such damage is usually associated with relatively small buildings.

3.2 Types of Floods

Floods are mainly inland or coastal. Table 1 shows the characteristics of the principal inland floods.

Table 1: Inland Flood Types

Type	Characteristics	Relative Duration	Relative Extent
Riverine Floods	Widespread heavy rain, large catchment, flat gradients, low flow velocities, floodplains.	Long	Extensive
Flash Floods	Locally heavy rain, steep gradients, high flow velocities, narrow valleys.	Short	Limited
Waterlogging	Locally heavy rain, flat land, poor drainage, no flow velocity	Medium	Limited
Hillside Runoff	Locally heavy rain, steep hillsides, high flow velocities, mixture of earth, rock, vegetation, and water	Short	Localized
Reservoir Backwater	Extensive rain for extended period, no flow velocity	Long	Limited
Detention Basin Flooding	Threatened extensive riverine flooding downstream, human action dependent	Long	Extensive

These floods may occur singly or in combination in a single flood event. In a major inland flood, all types of flooding could occur during a single event.

The three principal types of coastal flooding include tsunami, storm surge, and coastal riverine flooding. They are not relevant to the present study.

3.3 Insurability of Flood

Except for detention basin flooding, damage from all the types of inland flooding listed in Table 1 has the potential of being covered by flood insurance, whether indemnity-based or parametric, subject to meeting the normal conditions of insurability.

Flood risk varies greatly in the community. For the majority of property owners, flood is only a small risk, similar to that from wind and hail arising from severe storms, mainly because such storms are likely to be only cause of flooding due to local drainage problems. However, the risk of flooding may be as high as 5% or greater for a small number in any year, several levels greater to those listed above. Any attempt to group such risks together immediately creates a problem, since those at low risk will seek to opt out of flood insurance rather than pay excessively large premiums, giving rise to adverse selection. It also produces a disincentive for those at high risk who seek mitigation against this risk.

Consequently flood insurance can only be provided in a sustainable manner when insurance risk is assessed at individual property levels. Before the introduction of digital computers, the costs associated with calculation were so high that flood insurance was only considered possible in conjunction with planning regulations that prevent building construction below defined levels of flood equivalent to average return periods on the order of 100 years or greater.

Development of detailed flood maps at the community level has been a slow process, and it seldom occurs in a coordinated manner. Consequently, it has been difficult for insurance companies to access such information quickly and cheaply, which is necessary if premiums are not to be overloaded with administrative costs. However, progress is being made and an increasing amount of flood level risk information is becoming available in a form suitable for use by insurance companies. This is an essential first step for making flood insurance universally available.

Of the various types of flooding, riverine flooding generally poses the most risk in terms of the magnitude of the insured event loss. In general, most damage from flood is to contents, siding, finishes, and equipment. It is also the type of flooding for which the most flood risk mapping has been undertaken; thus, in principle, this should be the easiest type of flooding to handle. However, estimating the risks associated with total event loss from riverine flooding—which is needed for reinsurance purposes—is among the more difficult problems of flood risk analysis. Flash flooding and waterlogging are generally responsible for the most frequent small event losses. Analysis of risk from past losses is often a better guide for estimating these risks than analytical modeling of the risk which can be very complex and dependent on sparse knowledge of critical information.

A rational assessment of flood risk must be done for each floor level within a single building, thus requiring information about individual floor heights relative to flood risk levels. This differs from normal property insurance, which, if flood is included, is normally based purely on the building's location relative to flood maps, as are most mitigation measures. In a multistory environment, location is less important than floor level and occupancy. A high-rise building in a very flood prone area may be a safer location for its occupants and result in lower insured losses than a low-rise building in a less flood-prone area if it is designed such that occupants of lower floors can readily evacuate to higher levels with any movable contents, and if occupancy of flood-prone floors is limited to those with low vulnerability to flood.

The moral hazard associated with flood results primarily from the indemnity system of insurance, particularly if the amount insured is based on replacement basis. However the major problem arising from the indemnity system is that flood insurance becomes rapidly unaffordable as flood risk increases. Contents at risk of total loss from a flood with an average return occurrence period of 100 years will have a mean annual risk of 1%, (i.e., a premium rate of at least 1.5. Contents at risk of total loss from a flood with an average return period of 20 years translates to a mean annual risk of 5%, a premium rate of at least 7.5%. When insured on an indemnity basis, this fixes the premium, making indemnity flood insurance unaffordable for many of those at high risk.

For parametric insurance, the relevant parameter can be either measured flood levels or depth of inundation of a floor. Provided good information is available on floor levels relative to measured flood levels, the basis risk associated with both these methods will be small—much smaller than parametric insurance for other hazards. The basis risk will be lowest when based on depth of floor inundation, but this also will pose the greatest moral hazard, although the latter will still be much less than indemnity insurance because floods leave distinctive marks of their height, and comparisons can be made with adjacent buildings to check apparent anomalies. This makes flood more suitable for parametric insurance than most hazards.

Property protected by dikes poses a special problem for flood insurance. Whereas mitigation measures, such as increasing building strength, reduce the damage risk at all magnitudes of event apart from very extreme events for earthquakes and wind, dikes reduce the risk from events smaller than the magnitude for which they are designed, but have no effect for events above that level. Therefore, such property requires separate consideration in risk analysis because characteristics will be very different. Furthermore, because they often encourage building development in areas protected by them and previously considered too flood prone for building, they can increase a community's average annual flood risk. Unless designed for events with a return period of 100 years or more, there likely will be questions about the insurability of the buildings they protect.

In general, Detention Basin flood damage would be considered commercially uninsurable using normal indemnity insurance because it is dependent on human decision making. If linked to recorded flood characteristics uninfluenced by human intervention, it could be covered by a form of parametric insurance.

3.4 Categorization of Flood Risk for Riverine Flooding

While it would be possible to undertake all flood risk analyses on an individual floor level basis if the required databases existed, a satisfactory approach can be developed based on grouping the floor levels into categories of similar levels of flood risk. The following system was used in the study of Xinhua.

Flood Zones. Five flood zones for riverine flooding were defined as areas of land that would flood in the absence of any protective measures, during floods of different risks of occurrence:

Flood-free zone	Land above the probable maximum flood (PMF) level
Zone 100/PMF	Land year return period flood level and the PMF level between the 100
Zone 50/100	Land between the 50year and 100 year return period flood level
Zone 20/50	Land between the 20 year and 50 year return period flood level
Zone 0/20	Land below the 20 year return period flood level

Flood Insurance Categories. With riverine flooding, floor levels that are generally at risk, not whole buildings. Five Flood Insurance Categories (FIC) were defined for describing the exposure of individual building floor levels to flood when there are no protection measures. These are described in terms of their risk of inundation as follows:

Flood-free FIC	Floor levels above the PMF and at no risk from flooding
FIC 100/PMF	Floor levels between the 100 year return period flood level and the PMF level
FIC 50/100	Floor levels between the 50 year and 100 year return period flood levels
FIC 20/50	Floor levels between the 20 year and 50 year return period flood levels
FIC 0/20	Floor levels below the 20 year return period flood level

Three FIC were defined for describing the exposure of individual building floor levels to flood where there are protection measures against floods of a specified frequency of occurrence. These are described in terms of their risk of inundation as follows:

FIC P100	Floor levels below the 100 year return period flood level, which are protected from floods up to this level
FIC P50	Floor levels below the 50 year return period flood level, which are protected from floods up to this level
FIC P20	Floor levels below the 20 year return period flood level, which are protected from floods up to this level

These categories could also be used for waterlogging and reservoir backwater flooding, and with some modification to include a flow velocity factor for flash flooding.

4. Xinhua Pilot Study

The feasibility study was undertaken by focusing on Xinhua County Town, which was considered representative of most county towns and rural municipalities undergoing upgrades to flood defenses by the Hunan Hilly Regions Flood Management Project. It is also small enough for a relatively detailed study.

Xinhua is the administrative and commercial center for Xinhua County in Hunan Province. It has government offices, schools, hospitals, and other county services as well as an active commercial sector. At the time of the study in 2007, 51 medium-sized enterprises were involved in activities—such as coal and power, machinery, construction materials,

machinery and chemicals—and about 500 small enterprises were active in these and other sectors. It had an urban population of about 143,000. With increasing commercial and industrial activity and a growing and increasingly urbanized population, Xinhua's population likely will double by 2025.

The city is located on the floodplain of the Zi River and frequently experiences relatively small floods and occasionally very large floods. The most damaging flood in recent times occurred in 1996, when about 40% of its area was inundated. The flood has been estimated to have approximated the 100-year return period flood for Xinhua.

Prior to the Hunan Hilly Regions Flood Management Project, Xinhua was protected by a dike on one side of the river, providing only limited protection to the older parts of the city against the more frequent small floods. When the project is complete, the whole city will be protected from floods with average return periods of less than 20 years. By 2020, the level of protection likely will increase to the 50-year average return period. It appears that much of the planned population growth will occur on what was unprotected rural land below the 20-year flood level, and that area will be enclosed by new dikes.

The Xinhua study aimed to use Xinhua town as a basis for developing a representative profile of a Hunan rural urban area. The following procedure was adopted for the study:

- Identify the types of flood to which Xinhua is exposed.
- Obtain information on the number of buildings in each flood zone.
- Undertake a survey of individual buildings in Xinhua to determine their characteristics regarding height, plan area, type of building construction, occupancy at each floor level, and location in relation to flood zones.
- Develop an inventory of floor area in Xinhua in terms of flood insurance category.
- Estimate the vulnerability of buildings and contents to loss at each floor level in terms of depth of inundation.
- Derive premium rates for each flood insurance category for both indemnity insurance and parametric insurance for a range of alternatives in terms of reinsurance and government assistance.

In terms of affordability, feasibility can then be assessed by comparing the resulting premiums with the results of the survey of affordability undertaken in conjunction with the building survey.

4.1 How Vulnerable are Buildings in Xinhua to Flood Risk?

The primary type of flood to which Xinhua is exposed is riverine flooding that results from widespread heavy rain in the large catchment area upstream of Xinhua. Major riverine floods can last several days. With new dikes in place, flow velocities in the urban area can be

expected to be very low, and the risk of buildings being washed away will be negligible. Flood levels can be affected by reservoir backwater flooding from a downstream reservoir on the Li River; this is taken into account in flood risk mapping. Low-lying areas inside the levee banks will likely experience waterlogging before levees are overtopped; the drainage system is designed for rainfall intensities and durations with an average return period of 10 years.

Xinhua County Town was the site of a core subprojects of the main flood defense upgrading project undertaken to establish procedures that could be used as models for the remaining county towns and rural municipalities. As part of the initial feasibility study for this subproject, an overall analysis of flood exposure was undertaken. Based on this background information, the following distribution of building space in terms of floor area was assumed as representative of Xinhua prior to any redevelopment of rural land that could follow construction of the new dikes:

Flood-free zone	25%
100/PMF zone	15%
50/100 zone	15%
20/50 zone	25%
0/20 zone	20%

The project surveyed a representative sample of 204 buildings containing an estimated floor area of about 277,000 m² (approximately 6.5% of the total floor area in Xinhua). For each building, information was recorded on location, height in terms of number of stories and estimated total height, an approximate estimate of the plan area, the form of construction, the occupancy of each floor, and an assessment of the flood zone where the building was located, based on information provided by the Xinhua Water Bureau.

The forms of construction were divided into the following three categories: (i) brick and concrete (concrete floors with either brick walls or concrete columns and brick in-fill walls [usually modern]), (ii) brick and wood (primarily wood floors with brick walls), and (iii) wood (all-wood buildings [usually old]).

Occupancies were divided into the following four categories: (i) households; (ii) small business; (iii) industrial and commercial; and (iv) public buildings (including government offices, hospitals, and schools).

The number of buildings surveyed in the different flood zones was:

Flood-free zone	4
100/PMF zone	31
50/100 zone	19
20/50 zone	32
0/20 zone	118

An examination of the results indicated that there were no discernible distinct differences in the building characteristics between the flood zones, so a uniform distribution

of building characteristics was assumed across all flood zones, based on the characteristics derived from the total sample of buildings.

Figure 3 shows the estimated distribution of floor areas at different floor levels, derived from the survey information. Only a very small proportion of the buildings are single-story, and more than half the buildings have five stories or more. This brings considerable significance to the community's overall flood risk.

Figure 3: Distribution of Total Floor Area between Building Levels

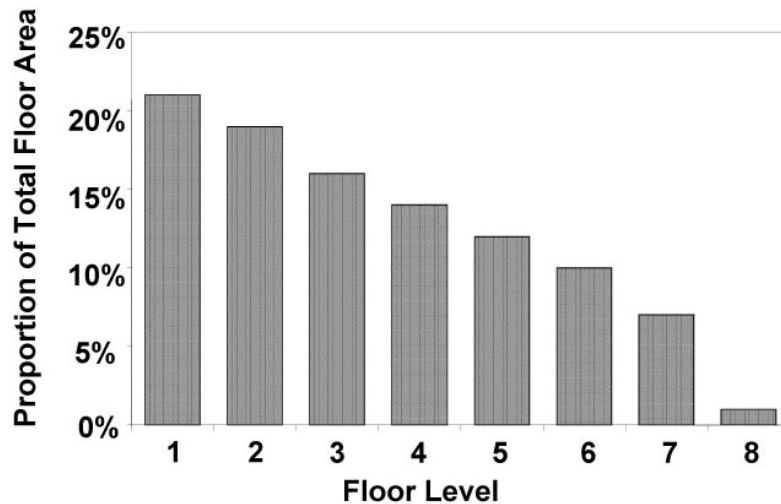


Figure 4 shows the assumed distribution of construction types at different floor levels, based on the results of the survey. Brick and concrete construction dominates, especially at the higher levels. However, the proportion of brick and wood construction is significant at the lower levels, which are the most exposed to flood. The proportion of wood buildings is very small but they were allowed in the analysis because they are the most vulnerable to inundation damage.

Figure 5 shows the assumed distribution of occupancy, based on the survey information. Small businesses and industrial and commercial enterprises occupy the largest proportion of the ground floor space, the level most exposed to flooding, and generally do not occupy space above the 3rd floor. When combined with the information on floor areas at each level, the overall distribution of floor space in terms of occupancy was about 56% household, 12% small business, 10% commercial and industrial, and 22% public building space.

The inventory of floor area exposed to flood in Xinhua was extrapolated from the survey sample and based on the average household size per person in Xinhua (approximately 17 m² as indicated in the 2005 Year Book), and an estimated urban population of about 142,500, suggesting a total household floor area of about 2.4 million m². Using the relative occupancy proportions based on the building survey, this indicated about 965,000 m² of

commercial and industrial floor area (including small business), and about 940,000 m² of public building floor area, or a total estimated floor area of about 4,305,000 m².

Figure 4: Assumed Distribution of Construction Types at Each Floor Level

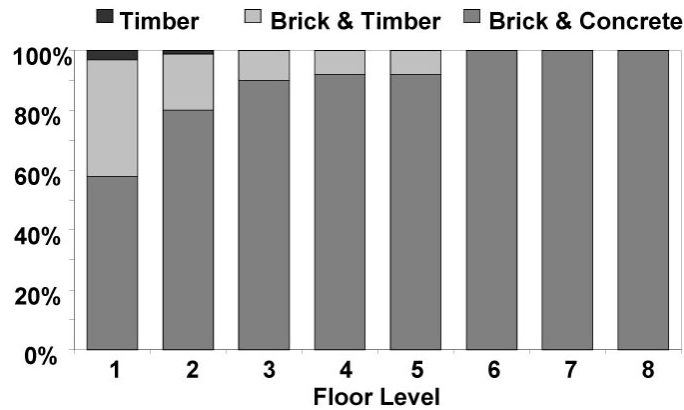
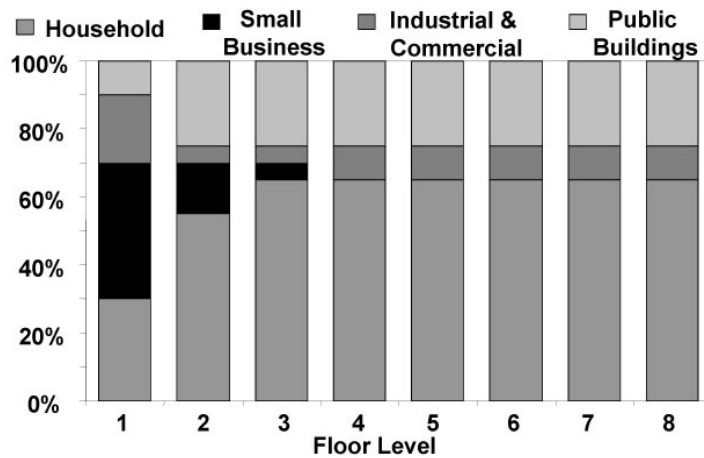


Figure 5: Assumed Distribution of Occupancies at Each Floor level



Using the information from the building survey, the study constructed a matrix of floor areas that showed the total floor area broken down into individual components corresponding to the different flood insurance categories, different floor levels, different construction types, and different occupancies. Analysis of this information indicated that about 75% of all ground floors were exposed to flooding, 33% of second floors, 11% of third floors, 5% of fourth floors, and no floors above this. This data is a function of Xinhua's topography and estimated flood risk levels as well as the height characteristics of buildings in Xinhua.

Table 2 shows the overall impact in the proportion of all floor space exposed to flooding.

Table 2: Estimated Proportion of Floor Area Exposed to Flood, %

Flood Insurance Category	Households	Small Business	Commercial & Industrial	Public Buildings	Total
Flood Free	83	39	66	83	76
100/PMF	5	13	8	5	6
50/100	4	13	7	4	6
20/50	4	19	11	4	7
P20	4	15	9	3	6

Households and public building space have the lowest average flood exposure, while small business has by far the largest. This is a direct consequence of the information shown in Figure 5. It also highlights the mitigation benefits arising from the use of medium- to high-rise construction in areas prone to riverine flooding.

For calculation of premiums from premium rates, the value of building property at risk was estimated using information on building costs for Xinhua from the 2005 Year Book and making some assessment of the differences between occupancies. The values assumed are shown in Table 3.

Compared with building values, contents values vary widely, but the averages in Asia are significantly consistent among different occupancies. The following values were used based on typical insurance experience in Asia:

Households	0.33 x building value
Commercial and industrial	Equal to building value
Public buildings	0.4 x building value

Table 3: Building Values CNY/m²

Occupancy	Brick & Concrete	Brick & Wood	Wood
Household	680	360	280
Industrial & Commercial	760	400	280
Public Buildings	800	440	320

Vulnerability to flood damage, which is needed for indemnity insurance, is normally expressed in terms of depth of inundation and generally based on detailed studies of damage following flooding. Because the study was unable to obtain such information for the

PRC, it used approximate assumptions based on experience. Table 4 shows those assumptions.

Table 4 assumed that a 20-year flood will just overtop the levee.

Table 4: Assumed Vulnerability of Flooded Floor Property to Loss

Flood Insurance Category	Return Period of Flooding	Building - Construction Type			Contents (%)
		Brick & Concrete (%)	Brick & Wood (%)	Wood (%)	
100/PMF	PMF	5	10	15	50
50/100	100	5	10	15	50
	PMF	8	15	25	70
20/50	50	5	10	15	60
	100	8	15	25	75
	PMF	10	20	40	90
P20	20	5	8	16	70
	50	8	12	24	80
	100	10	16	32	90
	PMF	13	20	40	100

4.2 How Much Would Flood Insurance Cost in Xinhua?

From the information on vulnerability as a function of the flood return period presented in Table 4, we can estimate average annual loss as a ratio of total insured value, commonly known as pure risk rate in the insurance industry. Actual premium rates are calculated by multiplying the pure risk rates by a premium loading factor, the mark-up applied to ensure sustainability of the insurance scheme and allowing for administration and reinsurance costs as well as investment income and, in the case of commercial insurance companies, profits for shareholders, along with any cross-subsidization of risks from other lines of insurance that might be adopted in response to market forces. For flood, the premium loading factor would be expected to vary between about 1.2 and 2, depending on the form of operation and market forces.

These rates should be regarded only as indicative, but of sufficient accuracy for assessing feasibility. In practice, a more detailed analysis of vulnerability would be required for the different occupancies, for which the vulnerabilities were equal for this exercise. Because the vulnerability of different occupancies in terms of total insured value was assumed to be equal, these premium rates are independent of occupancy.

For a household of 50 m² and CNY10,000 of contents, these premium rates would result in premiums in the order of those shown in Table 6.

For a typical small business, the building premiums would be similar to those for a typical household given in Table 5, but the premium for contents would be significantly higher because of higher value of contents covered.

Table 5: Expected Range of Premium Rates Assuming Full Indemnity Insurance

Flood Insurance Category	Building - Construction Type, %			Contents (%)
	Brick & Concrete	Brick & Wood	Wood	
100/PMF	0.04–0.06	0.07–0.12	0.11–0.18	0.37–0.61
50/100	0.10–0.17	0.20–0.34	0.30–0.51	1.02–1.69
20/50	0.24–0.41	0.49–0.81	0.83–1.38	2.56–4.27
P20	0.45–0.75	0.72–1.20	1.45–2.41	4.20–7.00

Table 6: Estimated Indemnity Annual Premiums for a Typical Xinhua Household

Flood Insurance Category	Building - Construction Type, CNY			Contents (CNY)
	Brick & Concrete	Brick & Wood	Wood	
100/PMF	12–20	13–20	15–25	35–60
50/100	35–60	35–60	45–70	100–170
20/50	85–140	90–150	115–190	260–430
P20	155–260	130–210	200–340	420–700

Table 7: Expected Range of Typical Premium Rates Assuming Parametric Insurance

Flood Insurance Category	Premium Rate (%)
100/PMF	0.75–1.2
50/100	1.8–2.8
20/50	3.7–6
P20	6–10

If parametric insurance is based solely on inundation (i.e., a fixed amount of sum insured, which can be claimed if a floor level is flooded), the pure risk premium rates in each flood insurance category will equal the average risk of floor inundation within each category. The range of premium loading factors was assumed to be the same as for indemnity insurance, although in practice they might be less because of the reduction in uncertainty and moral hazard through not having to take vulnerability into account. Table 7 shows the indicated range of premium rates from the analysis undertaken.

Whereas with indemnity insurance the question regarding feasibility is how much the premium will be, with parametric insurance the question is how much can be bought for a given amount of premium. Table 8 shows the approximate amount of coverage that could be purchased per CNY100 of premium.

Table 8: Range of Cover / CNY100 Premium Assuming Finite Insurance

Flood Insurance Category	Upper Limit (CNY)
FIC 2	8,000–13,600
FIC 3	3,600–6,000
FIC 4	1,600–2,700
FIC 4P	1,000–1,700

4.3 Can Xinhua Afford Flood Insurance?

A survey directed at gaining an understanding of the ability and willingness of property owners to pay for flood insurance was undertaken on a representative sample of 517 households, 82 small businesses, and 15 commercial and industrial enterprises in Xinhua, concurrent with the building survey. A detailed report on this survey and the investigation of affordability based on it is attached as Appendix 5 to the report on the flood insurance feasibility study.

Of the households surveyed, about 50% reported having no savings and another 20% reported savings of less than CNY200/month. Most households had experienced at least one flood (generally the 1996 flood). Of those who had paid for repairs and replacement of contents, the average reported amount was about CNY7,000 with a median value of CNY3,000, indicating a preponderance of relatively small amounts. About 6% of all households surveyed reported having property insurance. Respondents in about half the households surveyed indicated they would not be willing to pay for flood insurance. Of those who were, the average amount they were willing to pay as an annual premium was between CNY100 and CNY150, depending on the amount of coverage with a median value of about CNY50.

The responses from small businesses were similar overall to those from households. For all the small businesses surveyed, the monthly turnover was less than CNY100,000 while the average value of stock carried was about CNY73,000, although this varied significantly depending on the type of business. Stock value was relatively low for restaurants but twice as much for small supermarkets. Only about 2.5% reported having property insurance and, like households, about half of them indicated they would not be willing to pay for flood insurance. Of those who would be willing to pay for flood insurance, the average amount varied from about CNY200 to CNY400 depending on the level of coverage, with a median value of about CNY100.

The commercial and industrial enterprises surveyed varied in size from a turnover of about CNY100,000 per month to over CNY1,000,000 per month. Average values of stock, furnishings, and plant and equipment averaged about CNY5,000,000, but this was heavily influenced by the two largest enterprises. When those two were excluded, the average value of stock was about CNY800,000, the average value of furnishings was about CNY150,000 and the average value of plant and equipment was about CNY850,000. All but one had experienced damage due to flooding, mostly in 1996. Most had property insurance of some form, but several indicated unwillingness to pay for flood insurance even when located in flood-prone area. Of those willing to pay, the amounts they were prepared to pay varied widely, partly reflecting the wide range of enterprises sizes. Because of the relatively small sample and wide disparity of answers, it was difficult to draw any general conclusions from this group.

In regard to households, the study determined that a good benchmark for an affordable premium would be 0.5% of household income. For an average household in Xinhua, this equals about CNY100 per year, and for an average low-income household, about CNY50 per year.

4.3.1 Implications for Flood Insurance Feasibility

Households: The investigation of affordability indicated that a total premium of about CNY100 would be the limit that would be reasonably acceptable to an average household.

In the case of the average low-income household, this might be only CNY50. On this basis, the results suggest that indemnity flood insurance would only be affordable to the average household for property in flood insurance category 100/PMF at the upper level of premium loading factor considered, and marginally in flood category 50/100 as well at the lower level of premium loading factor considered. At the upper level of premium loading factor considered, flood insurance category 50/100 property could be made affordable for the average household by having 50% coinsurance (i.e., having the property owner assume liability for 50% of the loss). For the average householder, indemnity flood insurance of property in flood insurance categories 20/50 and P20 would appear to be feasible only if householders retained a significant proportion of the risk and accessed very significant government subsidies.

For low-income householders, indemnity flood insurance would be marginally affordable only in flood insurance category 100/PMF if the upper level of premium loading factor was applicable. A combination of a large proportion of losses being retained by the householders and large subsidies from government would be required to make it feasible for other flood insurance categories.

By its nature parametric flood insurance can always be made affordable since the amount of cover can be tailored to the amount of premium that is affordable. However the amount of coverage available for the premium paid may be regarded as too small for the insurance to be of value. This could be the case in flood insurance categories 20/50 and P20. This could be overcome by government subsidies.

Business: Small business is prepared to pay on average about twice what the average householder is prepared to pay but, because average contents are much larger, indemnity flood insurance likely will be less affordable. Full coverage is probably only feasible in category 100/PMF properties. If small businesses are to be adequately covered, those with large values of stock (small supermarkets and retail shops) would have to accept paying a significantly higher proportion of their income from sales as flood insurance premiums than they have indicated they would be happy to spend (currently on the order of 0.02% of annual turnover) or the government would need to provide subsidies of a similar magnitude to those required for households.

In the case of larger commercial and industrial enterprises, affordability is more related to the financial risk management of their operation, and the benefits of flood insurance must be weighed against the costs, which may include the cost of mitigation measures designed to reduce the risk of flood damage and, thus, premiums.

Government Subsidies: Universal flood insurance for households across all flood insurance categories in Xinhua likely could be provided at a reasonable level with a government subsidy of about CNY500,000 to help those in categories 20/50 and P20. If small businesses were to be similarly insured, a similar additional amount would be required.

4.4 How to Manage Flood Insurance

The premium loading factor depends on the nature of the scheme adopted to provide flood insurance. There are many possible schemes of operation; examples of the main types can be found in the review of international experience with flood insurance presented in Appendix 1 of this report. This discussion will be limited to three approaches considered organizationally possible and will encompass the extremes regarding the effect on the premium loading factor. The three approaches are (i) a separate standalone insurance pool scheme supported by insurance companies, (ii) a separate standalone government fund scheme, and (iii) a normal commercial property insurance operation.

4.4.1 Insurance Pool Scheme

This appears to be the approach adopted in Zhejiang province under the National Agricultural Insurance Program. It is also the approach essentially adopted in Norway and Switzerland for their natural disaster insurance schemes, although there is no government subsidization of premiums in these countries.

In this case, the premium loading factor is highly dependent on the cost of reinsurance, which will depend on a combination of the magnitude and frequency of the scheme event losses and the magnitude of the largest loss for which the reinsurance industry may be liable from the events reinsured under the scheme. In addition, an initial start-up pool, for which the subscribers will expect some return, will be required to enable the scheme to get started in a sustainable manner.

In general, if a pool is to operate in a sustainable manner, the expected annual average growth of the pool's funds must exceed the annual growth in sum insured values due to inflation and the expansion of property. These factors can be modeled on the computer using a probabilistic simulation of the financial operations of the scheme and inputting the pool event loss risk as a random variable. In the insurance world, such modeling is known as dynamic financial analysis (DFA). The premium loading factor is relatively sensitive to the pool event loss risk characteristics, increasing with every increase in the magnitude of the event risk. Estimating the pool event risk, where multiple locations can be affected by the same event, requires sophisticated hydrological analysis beyond the scope of this study. However, an approximate analysis suggested that a sustainable pool approach covering all the county towns and rural municipalities included in the Hunan Hilly Regions Flood Management Project would be sustainable with a premium loading factor in the order of 1.8–2.0. This might decrease if the government contributed to the initial start-up pool.

4.4.2 Government Fund Scheme

This is essentially the approach adopted in the United States for their National Flood Insurance Program. Insurance companies could collect the premiums for the government on a commission basis, with the government paying claims out of the resulting fund; if the fund is exhausted, the government would pay claims from general revenue. To reduce the risk to the government over time, they generally require the premium to be large enough to ensure that the fund grows at a reasonable rate. DFA modeling of these schemes can be used to establish the risk to government and the size of premium that would give an acceptable reduction in risk to the government over time. A limited analysis of this situation showed that a premium loading factor of 1.2 is about the minimum that could be applied to ensure reasonable growth of the fund.

4.4.3 Normal Commercial Insurance Approach

This approach would be undertaken by providing insurance through normal insurance companies as part of their normal commercial operation with any subsidization by government being a contribution to premiums. This appears to be the approach adopted in Hunan to the National Agricultural Insurance Program. It is also the approach used in most countries with no special scheme for flood insurance. Providing flood insurance through normal insurance companies allows some economies to be achieved regarding administration costs and possibly reinsurance costs. However reinsurance will still need to be purchased and it is unlikely that a company could use a premium loading factor less than about 1.6 without cross-subsidization of the flood insurance premiums from other lines of business. Reinsurance companies may prefer to deal with a single pool rather than a number of insurance companies, and effectively charge a higher rate to insurance companies than they would to a pool. Insurance companies may also not be keen to have a large flood exposure in their portfolio for fear that it would affect the overall cost of reinsurance.

4.4.4 Possible Insurance Structures

Figure 6 shows the structure of a scheme under which the insurance company would determine actuarially sound premium rates and the primary government support would be subsidization of the premiums. Only parametric insurance is envisaged to be available in FIC P20 and FIC 20/50 and it would be subsidized, with owners retaining significant risk. In FIC 100/PMF and FIC50/100 owners would be offered a choice of full indemnity insurance for the benefit of those prepared to pay the resulting premiums, or parametric insurance for those prepared to retain some of the risk.

Figure 6: Insurance Company Based System

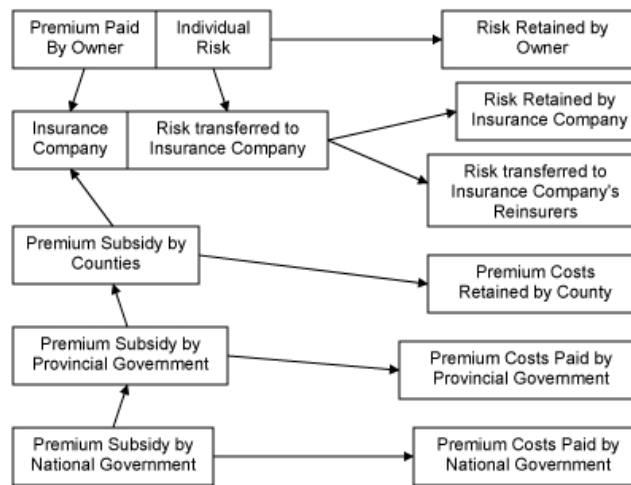
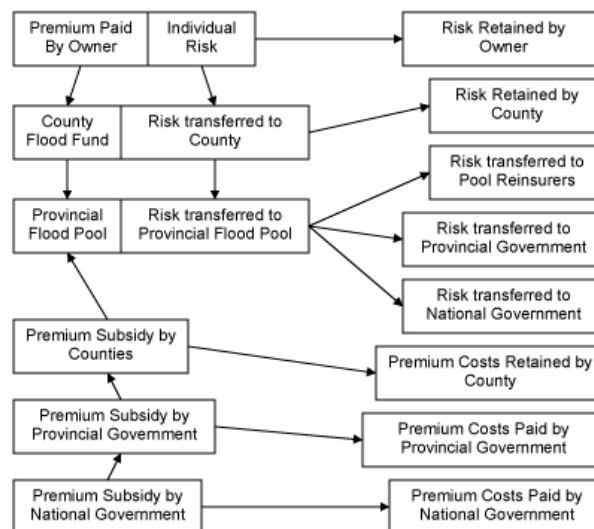


Figure 7: Provincial Government Flood Pool System



In the structure shown in Figure 6, most of the risk not retained by the owner will be reinsured through the insurance company's reinsurance program. To reduce the associated reinsurance costs, it would be necessary for various levels of government to assume some of the event risk. This normally requires some form of government pool or fund structure. A possible structure is shown in Figure 7.

This structure assumes that the individual premiums would be paid into a county fund that would be pooled with those from other counties to form a provincial flood pool to which the county fund subscribed. A parametric form of insurance such as recently proposed by Swiss Re is envisaged.⁹

5. Conclusions

- 1) Flood insurance is only feasible if supported by detailed mapping of flood risk and reliable data on building floor level elevations relative to flood risk levels.
- 2) Normal indemnity flood Insurance is likely to be
 - a. feasible for property in Xinhua located above the 100-year flood level;
 - b. probably feasible for property in Xinhua located below the 100-year flood level and above the 50-year flood level, providing that a significant amount of co-insurance is retained by the property owner; and
 - c. not feasible below the 50-year flood level unless accompanied by significant co-insurance by the property owner and government subsidies of the premiums.
- 3) Parametric insurance is more suited for flood than most other hazards because of much lower associated basis risk and is always affordable because the property holder can tailor the sum insured to the amount of affordable premium. However, the government may still consider it necessary to provide additional premium contributions for household property below the 50-year return period flood level to ensure a reasonable level of cover.
- 4) Parametric flood insurance appears to have a number of advantages for the insurance of properties in the higher risk categories, since it allows the property owner to select an amount of insurance cover independent of the type of property to be covered based on financial costs and benefits. It is simpler to administer, and it is less prone to moral hazard and disputation in respect of claims.

⁹ Michell, M., and R. Schnarwiler, 2008. Disaster Risk Financing: Reducing the Burden on Public Budgets. *Focus Report*, Swiss Re. www.swissre.com

- 5) In terms of affordability, a government fund scheme without reinsurance would appear to provide the most feasible approach to flood insurance, but would require a considerable commitment by the government to assume a liability for large losses from normal revenue in addition to subsidizing premiums.
- 6) If a scheme based on indemnity flood insurance is to be implemented, a detailed study of flood damage losses at the building floor level for different types of occupancy and construction type and different depths of floor inundation will be required to estimate premiums reliably.
- 7) To optimize the design of any proposed scheme of flood insurance, ensure a low rate of reinsurance, and manage the sustainability of the scheme, it will be necessary to undertake a detailed study of the potential event losses to the scheme and their frequency of exceedance. This requires significant hydrological research.
- 8) Despite about 75% of the buildings in Xinhua being in locations at risk from flooding, only about 25% of the floor space is at risk from being flooded because of the dominant use of medium-rise multistory buildings and the effect of the local topography on the range of possible flood heights. This makes the overall community flood risk significantly less than what it would be for low-rise buildings, reducing the level of government subsidization necessary for implementing universal flood insurance.
- 9) If, as apparently planned, a large proportion of the future expansion of Xinhua town occurs in low areas protected by the new dikes, it will be important to use the flood mitigation features of medium- to high-rise buildings, such as ensuring that lower floors at risk from floods of less than 100 years average return period are used for occupancies with a low vulnerability to flood damage, and not as living space for households, thus minimizing any demands on government for subsidizing flood insurance.
- 10) Flood insurance is only feasible if supported by detailed mapping of flood risk and reliable data on building floor level elevations relative to flood risk levels.
- 11) Normal indemnity flood Insurance is likely to be
 - a. feasible for property in Xinhua located above the 100-year flood level;
 - b. probably feasible for property in Xinhua located below the 100-year flood level and above the 50-year flood level providing a significant amount of co-insurance is retained by the property owner; and
 - c. not feasible below the 50-year flood level unless accompanied by significant co-insurance by the property owner and government subsidies of the premiums.

- 12) Parametric insurance is more suited for flood than most other hazards because of the much lower associated basis risk. It is always affordable because the property holder can tailor the sum insured to the amount of affordable premium. However, the government may still consider it necessary to provide additional premium contributions for household property below the 50-year return period flood level to ensure a reasonable level of cover.
- 13) Parametric flood insurance appears to have a number of advantages for the insurance of properties in the higher risk categories since it allows the property owner to select an amount of insurance cover independent of the type of property to be covered based on financial costs and benefits, it is simpler to administer, and it is less prone to moral hazard and disputation in respect of claims.
- 14) In terms of affordability, a government fund scheme without reinsurance would appear to provide the most feasible approach to flood insurance, but would require a considerable commitment by the government to a liability to large losses from normal revenue in addition to subsidizing premiums.
- 15) If a scheme based on indemnity flood insurance were to be implemented, a detailed study of flood damage losses at the building floor level for different types of occupancy and construction type and different depths of floor inundation would be required to estimate premiums reliably.
- 16) To optimize the design of any proposed scheme of flood insurance, ensure a low rate of reinsurance, and manage the sustainability of the scheme, it will be necessary to undertake a detailed study of the potential event losses to the scheme and their frequency of exceedance. This requires significant hydrological research.
- 17) Despite about 75% of the buildings in Xinhua being in locations at risk from flooding, only about 25% of the floor space is at risk from being flooded due to the dominant use of medium-rise multistory buildings and the effect of the local topography on the range of possible flood heights. This makes the overall community flood risk significantly less than if low-rise buildings were the dominant form of construction, reducing the level of government subsidization that would be necessary for implementing universal flood insurance.
- 18) If, as apparently planned, a large proportion of the future expansion of Xinhua town were to occur in low areas protected by the new dikes, it would be important to use the flood mitigation features of medium- to high-rise buildings such as ensuring that lower floors at risk from floods of less than 100 years average return period are used for occupancies with a low vulnerability to flood damage, and not as living space for households to minimize any demands on government for subsidization of flood insurance.

6. Policy Implications

Although this study was based on a relatively small rural city in a relatively poor region, the results as far as the feasibility of normal indemnity flood insurance is concerned are little different from the experience with flood insurance in the developed world, where generally it has been regarded as a problem unless floor levels are above the 100-year return period risk level.

The indemnity premium rates themselves are relatively robust in terms of differing locations when expressed in terms of the flood insurance categories as defined in this study. They are solely based on the vulnerability as a function of flood risk relative to the flood insurance category, and the possible range of these functions is limited. What makes the premiums themselves different is the local building costs and values of contents, and what makes their affordability different is the different economic circumstances. If there is a surprise from the study, it is that the latter two factors do not seem to make a big difference, suggesting that the combined effect on affordability is also relatively robust in socio-economic terms.

Significant innovative ideas arising from this study are

- Flood insurance is greatly simplified in terms of premium analysis and application if it applied on a floor level basis rather than whole of building basis.
- A parametric approach appears to have significant advantages over indemnity insurance for flooding where the risk of buildings being washed away is negligible, such as riverine flooding and waterlogging.
- In flood-prone areas, the flood insurance risk can be greatly decreased by the construction of medium- to high-rise buildings with households restricted to the upper levels, and the lower levels at high risk used for activities that do not pose a risk of large losses in the event of flooding.

In the developed world, indemnity insurance applied on a whole building basis is so ingrained in property insurance that changing to a parametric approach and a floor-based approach would require a major paradigm change. However, in developing countries where property insurance is much less established, this change may be easier to make. Indeed, the Chinese are already demonstrating in their approach to agricultural insurance—much of which has a major flood component—that they are prepared to encompass this type of innovation.

To be successfully implemented, flood insurance must be based on detailed risk assessment at both the individual property level and at the event level. For parametric insurance, this needs only to be concerned with the hazard risk whereas indemnity insurance also needs to include an assessment of vulnerability, which greatly increases the complexity of the analysis. Assessment of local hazard risk is needed for many other aspects of disaster management apart from insurance, and thus has a much higher priority

than studies which are only of value to insurance. In many cases flood mapping has been undertaken but the problem is that the information is not publicly available. Techniques exist for using this information to obtain event risk information, and if vulnerability can be ignored the process will considerably be simplified.

In the English-speaking world at least, the whole of building approach may be strongly related to the high level of single-family dwellings, which are generally the primary social concern of flood insurance. In the PRC and in some other Asian countries, the proportion of single-family houses in urban areas is very small and decreasing, with medium- to high-rise buildings being the dominant form of construction. It would seem important that the benefits of these in terms of flood mitigation be recognized in their planning. One outcome of the upgrading of the flood defenses in Hunan will be a significant increase in the use of land below the overtopping level of the levees for development. Flood insurance will be much more feasible with much lesser demands on governments for its subsidization if restrictions are placed on the occupancy of floors below the 50-year return period flood level with households perhaps being restricted to floor levels above the 100-year return period flood level. There is precedence for this approach in the National Flood Insurance Program in the United States.

The findings of the study point to a few valuable policy directions for flood insurance in Hunan. First, the study demonstrates that current community flood risk is less than generally perceived and, subject to certain provisos, flood insurance is feasible. Second, in terms of flood insurance design, a parametric insurance demonstrates significant advantages when compared to indemnity insurance. Furthermore, the design of flood insurance is greatly simplified in terms of premium analysis and application if it is applied on a floor level basis rather than on a whole building basis. Third, as far as affordability of flood insurance is concerned, government subsidies are required, but at a reasonable level. Fourth, in terms of flood insurance management, a government fund scheme without reinsurance would appear to provide the most feasible approach to flood insurance, but would require a considerable commitment by the government to a liability to large losses from normal revenue in addition to subsidizing premiums. Finally, it is imperative for the government to provide a policy package and environment to ensure the implementability and sustainability of flood insurance including flood maps and building codes. The last point is especially important at current time when the PRC is experiencing rapid urbanization and building construction.

Is Flood Insurance Feasible? Experiences from the People's Republic of China

Flood insurance, a component of catastrophe insurance, is universally available in only a few countries. In many countries, it is available in a restricted form and its conditions vary greatly. Coverage is usually denied to those regarded as relatively high risk for flooding. This working paper analyzes the feasibility of providing flood insurance vis-à-vis the experience in the People's Republic of China.

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