Economic Impacts of Natural Disasters: Development Issues and Applications

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This research was supported by
the Global Facility for Disaster Reduction and Recovery (GFDRR), the World Bank.

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Overview

-It has been observed that the frequency and intensity of natural disasters/hazards are increasing. *While disasters have become less life-threatening, they have become more threatening to the well-being of economies.*

- Economic impacts of disasters are complex and difficult to assess and evaluate, due to the features and uniqueness of disasters; however, some methodologies have been utilized to analyze the impacts.

- Empirical analyses of the economic impact of natural disasters are performed to estimate the global aggregate of disaster impacts during 1960 and 2007 and the recent major disasters for detailed analysis.

Terminologies for Disaster Impacts

Economic impacts of disasters are complex, and the terminologies are sometimes confusing:

- *Damages*: damages on *stock*, including physical and human capital

- (First-order) *Losses*: loss of *flows* due to business interruptions, such as production and/or consumption, caused by damages

-*Higher-order Effects*: system-wide impact on *flow* caused by the first-order losses through interindustry relationships

-*Total Impacts*: total of *flow* impacts, adding first-order losses and higher-order effects

Economic Models for Disaster Impact Analysis

Input-Output Analysis

- Most popular modeling framework for disaster impact analysis

  =>Detailed interindustry interdependency of economy

  => Able to derive higher-order effects with established method

  => Able to extend and/or integrate with other models, such as Miyazawa extension to include income generation process, integration with engineering models, or HAZUS

Economic Models for Disaster Impact Analysis

Social Accounting Matrix (SAM)

- Utilized to examine the higher-order effects across different socio-economic agents, activities, and institutions

=> An extended version of IO framework to include broader economic activities

=> Able to derive the distributional impacts of disasters

=> Has been used for development planning

Economic Models for Disaster Impact Analysis

	Strengths	Weaknesses
IO	- simple structure - detailed interindustry linkages - wide range of analytical techniques available - easily modified and integrated with other models	- linear structure - rigid coefficients - no capacity constraint - no response to price change - overestimation of impact
SAM	- more detailed interdependency among activities, factors, and institutions - wide range of analytical techniques available - used widely for development studies	- linear structure - rigid coefficients - no capacity constraint - no response to privet change - data requirement - overestimation of impact
CGE	- non-linear structure - able to respond to price change - able to cooperate with substitution - able to handle capacity constraint	- too flexible to handle changes - data requirement and calibration - optimization behaviour under disaster - underestimation of impact
Econometric	- statistically rigorous - stochastic estimate - able to forecast over time	- data requirement (time series and cross section) - not able to distinguish losses and higher-order effects

Issues in Development Context

-Most empirical studies show the negative relationship between development level and disaster losses.

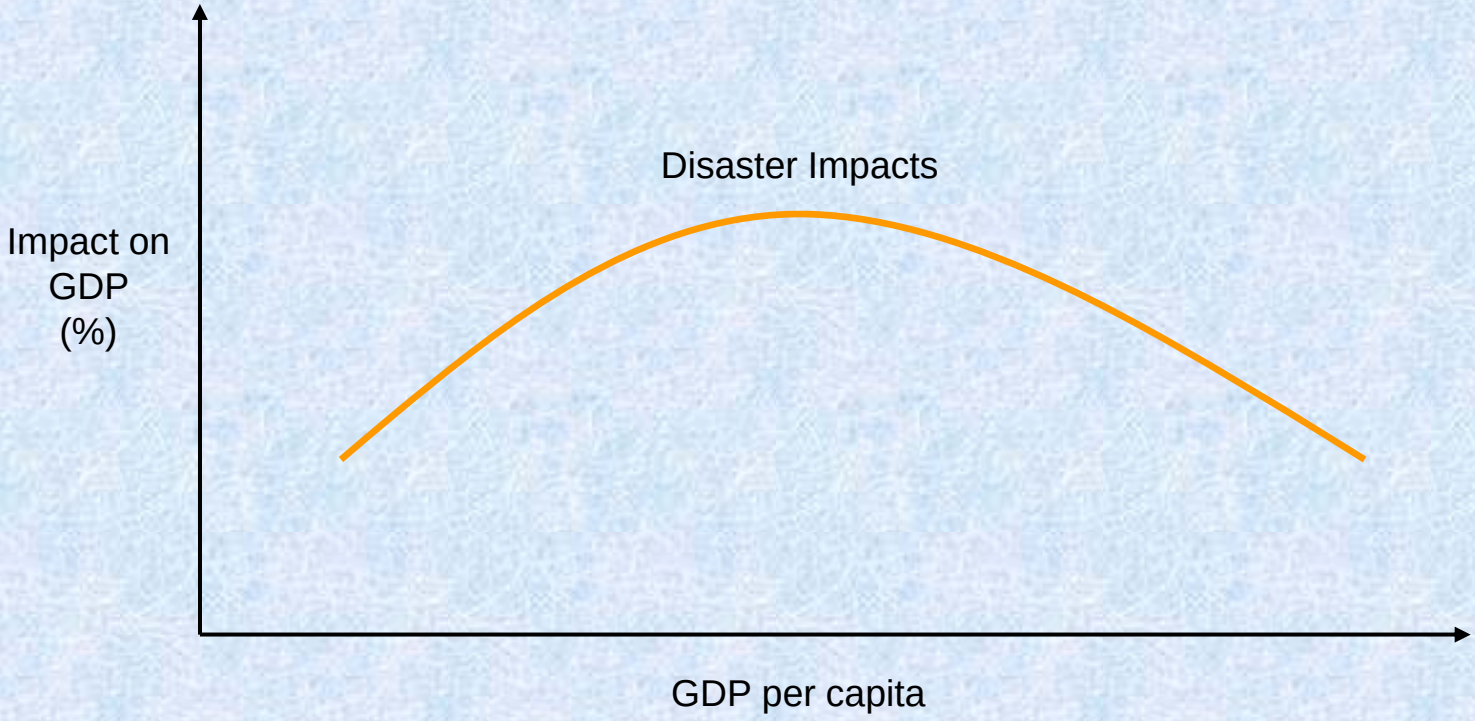
=> *The higher the development level is, the smaller damages and losses will be*.

-With the increasing complexity of society and interdependency within and across countries, the recent studies found that this relationship appears not so straightforward.

=> *Total impact over GDP per capita has an inverted "U" curve relationship.*

Issues in Development Context

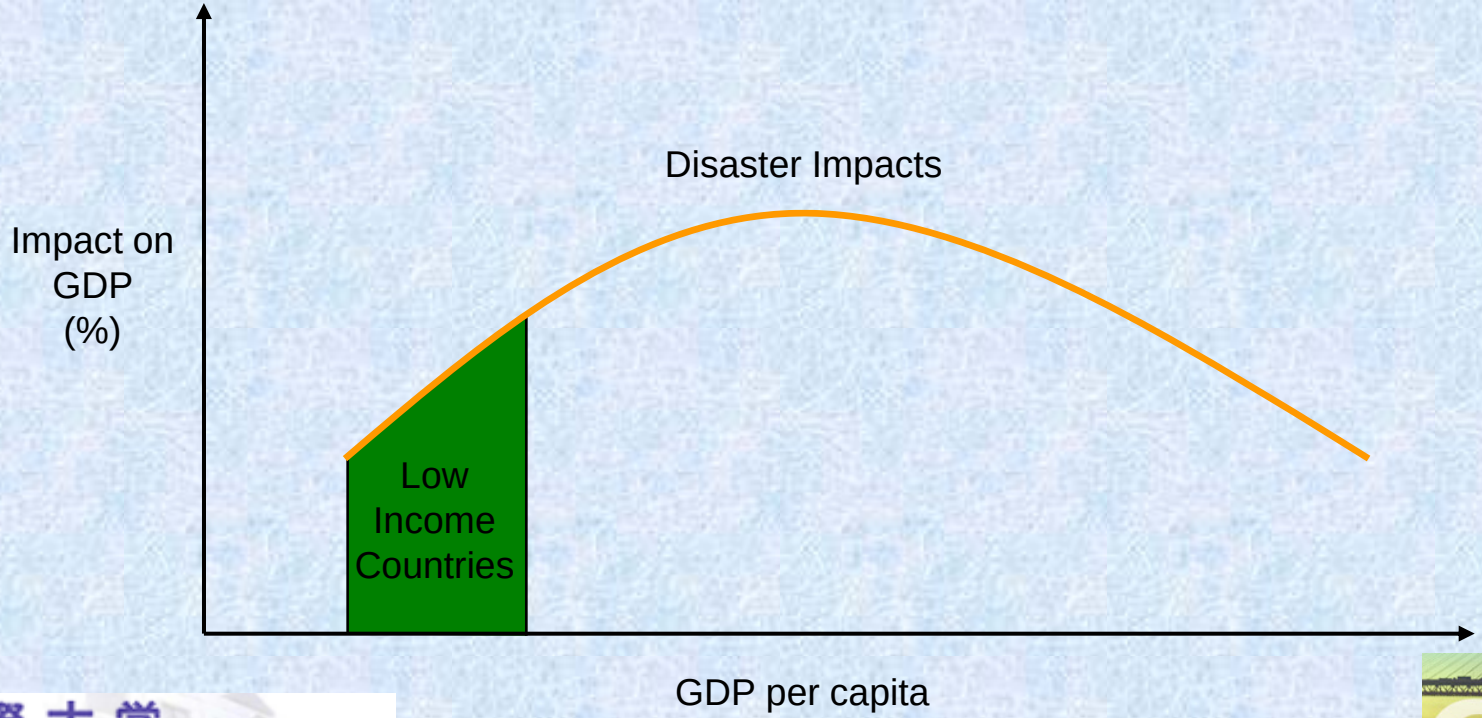
Inverted U Curve Relationship



Issues in Development Context

Inverted U Shape Curve

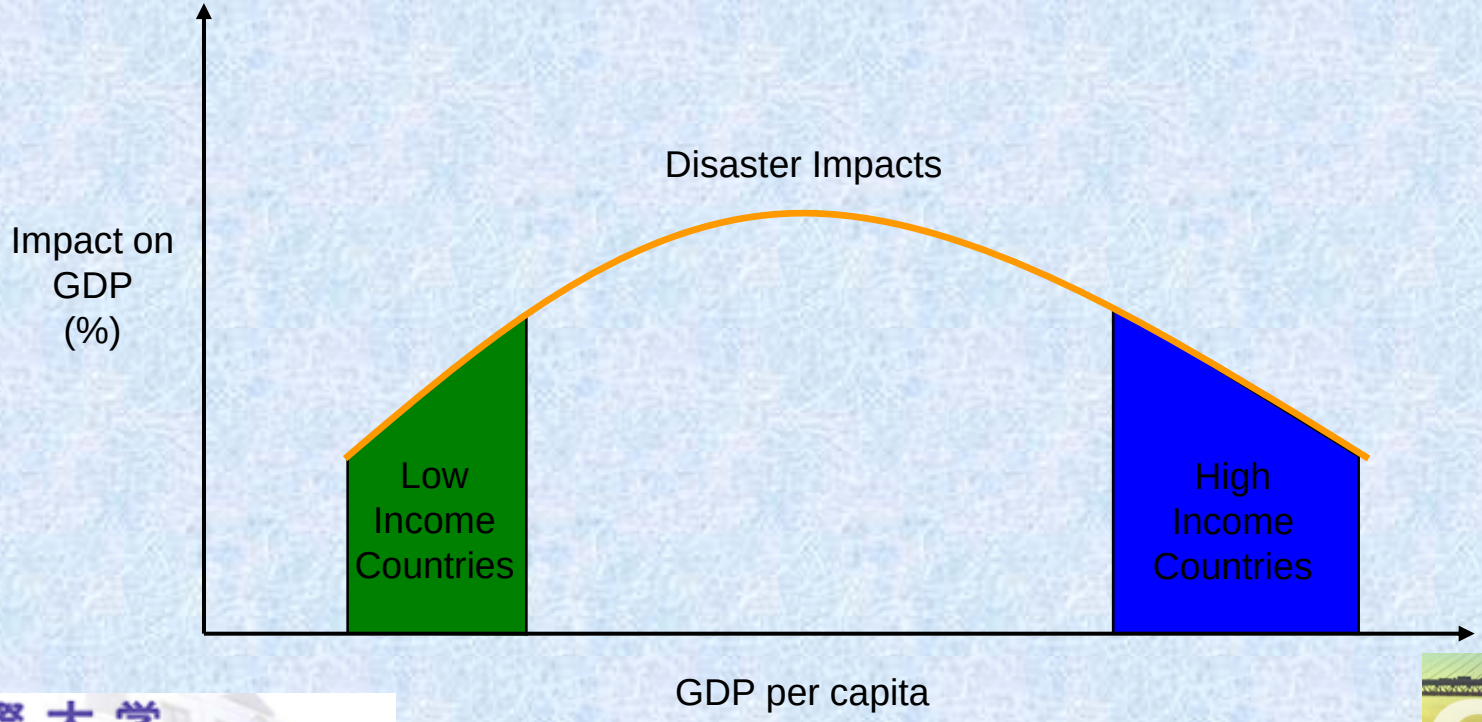
-Least developed countries tend to have simple economic structures, such as agriculture, so that the impact may not spread to the entire system.



Issues in Development Context

Inverted U Shape Curve

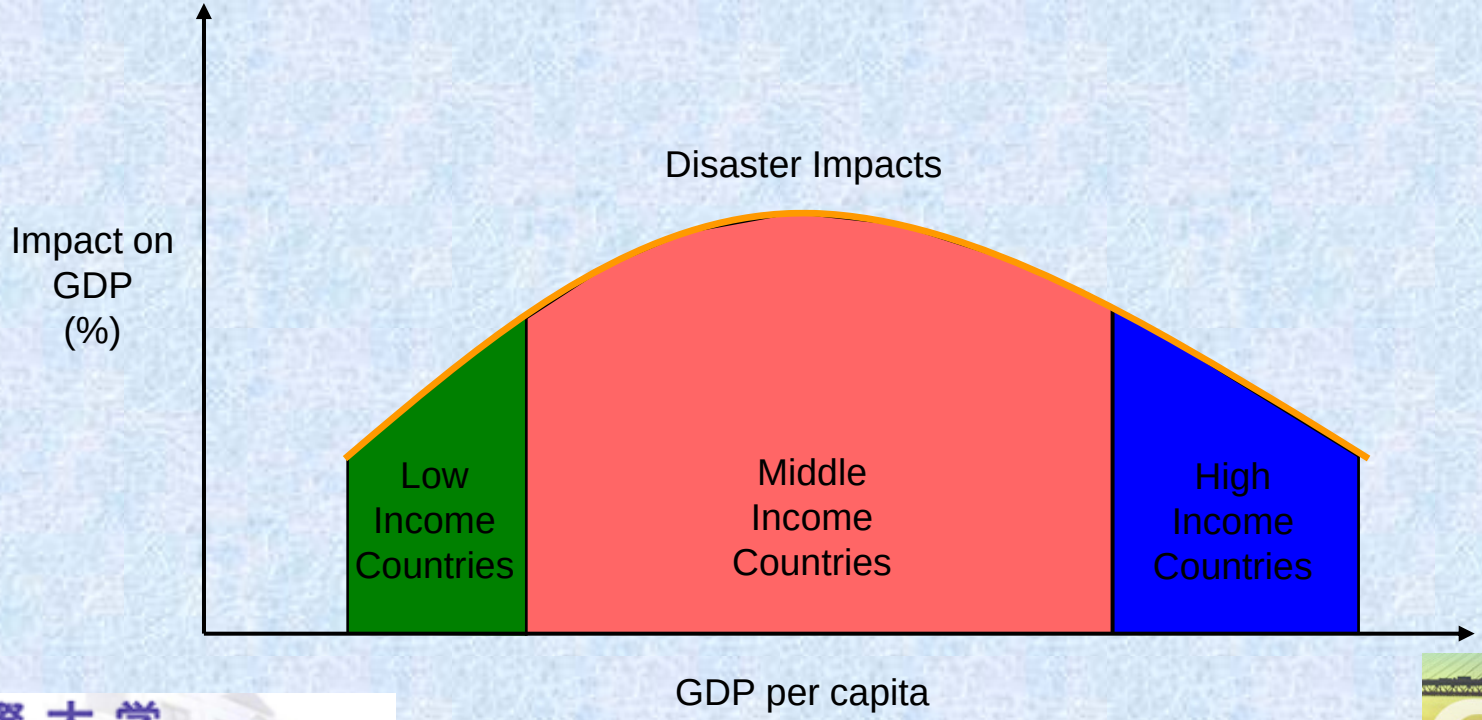
-Higher-income level countries have sufficient financial and technological resources to better manage disaster risks through the implementation of countermeasures and to better manage the adverse impacts of disaster.



Issues in Development Context

Inverted U Shape Curve

-Middle-income level countries with some diversifications seem more secure, but the higher order effects can be much greater and thus the total impacts from a disaster can be larger than in a simple agro-economy's.



Global Aggregate of Disaster Impacts

Disaster Impact Estimation

-Major natural disasters are selected during 1960 and 2007, based on economic damage data in EM-DAT and Munich Re's NatCat databases: 184 events are selected by the size of economic damages.

-Economic impacts, such as higher-order effects and total impacts, are calculated using the custom-built macro-SAM for each country in each decade.

-Disasters are categorized into:
Climatological (droughts, wildfires),
Geophysical (earthquakes, volcano eruptions),
Hydrological (floods, landslides), and Meteorological (storms).

Global Aggregate of Disaster Impacts

Estimation Process

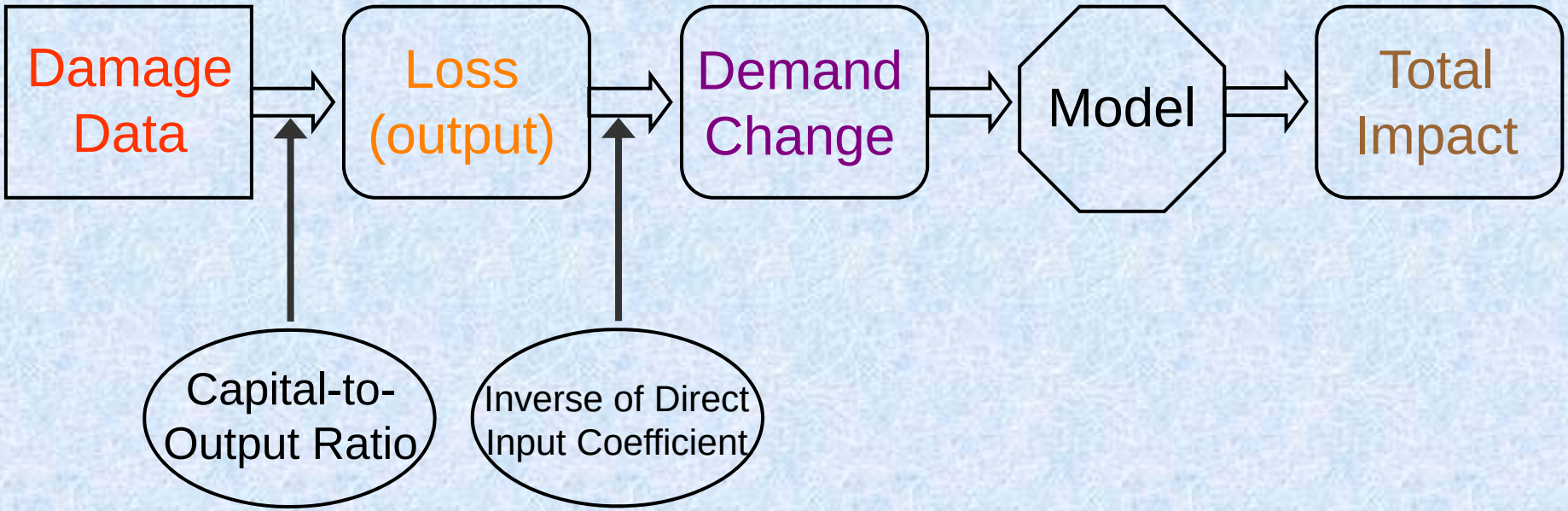
-Data from EM-DAT and NatCat are considered as "economic damages"--damages on stock.

-In order to estimate losses and higher-order effects, damages need to be transformed into *flow measure*. This process was carried out using capital-to-output ratio, based on the available and estimated physical capital data.

-Then, the transformed *flow measure* can be considered as losses (output decrease due to the damages); this is further converted to demand change, since the model used (SAM) is a demand driven model; this conversion is done by multiplication with the inverse of diagonal elements in direct input matrix.

Global Aggregate of Disaster Impacts

Estimation Process



Global Aggregate of Disaster Impacts

Structure of One-sector Social Accounting Matrix

	Production Activities	Factors	Households	Other Institutions	Rest of the World	Total
Production Activities						
Factors						
Households						
Other Institutions						
Rest of the World						
Total						

Global Aggregate of Disaster Impacts

Summary Table for Estimated Results

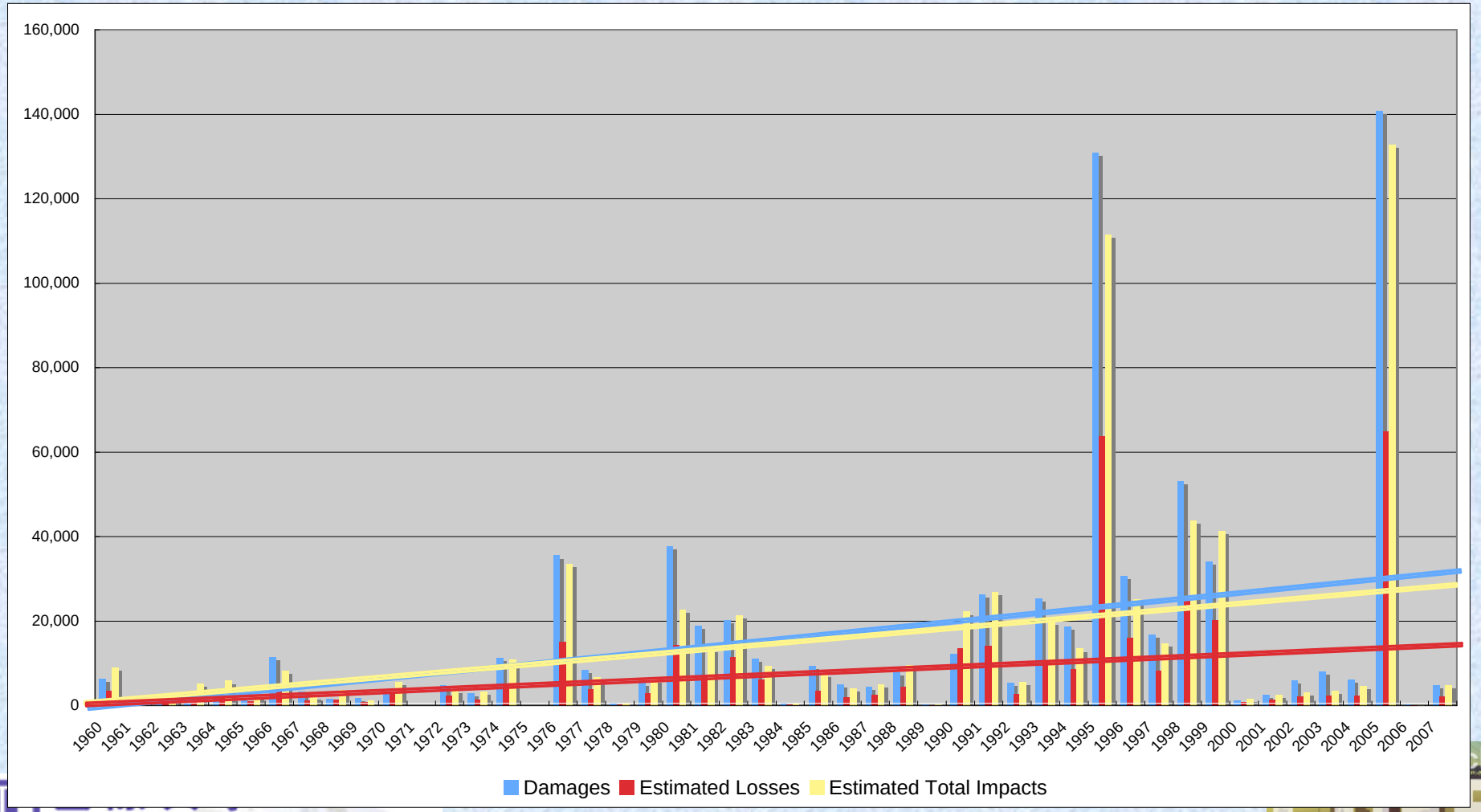
	Damages	Estimated Losses		Estimated Total Impacts	
	total value	total value	loss-damage ratio	total value	total impact-damage ratio
	share across column	share across column		share across column	total impact-loss ratio
Climatological	84,910	40,837	0.48	72,604	0.86
	11.4%	11.4%		10.7%	1.78
Geophysical	282,987	144,196	0.51	271,489	0.96
	38.1%	40.1%		40.1%	1.88
Hydrological	188,360	87,994	0.47	158,678	0.84
	25.4%	24.5%		23.4%	1.80
Meteorological	186,098	86,717	0.47	175,073	0.94
	25.1%	24.1%		25.8%	2.02
Total	742,356	359,744	0.48	677,844	0.91
					1.88

Remark: values are in constant 2007 US$ million

Global Aggregate of Disaster Impacts

Trends of Disaster Impacts

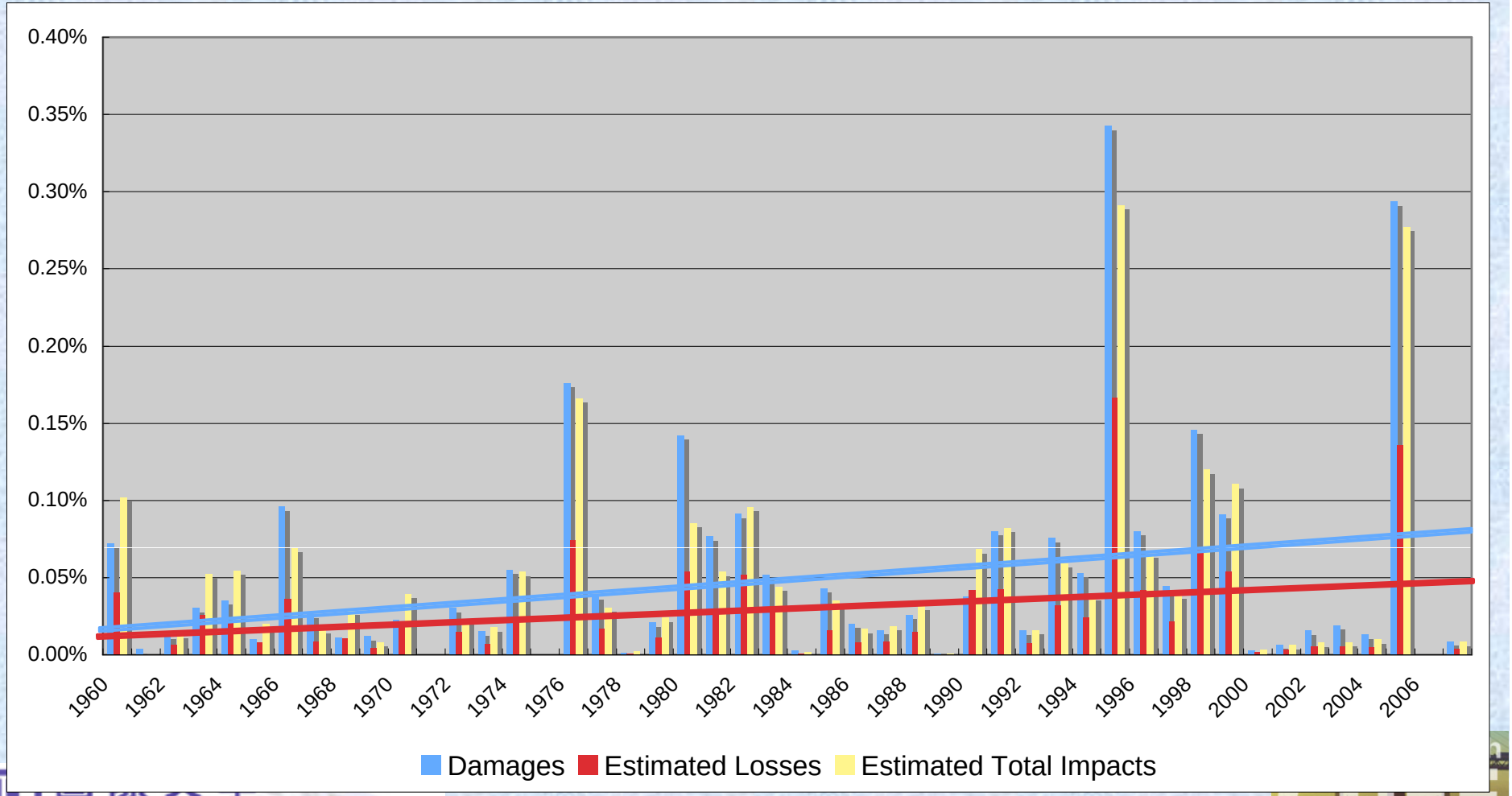
(values are in constant 2007 US$ million)



Global Aggregate of Disaster Impacts

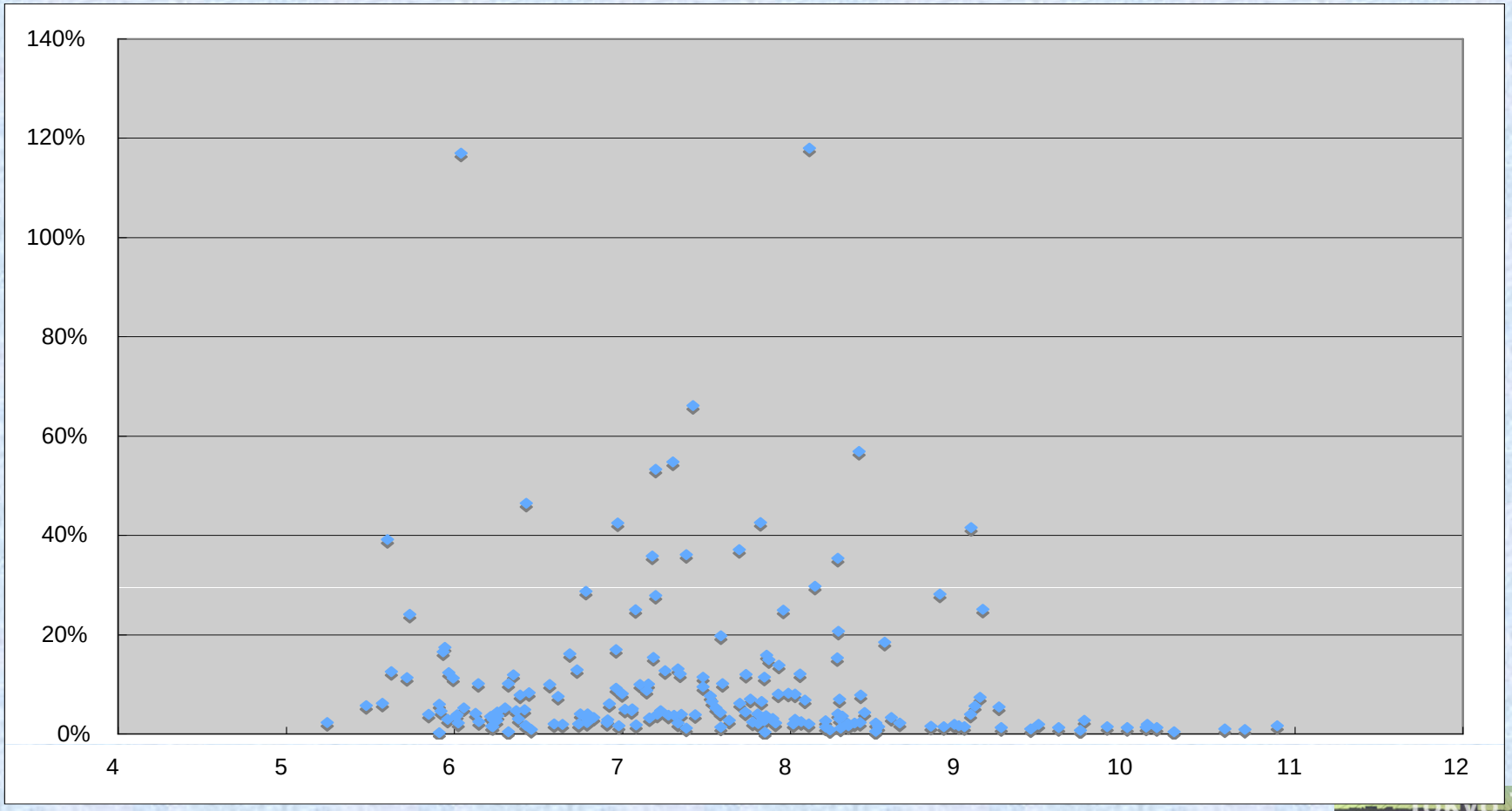
Trends of Normalized Disaster Impacts

(values are Global GDP share)



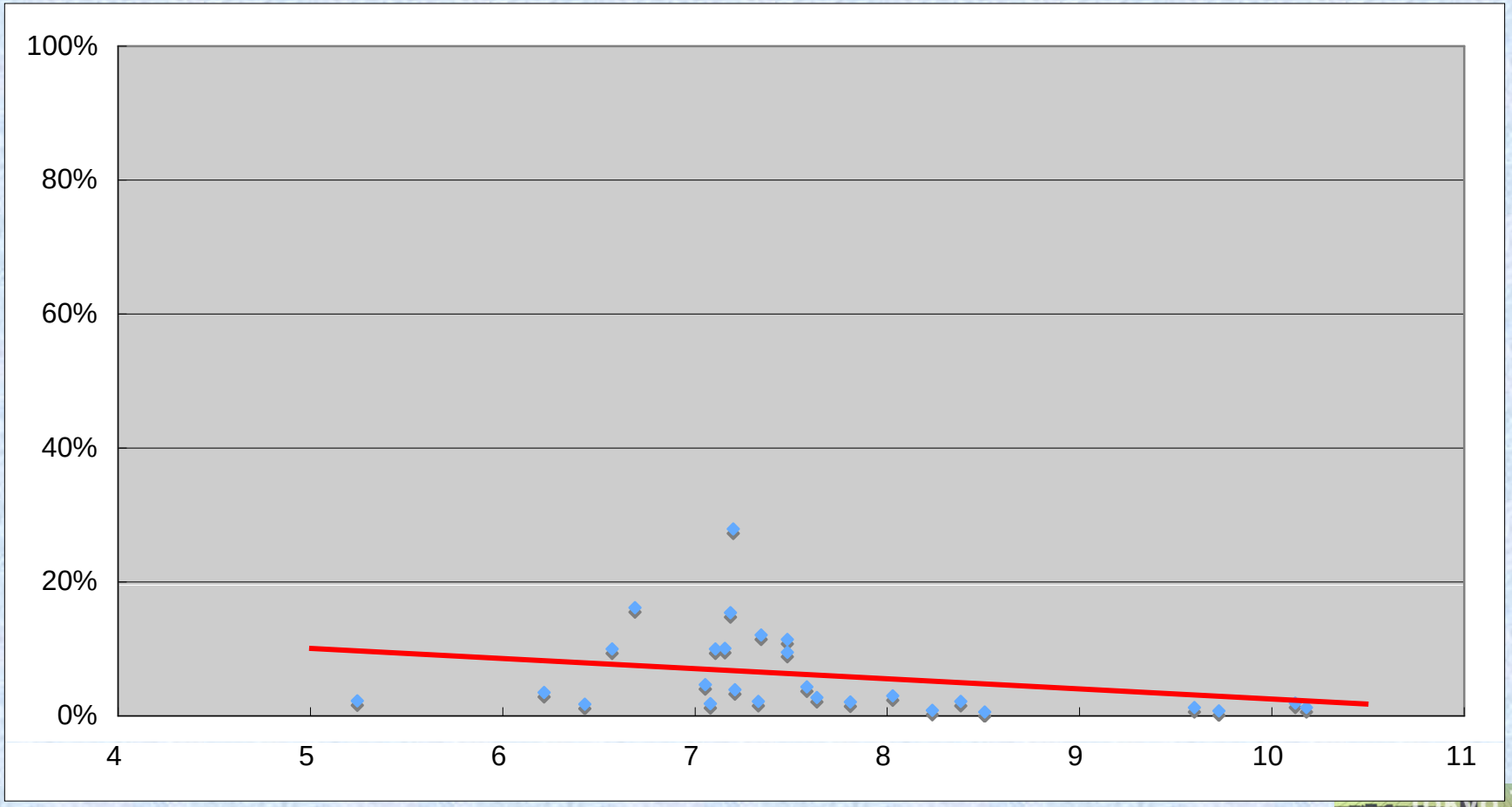
Global Aggregate of Disaster Impacts

Relationship between GDP Impacted and GDP per capita (all events)



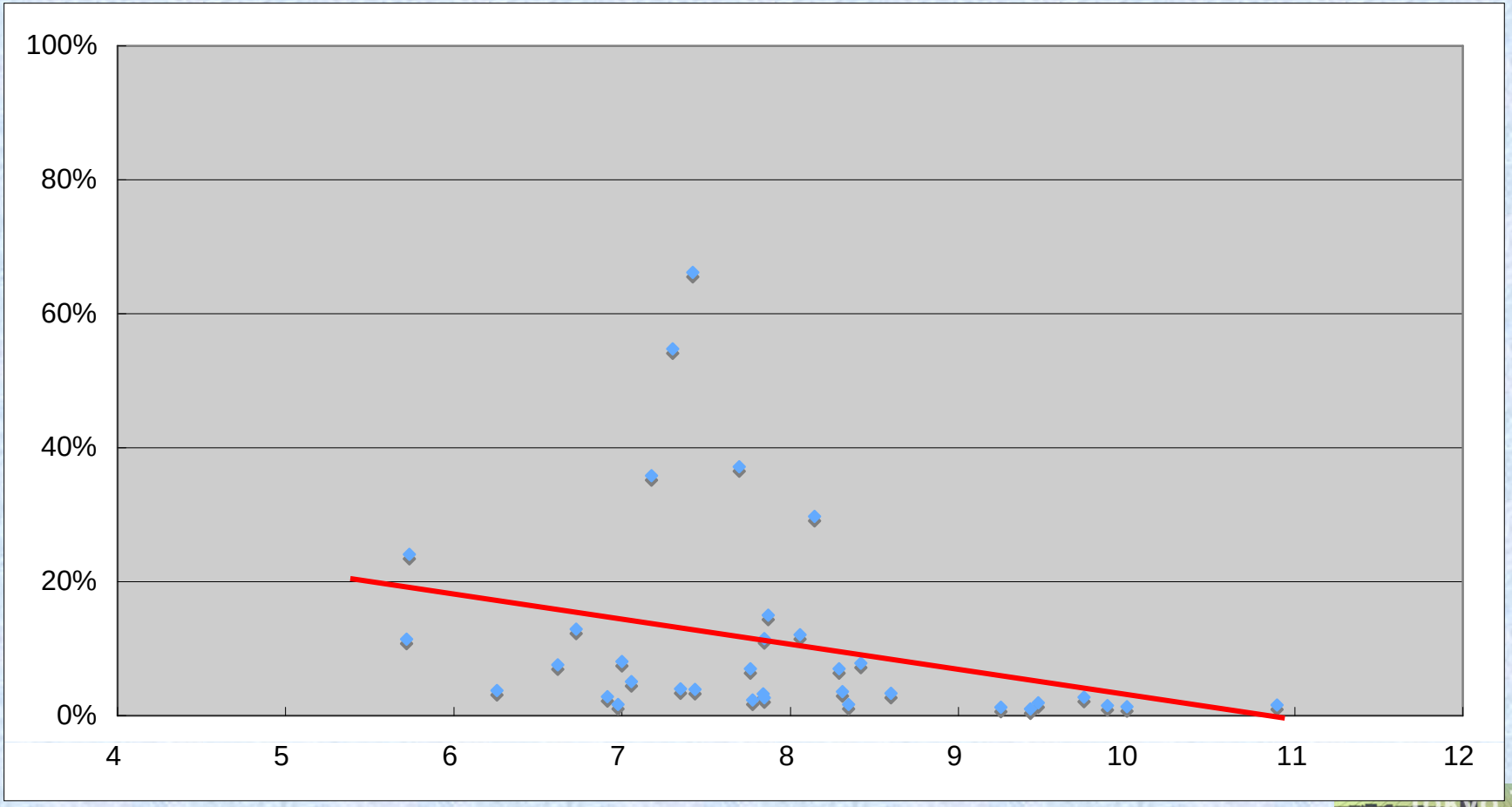
Global Aggregate of Disaster Impacts

Relationship between GDP Impacted and GDP per capita (climatological events)



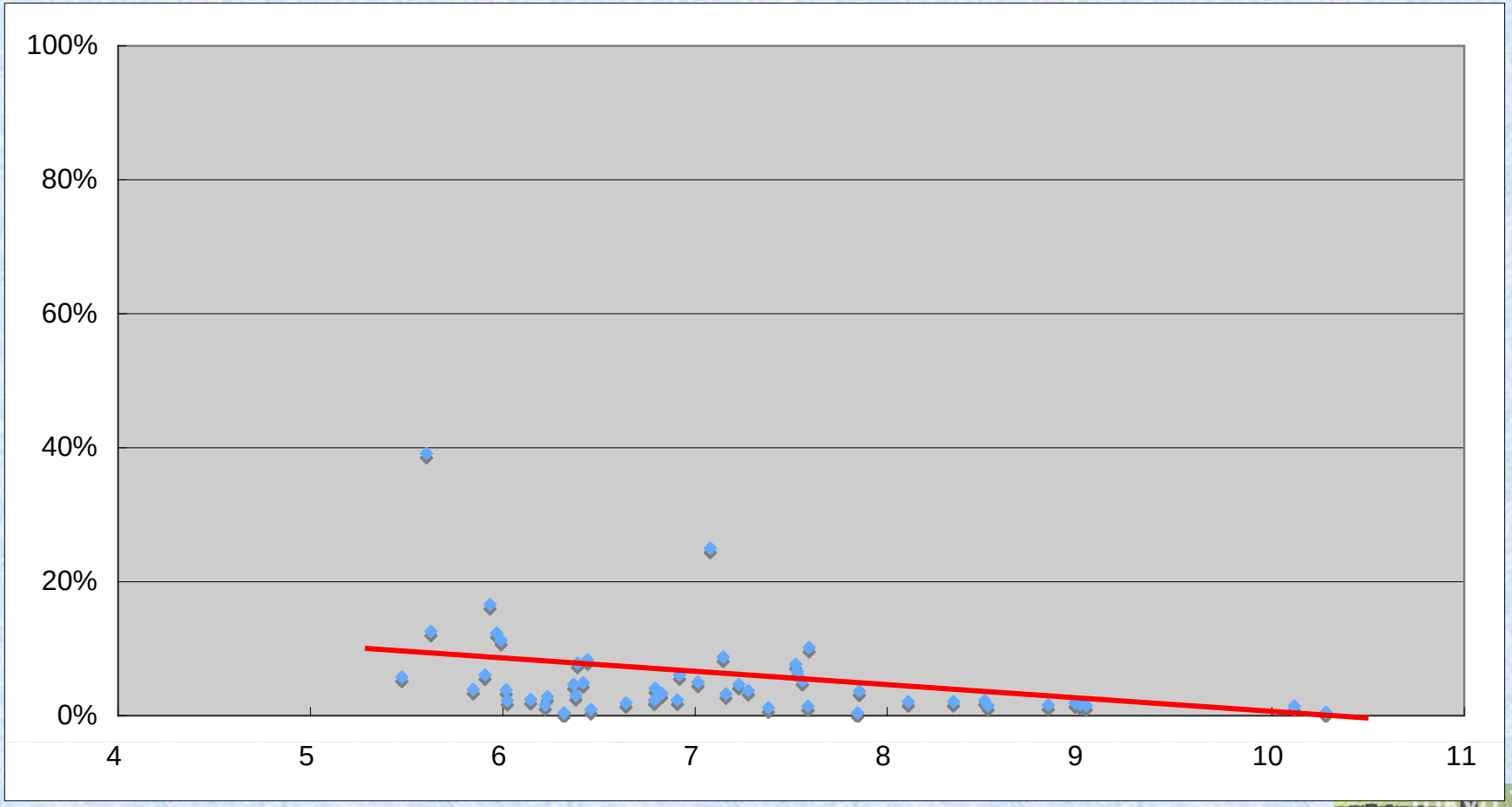
Global Aggregate of Disaster Impacts

Relationship between GDP Impacted and GDP per capita (geophysical events)



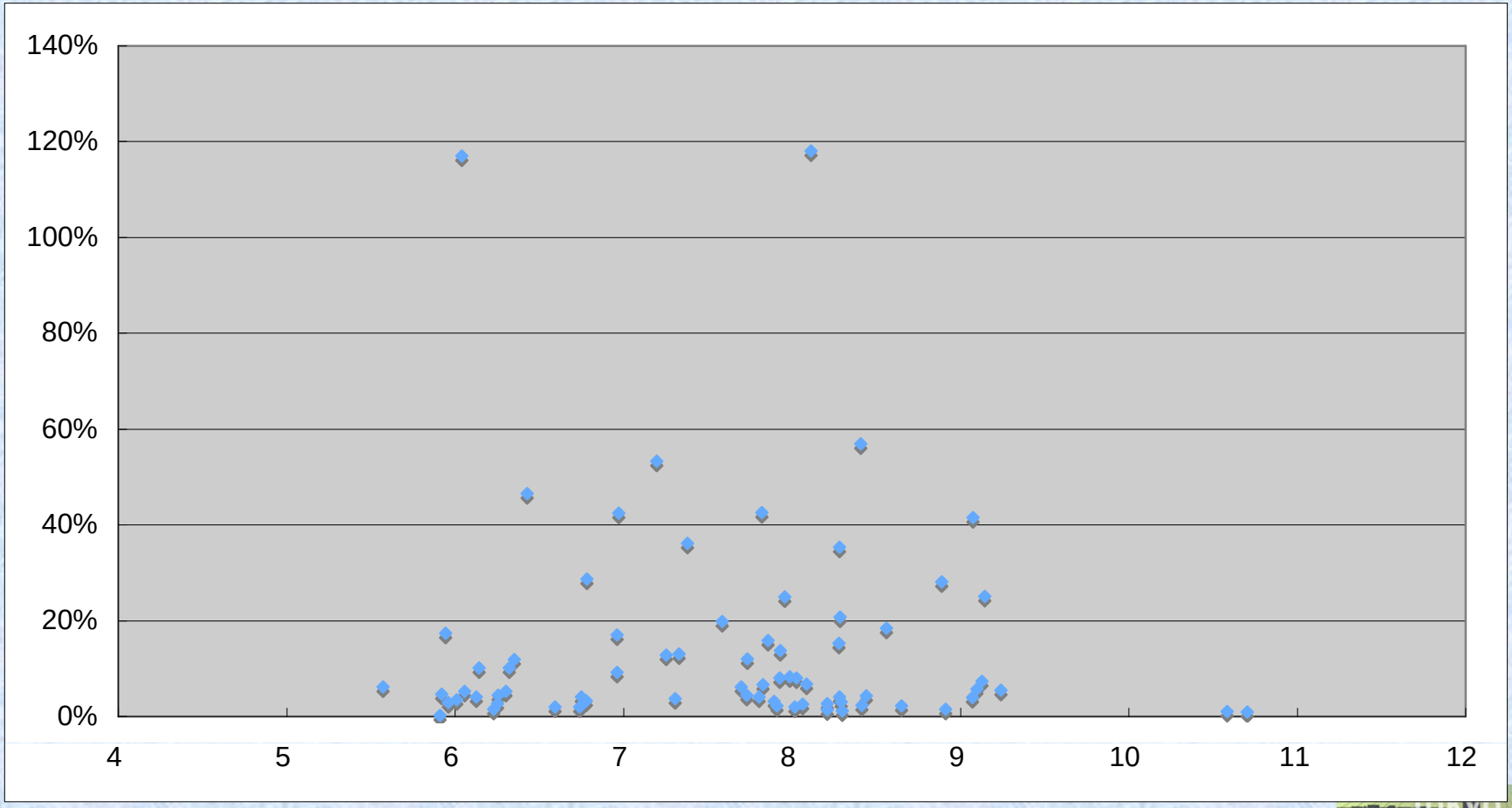
Global Aggregate of Disaster Impacts

Relationship between GDP Impacted and GDP per capita (hydrological events)



Global Aggregate of Disaster Impacts

Relationship between GDP Impacted and GDP per capita (meteorological events)



Case Studies of Disaster Impact Estimation

Disaster Impact Estimation

-Estimate the detailed disaster impacts of the recent cases using IO or SAM for comparing how the higher-order effect might be different or similar.

-Cases are selected from the recent disasters in developing countries, and the damage and loss data of them are based on the various damage assessment reports (most of them follow the ECLAC methodology for assessment).

-A large-scale disaster case, 2004 Indian Ocean Earthquake and Tsunami, are also analyzed.

Case Studies of Disaster Impact Estimation

Disaster Impact Estimation

Year	Disaster	Country	Type	Region
1998	Hurricane Mitch	Honduras Cost Rica	Meteorological	Caribbean
2000	Floods and Cyclone	Mozambique	Meteorological	Africa
2001	Gujarat Earthquake	India	Geophysical	Asia
2001	Earthquake	El Salvador	Geophysical	Caribbean
2004	Floods	Bangladesh	Meteorological	Asia
2005	Hurricane Stan	El Salvador	Meteorological	Caribbean
2006	Central Java Earthquake	Indonesia	Geophysical	Asia
2007	Cyclone Sidr	Bangladesh	Meteorological	Asia
Extreme Cases				
1995	Great Hanshin-Awaji (Kobe) Earthquake			
		Japan	Geophysical	Asia
2004	Indian Ocean Earthquake and Tsunami			
		Indonesia Thailand India Sri Lanka	Geophysical	Asia

Case Studies of Disaster Impact Estimation

Disaster Impact Estimation

Year	Disaster	Country	Model
1998	Hurricane Mitch	Honduras	1997 IFPRI SAM
		Cost Rica	1997 IFPRI SAM
2000	Floods and Cyclone	Mozambique	2001 GTAP SAM
2001	Gujarat Earthquake	India	2001 GTAP SAM
2001	Earthquake	El Salvador	2000 IFPRI SAM
2004	Floods	Bangladesh	2001 GTAP SAM
2005	Hurricane Stan	El Salvador	2000 IFPRI SAM
2006	Central Java Earthquake	Indonesia	2001 GTAP SAM
2007	Cyclone Sidr	Bangladesh	2001 GTAP SAM
Large-scale Disaster Cases			
1995	Great Hanshin-Awaji (Kobe) Earthquake		
		Japan	1985 MITI IRIO
2004	Indian Ocean Earthquake and Tsunami		
		Indonesia	2000 IDE AIO
		Thailand	2000 IDE AIO
		India	2001 GTAP SAM
		Sri Lanka	2001 GTAP SAM

Case Studies of Disaster Impact Estimation

Methodologies for Impact Estimation

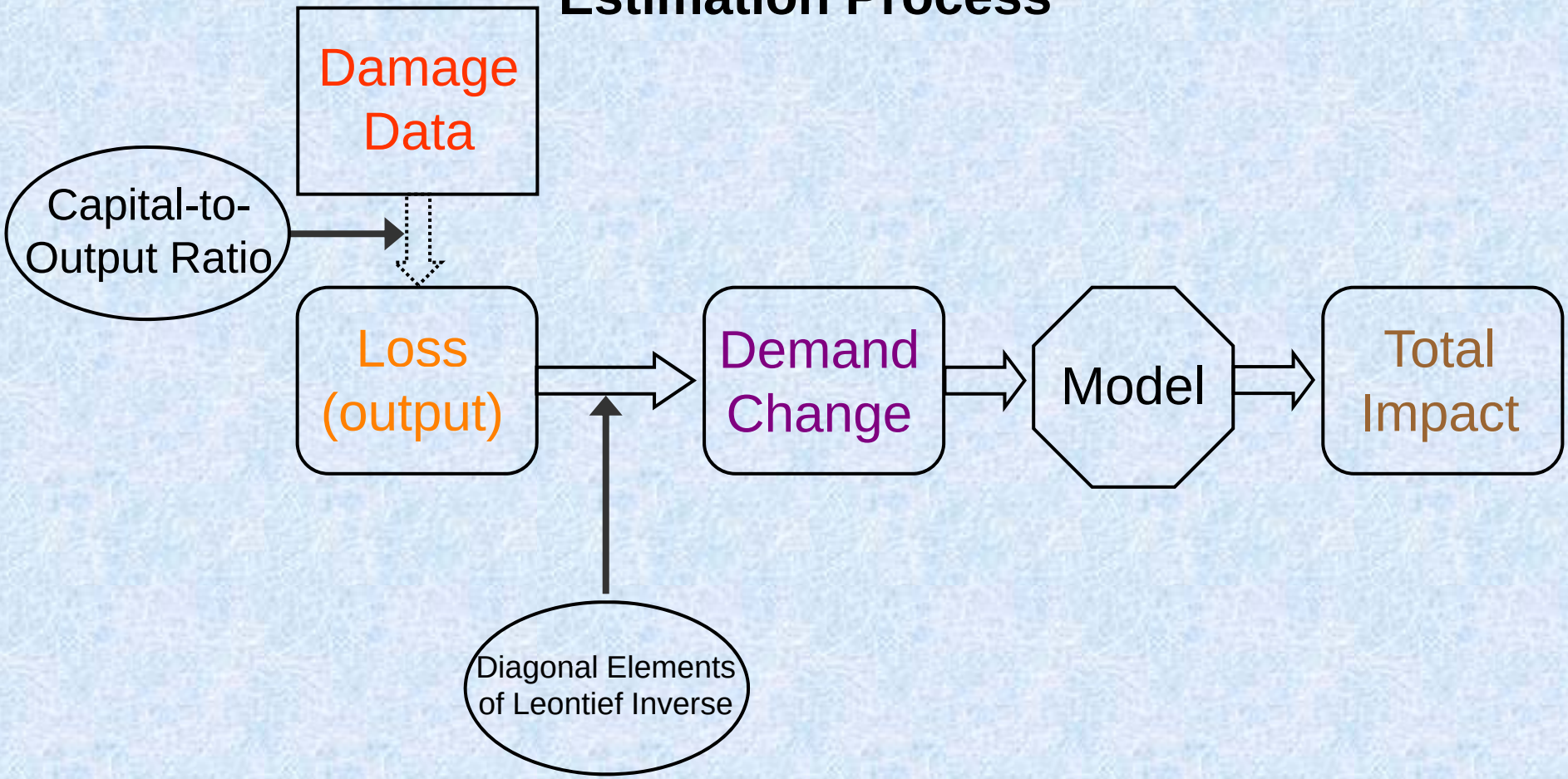
-SAM or IO for each case is aggregated mostly to the following sectors: Agriculture, Manufacturing, Utilities, Construction, Commerce, Services, Others (depending on the original table structure), to match with sector scheme in the damage assessment reports (ECLAC methodology).

-SAM includes household sector in institution category so that the induced effects of household income changes are included.

-Both IO tables (1985 MITI IRIO and 2000 IDE AIO) are interregional IO table and extended to Miyazawa framework to estimate the induced effects of income changes.

Case Studies of Disaster Impact Estimation

Estimation Process



Case Studies of Disaster Impact Estimation

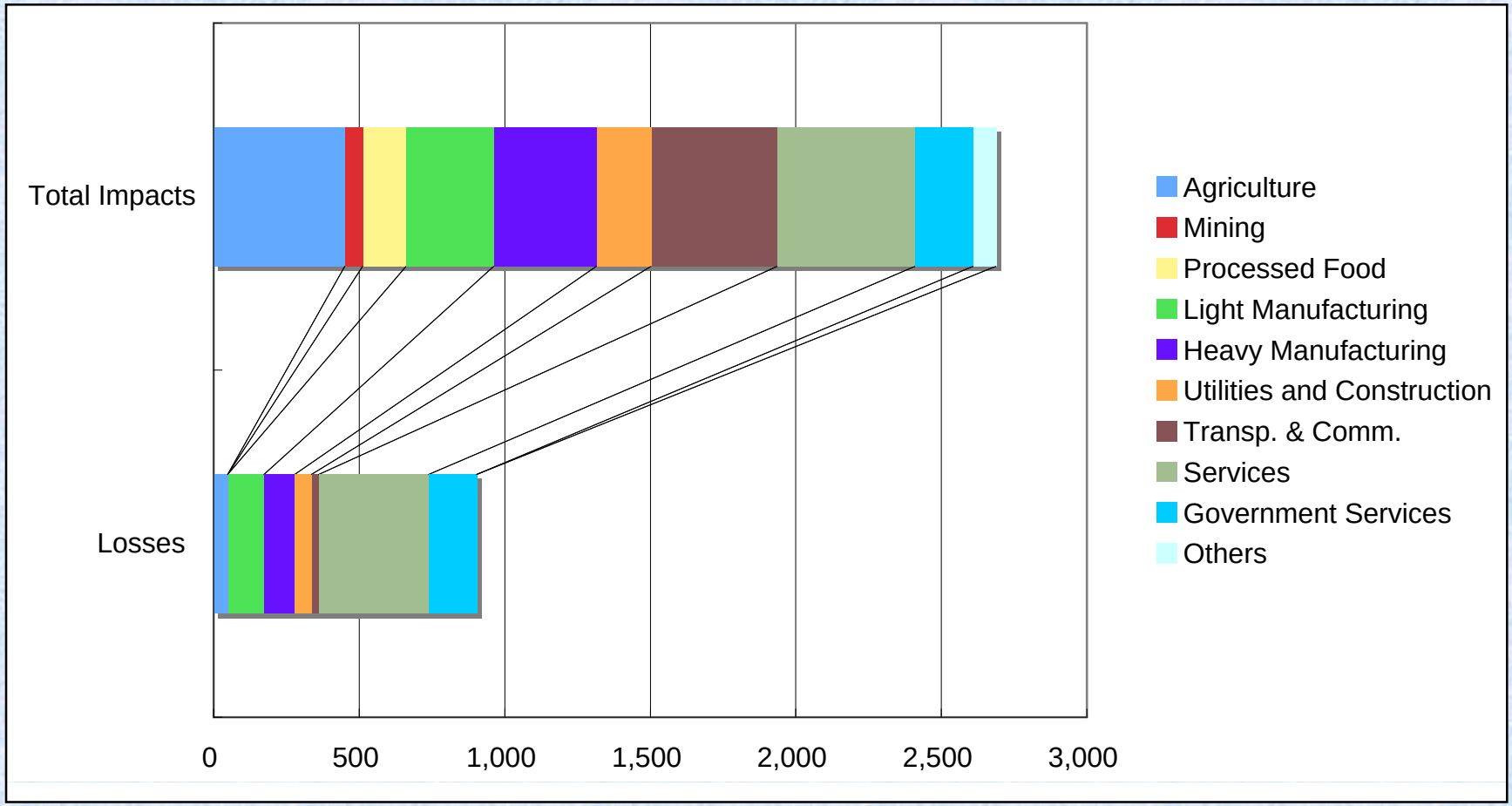
Results of Impact Estimation: 2001 Gujarat Earthquake, India

Sector		Data		Converted			Calculated	
		Damages	Losses	Sectors in model	Output decrease	Demand decrease	Output impact	HH Income impact
Infrastructure	Housing	1,111	223	Agriculture	49	29	494	
	Transport	101	25	Mining	0	0	66	
	Electricity	40	10	Processed Food	0	0	166	
	Water and Sanitation	50	13	Light Manufacturing	125	93	313	
	Urban and Municipal	103	26	Heavy Manufacturing	105	68	360	
	Water Resource	40	10	Utilities and Construction	59	49	193	
Social	Health and Nutrition	47	9	Transp. & Comm.	25	17	462	
	Education	144	29	Services	376	307	482	
Production	Agriculture	117	49	Government Services	38	36	85	
	Industry	73	230	Others	0	0	88	
	Service	250	376	HH Income decrease	223			1,114
	Tourism							
Total		2,076	1,000		1,000		2,709	1,114

Values are current US$ million.

Case Studies of Disaster Impact Estimation

Results of Impact Estimation: 2001 Gujarat Earthquake, India



Case Studies of Disaster Impact Estimation

Results of Impact Estimation: 2006 Central Java Earthquake, Indonesia

Sector		Data		Converted			Calculated	
		Damages	Losses	Sectors in model	Output decrease	Demand decrease	Output impact	HH Income impact
Infrastructure	Housing	1,496	149	Agriculture	69	54	161	
	Transport	10		Mining	0	0	97	
	Electricity	24	16	Processed Food	0	0	168	
	Water and Sanitation	9	0	Light Manufacturing	253	190	318	
	Urban and Municipal	15		Heavy Manufacturing	166	128	267	
	Water Resource			Utilities and Construction	24	22	74	
Social	Health and Nutrition	169	2	Transp. & Comm.	18	14	170	
	Education	239	6	Services	2	1	132	
Production	Agriculture	7	69	Government Services	8	8	23	
	Industry	437	419	Others	0	0	59	
	Commerce	20	13	HH Income decrease	149			521
	Tourism	9	2					
Total		2,434	676		689		1,470	521

Values are current US$ million.

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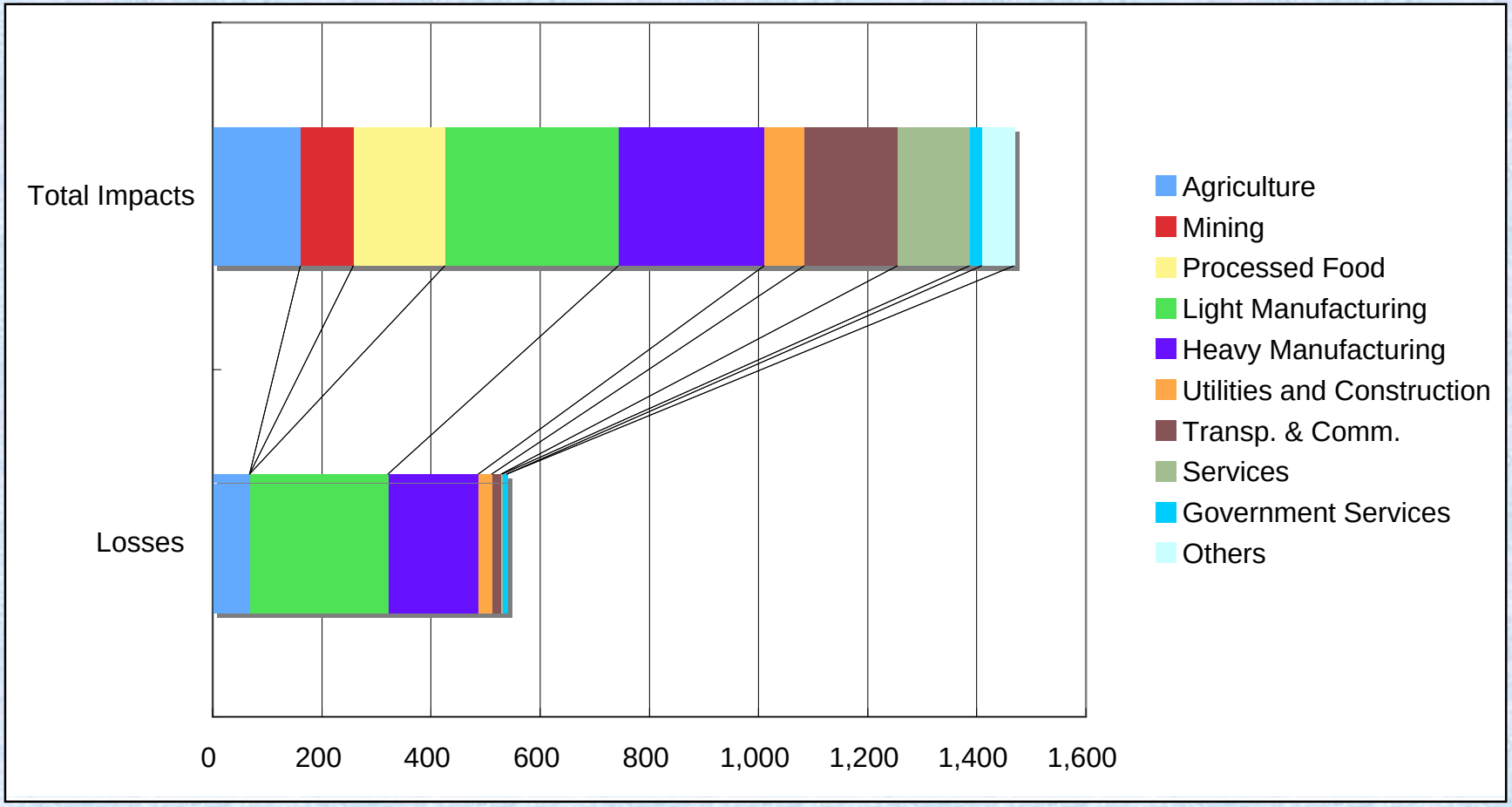
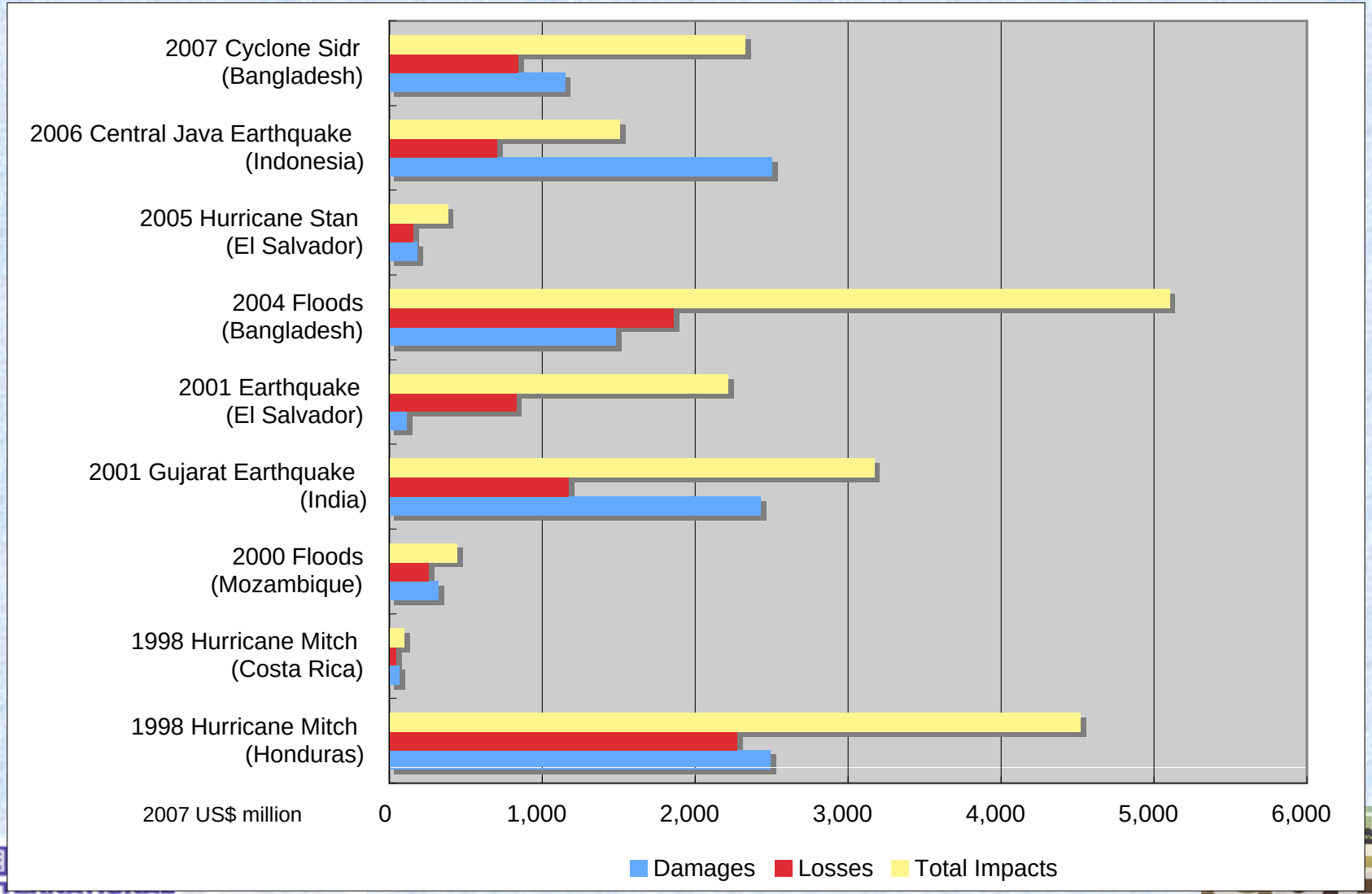
Case Studies of Disaster Impact Estimation

Results of Impact Estimation: 2006 Central Java Earthquake, Indonesia



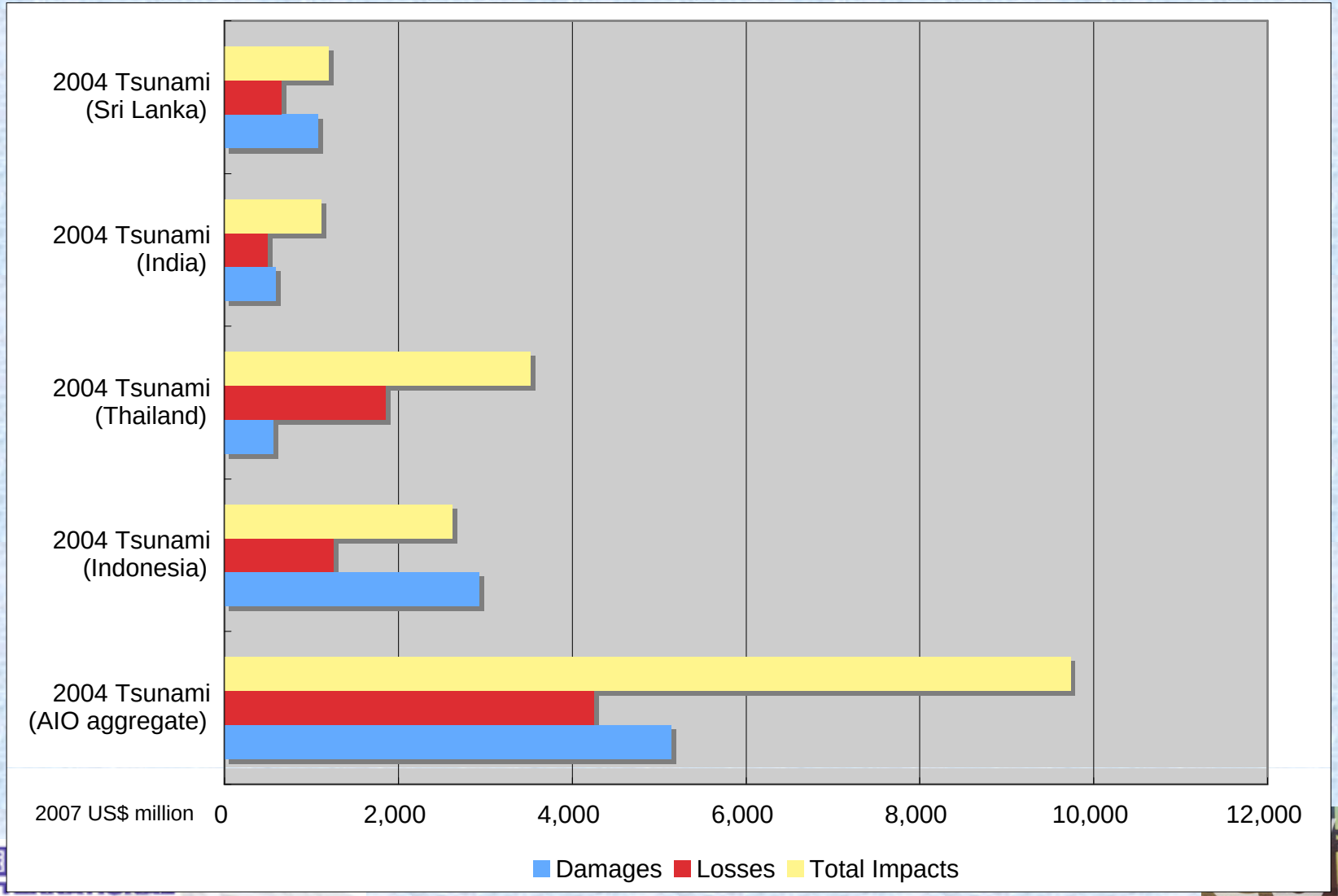
Case Studies of Disaster Impact Estimation

Comparison of Disaster Impacts



Case Studies of Disaster Impact Estimation

Comparison of Disaster Impact: 2004 Tsunami Case



Case Studies of Disaster Impact Estimation

International Disaster Impact: 2004 Tsunami Case (2000 IDE Asian Internationl IO Table)

	Sectors in model	*Indonesia*	*Thailand*	Malaysia	Philippines	Singapore	China	Taiwan	Korea	Japan	USA	Total
Output Impact	Agriculture	*672*	*228*	2	1	0	19	2	3	8	13	948
	Mining	*69*	*33*	5	0	0	7	0	0	1	4	118
	Manufacturing	*814*	*872*	36	7	33	96	42	59	230	120	2,307
	Utilities	*30*	*132*	1	1	1	6	1	2	11	7	192
	Construction	*20*	*3*	0	0	0	1	1	0	4	2	30
	Trade and Transport	*370*	*401*	5	2	7	14	9	7	64	47	926
	Services	*412*	*1,535*	9	2	9	14	15	19	110	114	2,239
	Total	*2,386*	*3,205*	58	14	50	156	69	90	428	306	6,761
Income Impact		*1,219*	*1,240*	22	5	12	39	24	26	154	143	2,885

Remark: 2004 US$ million

Conclusions

- Significant progress has been made in the recent years for estimating the economic impacts of disasters

- Estimated disaster impacts show that there are no particular trends or correlations among damages, losses, and higher-order effects between the types of disaster and the intensity of disasters. Economic impacts of disasters depend on the structure of economy that a hazard hits and where and how the economy is damaged.

- The first step for promoting disaster related economic analysis is to create the standard methodology for assessing damages and losses, such as the ECLAC methodology, and the standard framework for estimating the higher-order effects.