

Grid-based Socioeconomic Database for Exposure Estimation in Flooding Risk Analysis

MingDaw Su
sumd@ntu.edu.tw
National Taiwan UNiversity



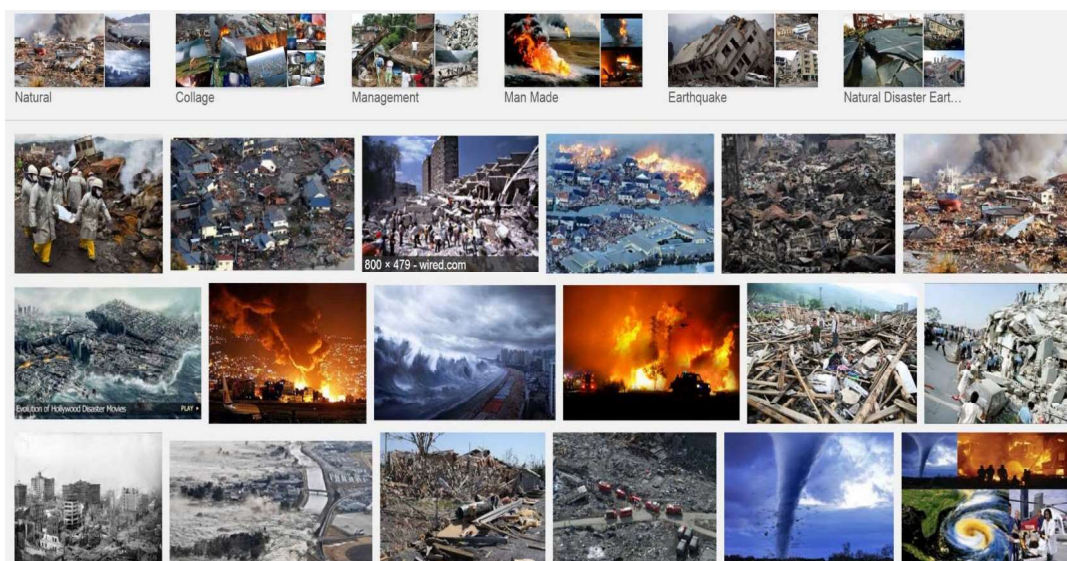
Disaster

- A serious **disruption of the functioning** of a community or a society involving widespread human, material, economic or environmental losses and impacts, which **exceeds the ability of the affected community or society to cope** using its own resources

--Wikipedia

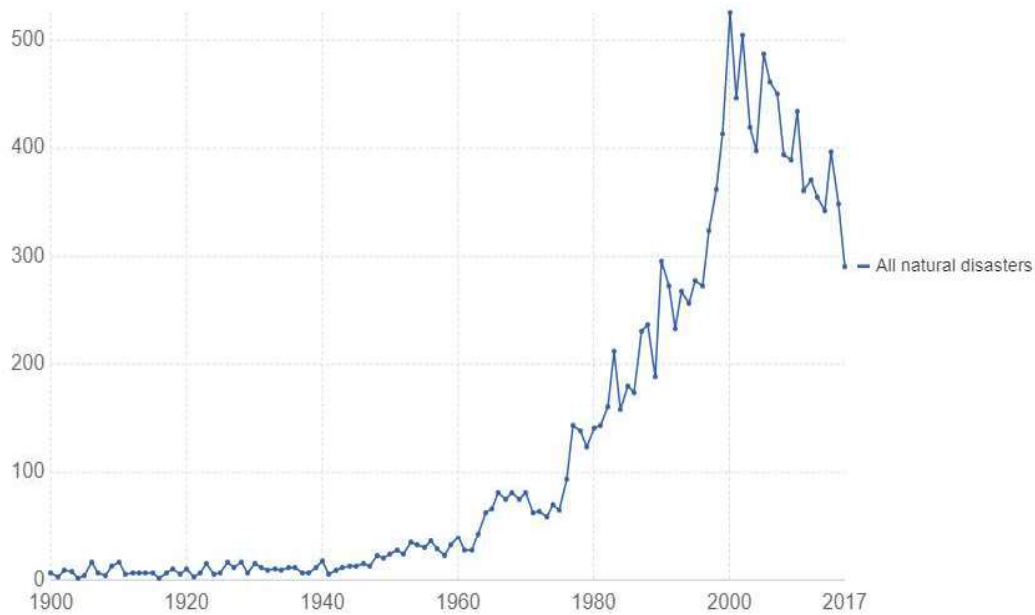
Big Long

Disasters



Number of recorded natural disaster events, All natural disasters

The number of global reported natural disaster events in any given year. This includes those from drought, floods, biological epidemics, extreme weather, extreme temperature, landslides, dry mass movements, extraterrestrial impacts, wildfires, volcanic activity and earthquakes.

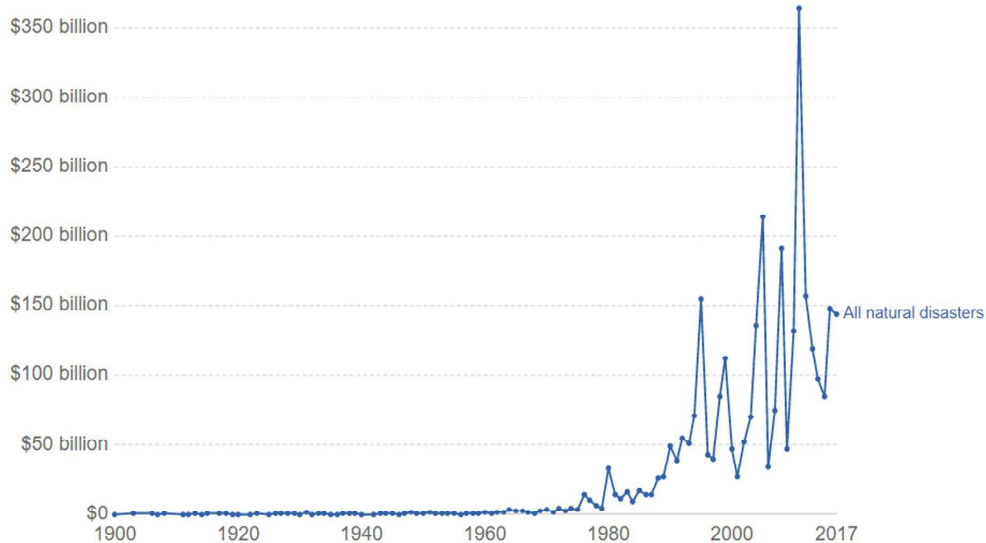


Source: Natural disasters - EMDAT (2017)

OurWorldInData.org/natural-catastrophes/ • CC BY-SA

Total damage costs from global natural disasters

Total economic cost of damages as a result of global natural disasters in any given year, measured in current US\$. Includes those from drought, floods, biological epidemics, extreme weather, extreme temperature, landslides, dry mass movements, extraterrestrial impacts, wildfires, volcanic activity and earthquakes.



Source: EMDAT, OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium

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Change disaster category

CHART

DATA

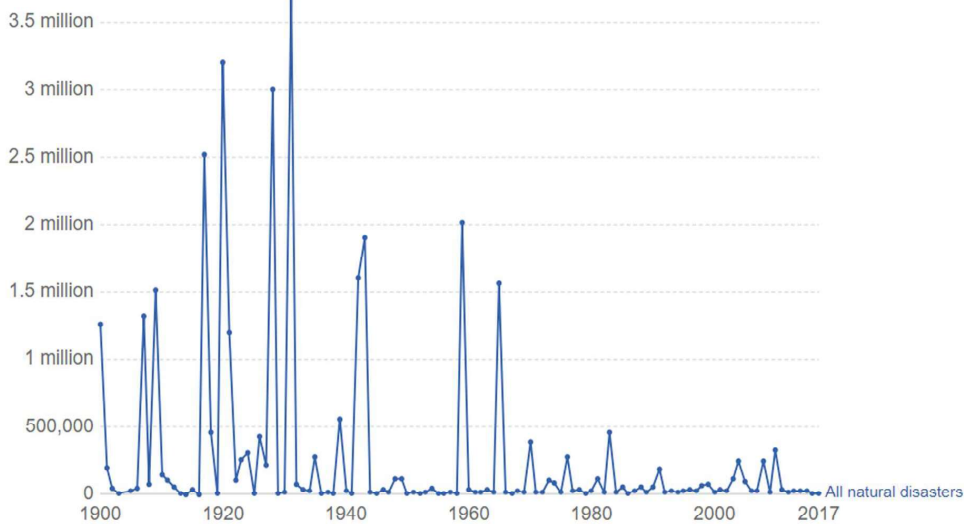
SOURCES



Number of deaths from natural disasters, All natural disasters

Absolute number of global deaths per year as a result of natural disasters. "All natural disasters" includes those from drought, floods, biological epidemics, extreme weather, extreme temperature, landslides, dry mass movements, extraterrestrial impacts, wildfires, volcanic activity and earthquakes.

Our World
in Data



Source: EMDAT: OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium

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Change disaster category

CHART

DATA

SOURCES

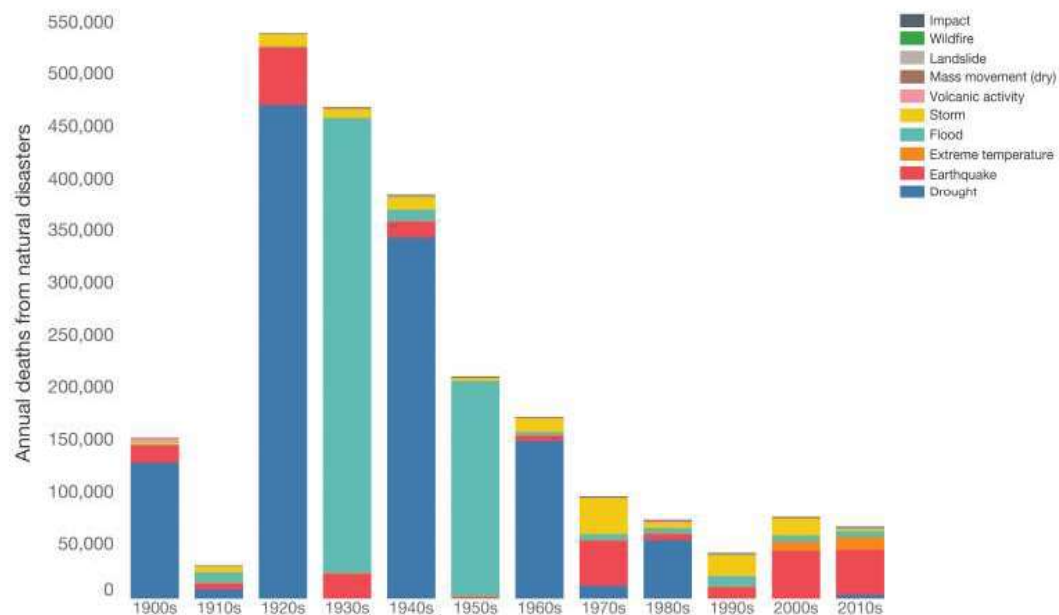


Global annual deaths from natural disasters, by decade

Absolute number of global deaths from natural disasters, per year.

This is given as the annual average per decade (by decade 1900s to 2000s; and then six years from 2010-2015).

Our World
in Data



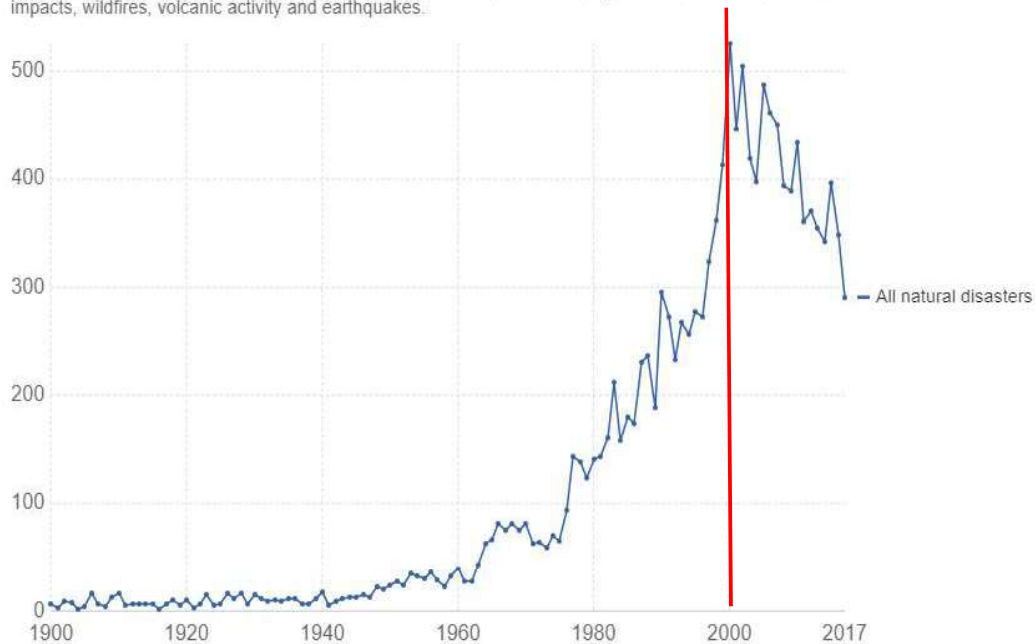
Source: EMDAT (2017): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium. The data visualization is available at OurWorldinData.org. There you find research and more visualizations on this topic.

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Number of recorded natural disaster events, All natural disasters

The number of global reported natural disaster events in any given year. This includes those from drought, floods, biological epidemics, extreme weather, extreme temperature, landslides, dry mass movements, extraterrestrial impacts, wildfires, volcanic activity and earthquakes.

Our World
in Data



There is **Nothing Natural** about **Disaster**



<https://www.youtube.com/watch?v=h7fbfZxoWlY>

Nature causes extreme events (called “hazards” when they threaten people), **but people create disasters.**

Millennium Development Goals (MGDs)

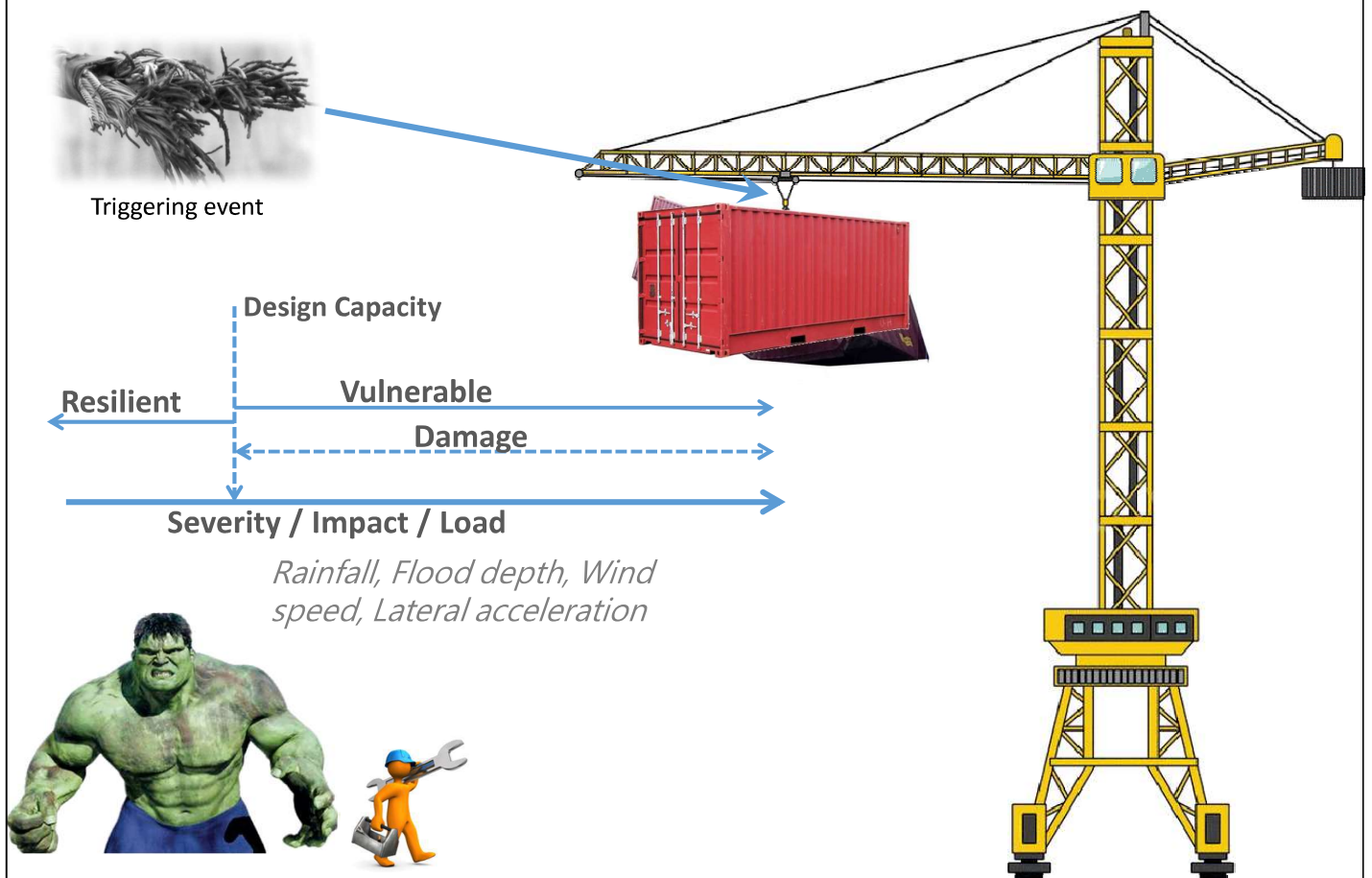


From MDGs toward SDGs



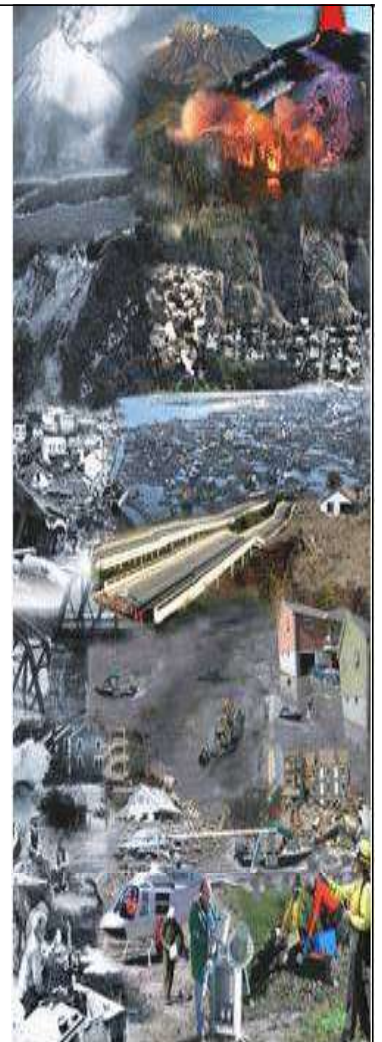


Hazard/Exposure/Vulnerability/Disaster



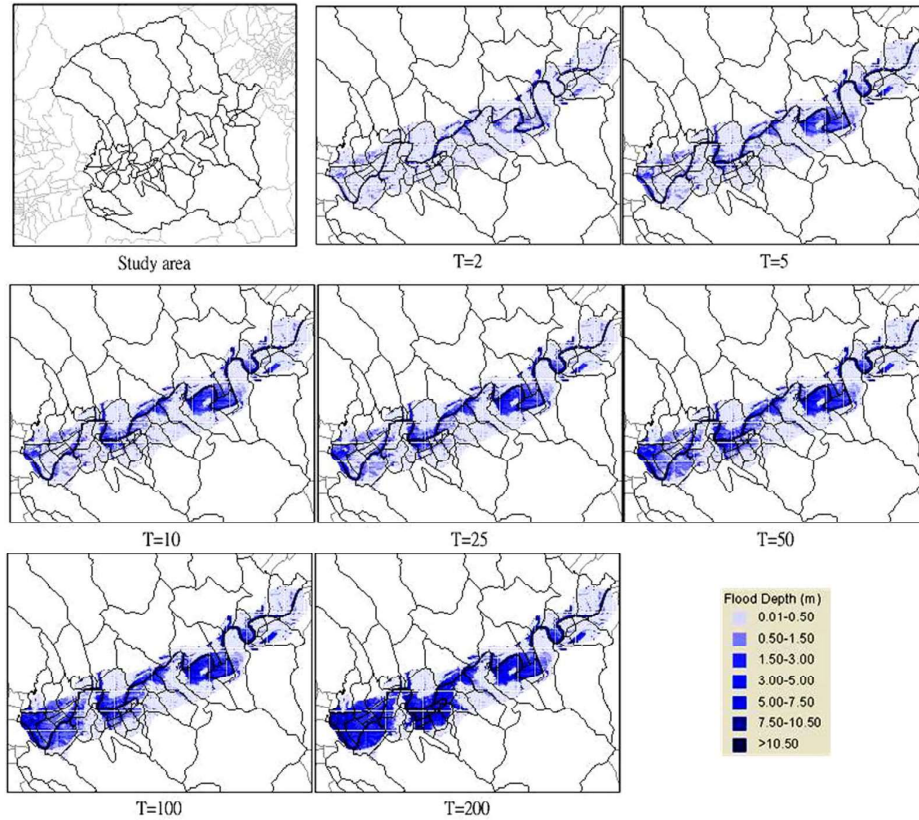
- **Hazard**
 - source of potential harm
- **Exposure**
 - *extent* to which an organization and/or stakeholder is *subject to an event*
- **Vulnerability**
 - *intrinsic properties* of something resulting in susceptibility to a risk source that can lead to an event with a consequence
- **Consequence**
 - outcome of an event affecting objectives
 - A consequence can be *certain or uncertain* and can have *positive or negative*, and expressed *qualitatively or quantitatively*.
- **Resilience**
 - *adaptive capacity* of an organization in a complex and changing environment

天然災害
**Natural
Disaster**



Flood hazard potential map

- ✓ Hazard indicator (inundation depth)
- ✓ Probability



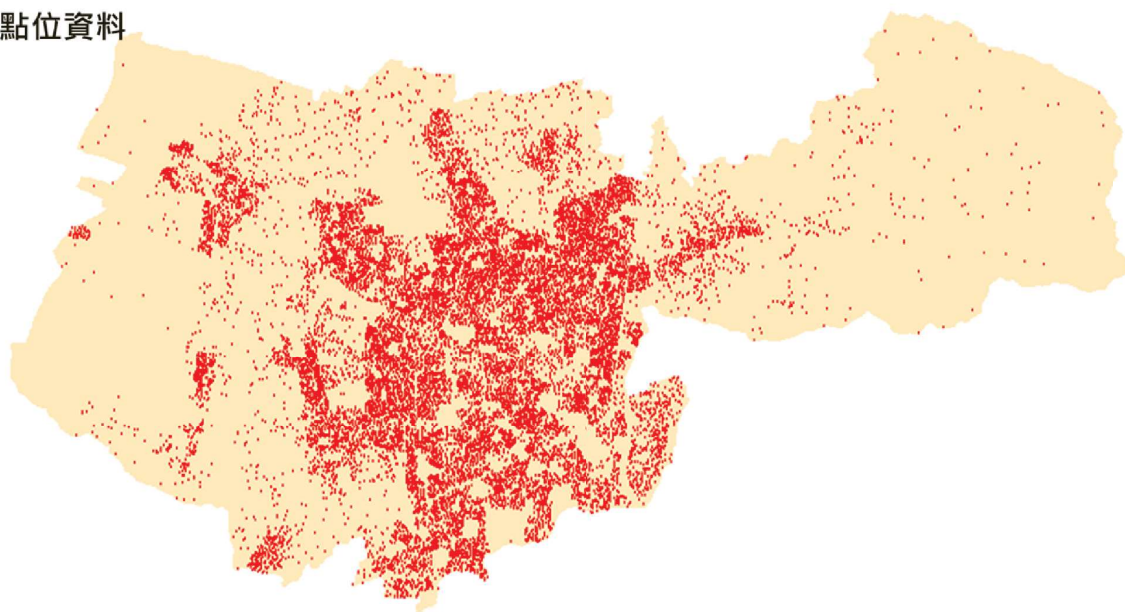
UNESCO

$$\text{Risk}_{\text{(total)}} = (\text{Hazard}) \times (\text{Elements at Risk}) \times (\text{Vulnerability})$$

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Demographic (Exposure)

點位資料



UNESCO

$$\text{Risk}_{\text{(total)}} = (\text{Hazard}) \times (\text{Elements at Risk}) \times (\text{Vulnerability})$$

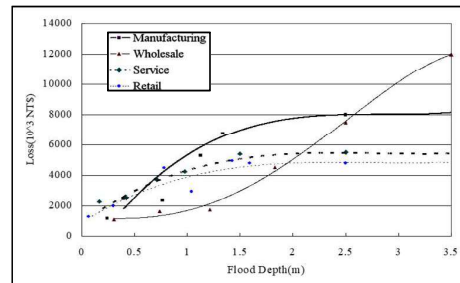
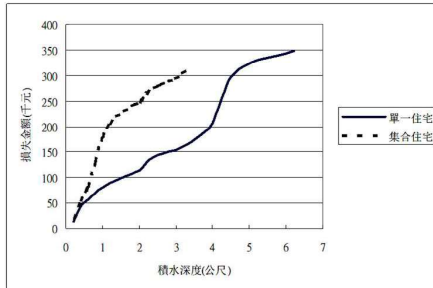
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Vulnerability

– Relationship of *damages vs. impact intensities*

– **Receptors** characteristics

- Residential: Single/Multiple family
- Manufacture, Wholesale, Retail, Service
- Vehicle, public work, infrastructure



http://africanleadership.co.uk/wp-content/uploads/2013/08/CostcutterRetailer_Selected.jpg

UNESCO

$$\text{Risk}_{\text{total}} = (\text{Hazard}) \times (\text{Elements at Risk}) \times (\text{Vulnerability})$$

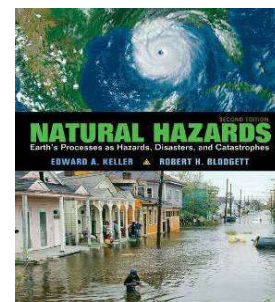
Natural Hazards Characteristics

• Repeat Occurrences (at same site)

- Geological: Earthquake/Landslide
- Meteorological: flood/drought/ tornado

• Damages may be recovered

- In relative short period
- Multiple/Accumulated Damage



<http://images.pearsoned-ema.com/jpeg/large/9780132318648.jpg>

Box 1: Selected definitions of risk from the literature

Total risk = Impact of hazard × Elements at risk × Vulnerability of elements at risk
(Blong, 1996, citing UNESCO)

"Risk" is the probability of a loss, and this depends on three elements, hazard, vulnerability and exposure". If any of these three elements in risk increases or decreases, then risk increases or decreases respectively.
(Crichton, 1999)

Risk = Hazard × Vulnerability × Value (of the threatened area) × Preparedness
(De La Cruz-Reyna, 1996)

"Risk (i.e. 'total risk') means the expected number of lives lost, persons injured, damage to property and disruption of economic activity due to a particular natural phenomenon, and consequently the product of specific risk and elements at risk.

"Total risk can be expressed in pseudo-mathematical form as:
$$\text{Risk}_{(\text{total})} = \text{Hazard} \times \text{Elements at Risk} \times \text{Vulnerability}$$

(Granger *et al.*, 1999)

Risk = Probability × Consequences
(Helm, 1996)

"Risk is a combination of the chance of a particular event, with the impact that the event would cause if it occurred. Risk therefore has two components – the chance (or probability) of an event occurring and the impact (or consequence) associated with that event. The consequence of an event may be either desirable or undesirable...In some, but not all cases, therefore a convenient single measure of the importance of a risk is given by: Risk = Probability × Consequence."
(Sayers *et al.* 2002)

"Risk is the actual exposure of something of human value to a hazard and is often regarded as the combination of probability and loss".
(Smith 1996)

"Risk might be defined simply as the probability of the occurrence of an undesired event [but] be better described as the probability of a hazard contributing to a potential disaster...importantly, it involves consideration of vulnerability to the hazard".
(Stenchion 1997)

Risk is "Expected losses (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability".
(UN DHA, 1992)

- **UNESCO**

- $\text{Risk}_{(\text{total})} = (\text{Hazard}) \times (\text{Elements at Risk}) \times (\text{Vulnerability})$

- **UN DHA**

- Expected losses due to a particular hazard for a given area and reference period.

Natural hazard risk

- **The expected damages within a period of time**

- Expected Annual Damage (EAD)

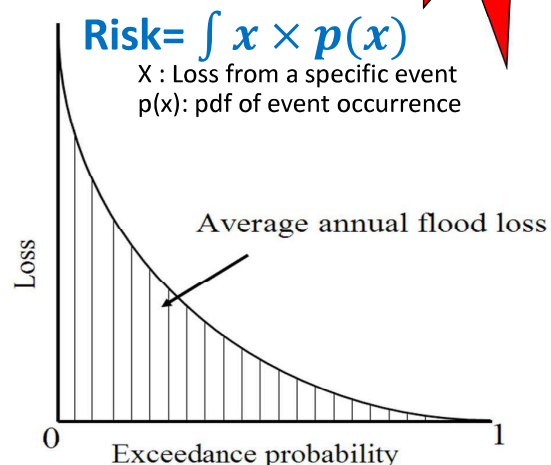
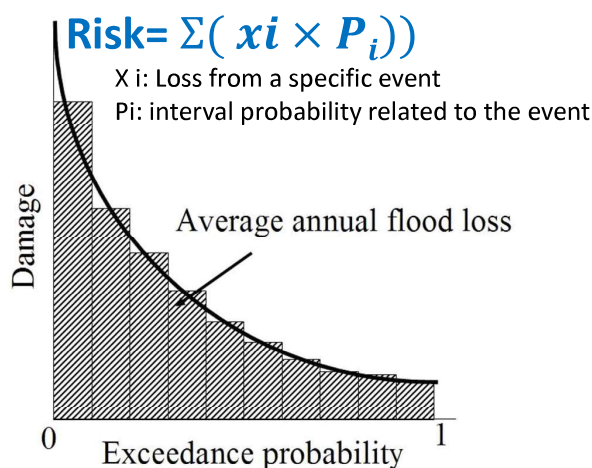
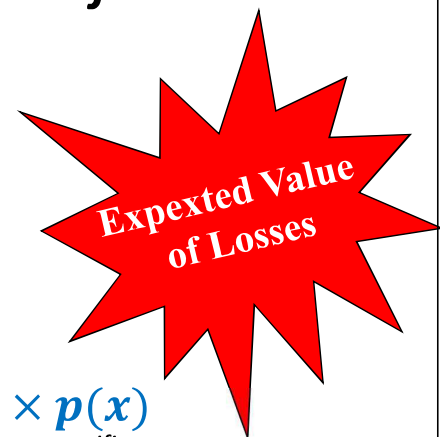
- **Consequences**

- Hazard * Exposure * Vulnerability

- **Multiple events**

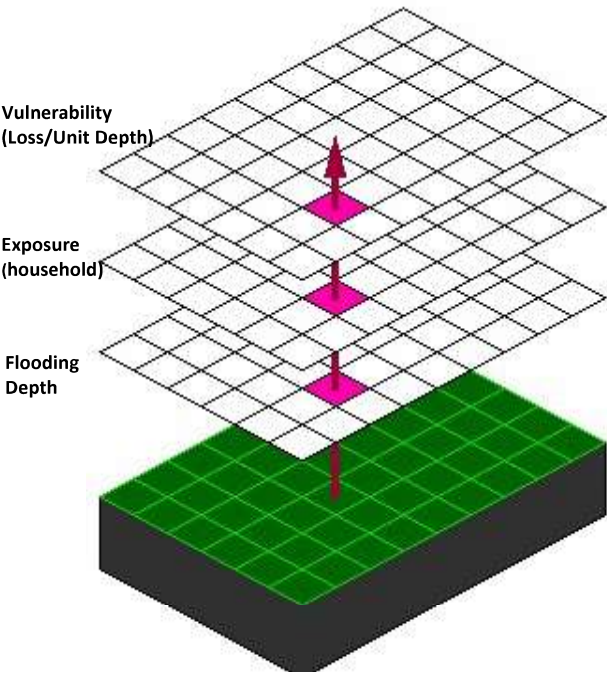
- Different scales (intensities)

- Different occurrence probabilities

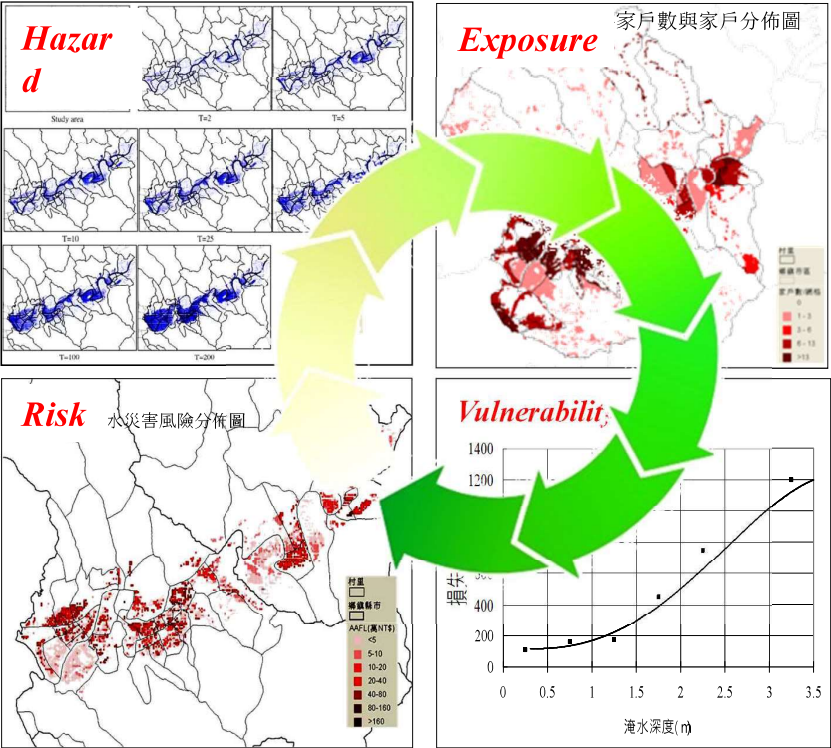


Grid-based Damage Estimations

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Data Sources

- **Census**

- *Population and housing*
- *Agricultural, Forestry, Fishery and Husbandry Census*
- *Industry, Commerce and Service Census*

- **Registry**

- *Building, Vehicle*

- **Survey**

- *Incomes and living expenses*
- *Land uses*

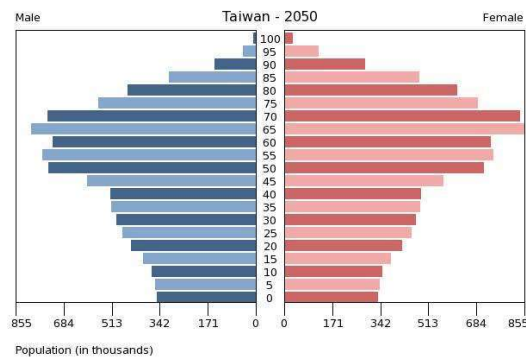
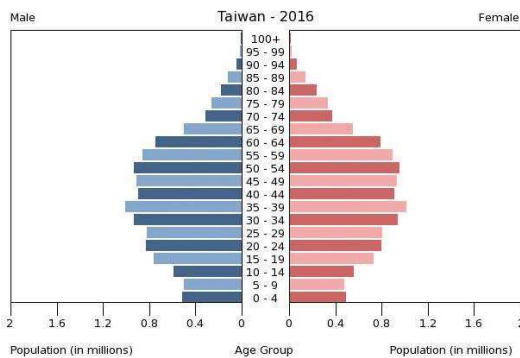
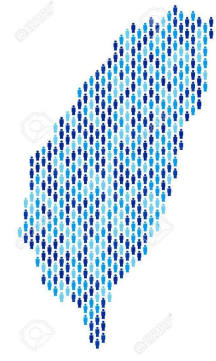
Population and Housing Census

- *The 1st one in 1904 (7 times till 1945)*
- *And conducted decennially since 1956*
- *Register and Sample-Assisted Census from 2010*



Demographic

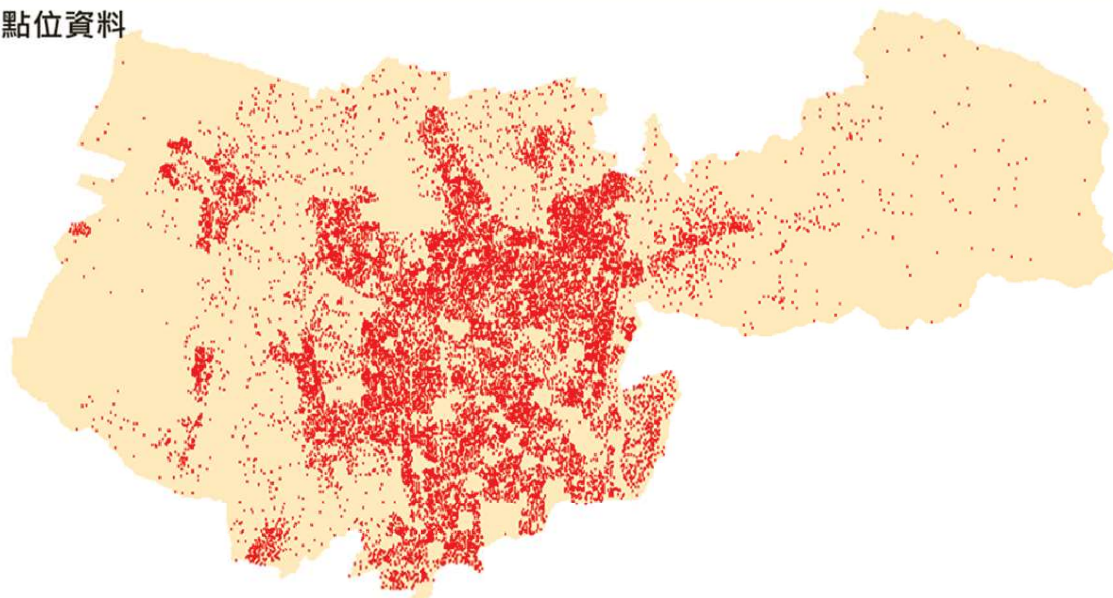
- *Population count*
- *gender, age, marriage, education,*
- *language, aboriginal, foreigner*
- *job, migration, commuting*
- *handicapped, social benefit, single parent*



Housing

- *Square footage, single/multiple family, ownership, vacancy, construction time, living periods, rooms*

點位資料



Agricultural, Forestry, Fishery and Husbandry Census

- *Once every 5 years (last one in 2015)*
 - *Labor force, Capital, Facilities*
 - *Type/ Area /Scale*
 - *Revenues*



Industry/Commerce/Service Census

- **Based on Taiwan ISIC**
 - *3 hierarchical levels*
 - *Manufacturing (Type/Scale)*
 - *Business: Wholesale/Retail*
 - *Services : Type/Scale, (banking, education, law, office....)*
 - *Warehouse*
- # of firm, Floor footage,
- # of Employment, Average salary
- Years of operations, Expenses/Revenues



Manufacturing

- **1.Commodity / Consumer goods**
 - *Foods, Clothes, Drink, Furniture.....*
- **2.Chemical Industry**
 - *Leather, plump, Printing, Petroleum, Chemical, Pharmaceutical, Rubber, Plastic, etc.*
- **3.Metal and Mechanical Industry**
 - *Metal, Electrical, Mechanical, Automobile, Parts, etc.*
- **4.Information and Electronic Industry**
 - *Computer, Electronical, Optical, etc.◦*

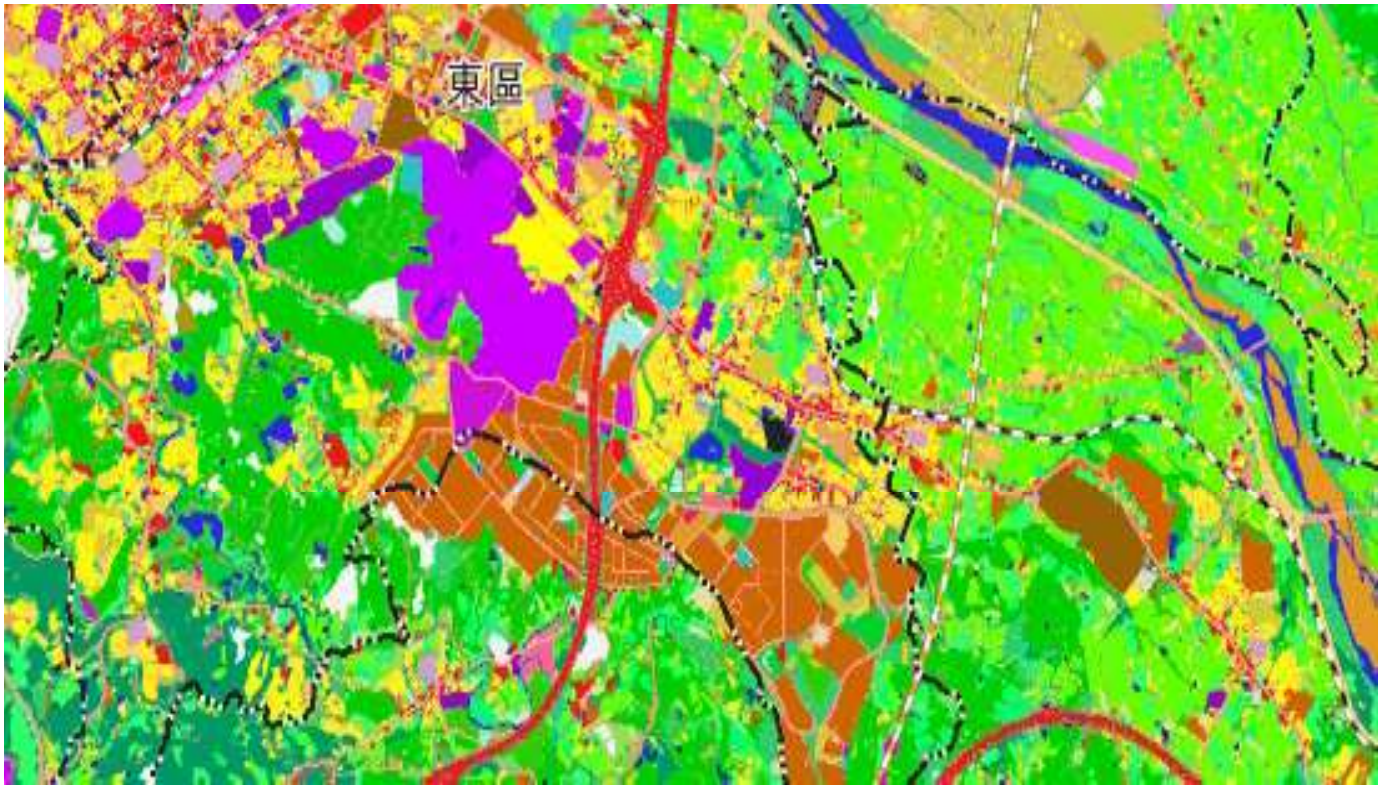
Land Use



http://www.surrey.ca/images/cos-master/pagelimages/Heritage/Land_Use_Aerial_Photo_Surey_ALR.jpg

Land use surveying

https://www.nlsc.gov.tw/LUI/Home/Content_Home.aspx



Land use classification

- **01 Agriculture**
 - 0101 Farming
 - 010101 Paddy
 - 010102 Upland
 - 010103 Orchard
 - 010304 Fallow
 - 0102 Aquaculture
 - 0103 Livestock
 - 0104 Facility
- **02 Forestry**
- **03 Transportation**
- **04 Water**
- **05 Building**
 - 0502 Residential
 - 050201 Pure Res.
 - 050202 Res/Ind.
 - 050203 Res/Commercial
 - 050204 Others
 - 0503 Industrial
 - 050301 Manufacturing
 - 050302 Warehouse
 - 0504 Other
- **06 Public/Gov.**
 - 0601 Institution
 - 0602 Education
 - 0603 Medical
 - 0604 Social welfare
 - 0605/06 Other
- **07 Recreation**
- **08 Mining**
- **09 Others**
 - 0901 Military
 -

Land use classification

類別代碼	類別名稱	R	G	B	色塊
01	農業利用土地	152	230	0	
0101	水田	209	255	115	
010101	水稻田	171	220	97	
010102	其他水田	110	221	97	
0102	旱田	233	255	190	
010201	旱作	198	230	150	
010202	牧場	56	204	61	
010203	雜草地	200	205	56	
0103	果園	126	237	39	
010301	常綠果樹	99	192	59	
010302	落葉果樹	170	192	60	
010303	橡膠	142	169	68	
0104	水產養殖	138	255	218	
010400	水產養殖	138	255	218	
0105	畜牧	159	177	105	
010501	畜舍	112	134	79	
010502	牧場	147	203	62	
0106	農業相關設施	168	168	0	
010601	溫室	107	144	75	
010602	其他農業相關設施	77	101	57	

類別代碼	類別名稱	R	G	B	色塊
03	交通利用土地	255	85	0	
0301	機場	174	120	255	
030100	機場	174	120	255	
0302	一般鐵路及相關設施	255	110	255	
030201	一般鐵路	233	119	210	
030202	一般鐵路相關設施	176	87	158	
0303	高速鐵路及相關設施	109	0	189	
030301	高速鐵路	129	81	212	
030302	高速鐵路相關設施	99	62	162	
0304	捷運及相關設施	163	38	255	
030401	捷運路線	148	78	239	
030402	捷運相關設施	115	59	189	
0305	國道	230	0	0	
030500	國道	230	0	0	
0306	省道	255	120	120	
030600	省道	255	120	120	
0307	快速公路	255	20	165	
030700	快速公路	255	20	165	
0308	一般道路	231	148	163	
030800	一般道路	231	148	163	
0309	道路相關設施	211	142	191	
030901	停車場	143	120	174	
030902	其他道路相關設施	95	76	119	
0310	港口	103	141	174	
031001	碼頭	79	108	203	
031002	輪渡	116	134	192	
031003	專用港	90	109	169	
031004	其他港口設施	63	72	101	

類別代碼	類別名稱	R	G	B	色塊
05	建築利用土地	255	161	161	
0501	商業	194	0	6	
050101	零售批發	216	5	61	
050102	服務業	228	62	106	
0502	住宅	255	244	41	
050200	住宅	255	244	41	
0503	混合使用住宅	235	224	82	
050301	工業使用住宅	202	178	26	
050302	商業使用住宅	228	180	25	
050303	兼其他使用住宅	236	193	83	
0504	製造業	255	194	61	
050400	製造業	255	194	61	
0505	倉庫	165	129	68	
050500	倉庫	165	129	68	
0506	宗教	197	0	255	
050600	宗教	197	0	255	
0507	殯葬設施	130	130	130	
050700	殯葬設施	130	130	130	
0508	其他建築用地	205	205	102	
050801	興建中	209	136	9	
050802	其他	186	104	73	

類別代碼	類別名稱	R	G	B	色塊
07	遊樂利用土地	255	251	20	
0701	文化設施	255	255	190	
070101	法定文化資產	205	205	93	
070102	一般文化設施	233	233	132	
070103	其他文化設施	230	230	147	
0702	公園綠地廣場	147	255	47	
070200	公園綠地廣場	147	255	47	
0703	休閒設施	191	255	191	
070301	遊樂場所	246	171	171	
070302	體育場所	172	172	247	

類別代碼	類別名稱	R	G	B	色塊
08	礦業利用土地	206	140	255	
0801	礦業及相關設施	206	153	29	
080100	礦業及相關設施	206	153	29	
0802	土石及相關設施	149	111	35	
080200	土石及相關設施	149	111	35	
0803	礦業及相關設施	140	140	140	
080300	礦業及相關設施	140	140	140	

類別代碼	類別名稱	R	G	B	色塊
02	森林利用土地	90	194	0	
0201	針葉林	58	122	42	
020100	針葉林	58	122	42	
0202	闊葉林	56	168	0	
020200	闊葉林	56	168	0	
0203	竹林	79	190	15	
020300	竹林	79	190	15	
0204	混交林	24	141	13	
020401	針葉混交林	44	124	10	
020402	針葉混交林	74	162	37	
020403	針葉混交林	36	97	10	
020404	針葉混交林	35	81	16	
0205	灌木林	122	186	101	
020500	灌木林	122	186	101	
0206	其他森林利用土地	58	81	23	
020601	伐木跡地	193	169	71	
020602	苗圃	44	199	70	
020603	防火線	196	161	77	
020604	土壤	225	173	52	

類別代碼	類別名稱	R	G	B	色塊
04	水利利用土地	151	219	242	
0401	河港	190	232	255	
040101	河川	164	215	245	
040102	運河	16	215	245	
040103	運河	110	199	250	
0402	堤防	156	156	156	
040200	堤防	156	156	156	
0403	海堤	166	205	213	
040300	海堤	166	205	213	
0404	水庫	70	212	206	
040400	水庫	70	212	206	
0405	湖泊	121	238	233	
040500	湖泊	121	238	233	
0406	蓄水池	158	215	194	
040600	蓄水池	158	215	194	
0407	水壩沙洲灘地	214	136	0	
040700	水壩沙洲灘地	214	136	0	
0408	水利構造物	53	95	96	
040801	水閘門	87	103	124	
040802	抽水站	112	143	161	
040803	水庫壩壩	90	133	158	
040804	地下取水井	36	120	168	
040805	其他水利設施	92	126	145	
0409	防汛道路	204	204	204	
040900	防汛道路	204	204	204	
0410	海面	158	202	255	
041000	海面	158	202	255	

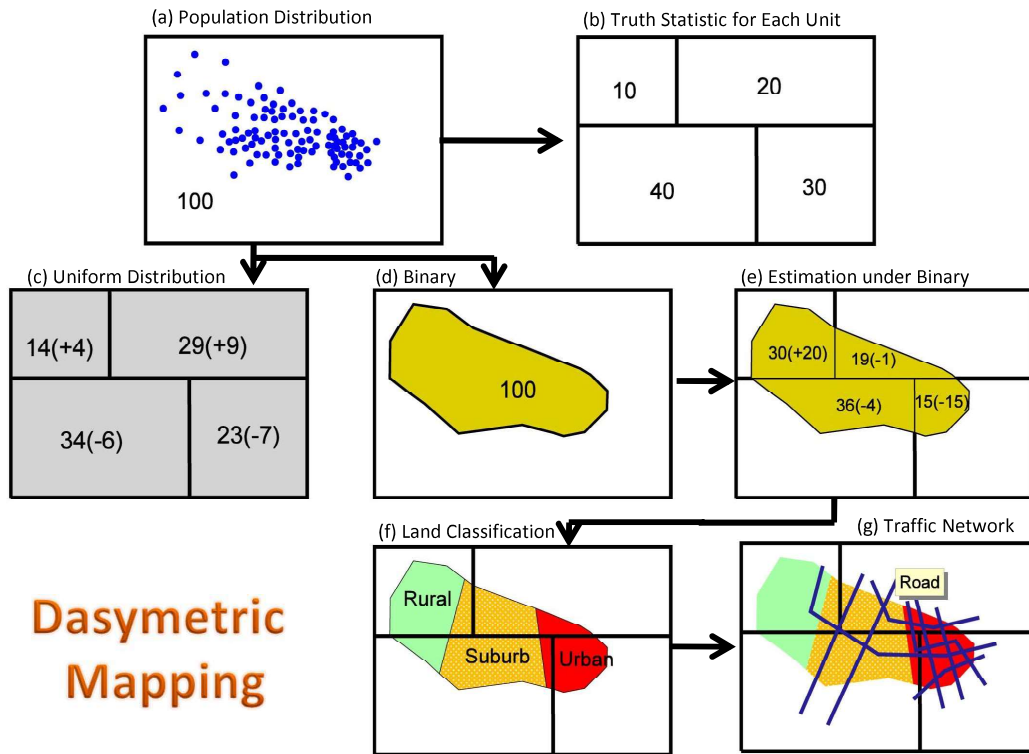
類別代碼	類別名稱	R	G	B	色塊
06	公共利用土地	255	197	89	
0601	政府機關	255	159	41	
060100	政府機關	255	159	41	
0602	學校	232	190	255	
060201	幼兒園	235	186	255	
060202	小學	227	158	255	
060203	中學	218	129	255	
060204	大專院校	209	101	235	
060205	特種學校	201	73	255	
0603	醫療保健	161	139	246	
060300	醫療保健	161	139	246	
0604	社會福利設施	249	224	165	
060400	社會福利設施	249	224	165	
0605	公用設備	255	218	150	
060501	倉庫	147	161	232	
060502	電力	239	114	135	
060503	瓦斯	164	175	232	
060504	自來水	123	153	148	
060505	加油站	216	141	103	
0606	殯葬設施	216	141	103	
060600	殯葬設施	216	141	103	

類別代碼	類別名稱	R	G	B	色塊
09	其他利用土地	225	225	225	
0901	濕地	0	168	132	
090100	濕地	0	168	132	
0902	草地	176	211	38	
090200	草地	176	211	38	
0903	裸地	179	168	46	
090301	裸地	201	173	137	
090302	裸地	154	137	105	
090303	裸地	192	108	34	
0904	廢棄剩餘土石收容處理相關設施	51	51	51	
090400	廢棄剩餘土石收容處理相關設施	51	51	51	
0905	空置地	255	236	201	
090501	未使用地	192	174	84	
090502	八工改變中土地	188	146	62	

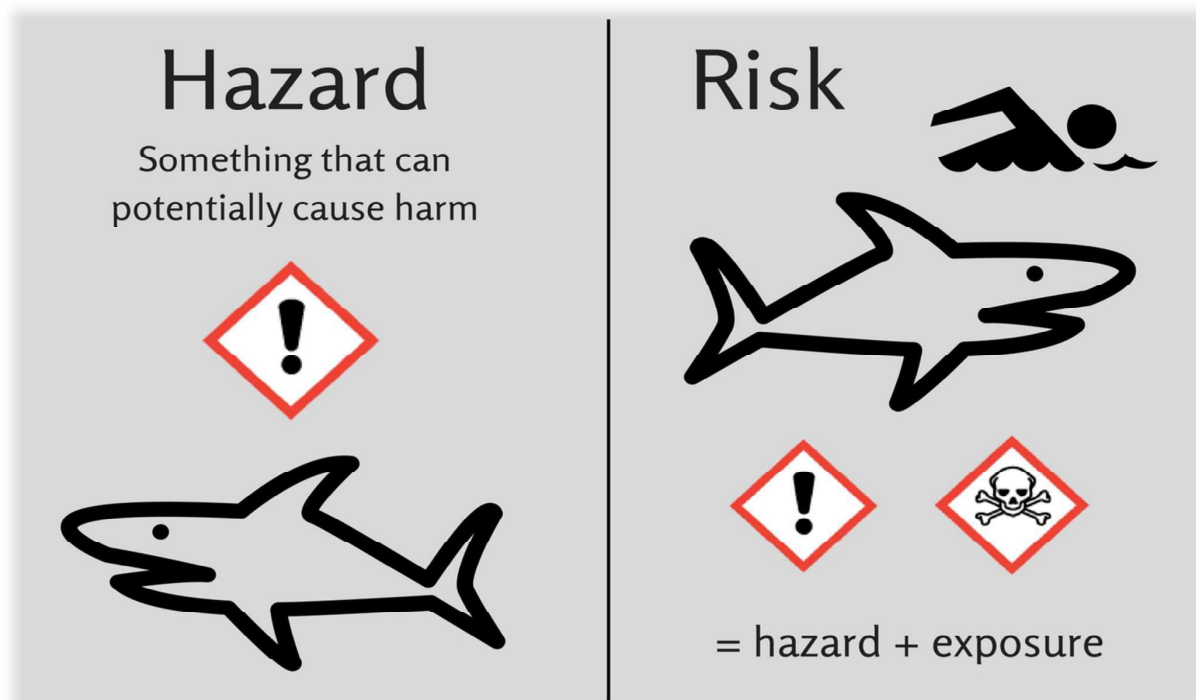
Grid System

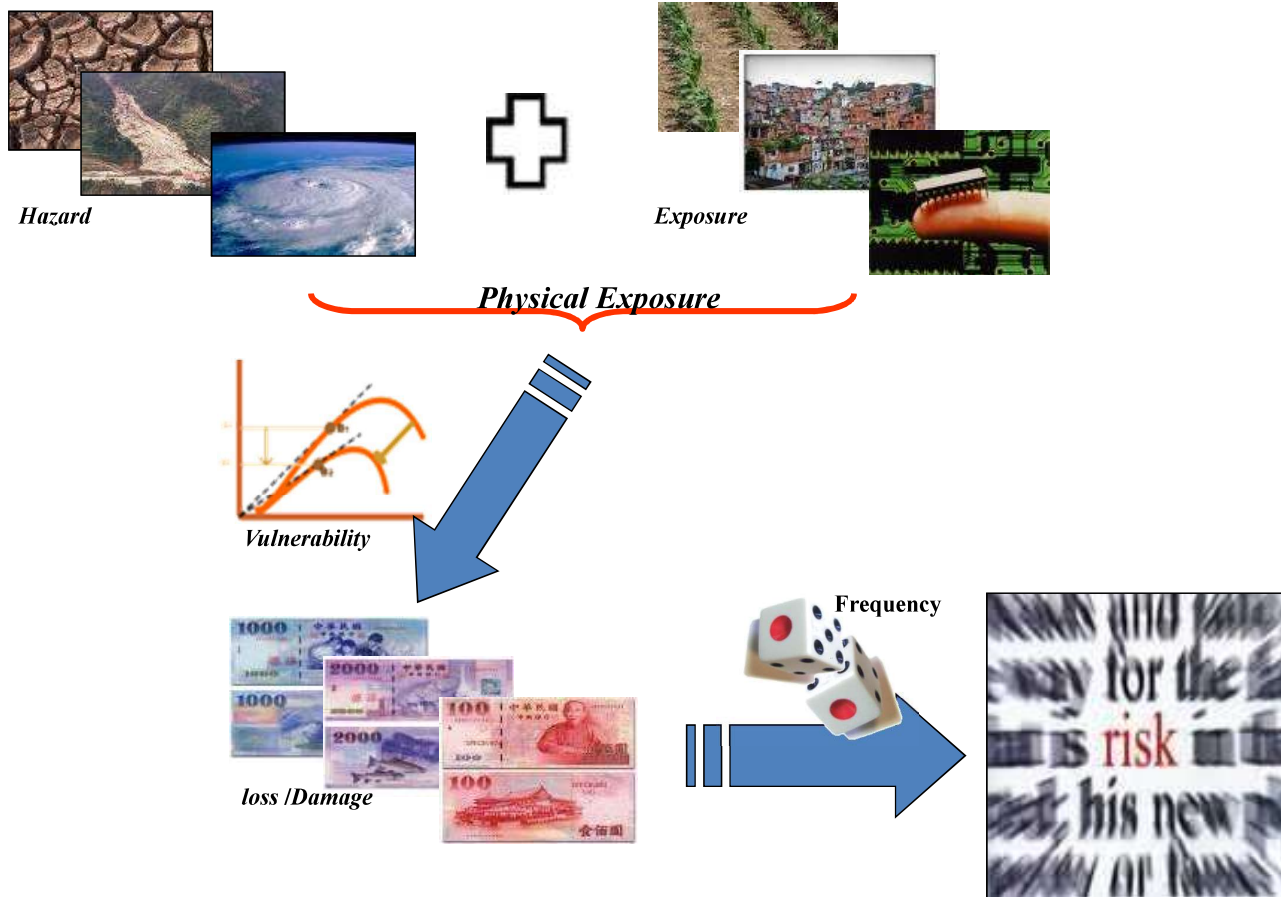
- Resolution 40 x 40m
- Grid-based vs. Parcel-based
 - Coupled with Hazard simulation models
 - Privacy: de-identification
 - Data Availability / Maintainability

Spatial Interpolation

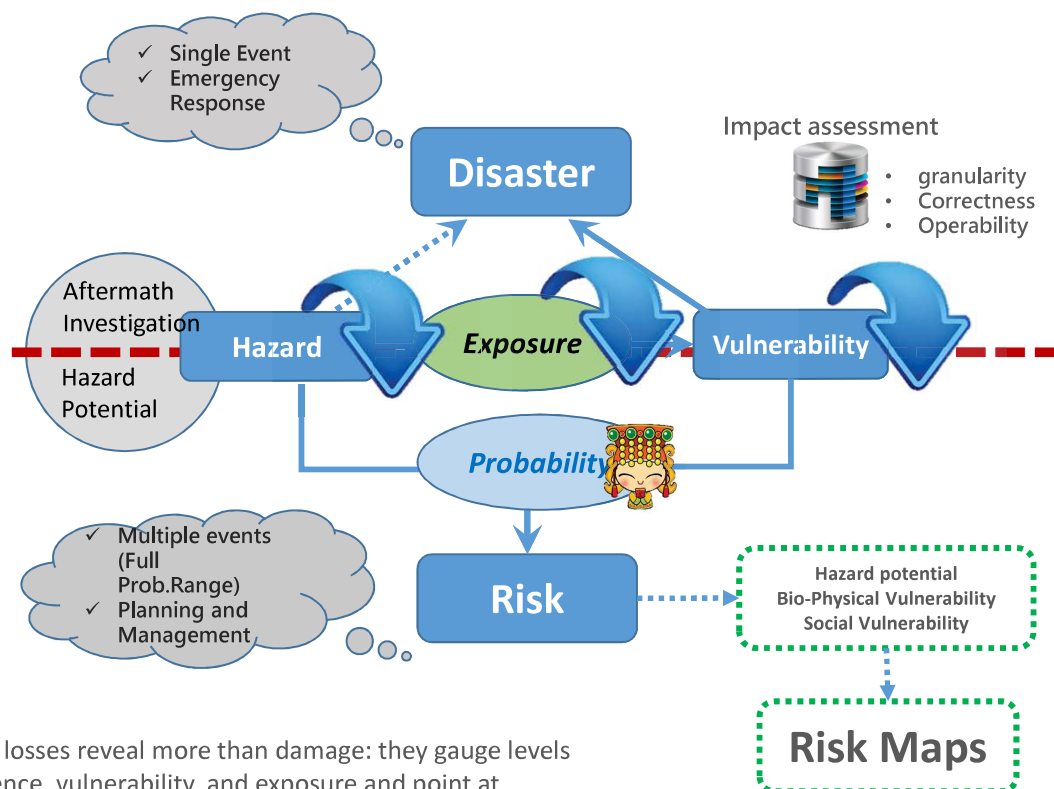


Risk Exposure





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Disaster losses reveal more than damage: they gauge levels of resilience, vulnerability, and exposure and point at underlying conditions that make people and places susceptible to losses.

Together,
We make tomorrow even better.

TAIPEI 101

Olympus E-T F18, D-17100s ISO100

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<http://kongmu.files.wordpress.com/2011/06/taipei101.jpg>