Introduction

Sam Gutterman
The IAA – An association of associations

- Represents 70,000+ actuaries in 115+ countries
- Numerous practice, professionalism and member development committees
- 7 Sections
  - 5,000+ Section members
- Incorporated in Switzerland
  - Based in Canada
- 800+ volunteers
- Latest Full Member: Nigeria
The IAA’s Membership in 2019

Congresses: every 4 years (in Congress year, Section Colloquia held in conjunction with Congress)

2019
- Full Members
- Associate Members
- Non-member Association
- Actuaries, No Association
The REWG’s work

- **Past papers**
  - Climate change and mortality (2017)
  - Decarbonization (2018)
  - Flood risks (2019)
  - Climate change, insurance and vulnerable populations (2019)

- **Works in progress**
  - Water quality risks
  - Climate change adaptation
  - Disclosure for pension plans
  - Climate Change Risks – a chapter for the IAA Risk Book
Scope of Paper – by chapter

(1) Introduction
(2) Flood risk – what is it (Sam)
(3) Flood risk management (Sam)
(4) Role of insurance (Stuart)
(6) Pricing (Stuart)
(5) Constraints (Rade)
(7) Role of government (Rade)
(8) Role of actuaries (Rade)
Flood Risk
Sam Gutterman
The start - definitions

• **Flood**
  – a water event, usually occurring when an area receives water and there is no place for it to go

• **Types of floods**
  – Coastal or surge floods
    • Higher-than-normal levels along the coast and in lakes or reservoirs
  – Riverine or fluvial floods
    • Overflow of water from a stream channel onto normally dry land in a floodplain
    • Types: overbank and fluvial (high intensity and water velocity)
  – Flash, surface, or pluvial floods
    • Ponding of water at or near the point where the rain fell
    • From intense rain or storms, not necessarily close to a body of water
Percentages of Occurrence of Natural Disasters by Disaster Type (1998–2017)

Flood risk losses

• Damages
  – Between 1980 and 2009, global direct economic losses due to floods exceeded US$1 trillion* (2013 values)

• Direct and indirect
  – Tangible
    • Homes, businesses (property and interruption), vehicles, public property (e.g., roads)
  – Intangible
    • Injuries, deaths, opportunity cost, public services, migration, tax revenue, psychological effects

*Winsemium et al. “Global Drivers of Future River Flood Risk” Nature Climate Change, Volume 6, April 2016
### Characteristics of the three types of floods

<table>
<thead>
<tr>
<th>Type</th>
<th>Cause</th>
<th>Threatened Areas</th>
<th>Loss Factors</th>
<th>Loss Prevention</th>
<th>Effects of Climate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal floods</td>
<td>High level of water due to wind set-up, high waves, Tsunamis</td>
<td>Relatively narrow strip of coast</td>
<td>Salt water, Wave forces</td>
<td>Land-use rules, Early warning</td>
<td>Sea level rise, Glacial melt</td>
</tr>
<tr>
<td>Riverine floods</td>
<td>Prolonged, copious large-scale precipitation (possibly snow melt)</td>
<td>Recurrently the same areas near rivers</td>
<td>Prolonged impact of water, Water contamination (e.g., by oil)</td>
<td>Land-use rules, Early warning, Structural flood control, Temporary protection of property, Placement of hard-to-move objects somewhere else, Evacuation</td>
<td>Glacial melt, Increased rainfall</td>
</tr>
<tr>
<td>Flash floods</td>
<td>Mostly local torrential rain (thunderstorms)</td>
<td>Practically anywhere, including places far from watercourses</td>
<td>Mechanical impact of fast-flowing water, Possibly large amounts of sediment</td>
<td>Adequate drainage, Effective building construction and maintenance, Quick evacuation</td>
<td>More intense rainfalls, More intense and stalled cyclones</td>
</tr>
</tbody>
</table>
Causes – types of drivers

- Weather
- Geography
- Environmental and physical land features
- Human actions or inaction
  - Improper land use
  - Socioeconomic and demographic
  - Structural failure
  - Inadequate infrastructure, e.g., drainage systems
- Increased urbanization
Causes – exacerbating factors

- Sea level rise
- Glacial melt
- Increased rainfall
- More intense and stalled cyclones

Note: the paper does not focus on tsunami-related risks
How flood risk changes over time

• Examples
  – Course and size of rivers
  – Population and property exposed to flood risk can increase or decrease
  – Climate change leads to higher sea levels, extreme weather events (including torrential rain storms), and changing temperatures

• Function of ability or willingness to invest in flood mitigation and adaptation activities
Flood Risk Management

Sam Gutterman
Flood risk management process - what is it

- Similar to other risks, an effective risk management process can help to control flood risk
Mitigation and adaptation

• Public and private sector actions
• Especially relevant
  – Flood control and public infrastructure
    • Floodplain management
  – Land use
  – Resilient buildings
  – Early warning systems
• Financing
  – Private insurance
  – Public programs
  – Public emergency funding and safety nets
  – Community involvement
Measurement – flood risk characteristics

- Individual exposures
- Low frequency / high severity events
- Keep current
- Scope of damages
- Concentration risk
- Granularity
- Correlation and causation
The Role of Insurance
Stuart Mathewson
The protection gap

• A protection gap exists when the financial needs of individuals and businesses following a catastrophic event are greater than the funds available

• A primary objective of public programs, private sector insurers, and public–private initiatives directed at flood insurance is to minimize the protection gap

• In the event of a severe flood, the protection gap can create a significant strain on the resources of those in the flooded area
Types of relevant insurance

• Insurance can address damages resulting from the three major types of flood and their associated perils.

• The most commonly used form of insurance for flood risk is property insurance:
  – Often excluded from personal and small commercial property policies.
  – Included in large commercial “all-risk” policies.
  – If excluded, there is a need for specialized coverage.

• Life and health insurance policies can be exposed to flood risk.
Challenges associated with insurance for flood risk (I)

- Availability of high-quality data (i.e., data that are sufficient and reliable) for ratemaking
- Changing conditions that make historical data less relevant for the projection of future losses
- Sensitivity to variations in location due to differences in geographical location and relatively small differences in land and building elevation
- Low penetration for the coverage, due partly to a lack of awareness of the availability of insurance and to misperceptions about the real risk of flood by individuals and businesses
Challenges associated with insurance for flood risk (II)

- Limited interest in spending money for mitigation and adaptation activities
- Adverse selection, whereby only consumers with actual or perceived risk purchase flood insurance
- Population growth and over-concentration in areas prone to flooding
Public and private sector approaches

• Pure public approaches include:
  – post-event government assistance
  – existent and ongoing government agencies that provide flood insurance either directly to consumers or through intermediaries

• Private sector approaches include local, national, and international insurers and reinsurers

• Private premiums can be set consistent with the risk characteristics involved; this would provide price signals to promote prevention or mitigation while remaining self-supporting for non-catastrophic losses
Public and private sector approaches

- Public–private approaches juxtapose a state guarantee (i.e., public reinsurance) with private insurance, which limits insurers’ payouts to amounts that could be insured through affordable premiums.
- An example of a public–private partnership exists in the United States with “Write-Your-Own” (WYO) insurers.
- As alluded to earlier, market penetration of flood insurance in many jurisdictions is far from complete, even in flood-prone areas.
- Reliance solely on public, post-event assistance can lead to incomplete or inadequate reconstruction of damaged buildings and structures after a flood.
Use of self-insurance

- Self-insurance can take many forms, including large deductibles and self-insured retentions, self-insurance funds, pooling programs, and captive insurance companies.
- Repercussions can result if self-insurance provisions set aside for flood risk are too small or too large.
Monoline vs. multiline insurance policies

• Flood insurance products can take the form of a stand-alone insurance policy that provides only for flood coverage, or, more often, the coverage can be through an endorsement (also known as a rider) to a standard property or multi-peril insurance policy.

• Coordination of flood insurance with other protection is important, as there can be gaps in coverage offered by private sector insurance or a government program.

• Flood risk is one of numerous natural catastrophe risks facing individuals and businesses.

• Grouping multiple perils can also result in a greater spread of risk.
Consequences of subsidies and inadequate premiums

- In the case of flood insurance, in many countries there is no effective market
- Premiums for government programs do not necessarily reflect expected losses of individuals, nor do such programs always provide a risk margin for funding future large events
- To remain sustainable, losses incurred by insurers with inadequate revenue have to be financed by others
- Premiums will more likely be reasonable and affordable if insurance is compulsory or if there is a high market penetration
Reinsurance and government grants

- The catastrophic nature of flood risk means that flood events are typically low-frequency/high-severity events.
- To address the financial volatility and protect themselves against possible catastrophic losses associated with flood insurance, private sector insurers purchase reinsurance.
- Reinsurance can be purchased from the private sector market or through public-sponsored programs.
- Protection from extreme loss events can also be provided by government programs.
Consequences of limited financial protection

- A Munich Re report titled “Asian Floods Overshadowed by Houston Flooding” offers details of the extent of uninsured losses related to 2017 flood events in Asia.
- In the Munich Re report, Wolfgang Kron speaks about disparities in flood protection between developed and developing countries.
- South Asia is representative for the many poorer regions of the world that were afflicted with flood disasters in 2017. Peru, Colombia, Sierra Leone and the Congo were also affected.
- In absolute terms, losses are often one or two orders of magnitude smaller than in Europe or North America. Yet the impact on people’s lives and livelihoods in these poorer countries is generally much more dramatic, given the frequent lack of insurance cover that could otherwise cushion the negative consequences.
Kron comments on the tremendous effect of flood insurance:

- It has been shown time and again that countries with an effective insurance system against natural hazards are able to return to normal conditions after a disaster much faster than countries without any such protection in place.

- Whereas the trail of devastation in the flood regions of Asia and Africa could still be seen weeks and even months after the event, life in Houston had returned to almost normal just a few days after the flooding. Apart from one or two tell-tale signs, it was difficult to find any evidence that large parts of the city had been a metre deep in water a short time before.
Actuarial/Cost-Based Pricing

Stuart Mathewson
Principle

• The price of any private sector insurance product should adequately provide for all costs associated with the transfer of risk, including losses, expenses, and a reasonable return for the insurer.
Importance of up-to-date, granular, high-quality data

- To produce premiums that are in accordance with actuarial standards and best practices, actuaries need data that is up-to-date, granular, and of high quality.
- Flood risk is a function of weather (generating water), other natural disasters such as offshore earthquakes, local topography and bathymetry, soil, drainage, building characteristics, and infrastructure (much of which may be hundreds of miles from the area being examined for flood exposure).
- Some of these parameters, which are critical to actuaries quantifying flood risk, can change often and at times dramatically.
- Development of areas near rivers, streams, or seashore changes the topography, adding hard ground cover where water runs off instead of soaking in.
- Deforestation, as in Brazil and Indonesia, can also lead to devastating flash floods.
Effects of catastrophes

- Although many loss-causing flood events are relatively small, catastrophic floods result in the largest share of flood-related losses.
- After floods in the United States in the late 1920s, private sector insurers effectively refused to write flood insurance, deeming the peril uninsurable.
- Also, after Hurricane Andrew in 1992, many U.S. insurers drastically reduced their writings.
- For a ratemaking analysis to produce adequate premiums over time, the long-term catastrophe potential should be considered and appropriately reflected.
- Catastrophe losses can be estimated based on average annual losses (AAL) that account for the possibility of extreme events using actual historical data or simulated values from a catastrophe model.
- In addition, given the significant uncertainty in estimating annual expected losses for flood risk, premiums should also contain an appropriate risk loading in the profit provision.
Quantification of flood risk (I)

- In quantifying risk for catastrophic perils, the usefulness of historical insurance loss data can be quite limited.
- Actual loss experience can be used to determine the amount of overall premiums needed for a large geographic area.
- For individual rate making, however, other methods are more useful.
- A flood simulation model produces various metrics, including the AAL, the maximum probable loss, and applicable risk tolerance, at whatever level of granularity needed.
- Loadings for the cost of reinsurance, expenses, risk margin, and overall profit load.
The use of catastrophe models for flood risk is rapidly becoming the market norm, not only in Europe, Asia and Australia, where such models have been in use for some time, but also in the United States and Canada.

Catastrophe models use extremely detailed information about exposures to analyze the likelihood of water levels.

The models generate an exhaustive library of potential events that can be simulated for a portfolio of insured properties to generate measures of large loss likelihood and AAL.

Computer modelling for flood losses, however, can be more difficult than for hurricane or earthquake due to the localized character of flood hazard.
Loading for uncertainty (risk loading)

• For properties susceptible to catastrophic losses (i.e., low-frequency/high-severity events), the uncertainty is quite high.
• The size of the risk loading depends heavily on the concentration of properties that can be damaged by a single event and the insurer’s appetite for risk.
• Catastrophe models can be useful in estimating the risk loading for ratemaking purposes.
Constraints
Rade Musulin
Risk/Reward mismatch

• Many stakeholders seek near-term rewards:
  – Local councils (building permit revenue), builders (revenue from construction), or realtors (selling properties)
• Property owners and their insurers have a mixture of motivations
• Mitigation often requires a long-term investment to avoid a low probability (in any year) event
• This leads to tension between short-term economic gain and long-term sustainability and community resilience
Risk perception

• Risk perception is critical to risk management
• Requirements:
  – High quality data
  – Sophisticated modeling tools to interpret it
  – Mechanism to communicate economic signals
• Examples of breakdowns:
  – US NFIP “bright line” flood zones
  – Thailand floods in 2011 “unmodeled risk is still real risk”
• Changing risk perceptions can cause market disruption
Factors triggering changing perceptions

• Technological advances enabling better resolution, such as address level vs. post code level pricing
• Development changing drainage patterns (Harvey US)
• Flood control measures decreasing risk where implemented, but increasing it elsewhere (e.g. downstream)
• Climate change increasing or decreasing risk:
  – Extreme precipitation
  – Drought or decline in river flow
  – More extreme tropical cyclones (or lower frequency)
  – Rising sea levels
Example of changing risk – rising seas

- Sea levels are rising globally, due to a combination of melting land ice, thermal expansion of oceans, and land subsidence.
- Property constructed to withstand today’s sea levels may not be viable during the building’s design lifetime.
- Building codes generally do not reflect future conditions.
- Property insurance premiums tend to be one year focused.
- Result: property being constructed today is not receiving proper signals, either from codes or insurance, about risk.
Actuaries Climate Index – Sea Level

For North America, released August 2019
http://actuariesclimateindex.org/explore/component-graphs/
Social issues when risk perception changes

- Who is responsible for “unaffordable” premiums triggered by technological change such as address level rating?
- When risk perception changes, should burdens fall on property owners or society in general?
- What is the responsibility of government authorities which approved building to inadequate standards?
- If rising seas are being caused by carbon pollution, who should pay for losses, the property owner or polluter?
Key questions and how actuaries can help

• Questions:
  – To what extent should building codes and land-use policies reflect possible future conditions expected during a building’s design life?
  – To the extent the future is uncertain, how can the costs and benefits of various building code strategies be brought into a coherent flood insurance framework?

• How can actuaries help?
  – Extend existing catastrophe and economic capital modelling tools to inform public policy decision making
  – Extend thinking beyond traditional activities
Role of Government

Rade Musulin
Non-insurance government activities

• Data aggregation
  – Historical records
  – Maps of risk
  – Building inventories

• Financial investment
  – Constructing and maintaining dams and levees
  – Managing water resources
  – Providing disaster assistance
  – Relocating population and infrastructure (e.g. Indonesia)

• Development of land use and building code guidelines
Triggers for private market failure

- Difficulty obtaining high quality data
- Limited coverage of models
- Significant exposure to catastrophes (tail risk)
- Difficulty modeling human factors (e.g. infrastructure failure or dam management)
- Affordability of coverage for high risk insureds
- Reluctance of low risk insureds to buy coverage
- Poor risk perception among buyers of coverage
## Government and private sector “rules”

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Private</th>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk selection</td>
<td>Voluntary for both buyer and seller</td>
<td>Mixture of voluntary and mandatory for buyer; seller usually must “take all comers”</td>
</tr>
<tr>
<td>Source of funds</td>
<td>Premium, capital, and reinsurance; must be available before event</td>
<td>Premium, accumulated balance, reinsurance, and external sources such as taxation or assessment; need not be available before event</td>
</tr>
<tr>
<td>Ability to spread risk</td>
<td>Across space only (e.g. geographic or line of business diversification)</td>
<td>Across both space (e.g. geographic or line of business diversification) and time (e.g. bonding)</td>
</tr>
<tr>
<td>Pricing</td>
<td>Reflects relative risk and full cost of risk transfer</td>
<td>Need not reflect risk or risk transfer costs; sovereign power can be used to raise revenue for cross-subsidies</td>
</tr>
<tr>
<td>Ability to cross-subsidize</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Mitigation incentive</td>
<td>Pricing and underwriting</td>
<td>Pricing and regulation</td>
</tr>
</tbody>
</table>
Key questions

• For government entities:
  – How much revenue is expected to come from policyholders?
  – How much external or post-event financing is available?
  – What degree of cross-subsidization is desired?

• When considering private vs. government solutions:
  – How can affordability issues be addressed without dampening mitigation incentives?
  – How can government programs maintain pricing discipline and avoid large deficits?
  – How can systems that operate with different “rules” coexist?
General observations

- **Private sector programs tend to:**
  - Include the ability to select and reject risks
  - Charge premiums reflecting current year risk exposures
  - Have a refined set of risk classifications

- **Government programs tend to:**
  - Use one or more external sources for financing large losses
  - Take all comers that meet specified conditions
  - Have a less refined risk classification
  - Spread losses over time such that not all losses are financed from current year revenue
Australia

- Private sector focused; no government program
- No regulation of rates
- Historical confusion over what types of flood are covered
- Widespread coverage in market
- Affordability issues for some high-risk properties
France

• All home policies must cover natural catastrophes
• State-owned government-guaranteed reinsurance through the Caisse Centrale de Réassurance (CCR)
• Private sector insurers can voluntarily transfer 50% of their natural catastrophe risks to the CCR, which offers a low reinsurance premium and has an unlimited government guarantee
• Private sector insurers pay the government 12% of premiums received to finance mitigation projects
• Low cost reinsurance provides an incentive for private insurers to offer coverage
Thailand

- Extreme flooding in 2011; significant questions about government water management
- Home to many large industrial facilities located on rivers to facilitate transport
- Flood risk not well understood prior to 2011 due to poor model coverage
- Large uninsured loss in 2011
- Government created the National Catastrophe Insurance Fund (NCIF)
- Available to individuals, small and medium-size enterprises, and the industrial sector for a premium that ranges from 0.5% to 1.25% of the coverage amount
United Kingdom

- Historical “understanding” private insurers would offer flood coverage
- Following major floods in 1998 and 2000, “Statement of Principles” developed requiring government to improve defenses while private insurers provide coverage
- Flood Re established in 2016
  - All residential policies covered for flood
  - Insurers can reinsurance high-risk policies with Flood Re
  - Flood Re premiums supplemented by levy
  - Flood Re purchases reinsurance
  - Program scheduled to expire in 2039
  - Insurance premiums not regulated, meaning Flood Re provides an indirect effect
  - Flood Re is intended to operate without subsidy from Treasury
Most flood written by the National Flood Insurance Program (NFIP)
NFIP offers coverage in communities in exchange for adopting strong building codes
Law requires cross-subsidies and limits premium increases; historical rate development methods failed to provide sufficient revenue to cover extreme events (e.g. Katrina or Harvey)
Debt through 2018 was USD$20.5 billion, after debt forgiveness of USD$16 billion
Authorized with fixed expiration date; frequent need for reauthorization
Low participation outside 100-year flood zones
Private market is beginning to grow, but NFIP writes bulk of coverage
Observations on flood frameworks

- There is a wide range of flood frameworks across the world (a summary table of these is found in the paper)
- Encouraging mitigation is a key
- Technological change has been important by enabling private markets but creating affordability problems
- Catastrophes are a major issue
- Government decisions about which risks can be covered in a program is important
Role of Actuaries

Rade Musulin
Applicable actuarial skills include

- Risk assessment and identification
- Modeling
- Pricing
- Reserving
- Reinsurance
- Capital adequacy and management
- Risk funding framework design
- Quantifying benefits of mitigation activities
- Discounting; comparing costs and benefits across time
Working with other experts and stakeholders

• Understanding flood risk involves multidisciplinary teams including structural engineers, hydrologists, computer scientists, government planners, and risk management experts

• Various stakeholder interests must be understood:
  – Property owners
  – Governments
  – Builders
  – Realtors
  – Taxpayers
  – And many more…
Flood risk management is a growth area for actuaries

- Flood is a major cause of loss around the world
- Flood, and water management issues in general, are likely to become more important as due to climate change
- Actuaries can make valuable contributions:
  - Identification and assessment of risk
  - Risk reduction and prevention
  - Measuring risk
  - Design of risk transfer mechanisms
  - Monitoring and adjustment
Questions?
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