行政法人 國家災害防救科技中心
National Science and Technology Center for Disaster Reduction

Introduction of Taiwan Typhoon Loss Assessment System

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    - **N**ational Science and Technology **C**enter For **D**isaster **R**eduction
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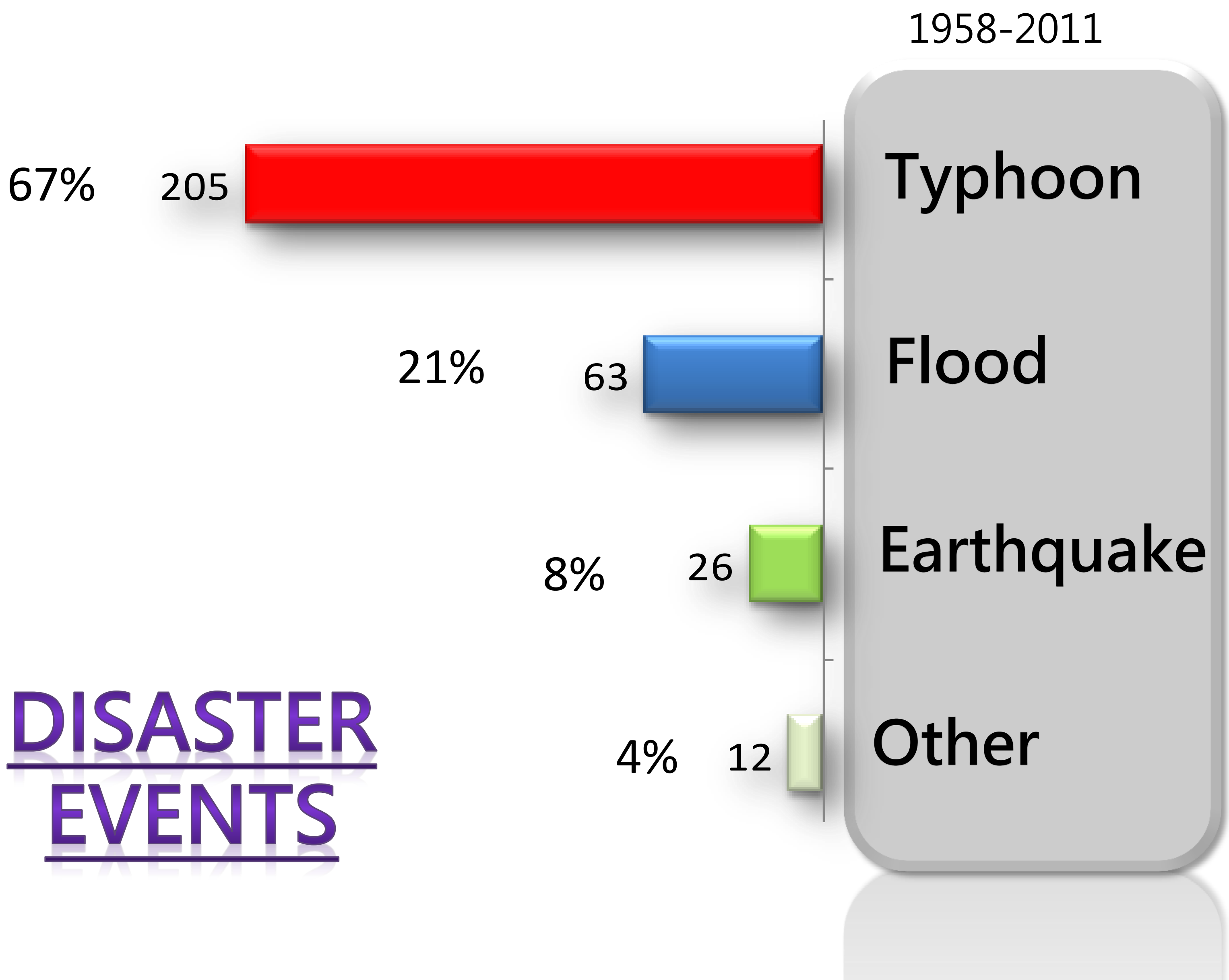
Natural Disasters in Taiwan

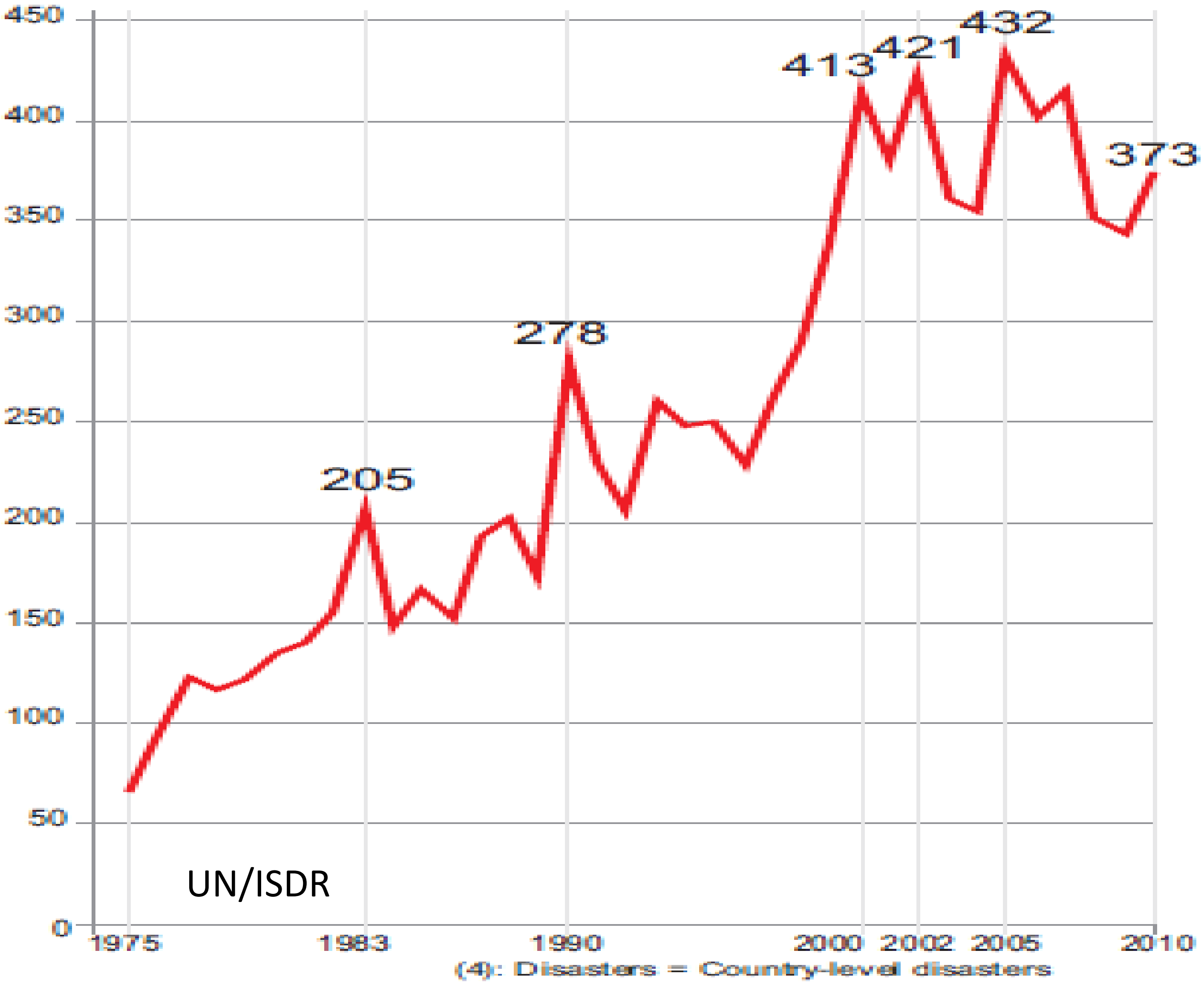


SOURCE: PING-TUNG UNIVERSITY


2009.08.08
Morakot
2010.09.19
Fanapi
2008.07.18
Kalmaegi
2006.07.15
Bilis
2005.07.18
Haitang
2007.08.14
Heavy-Rainfall
2008.07.28
Fung-wong
Data source:NCDR


SOURCE: CHUN-HSING UNIVERSITY

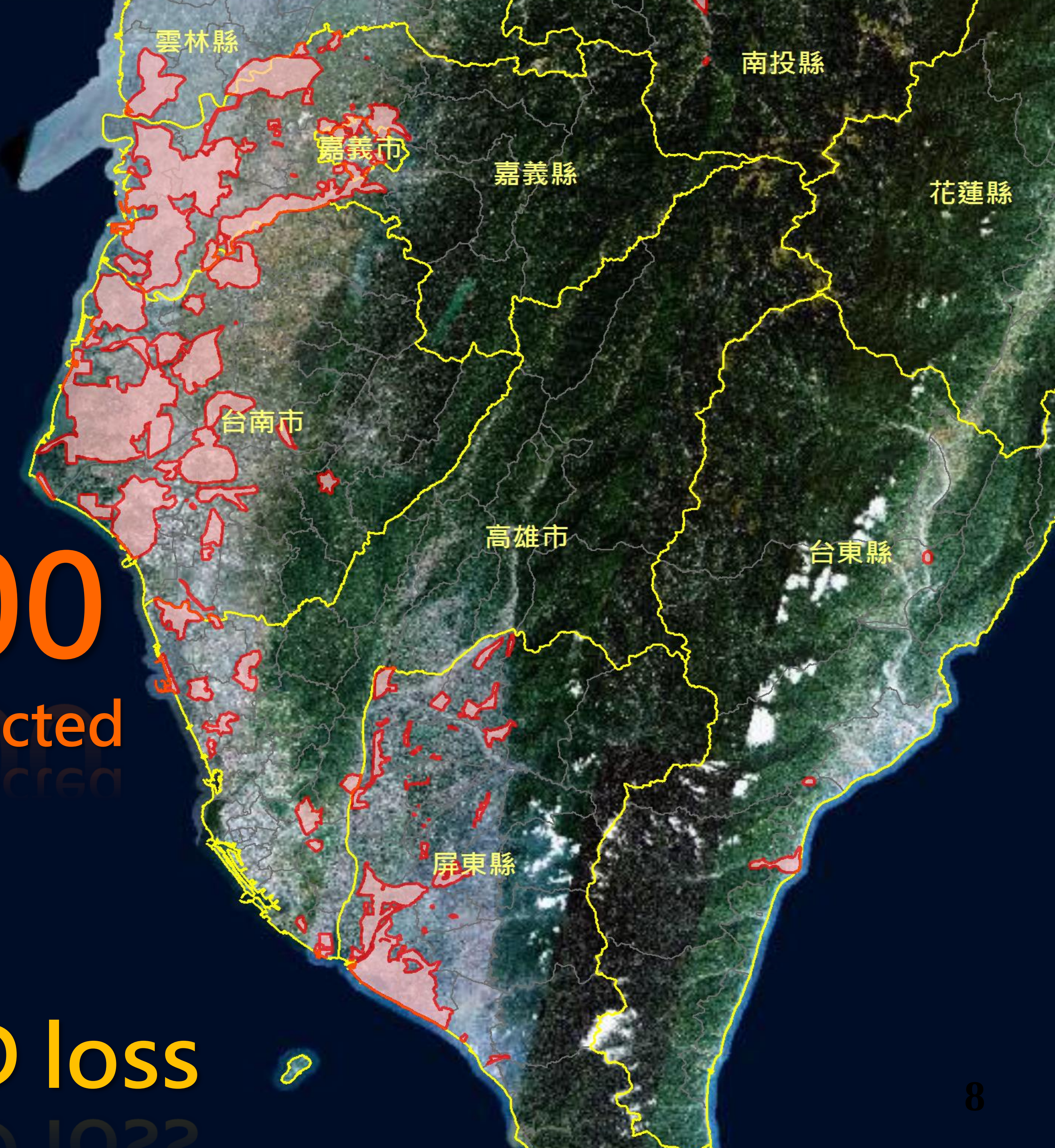
Time trend of reported disasters, 1975-2010



Research Background

TLAS TAIWAN
國 家 災 害 防 救 科 技 中 心
臺灣颱洪災損評估系統
Taiwan Typhoon Loss Assessment System

2009 TYPHOON MORAKOT



330,000 household affected

200 billion NTD loss

Typhoon Morakot

2009.8.8

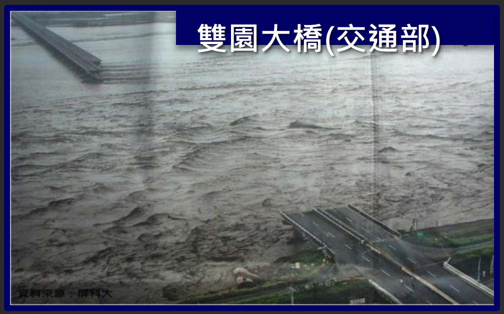
200billio
n

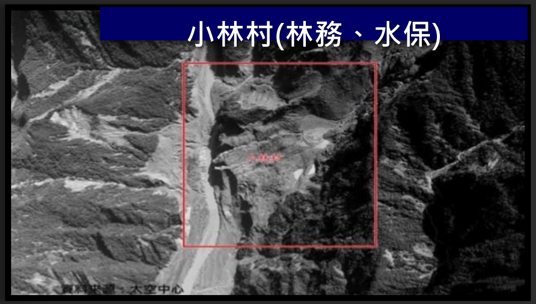
1month
2m
3m
12m(1 year)
18month

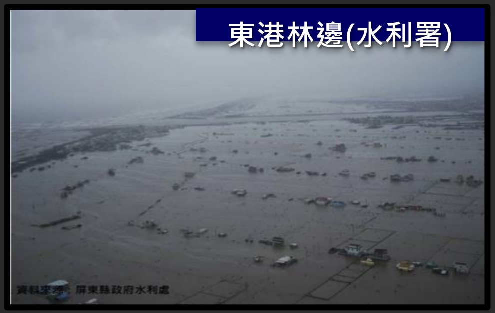
2009.08.28
120billion
NTD

Recovery

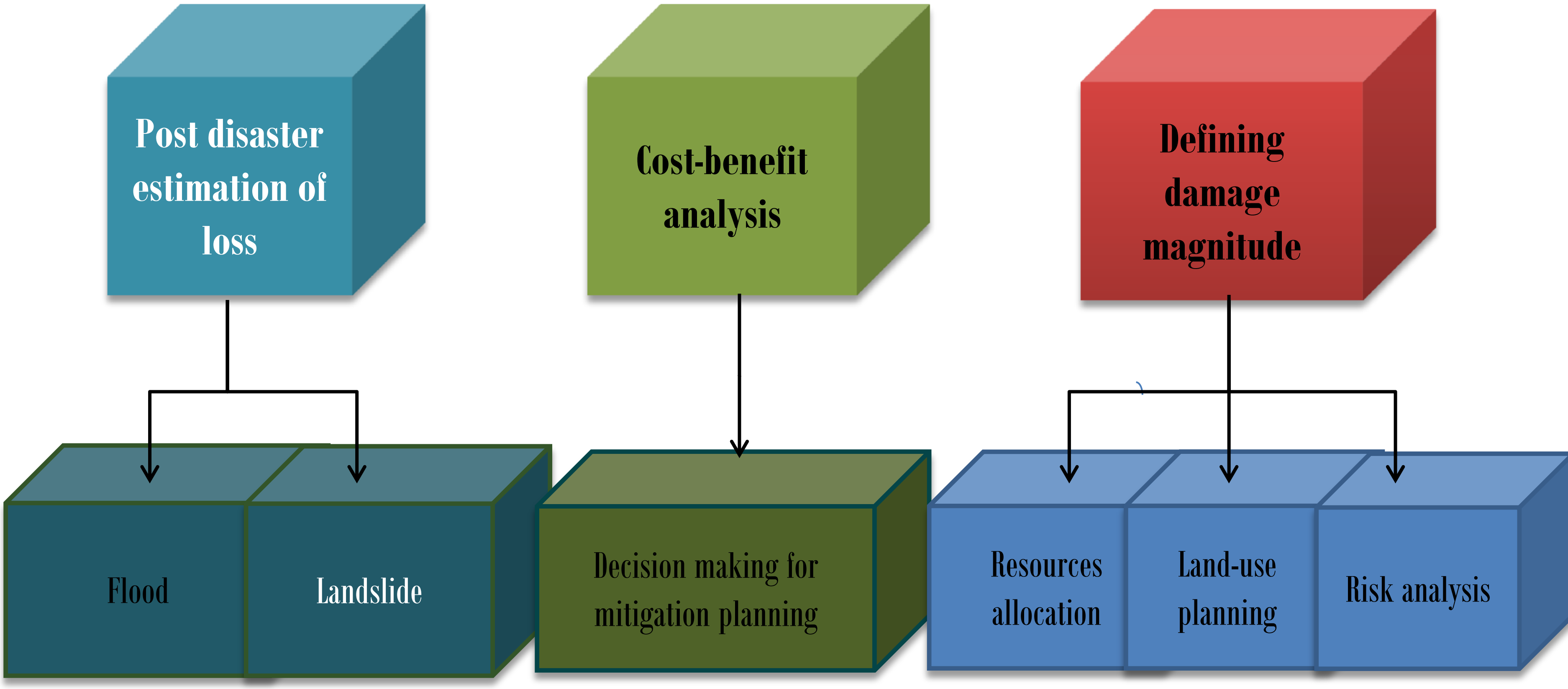
Loss data separate in different department

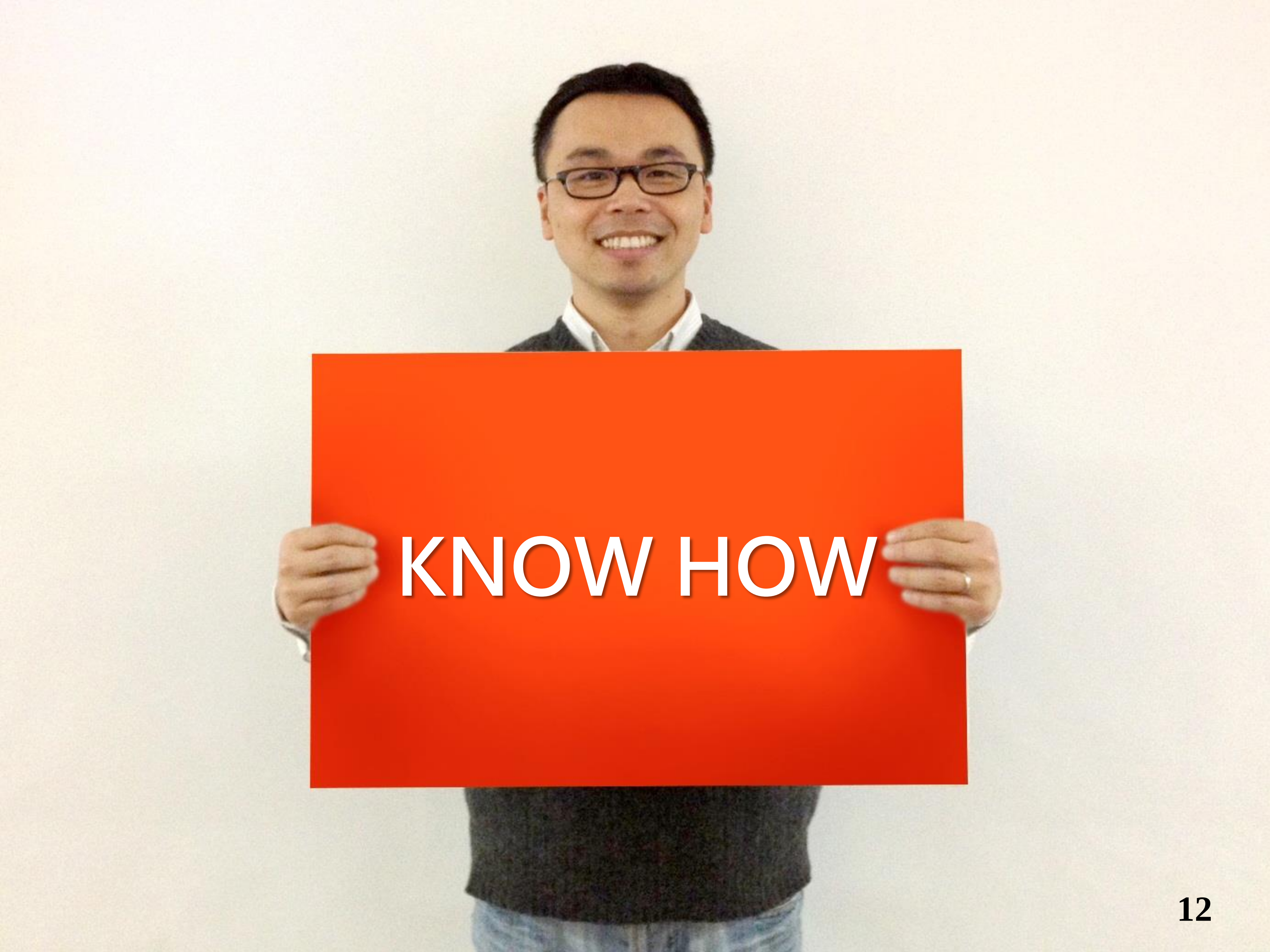






Typhoon Loss Assessment System




KNOW HOW

Loss Researches in Taiwan

王如意等(2001,2002)
水災損失評估系統模式之建立

糠瑞林等(2005)
工商業淹水災害損失曲線

劉錦龍等(2007)
颱洪災害損失評估與風險分攤及減輕機制之研究

李欣輯等(2010)
水災及坡地災害之GIS損失評估系統

王如意等(2001,2002)
水災損失評估系統模式之建立

張靜貞等(2003)
公共部門颱洪災害損失評估與風險分攤及減輕機制之研究

許文科(2005)
整合性洪災風險評估系統之開發

劉格非等(2009)
土石流直接災損評估之研究

李欣輯(2010)
水災及坡地災害之GIS損失評估系統

House

Agriculture

Industry

Public

蘇明道等(2001,2006)
普查資料於洪災損失推估之應用
區域洪災風險評估系統中損害評估模組之建立

蕭代基等(2002-2003, 2007)
個人與家戶颱洪災害損失評估與風險分攤及減輕機制之研究
淡水河流域洪災損失機率風險分析

張靜貞等(2003)
基隆河汐止、五堵地區居民參與意洪災保險意願之研究

楊曉文(2007)
分區分級颱洪災害保險制度下風險衡量與合理保費之分析

李欣輯(2008,2010)
水災家戶損失模型建立
坡地災害家戶損失模型建立

陳吉仲等(2003)
農業颳洪災害損失之估計與風險分攤及減輕之經濟分析

張靜貞等(2003)
基隆河汐止、五堵地區居民參與意洪災保險意願之研究

劉格非等(2009，2010)
土石流直接及間接災損評估之研究

Disaster Survey by NCDR

2005	2006	2007	2008	2010	2011	2012	2014	2015
Flood	Flood	Flood	Earth-quake	Typhoon	Typhoon	Typhoon	Typhoon	Typhoon
Landslide	Landslide	Typhoon		Landslide	Landslide	Landslide	Landslide	
				Flood	Flood	Flood	Flood	

Literature review- Loss Assessment

（Shaw, et al., 2005）

Damage Loss =

Lost value of service flows ***from the date of the flood until the date of the decision to restore*** *the damaged capital*

\+ Min

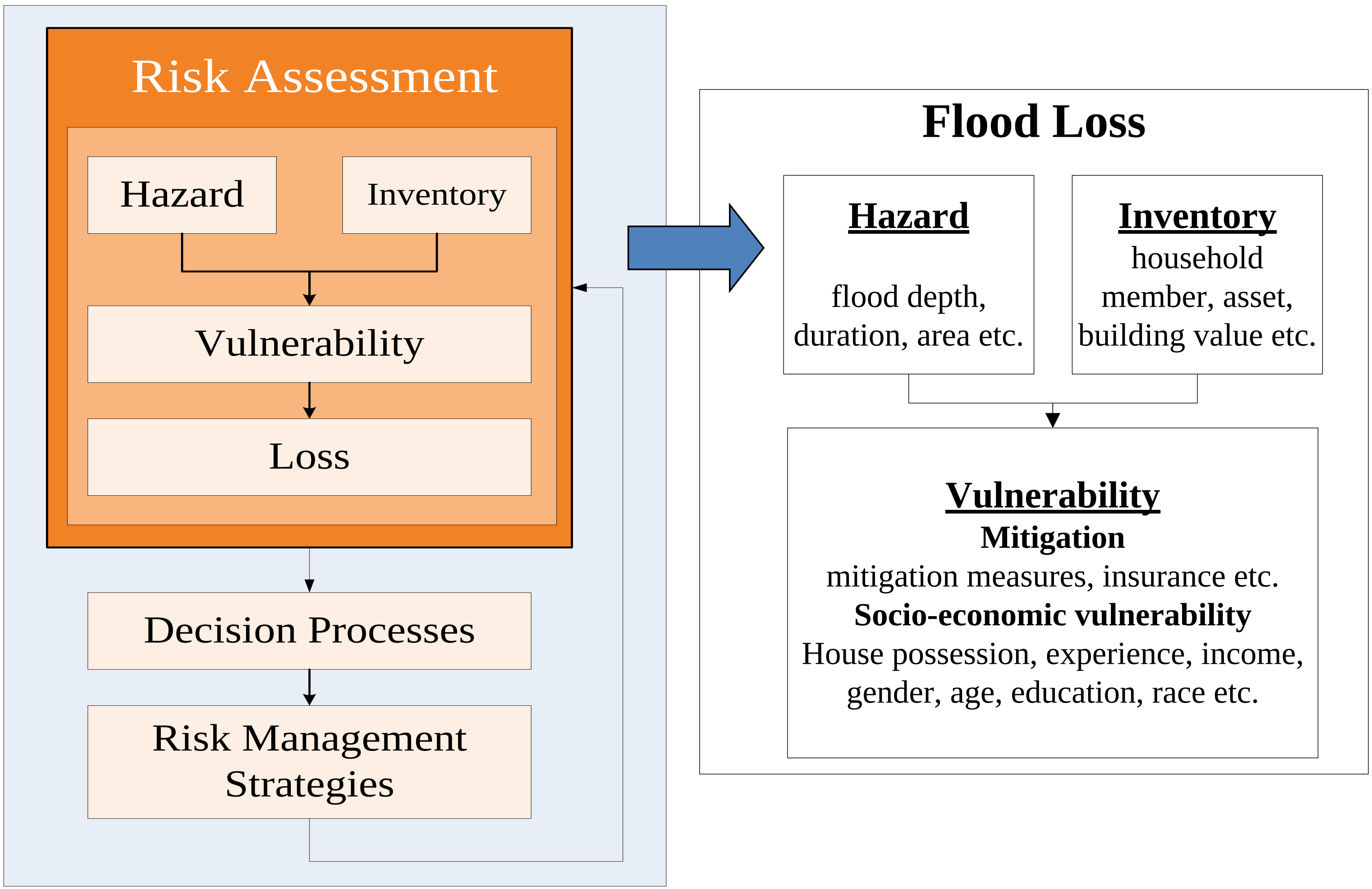
1. *Lost value of service flows* ***from the date of the decision to restore the damaged capital until an indefinite future.***
2. ***The cost of restoration*** *plus the lost value of services during the period of restoration*
3. ***The cost of replacement*** *plus the lost value of services during the period of replacement*

An example for Car loss after flood disaster

Method / Content	Economics Method	Engineering Method
(1) The loss of car services during the car broke 	V	?
(2) The loss of replacement 	V	V
(3) The loss of restoration 	V	?
Total Loss	(1)+(2) Or (1)+(3)	(1)

Framework of risk assessment

(Grossi et al. 2005, Cutter et al. 2003)



The Content of Loss Estimation

Capital	Item	Loss Content	
Human Capital	Human Capital Loss	The cost for absence form work	
		The cost of disease caused by disaster	Medical expenses
			The cost for absence form work
Man-made Capital	House Loss	The cost of structure recovery	
		The cost for taking refuge	
		The cost of clean and decoration	Absence from work
			Pay for clean
	Appliances Loss	The cost for fixing or losing furniture or electric equipment.	
	Transportation	The cost for fixing or losing car or motorbike.	
	Public Facility	The cost of fixing public facility	
Natural Capital	Land Loss	The value of land	

Total Loss = Human capital Loss+ House Loss+ Appliances Loss
+ Transportation Loss+ Public Facility Loss+ Land loss

The survey data of flood loss

- Survey
  Typhoon --MINDULLE（2004/07/01）
  Typhoon --AERE（2004/08/25）
  911 Flood （2004/09/11）
- Survey area：Five counties
  (Taipei, Keelung, Taichung, Chiayi and Yulin)
- Survey method：367 samples
  (sample error is 5.1%)

敏督利(2004)颱風路徑圖
7月2日23時
解除陸上警報
7月2日17時
7月2日08時
7月1日14時
7月1日08時
6月30日20時
7月1日05時
發布陸上警報
6月29日23時

Loss Simultaneous Model

$$Loss = f\,(X_1, X_2, X_3)$$

X_1 : hazard indicators

X_2 : exposure indicators

X_3 : vulnerability indicators related to preparedness, coping and recovery abilities

Flood household loss model

Variables	Coefficient	T-statistics	P Value
Constant	-1.418	-0.582	(0.561)
Log (flood depth (cm))	1.966	8.300	(0.000)***
Log (regional flood duration (hour))	0.493	3.512	(0.001)***
Log (house member)	0.756	2.875	(0.004)**
House possession dummy	-1.515	-2.969	(0.003)**
Log (flood experience)	0.346	1.782	(0.076)
Log (average household income)	0.166	0.708	(0.480)
F value		(16.758)***	

* Significance at 95% level ** Significance at 99% level *** Significance at 99.9% level

Verification of flood loss model

Data	Average loss/ household	Inaccuracy
Flood survey on 2004	27,407 NTD	11.22%
Model Result	30,483 NTD	

Data	Average loss/ household	Inaccuracy
Flood survey on 2005	32,110 NTD	10.24%
Model Result	28,821 NTD	

Model accuracy nearly 90 %

Landslide household loss model

Hazard indicators

- Landslide coverage
- Height of landslide
- The size of the biggest stone

Exposure indicators

- Household type
- Number of household people

Vulnerability indicators

- Education
- Sex
- Religion
- Hazard experience
- Living period
- Income
- Community/household preparedness

Landslide household loss model

The total effective sample size were 241.

Independent Variables	B	Beta
Constant	9.360	---
Log square measure being covered by debris flow (m2)	0.736	(0.000)***
Log height of debris flow coverage (m)	0.603	(0.000)***
Number of members per household	0.092	(0.009)***
Disaster experience having been through	0.210	(0.001)***
House type- Pure residence	-0.015	(0.000)***
Community disaster preparedness	-0.231	(0.000)***
Construction type – RC material	0.451	(0.010)**
Adj. R2	0.536	

* Significance at 0.05 level ** Significance at 0.01 level *** Significance at 0.001 level

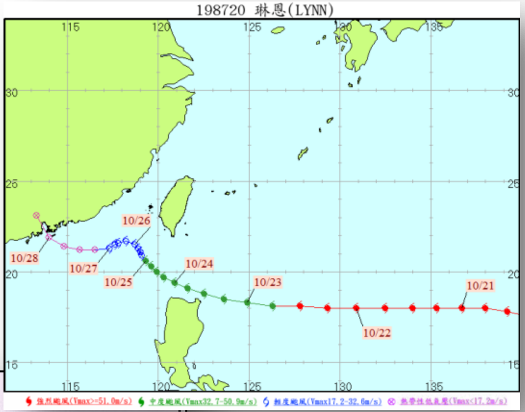
Business Loss

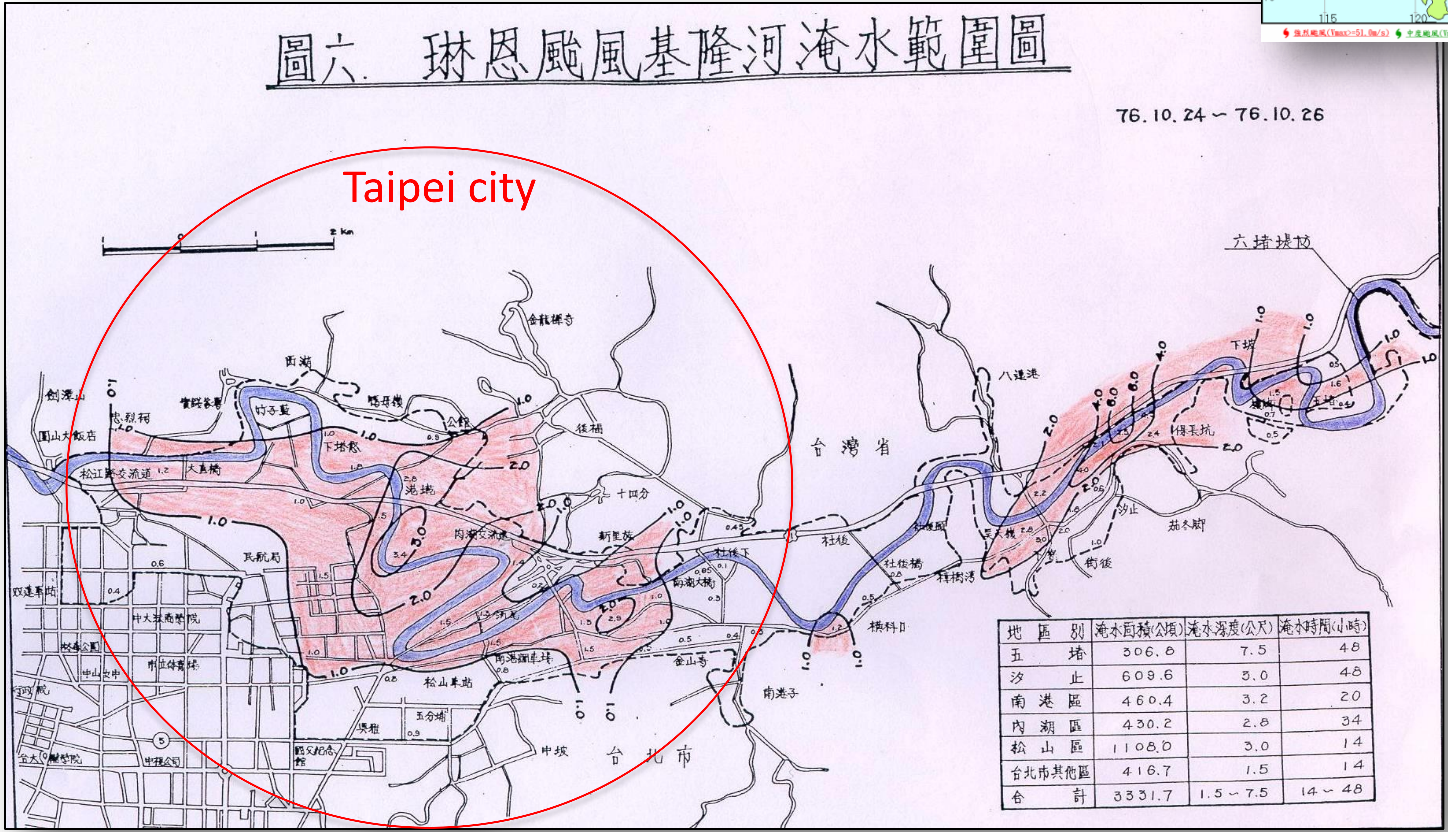
Typhoon Events of Business Loss

1987 Typhoon LYNN

Flood depth 3m

Total loss US 36 Million





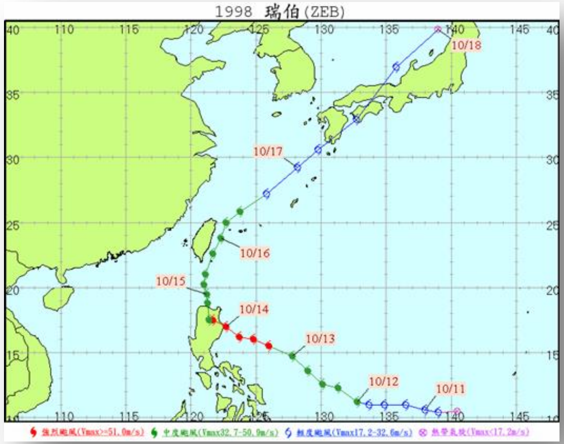
地區別	淹水面積(公頃)	淹水深度(公尺)	淹水時間(小時)
五堵	306.8	7.5	48
汐止	609.6	3.0	48
南港區	460.4	3.2	20
內湖區	430.2	2.8	34
松山區	1108.0	3.0	14
台北市其他區	416.7	1.5	14
合計	3331.7	1.5 ~ 7.5	14 ~ 48

Typhoon Events of Business Loss

1998 Typhoon ZEB

Flood depth 5 m

Total loss US 200 Million

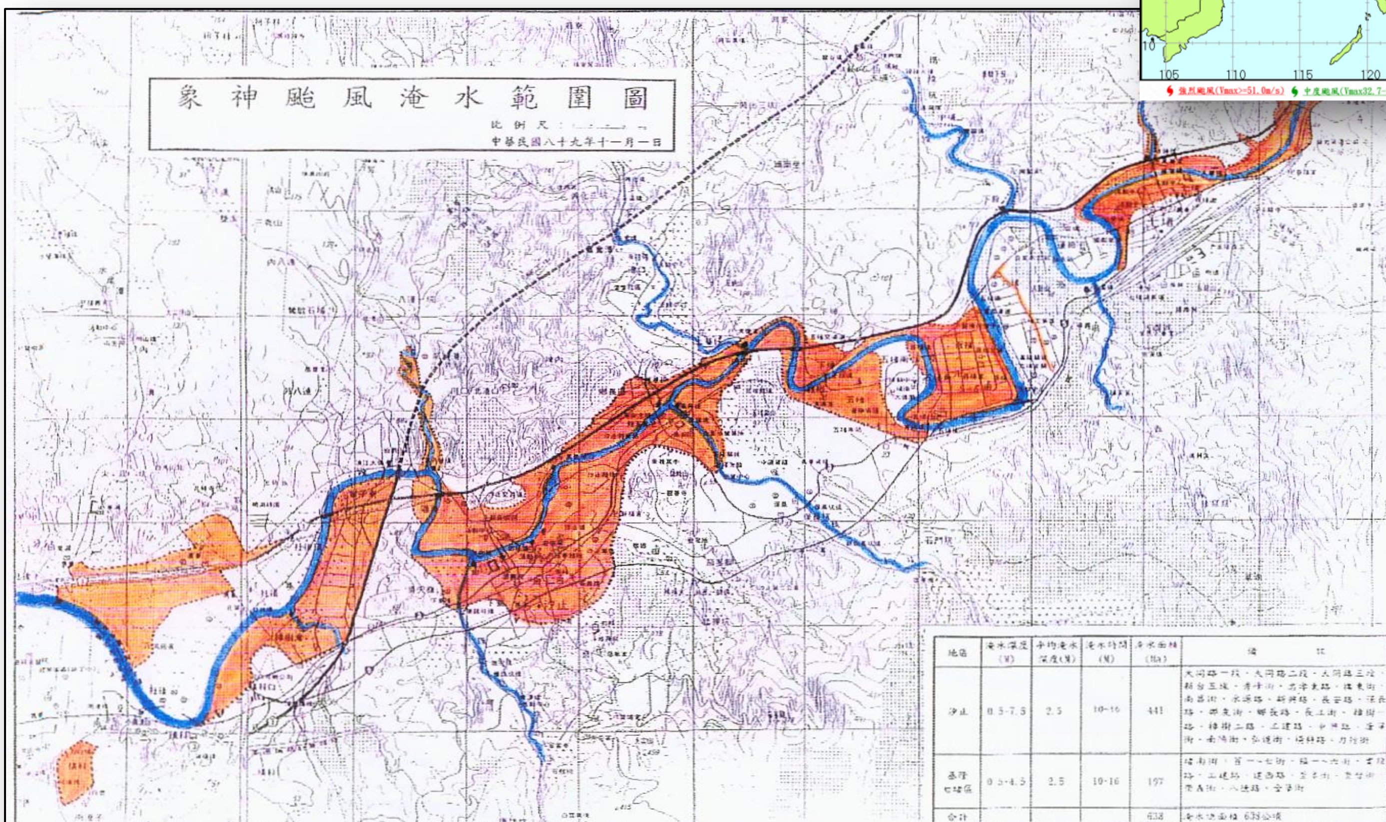


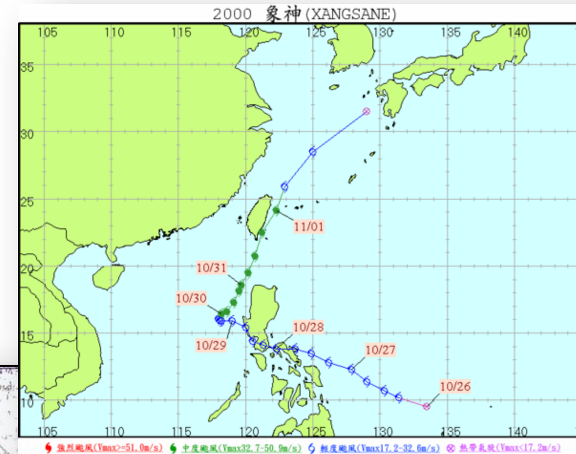
Typhoon Events of Business Loss

2000 Typhoon XANGSANE

Flood depth 8 m

Total loss US 100 Million



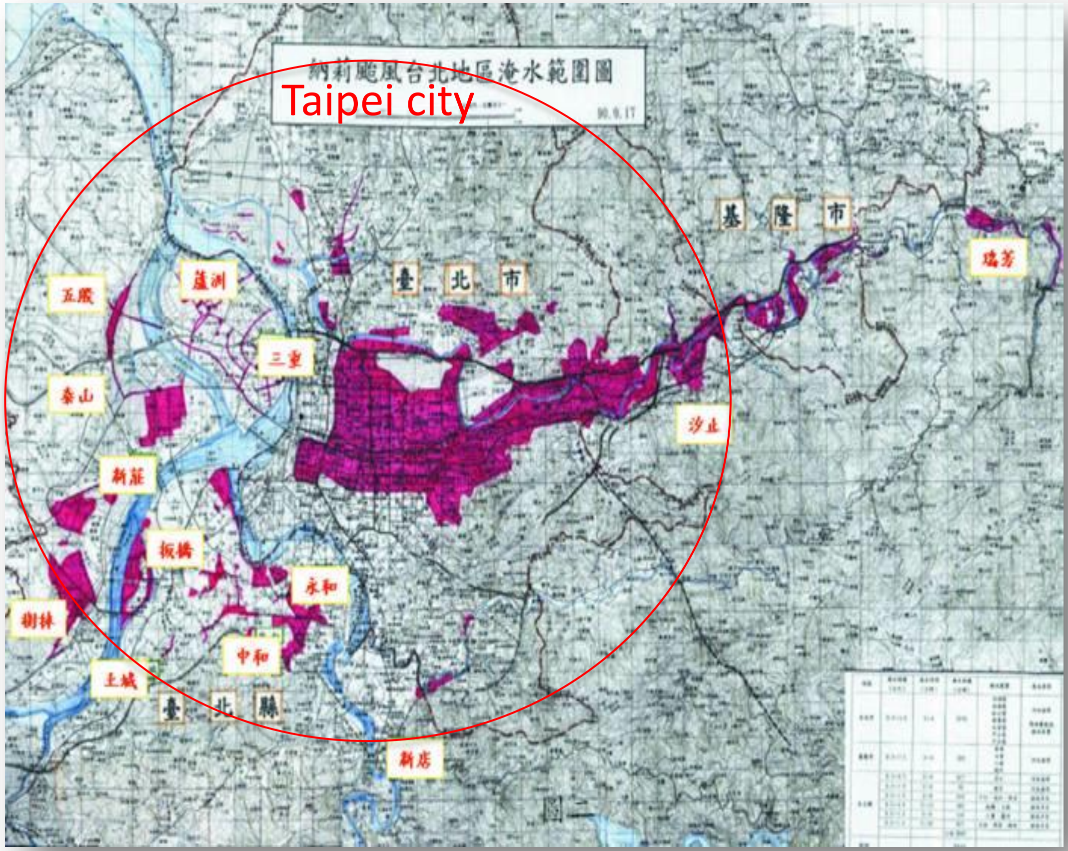


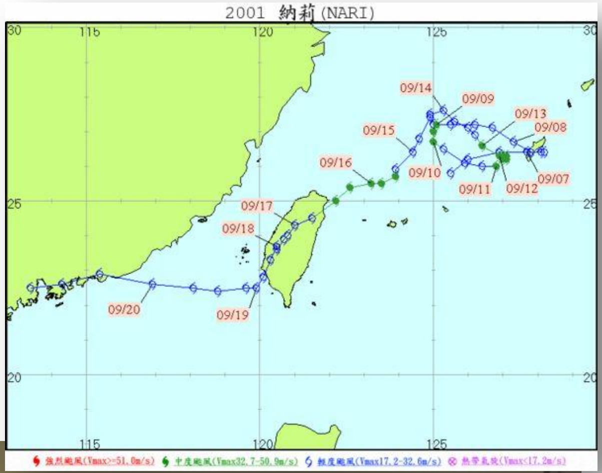
Typhoon Events of Business Loss

2001 Typhoon NARI

Flood depth 8 m

Total loss US 1 billion



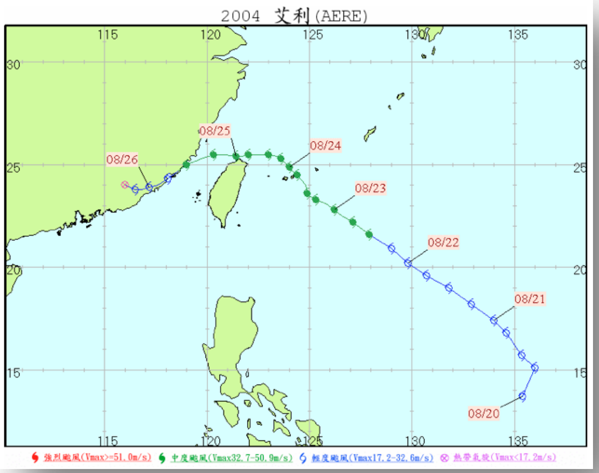


Typhoon Events of Business Loss

2004 Typhoon AERE

Flood depth 3 m

Total loss US 70 Million



DATA SURVEY

Fubon Financial | About Us | Brand Story | CSR | Investors | Corporate Governance | News

About Fubon > Milestones

Milestones

Years Select

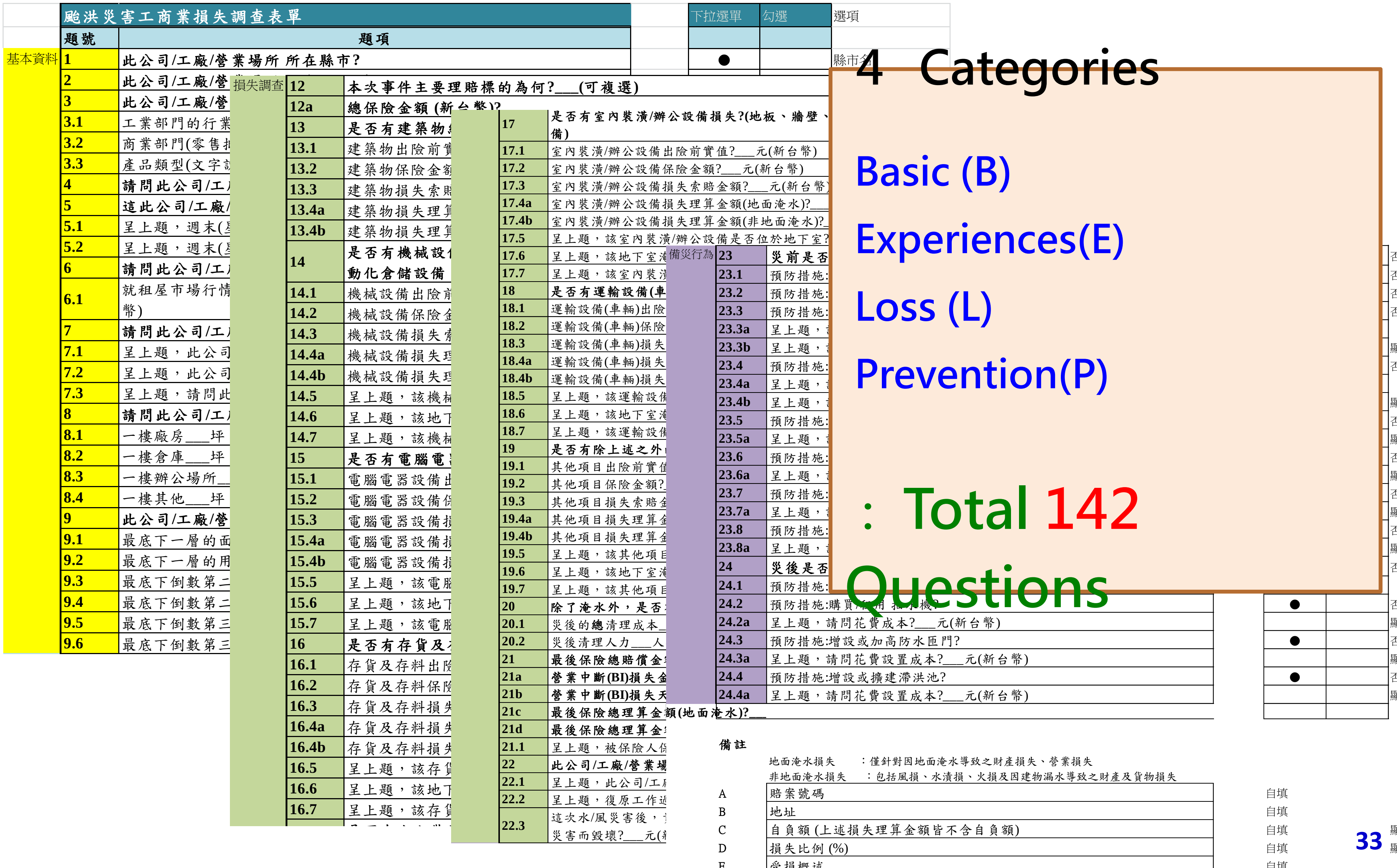
1982

- Fubon Insurance takes over the top spot in Taiwan's property and casualty insurance market.

1961

- Cathay Insurance Co., Ltd.—the predecessor of Fubon Insurance—is founded, launching the Fubon Group on its path to prosperity.

DATA SURVEY-QUESTIONNAIRE



4 Categories

Basic (B)

Experiences(E)

Loss (L)

Prevention(P)

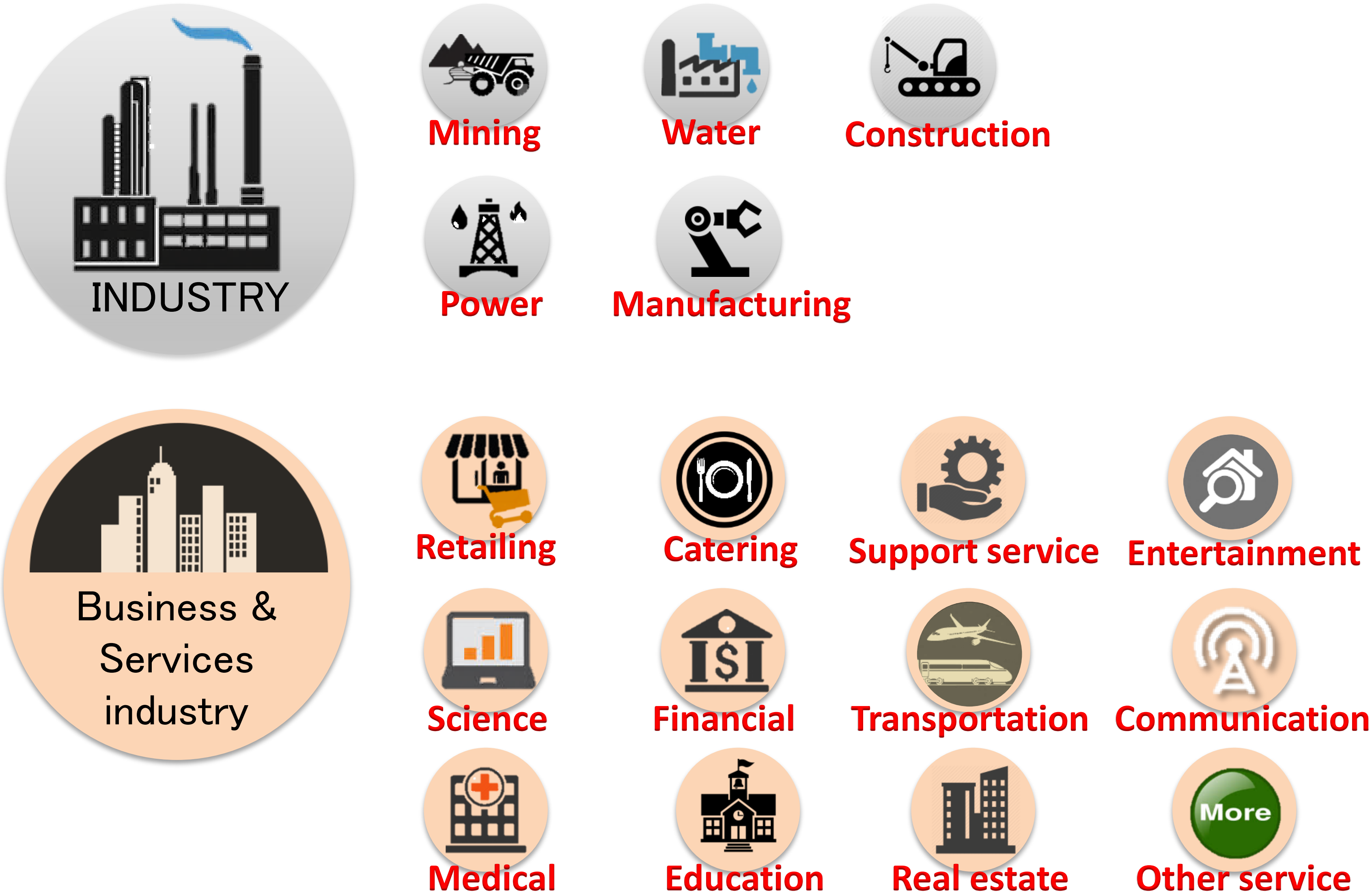
：Total 142 Questions

DATA SURVEY

Loss Issue

- Building
- Machine
- Electric
- Stock
- Decoration
- Transportation
- Basement
- Business Interruption

DATA ANALYSIS_ sample type



DATA ANALYSIS_ typhoon events

NCDR

Total 26 events

2001
納莉颱風

2004
艾利颱風

2005
龍王颱風
海棠颱風
泰利颱風
蘇拉颱風

2007
0605豪雨
聖帕颱風
韋帕颱風
柯羅莎颱風

2008
鳳凰颱風
辛樂克颱風
薔蜜颱風

2009
莫拉克颱風

2010
凡那比颱風
梅姬颱風

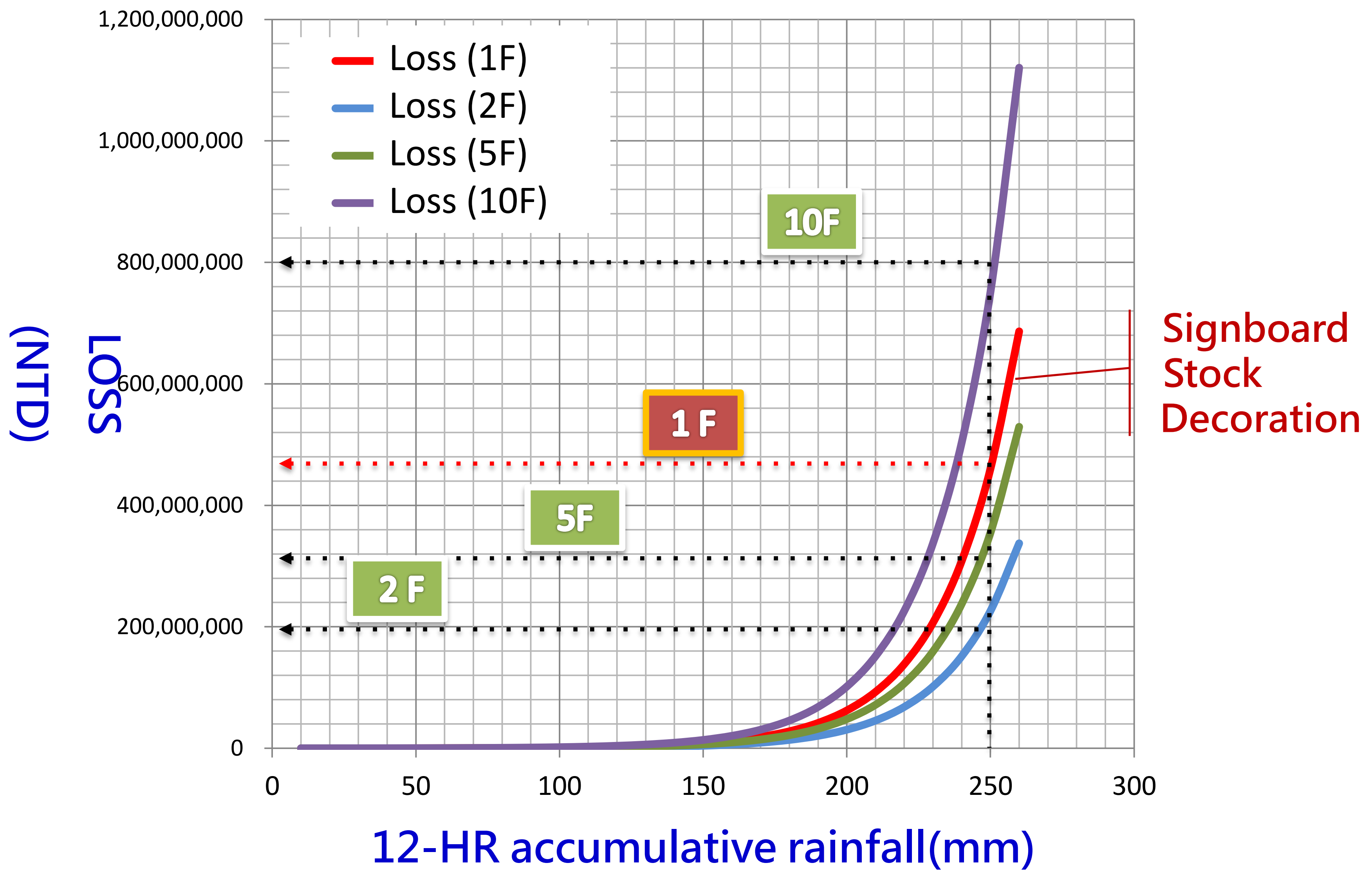
2011
米雷颱風

2012
0612豪雨
蘇拉颱風
天秤颱風
杰拉華颱風

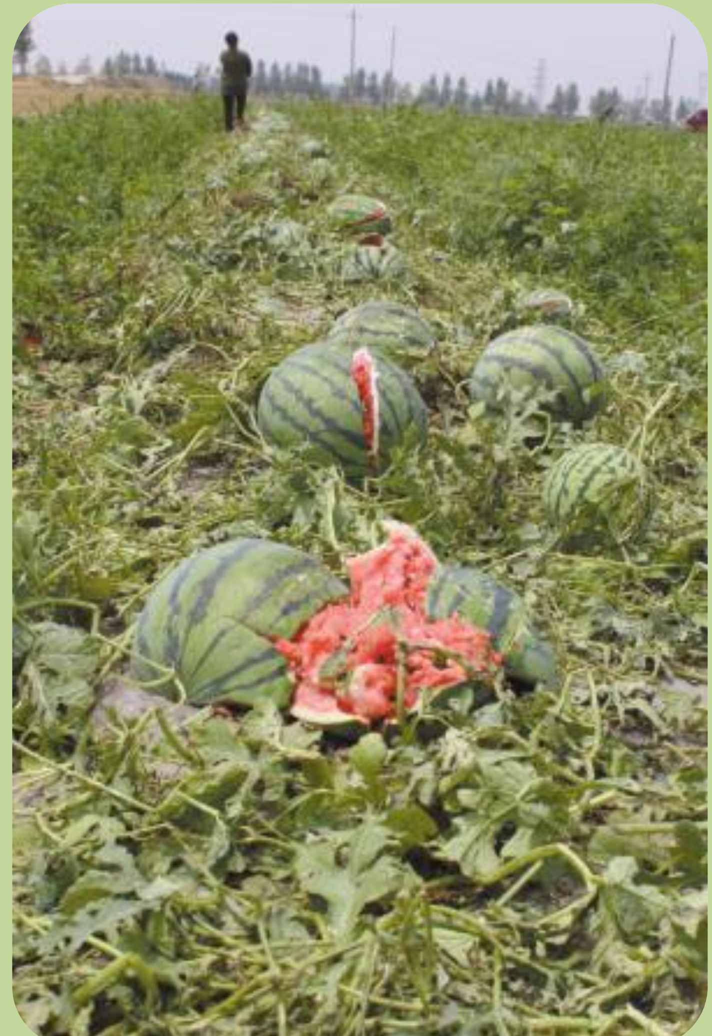
2013
蘇力颱風
潭美颱風
天兔颱風

2014
0529豪雨
麥德姆颱風

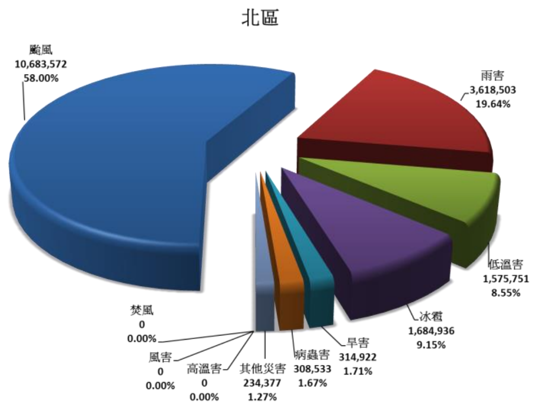
Wind Loss-Taipei & New Taipei city

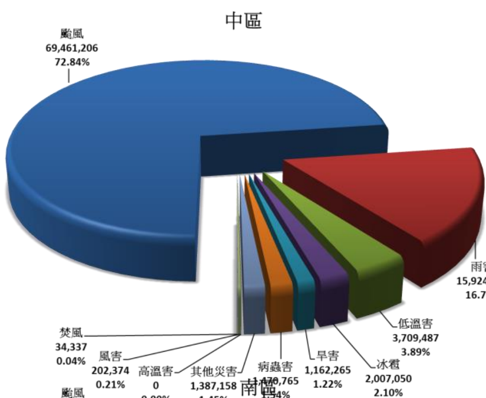


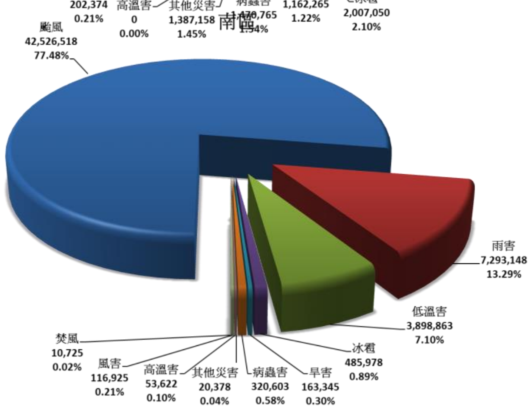
Agriculture Loss



Agriculture Loss

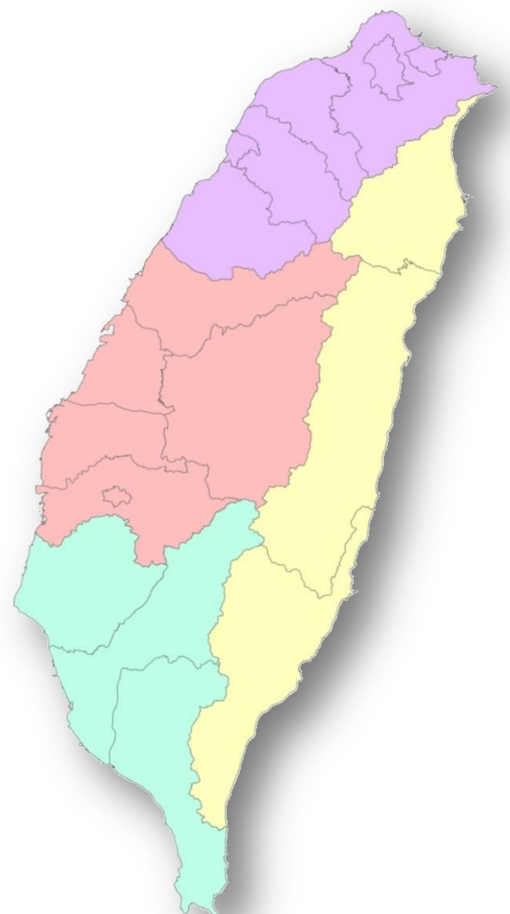


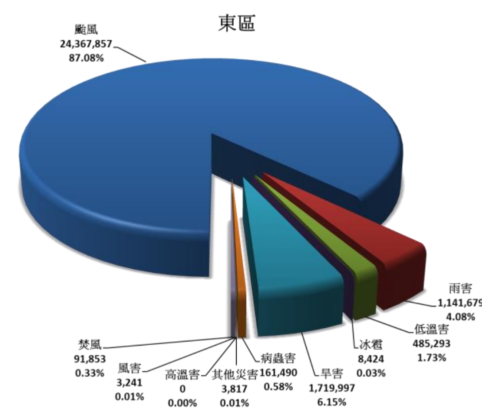




單位：千元 /年

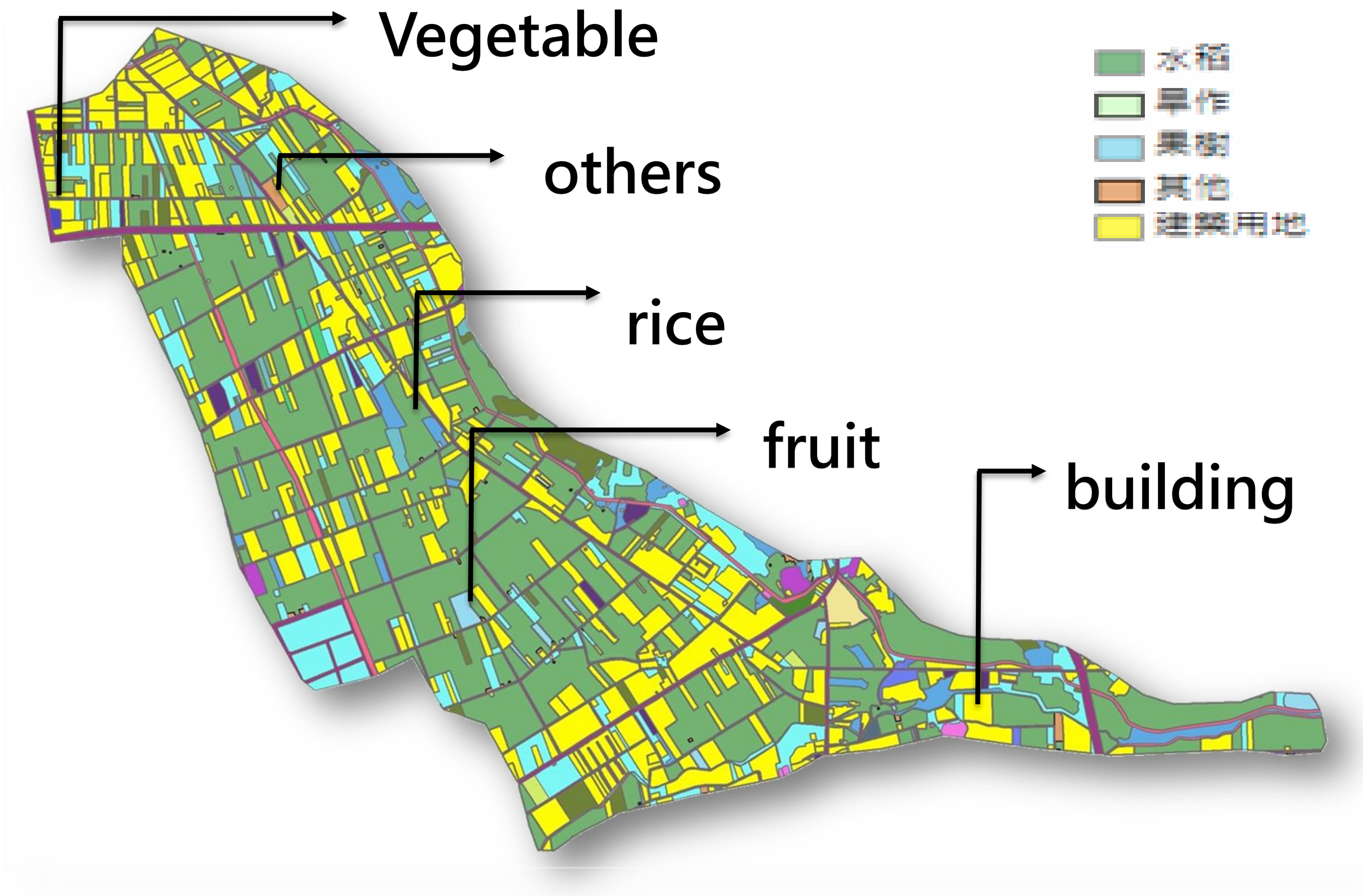
- 颱風
- 雨害
- 低溫害
- 冰雹
- 旱害
- 病蟲害
- 其他災害
- 高溫害
- 風害
- 焚風



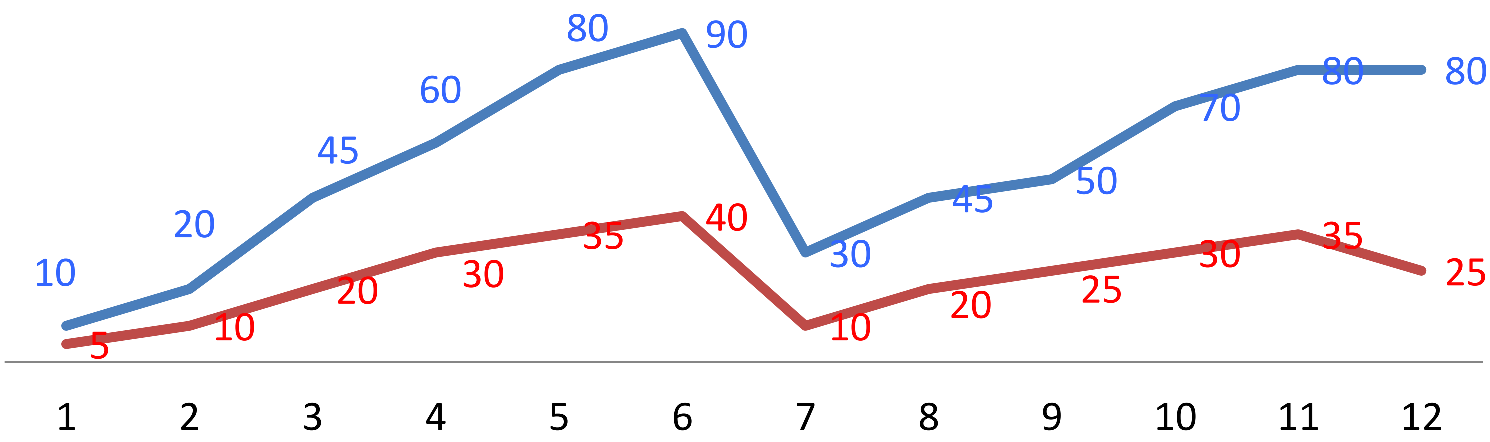


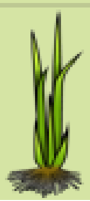
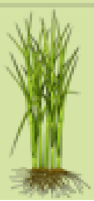
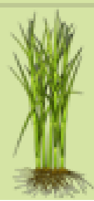
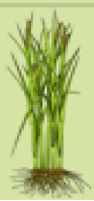
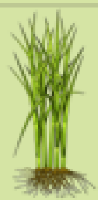
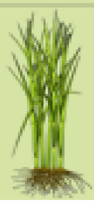
註：災害損失價值為民國70-99年平均
(資料來源：農試所)

Agriculture Loss

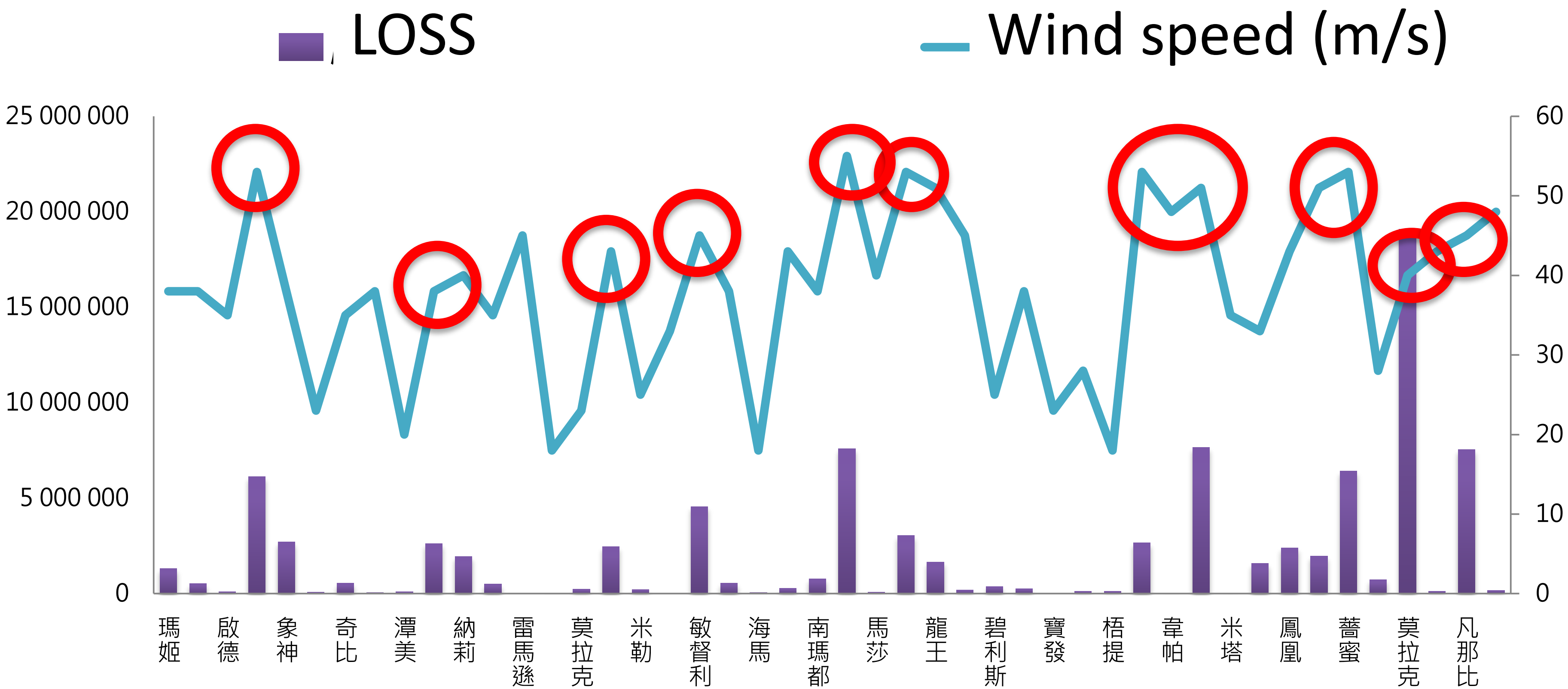


Rice Loss ratio

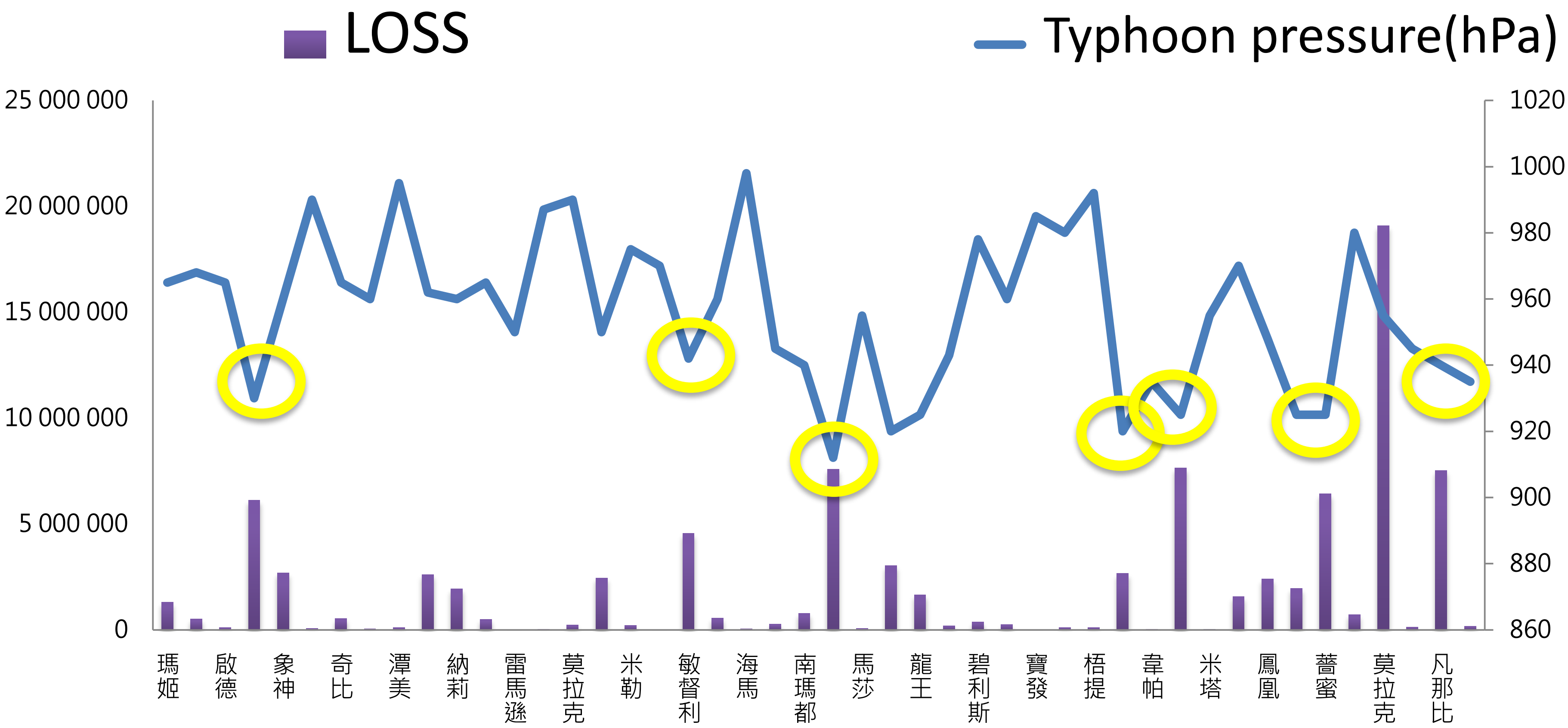


月份	1	2	3	4	5	6	7	8	9	10	11	12
易發生災害	寒害 旱害	寒害 旱害	病蟲害 水害 冰雹		病蟲害 高溫 水害	颱風 水害	颱風 水害 高溫			病蟲害 颱風 焚風	水害 霪雨	水害
生育時期	苗期		最高分蘗期	孕穗期與開花期	穀粒充實期	成熟期	苗期	最高分蘗期		孕穗期與開花期	穀粒充實期	成熟期
生長示意圖												

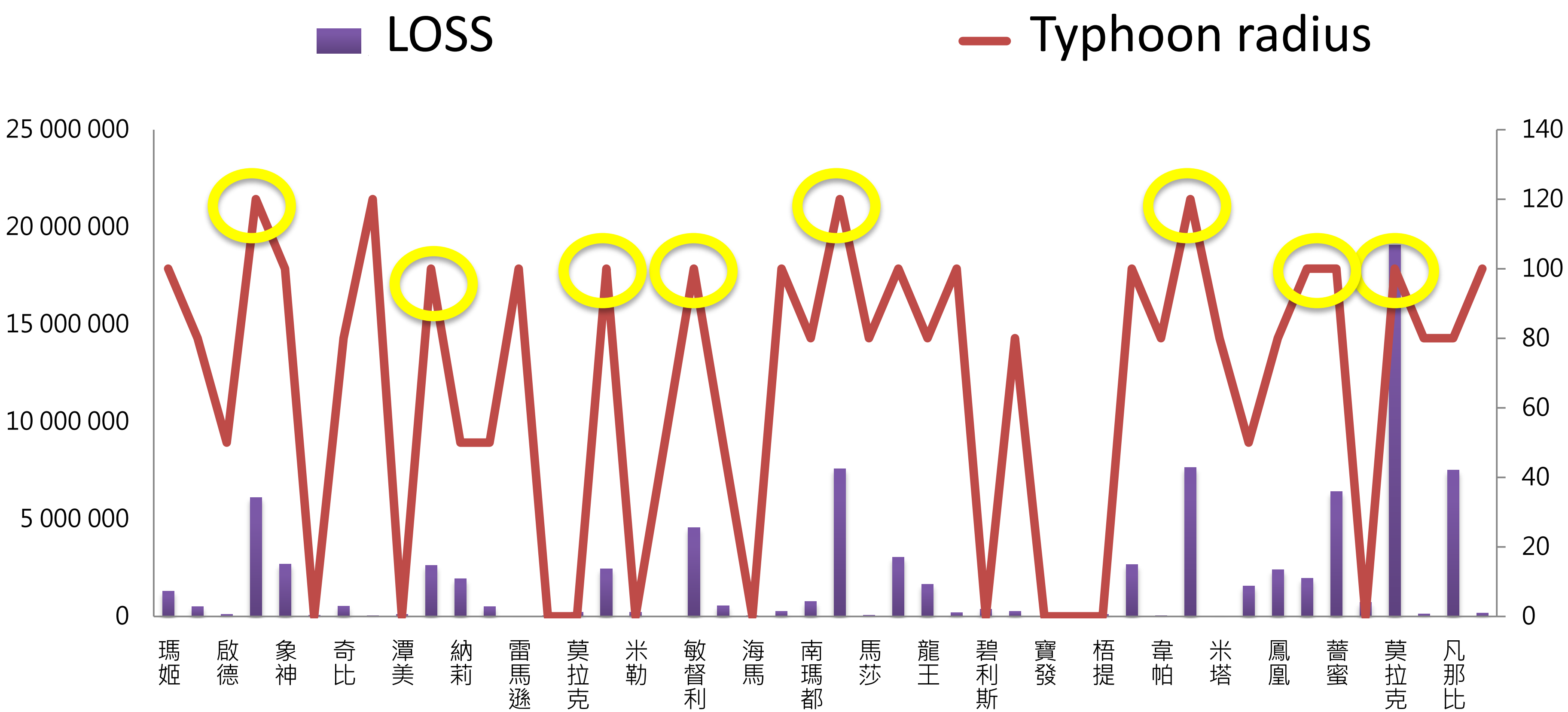
Agriculture Loss Factors

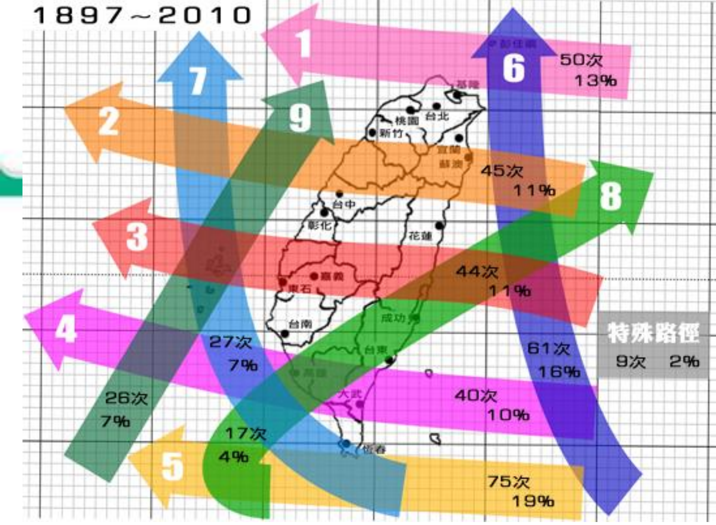


Agriculture Loss Factors

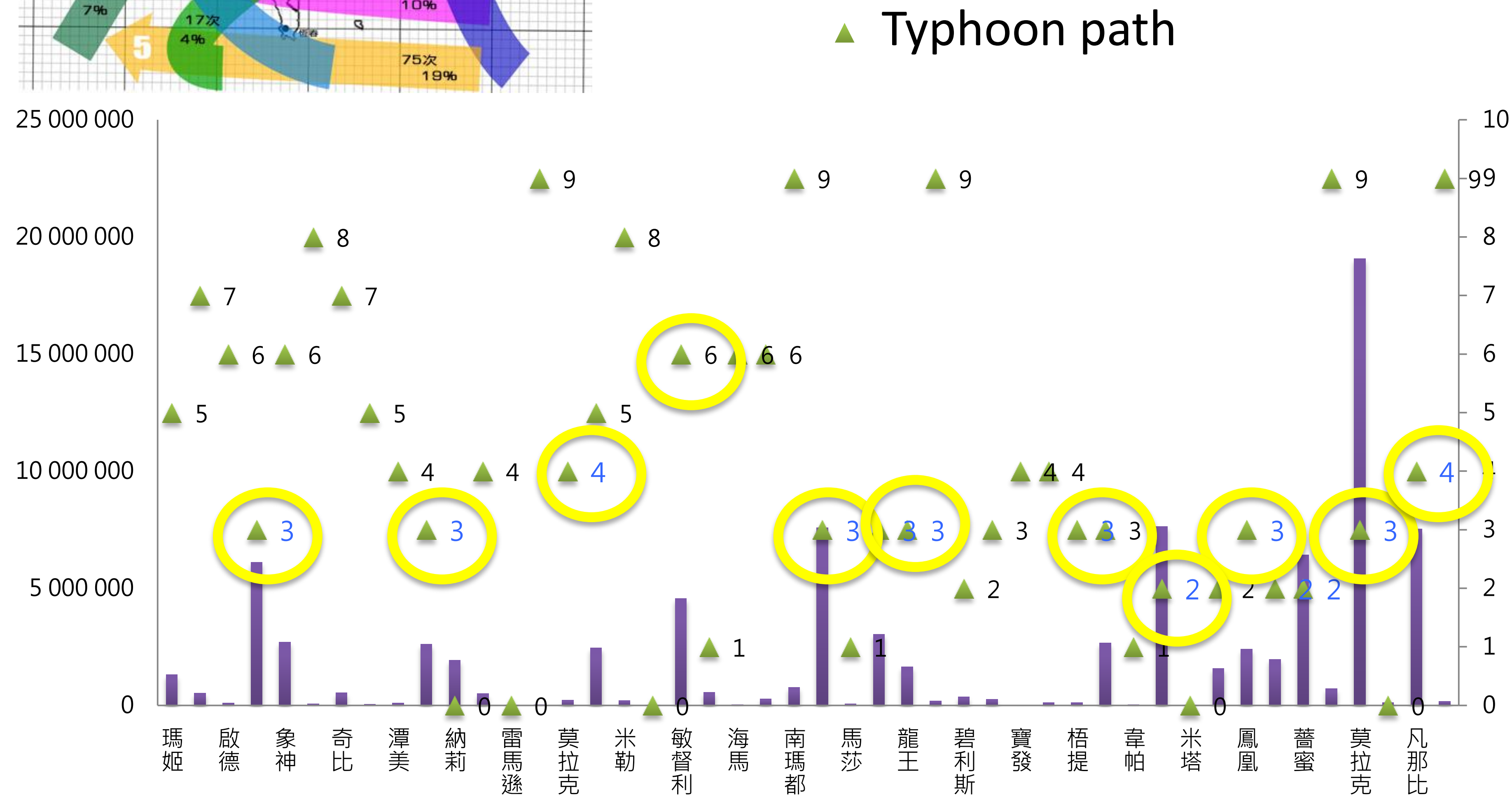


Agriculture Loss Factors





Loss Factors



Loss models

Our system now able to calculate loss by 27 main land-use types.

代碼	類別_1	R	G	B	色塊
01	農業使用土地	102	255	000	
0101	農作	102	255	000	
010101	稻作	102	255	000	
010102	旱作	051	255	102	
010103	果樹	000	255	102	
010104	廢耕地	204	255	153	
0102	水產養殖	204	255	204	
010200	水產養殖	204	255	204	
0103	畜牧	153	255	102	
010301	畜禽舍	153	255	051	
010302	牧場	000	255	051	
0104	農業附帶設施	204	255	000	
010401	溫室	204	255	102	
010402	倉儲設施	102	255	153	
010403	農產品展售場	102	255	051	
010404	其他設施	102	255	102	

代碼	類別_2	R	G	B	色塊
02	森林使用土地	000	153	000	
0201	天然林	000	153	000	
020101	天然針葉樹純林	051	204	153	
020102	天然闊葉樹純林	051	204	051	
020103	天然竹林	102	204	000	
020104	天然竹針闊葉混淆林	000	204	000	
0202	人工林	051	153	000	
020201	人工針葉樹純林	051	153	000	
020202	人工闊葉樹純林	051	204	000	
020203	人工竹林	153	204	102	
020204	人工竹針闊葉混合林	000	153	102	
0203	其他森林使用土地	000	153	051	
020301	伐木跡地	204	204	153	
020302	苗圃	051	255	000	
020303	防火線	204	051	153	
020304	土場	204	153	000	

代碼	類別_3	R	G	B	色塊
03	交通使用土地	255	153	153	
0301	機場	051	000	255	
030100	機場	051	000	255	
0302	鐵路	255	051	255	
030201	一般鐵路	255	051	255	
030202	高速鐵路	255	000	255	
030203	鐵路相關設施	255	102	255	
0303	道路	255	153	153	
030301	國道	255	051	051	
030302	省道、快速道路	255	102	102	
030303	一般道路	255	153	153	
030304	道路相關設施	204	204	204	
0304	港口	255	051	204	
030401	商港	255	000	204	
030402	漁港	255	000	153	
030403	專用港	255	051	153	
030404	其他港口相關設施	255	051	102	

代碼	類別_4	R	G	B	色塊
04	水利使用土地	051	051	255	
0401	河道	051	051	255	
040101	河川	051	051	255	
040102	減河	051	051	204	
040103	運河	000	102	255	
040104	堤防	255	255	102	
0402	溝渠	051	102	255	
040200	溝渠	051	102	255	
0403	蓄水池	102	153	204	
040301	水庫	000	000	102	
040302	湖泊	000	000	255	
040303	其他蓄水池	000	000	153	
040304	人工湖	000	051	204	
0404	水道沙洲灘地	204	153	051	
040400	水道沙洲灘地	204	153	051	
0405	水利構造物	051	051	102	
040501	水閘門	102	102	102	
040502	抽水站	051	051	102	
040503	水庫堰壩	102	102	051	
040504	地下取水井	000	000	102	
040505	其他設施	000	051	255	
0406	防汛道路	153	153	102	
040600	防汛道路	153	153	102	
0407	海面	000	000	204	
040700	海面	000	000	204	

代碼	類別_5	R	G	B	色塊
05	建築使用土地	255	255	000	
0501	商業	255	000	000	
050101	零售批發	255	000	000	
050102	服務業	204	000	000	
0502	住宅	255	255	000	
050201	純住宅	255	255	000	
050202	兼工業使用住宅	255	204	000	
050203	兼商業使用住宅	204	000	102	
050204	兼其他使用住宅	255	255	051	
0503	工業	204	102	000	
050301	製造業	204	102	000	
050302	倉儲	255	153	000	
0504	其他建築用地	153	102	000	
050401	宗教	051	000	204	
050402	殯葬設施	255	255	255	
050403	興建中	255	204	102	
050404	其他	153	102	000	

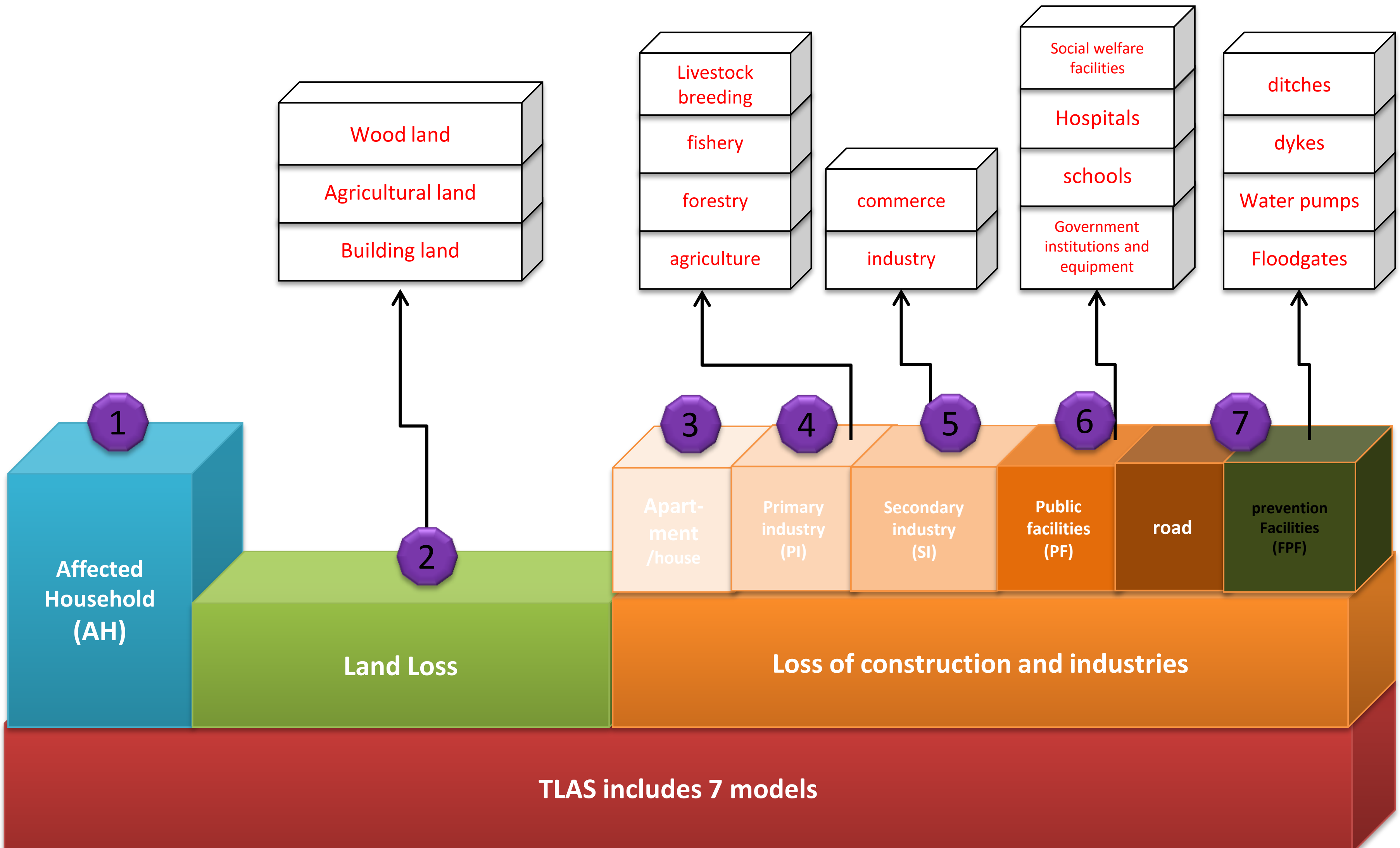
代碼	類別_6	R	G	B	色塊
06	公共設施使用土地	204	000	204	
0601	政府機關	204	000	204	
060100	政府機關	204	000	204	
0602	學校	153	000	153	
060201	幼稚園	204	153	204	
060202	小學	153	000	153	
060203	中學	153	000	204	
060204	大專院校	204	000	255	
060205	特種學校	153	051	204	
0603	醫療保健	000	102	204	
060300	醫療保健	000	102	204	
0604	社會福利設施	255	153	255	
060400	社會福利設施	255	153	255	
0605	公用設備	000	204	204	
060501	氣象	000	255	255	
060502	電力	051	255	255	
060503	瓦斯	102	255	255	
060504	自來水	000	204	255	
060505	加油站	204	051	051	
0606	環保設施	153	255	255	
060600	環保設施	153	255	255	

代碼	類別_7	R	G	B	色塊
07	遊憩使用土地	000	051	000	
0701	文化設施	204	204	000	
070101	法定文化資產	204	204	000	
070102	一般文化設施	153	153	000	
070103	其他文化設施	204	204	102	
0702	休閒設施	000	204	051	
070201	公園綠地廣場	000	204	051	
070202	遊樂場所	255	102	253	
070203	體育場所	204	204	255	

代碼	類別_8	R	G	B	色塊
08	礦鹽使用土地	102	051	102	
0801	礦業	051	000	000	
080101	礦場	051	000	000	
080102	礦業相關設施	153	102	051	
0802	土石	102	051	102	
080201	土石採取場	102	051	102	
080202	土石相關設施	153	102	153	
0803	鹽業	153	153	204	
080301	鹽田	153	153	204	
080302	鹽業相關設施	153	153	255	

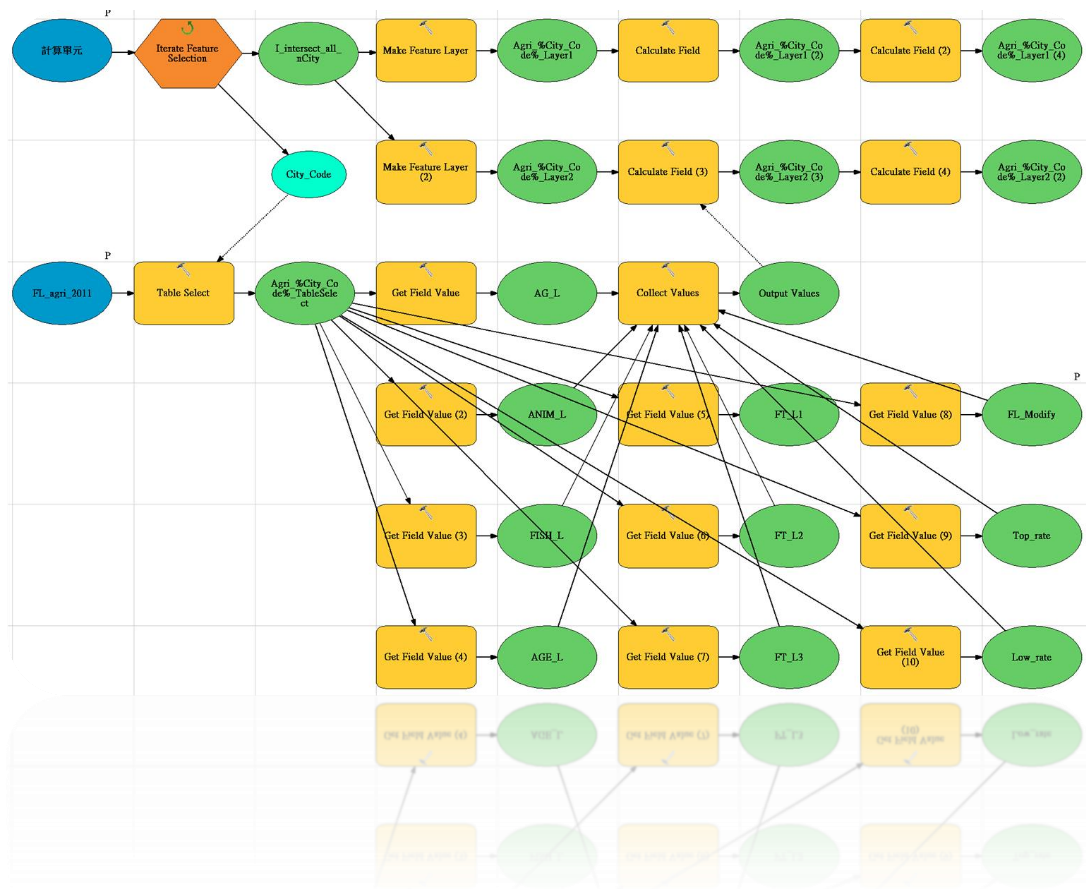
代碼	類別_9	R	G	B	色塊
09	其他使用土地	051	051	051	
0901	軍事用地	204	051	255	
090100	軍事用地	204	051	255	
0902	濕地	000	204	102	
090200	濕地	000	204	102	
0903	草生地	051	204	102	
090300	草生地	051	204	102	
0904	裸露地	102	051	000	
090401	灘地	051	051	000	
090402	崩塌地	102	102	000	
090403	礁岩	204	102	051	
090404	裸露空地	204	102	102	
0905	灌木荒地	153	153	051	
090500	灌木荒地	153	153	051	
0906	災害地	000	000	000	
090600	災害地	000	000	000	
0907	營建剩餘土石方	051	051	051	
090700	營建剩餘土石方	051	051	051	
0908	空置地	255	255	204	
090801	未使用地	204	204	051	
090802	人工改變中土地	204	153	102	
090803	[illegible]	153	000	051	

TLAS Taiwan Framework



TLAS character

- A ArcGis 10.0 based system
- Using a ArcGis tool "Model builder " to build Loss models calculation processes
- Recognizing Spatial /geographical area data only



Processes of Calculation

$$AH = \sum_{i=1}^{n} H\boldsymbol{F}A_i$$

(Household Number in disaster Area)

$$Landloss = \sum_{i=1}^{n} LV_i \times LLA_i$$

$$Plloss = \sum_{i}^{n} \propto_i [PIP_i \times PIA_i]$$

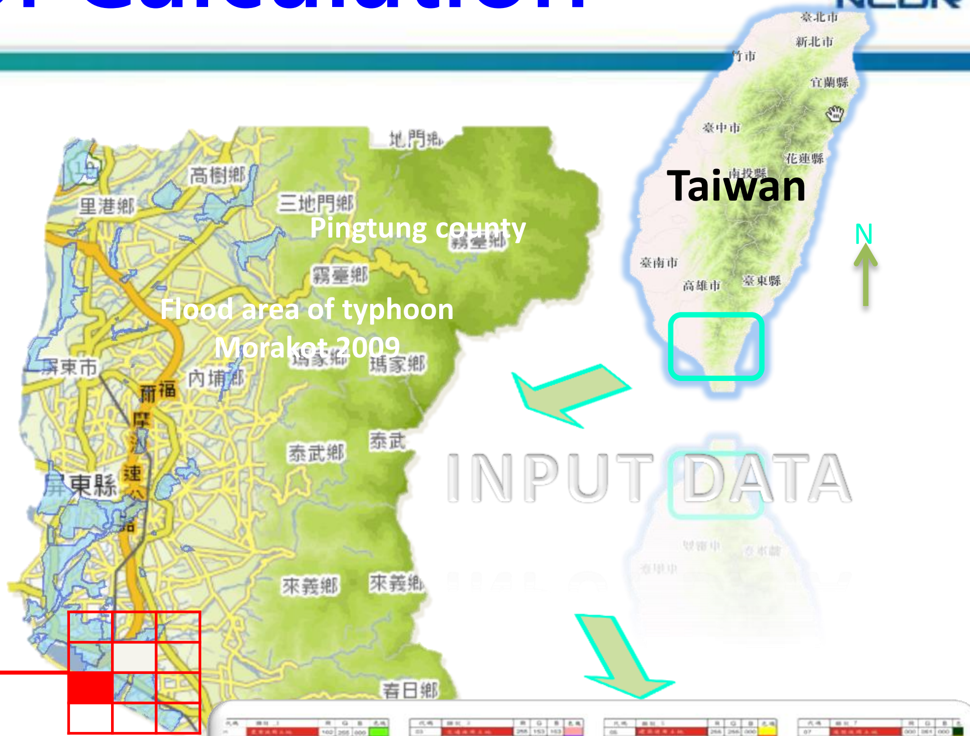
$$Slloss = \sum_{i}^{n} \propto_i [SIP_i \times SIA_i]$$

$$PFloss = \sum_{i=1}^{n} \sum_{j=1}^{m} \propto_i [PFP_{ij} \times PFA_{ij}]$$

$$\text{Road/FPF } loss = \sum_{i=1}^{n} \propto_i [\text{R/FPFP}_i \times \text{R/FPFA}_i]$$

householdloss=-0.421+1.875 Ln(flood depth)
-1.060(house possession)
+0.736 Ln(household members)
+0.159 Ln(income)
+0.637 Ln (flood duration)
-0.834 (apartment/mansion)
-0.028 (residential years)

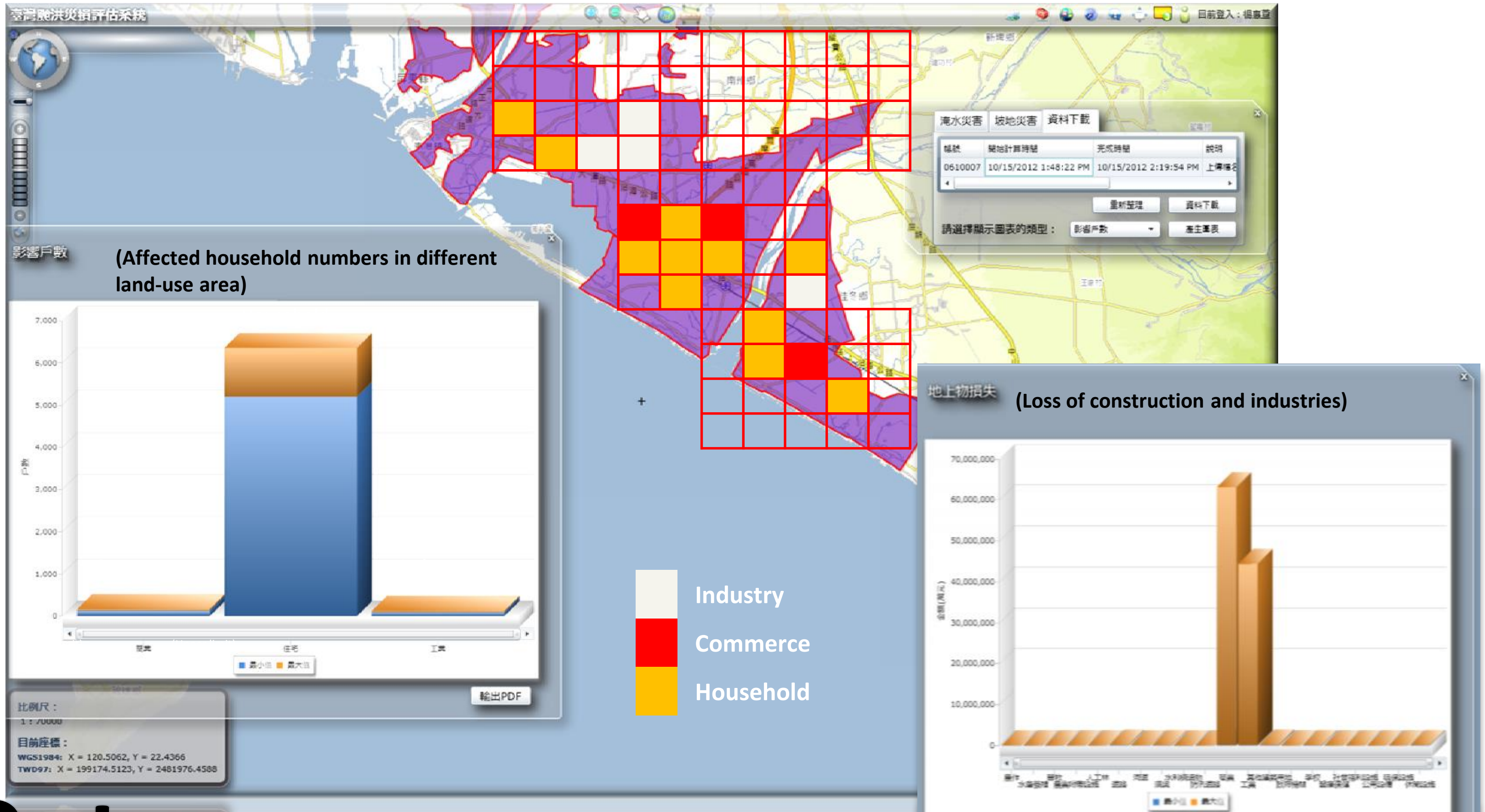
FORMULAS



INPUT DATA

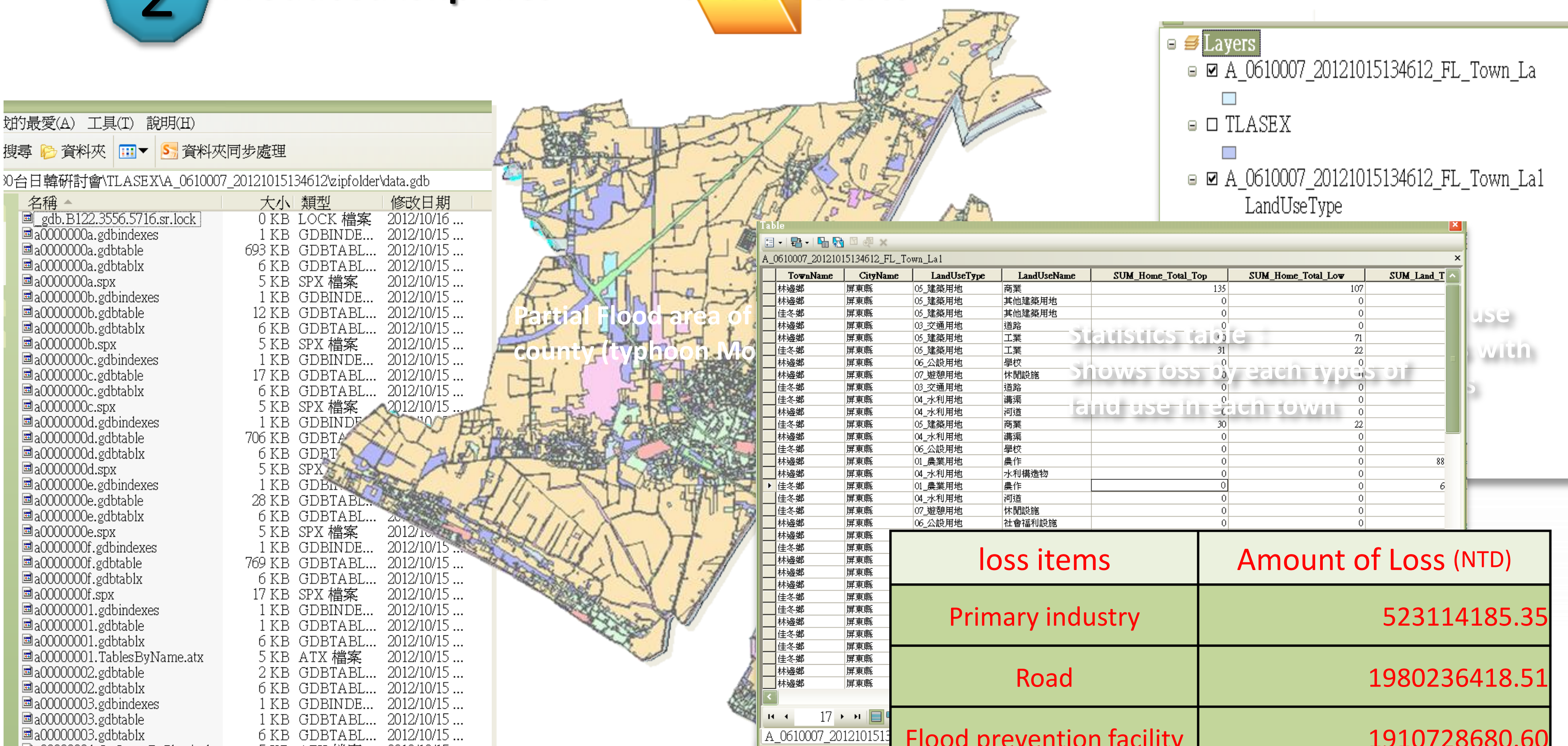
LAND-USE CATEGORIES

Automatically produced bar chart：Affected household Numbers, loss of production / structures



Outcomes

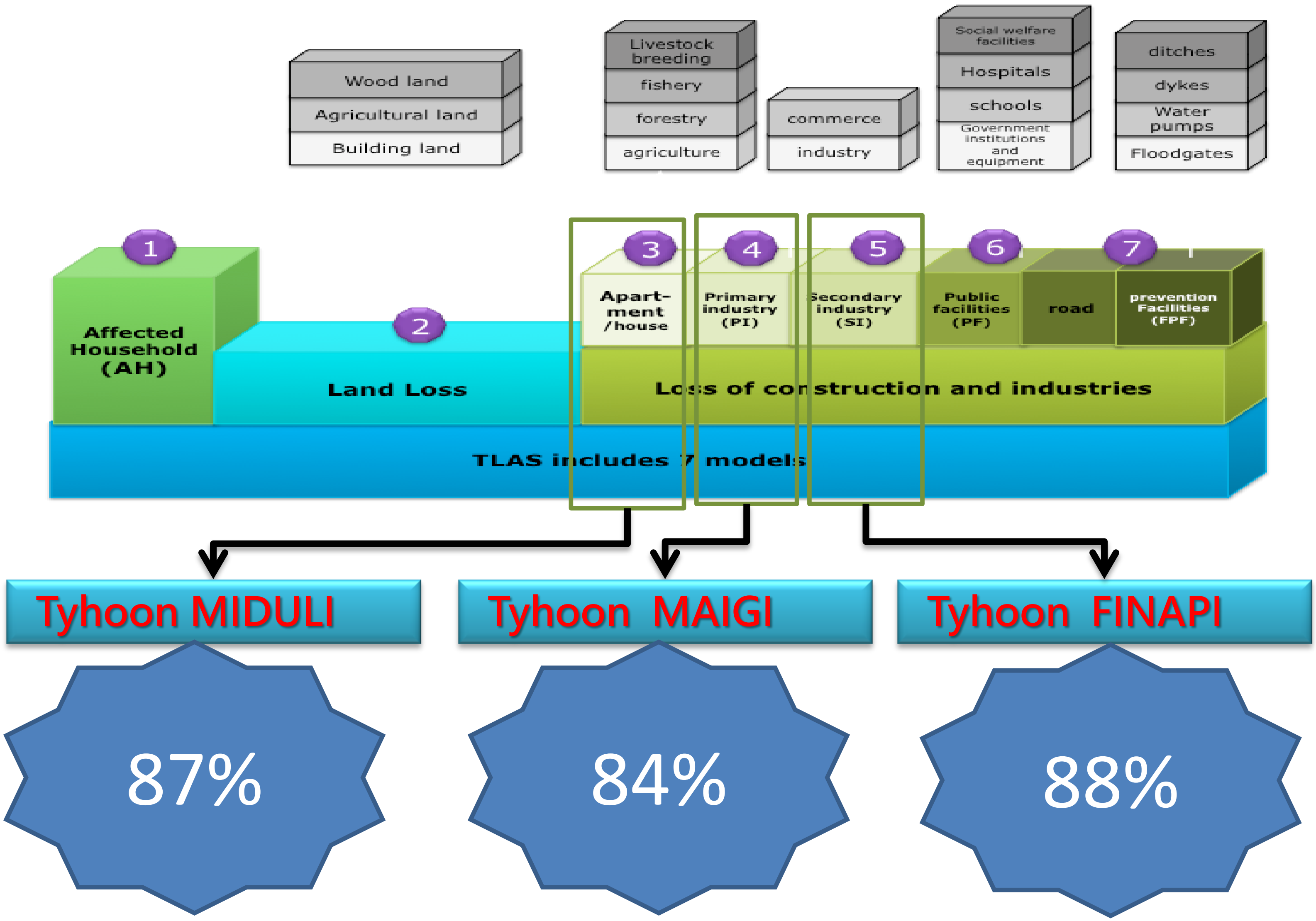
2 Produced .shp files and statistics



loss items	Amount of Loss (NTD)
Primary industry	523114185.35
Road	1980236418.51
Flood prevention facility	1910728680.60
Public facility	2826666880.11

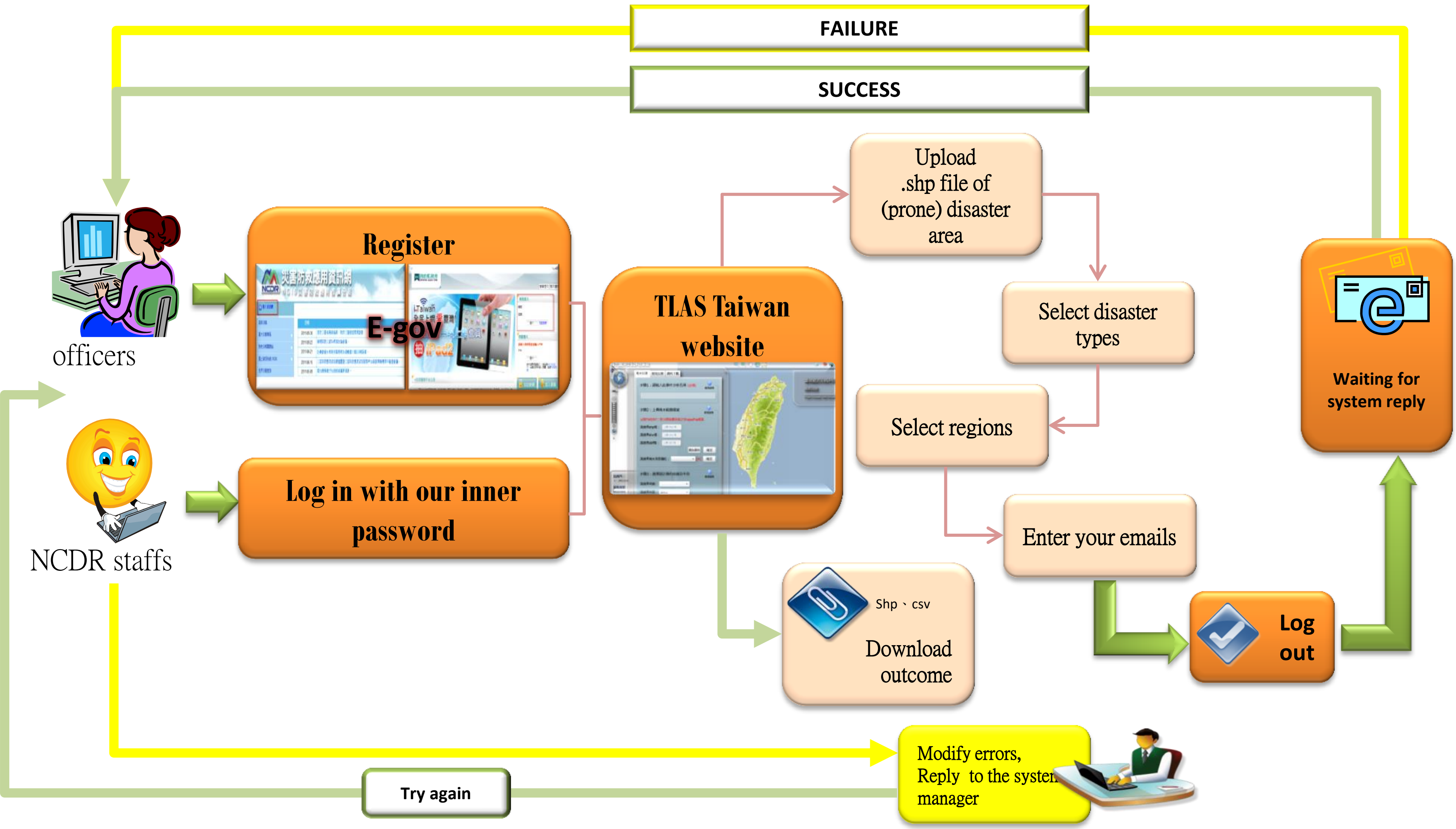
Outcomes

Loss Model Verification



Internet Server

TLAS Online operating procedure



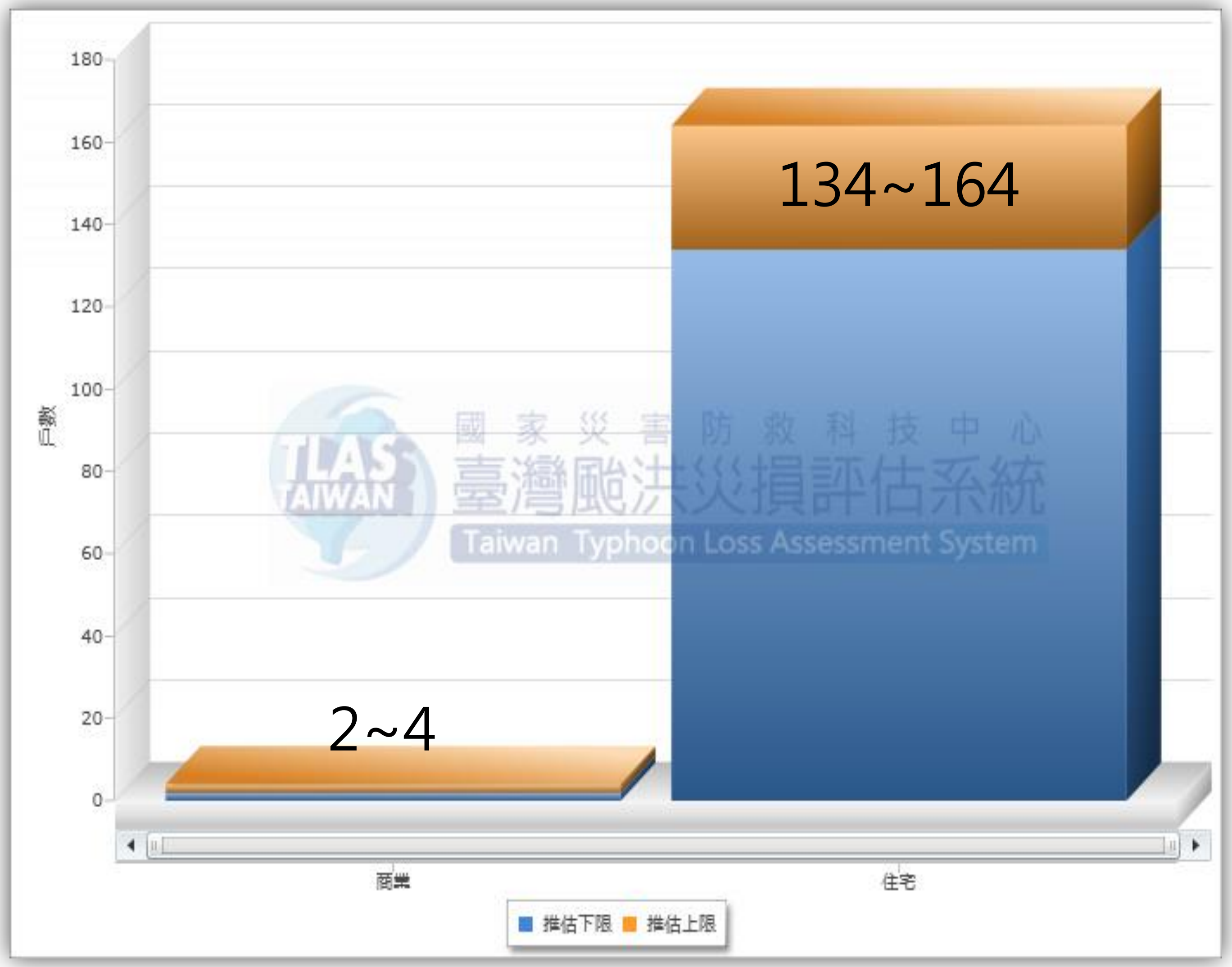

臺灣颱洪災損評估系統
臺灣颱洪災損評估系統
最新消息
Project Template: ESRI Standard Map Application
使用者登入
請輸入 AD 帳號、密碼
請輸入帳號：
請輸入密碼：
登入
比例尺：
1：2384380
目前座標：
WGS1984: X = 121.6199, Y = 24.4619
TWD97: X = 312842.9, Y = 2706318.8035
esri

LANDSLIDE LOSS ESTIMATION

Application examples

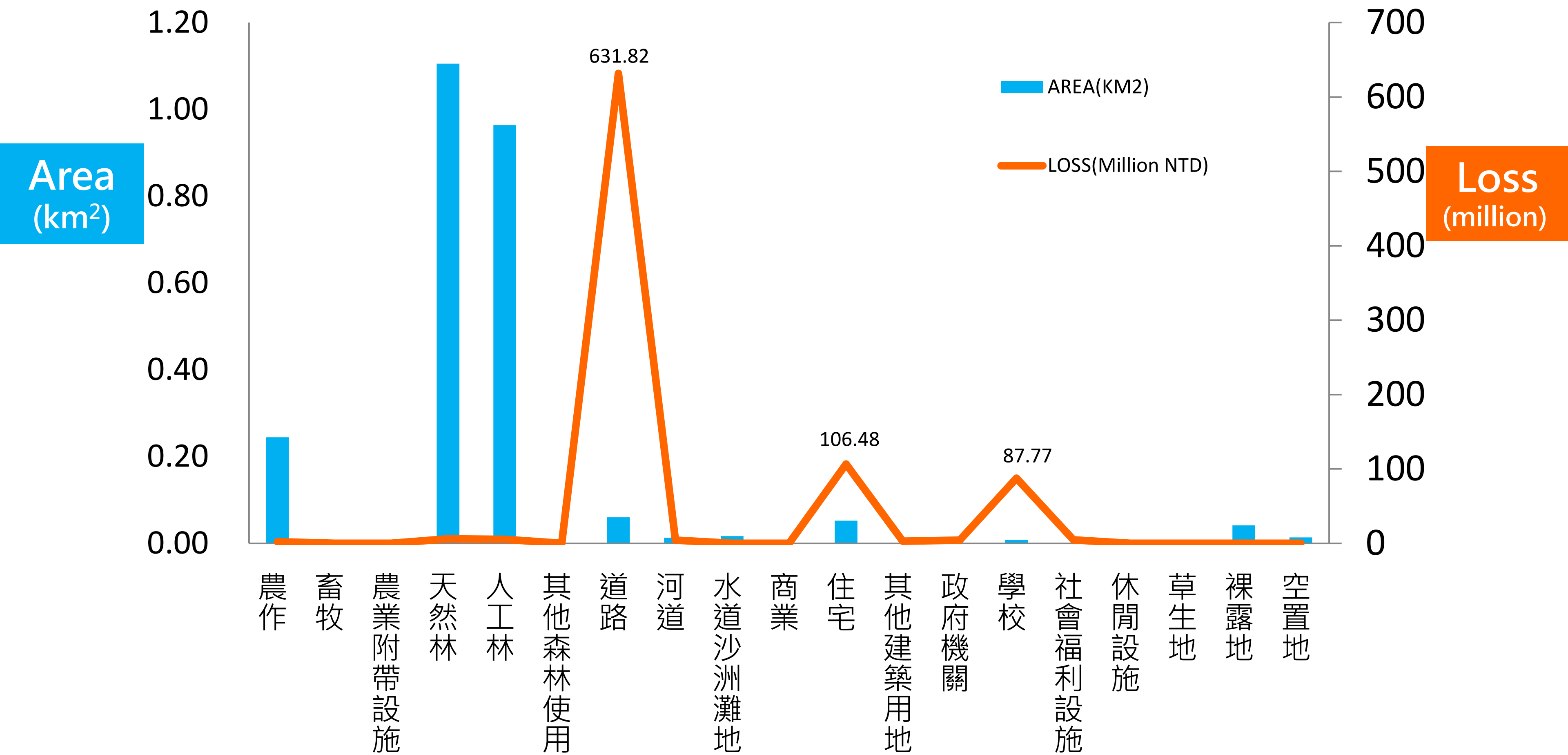
Application examples

AFFECTED 150 HOUSEHOLDS



Total Loss 8 Million NTD

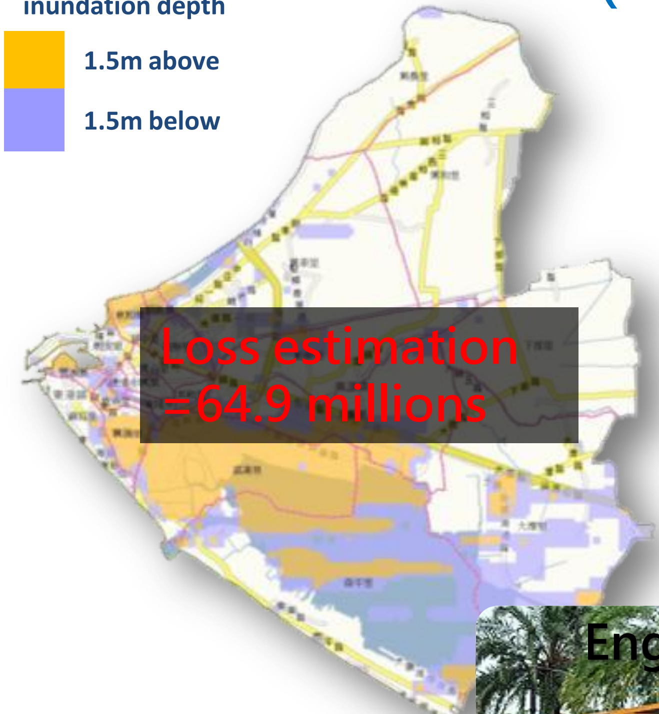
Application examples



Cost-benefit analysis
(single event example)

inundation depth

- 1.5m above
- 1.5m below



Loss estimation =64.9 millions

potential inundation area

Simulation

before | after

61.8 millions

Loss estimation =3.1millions

potential inundation area after execution of engineering project

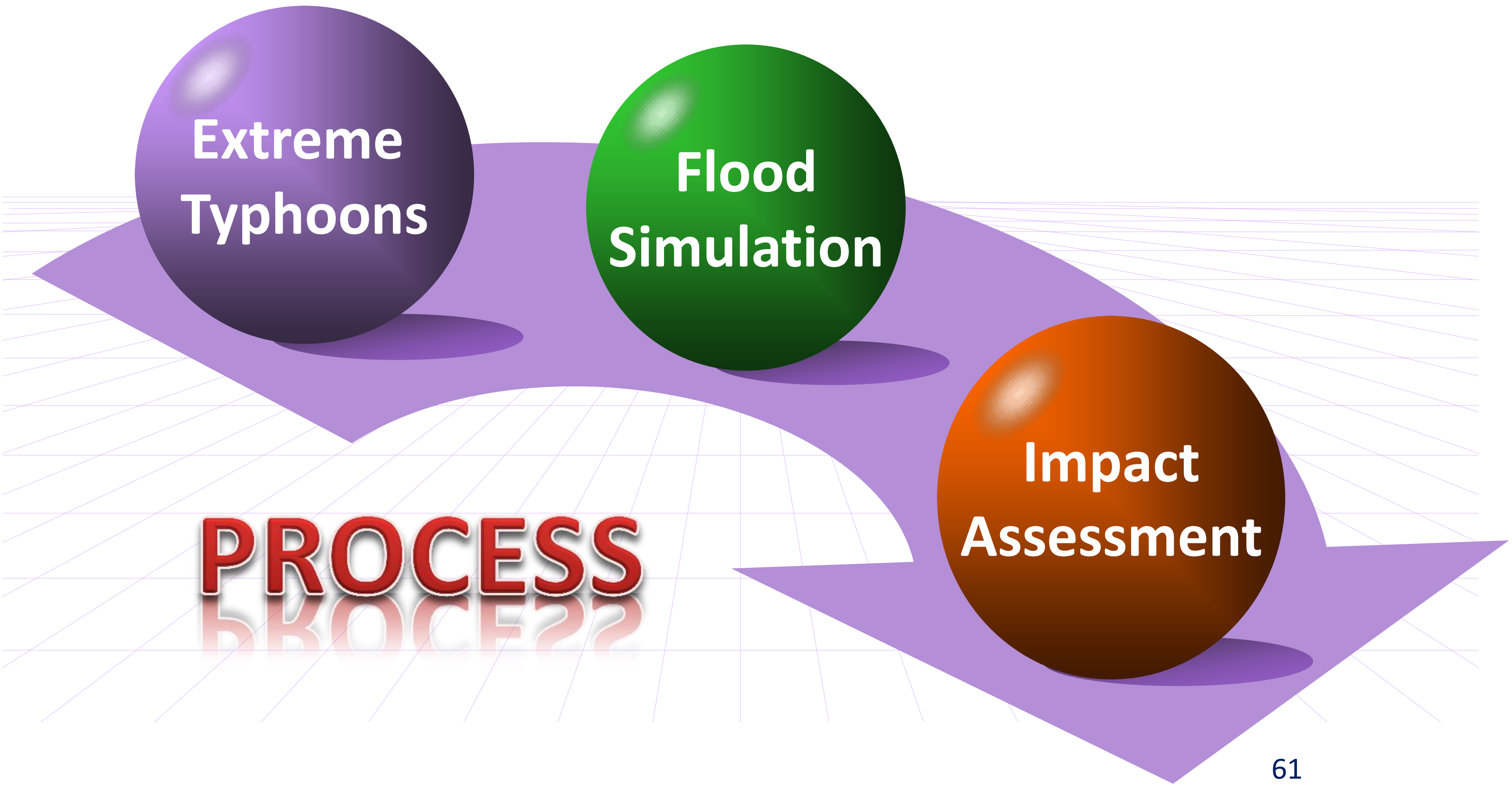
Engineering projects for flood mitigation (Costs 50 millions)

61.8-50=11.8(million)

(benefits)

Application examples

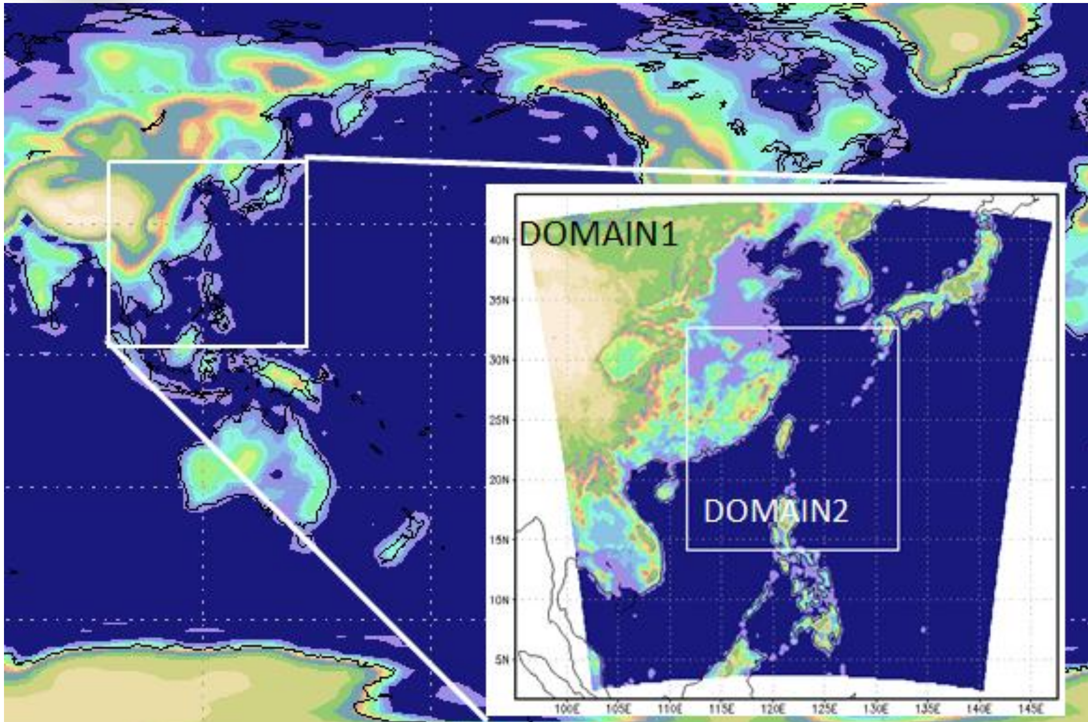
Assess Extremely Flood Impact

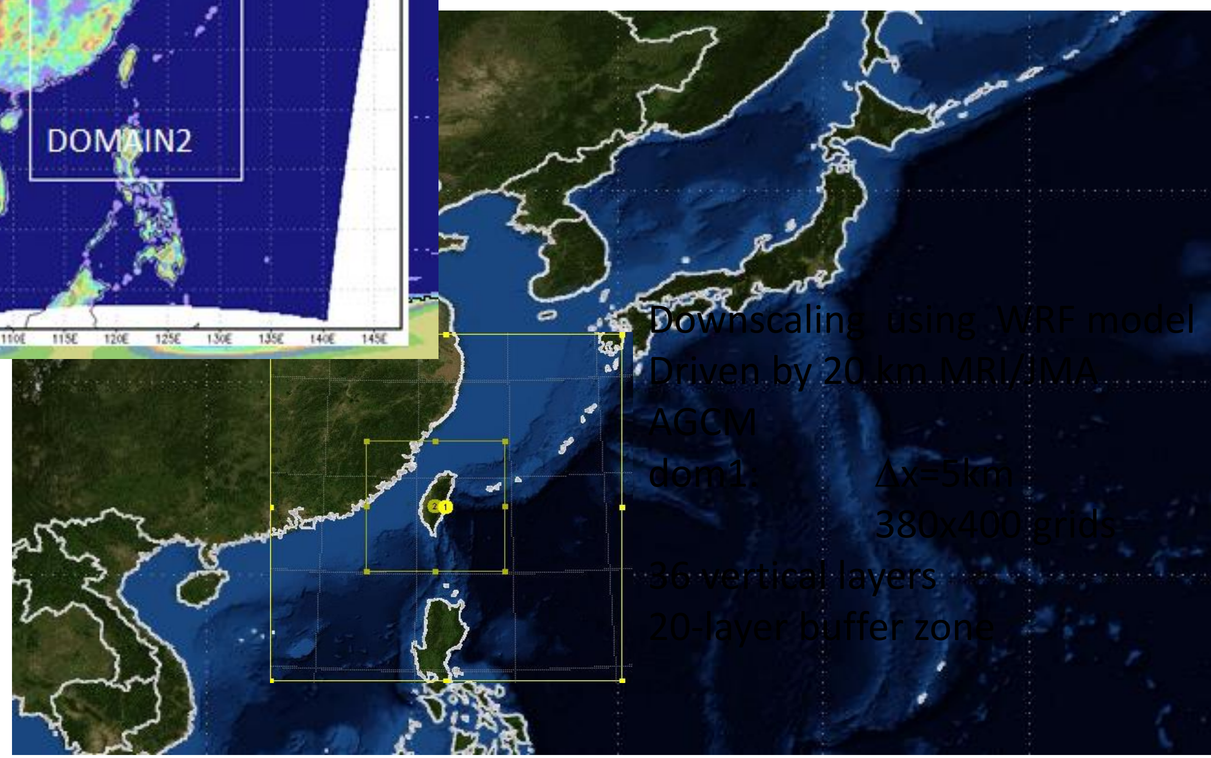


Extreme Typhoons

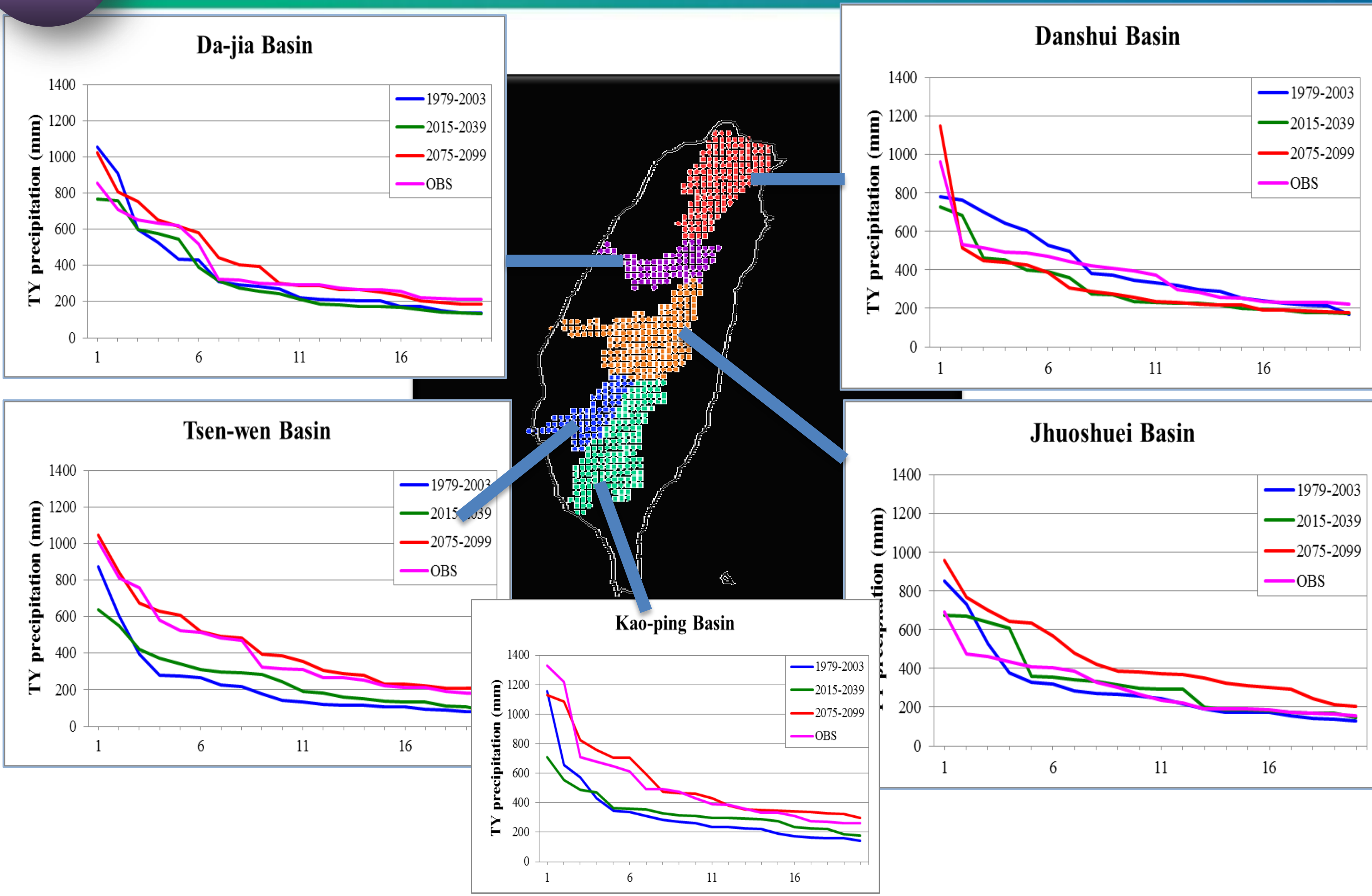
Dynamical Downscaling

ECHAM5-WRF & MRI-WRF

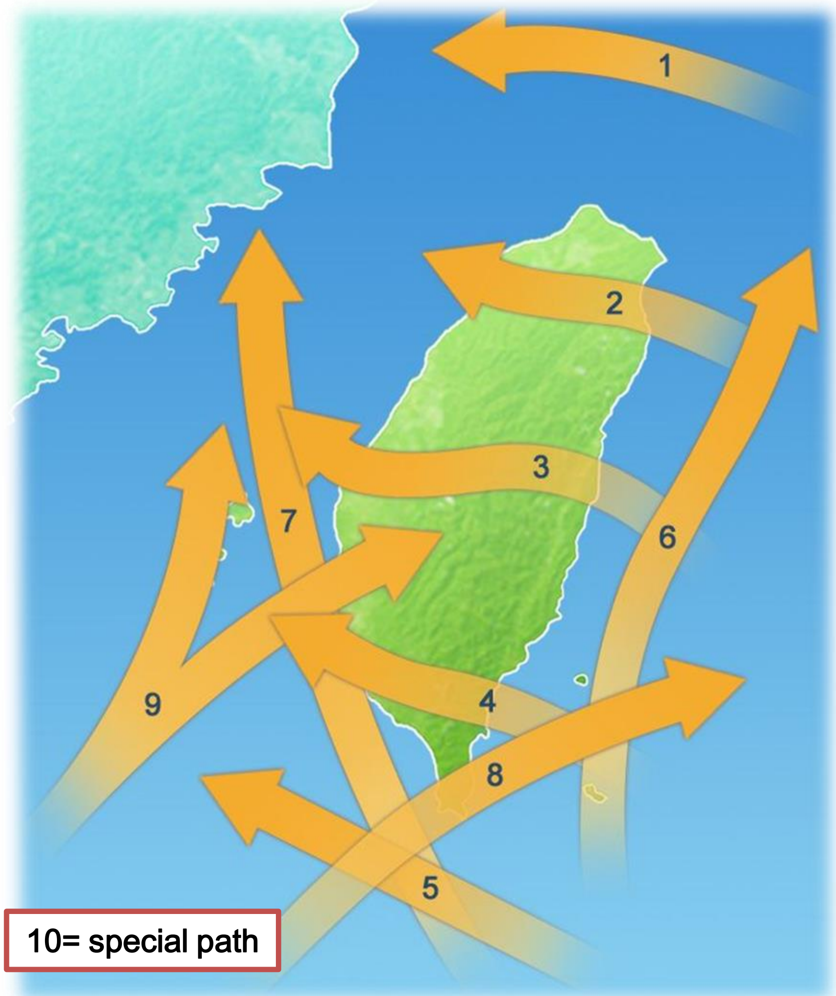




Selection of Extreme Typhoons



Top-10 typhoons for Tzeng-wen river basin



The End of Century

The river discharge assessment: Tseng-wen river basin

	TOP1	TOP2	TOP3	TOP4	TOP5	TOP6	TOP7	TOP8	TOP9	TOP10
Base	13531.38	7719.586	3156.794	3780.836	5441.979	3387.93	3856.473	1311.433	3507.61	2343.363
Near future	11782.82	11349.87	6750.627	7840.786	3367.139	5758.54	7926.844	4445.437	2353.962	4801.892
End of the century	18891.62	15937.19	11805.61	10783.4	12125.96	11170.08	10710.55	7011.56	5973.875	7021.806

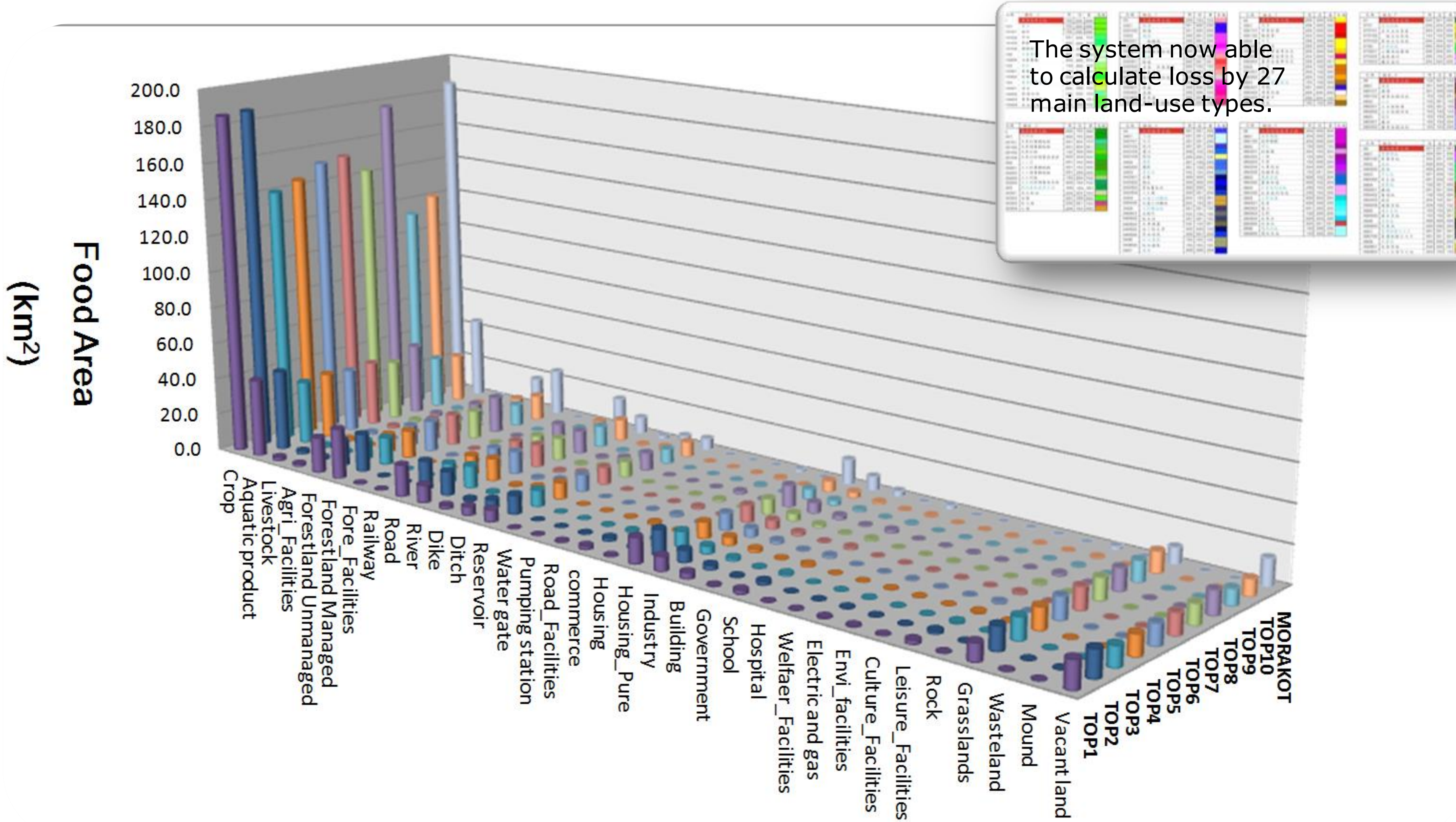
Design discharge: 9890cms)

The analysis on extreme weather event shows that

The frequency of exceeding design discharge will increase

Impact Assessment

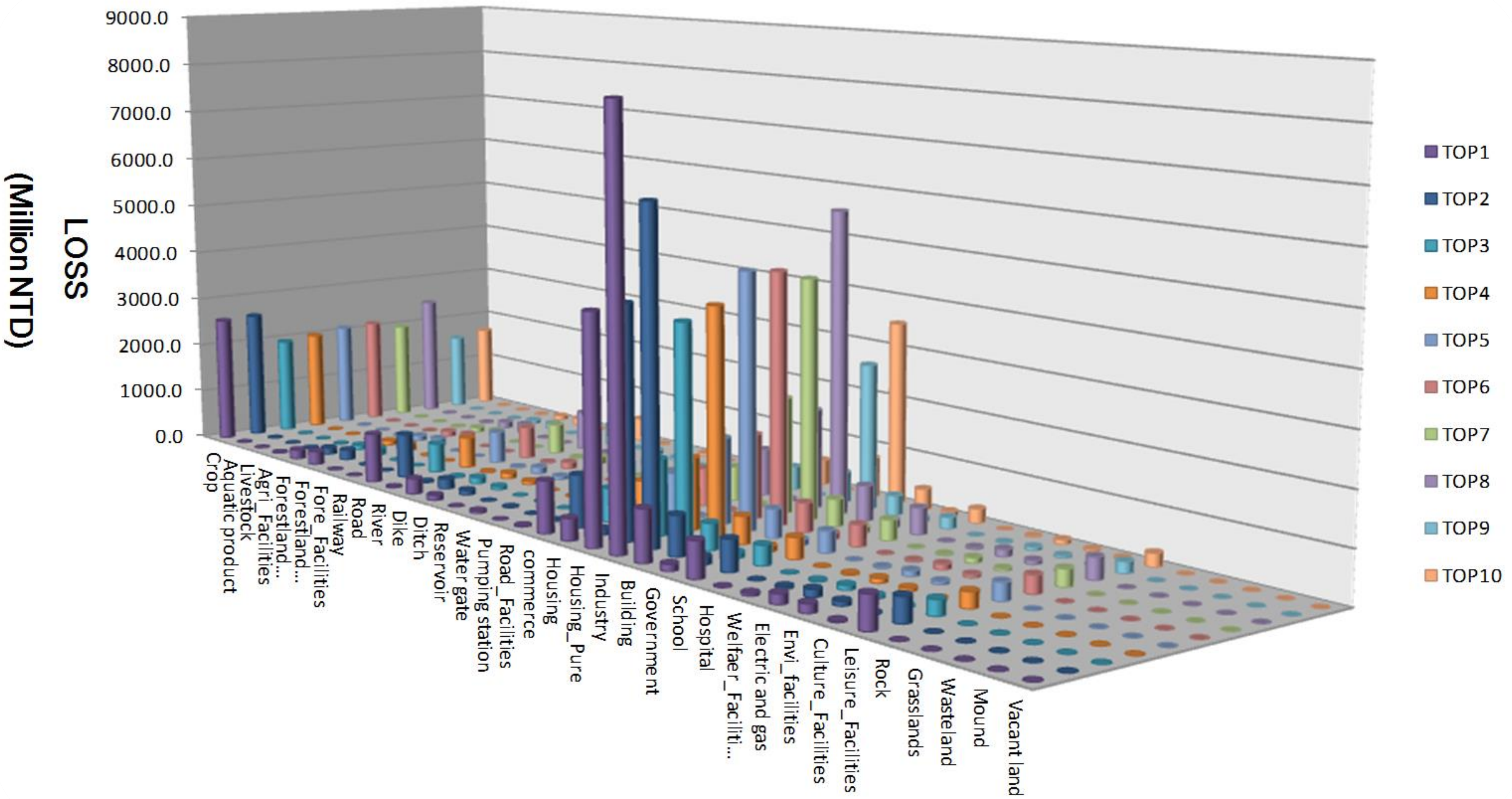
Flood Area with Land Usage



The system now able to calculate loss by 27 main land-use types.

Impact Assessment

Flood Loss with Land Usage



FACTOR ANALYSIS

NCDR

- TOP1
- TOP2
- TOP3
- TOP4
- TOP5
- TOP6
- TOP7
- TOP8
- TOP9
- TOP10
- MORAKOT

EVENTS

Total rainfall

Maximum 3、6、12、24、72 hours accumulated rainfall

Total runoff

Flood peak duration

Maximum hour runoff

Land usage type

AFFECTED FACTORS

Total Flood Loss

LOSS

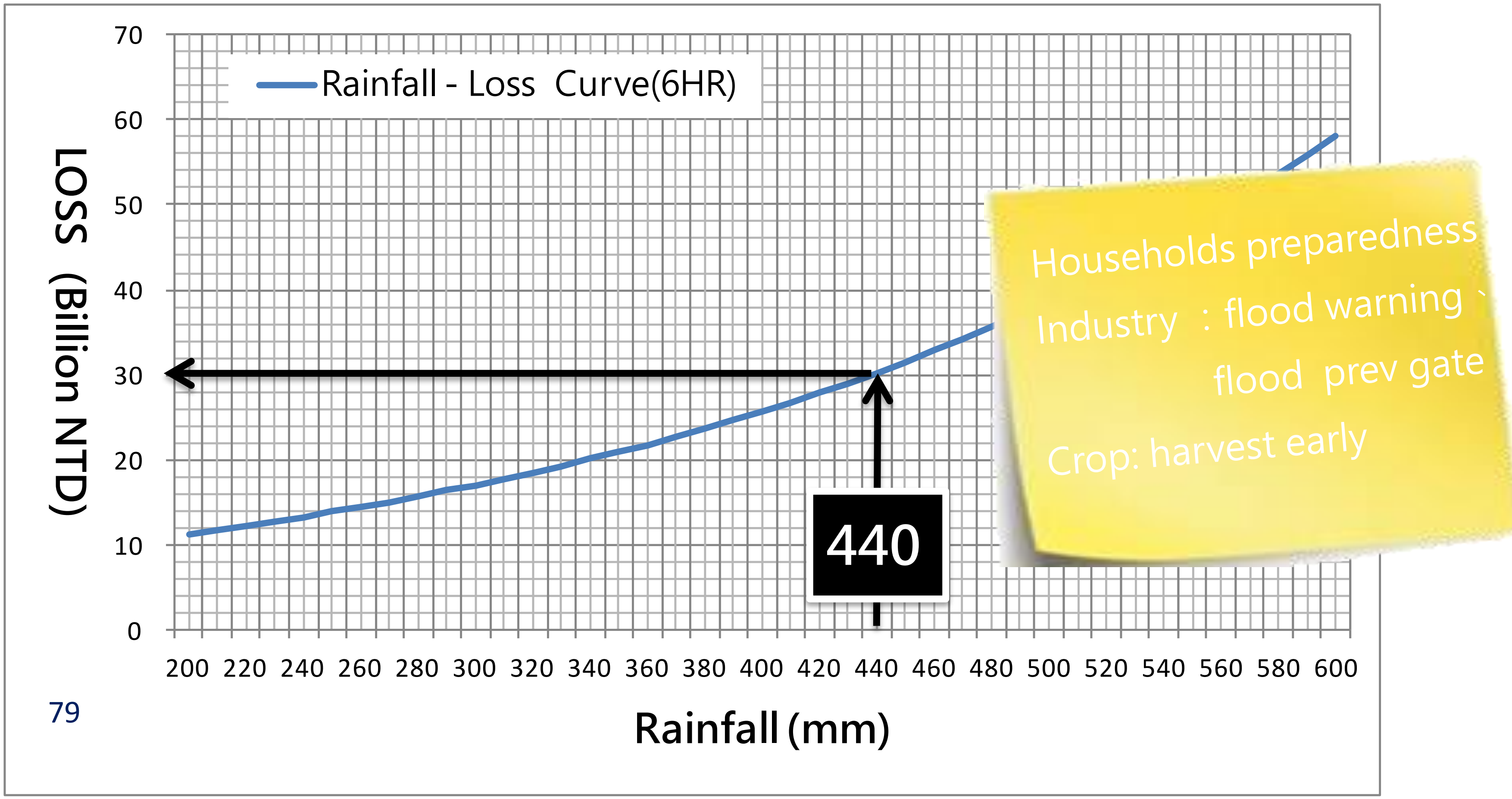
FACTOR ANALYSIS

NCDR

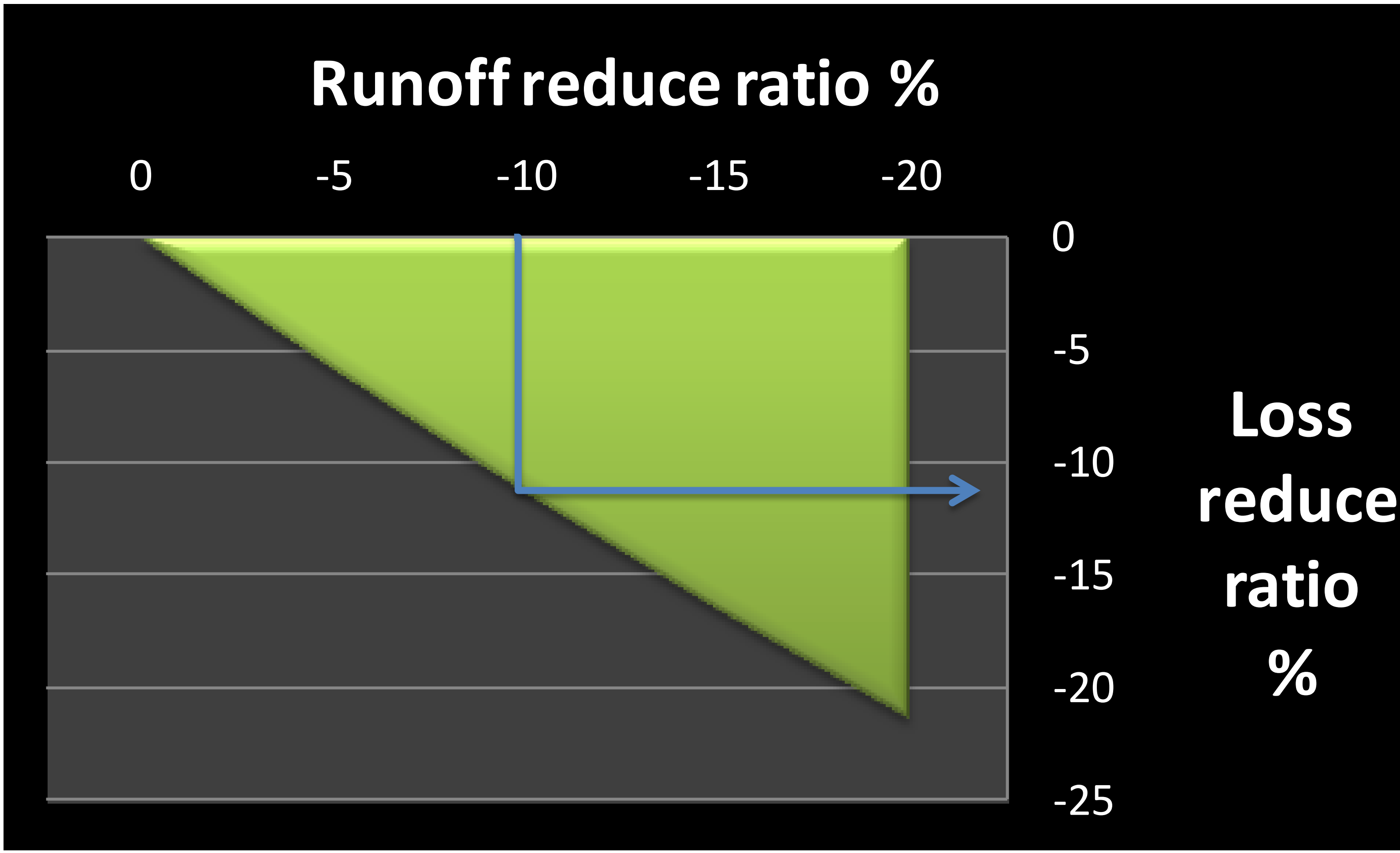
Climate Factor	• Max. 6 hours accumu... rainfall — 88%
Hydraulic Factor	• Max. Hour Runoff — 95%
Soci-Economic Factor	• Industry Loss • Household Loss • Crop Loss

ADAPTATION

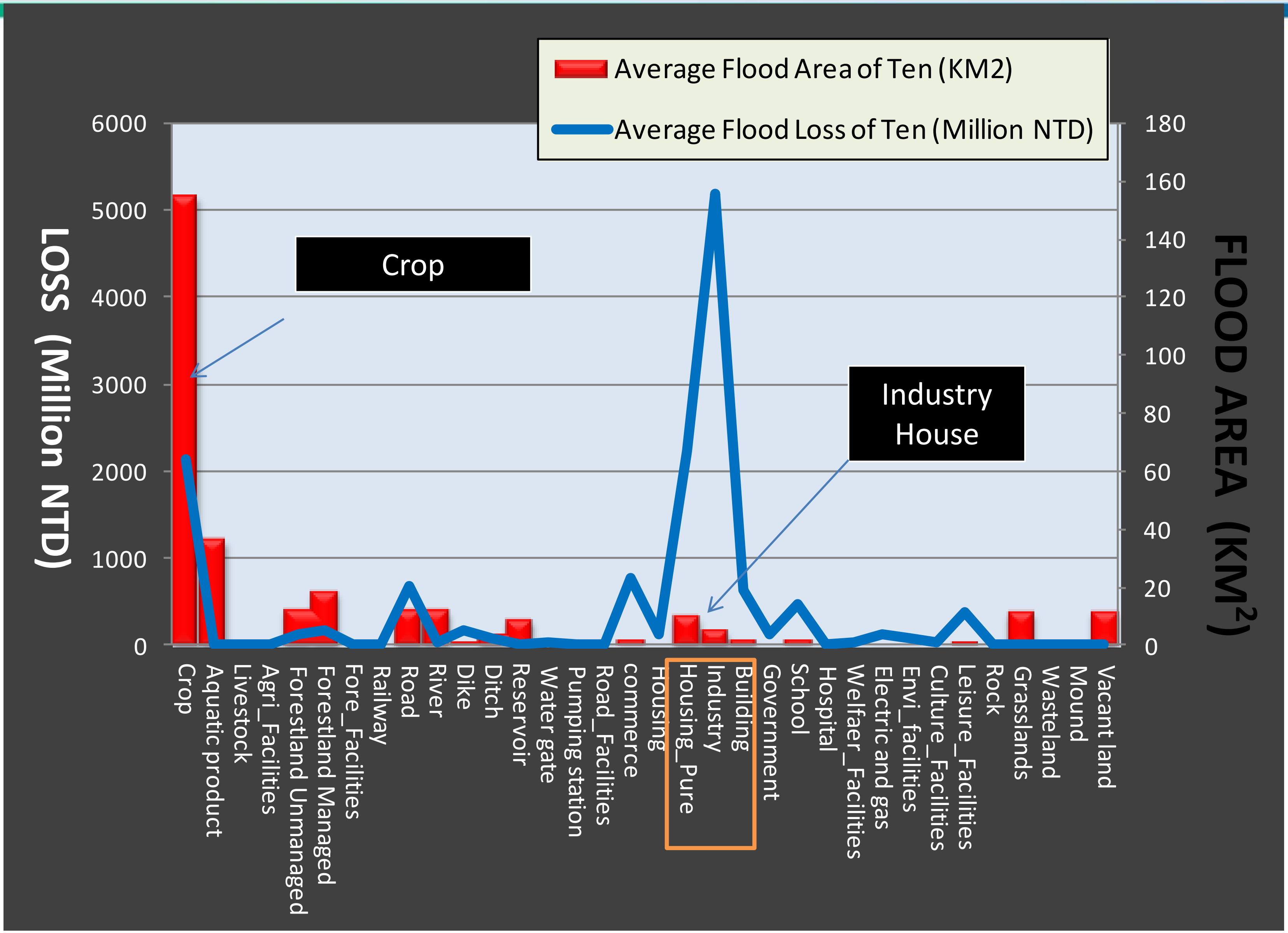
Act Early ： Loss – Rainfall Curve



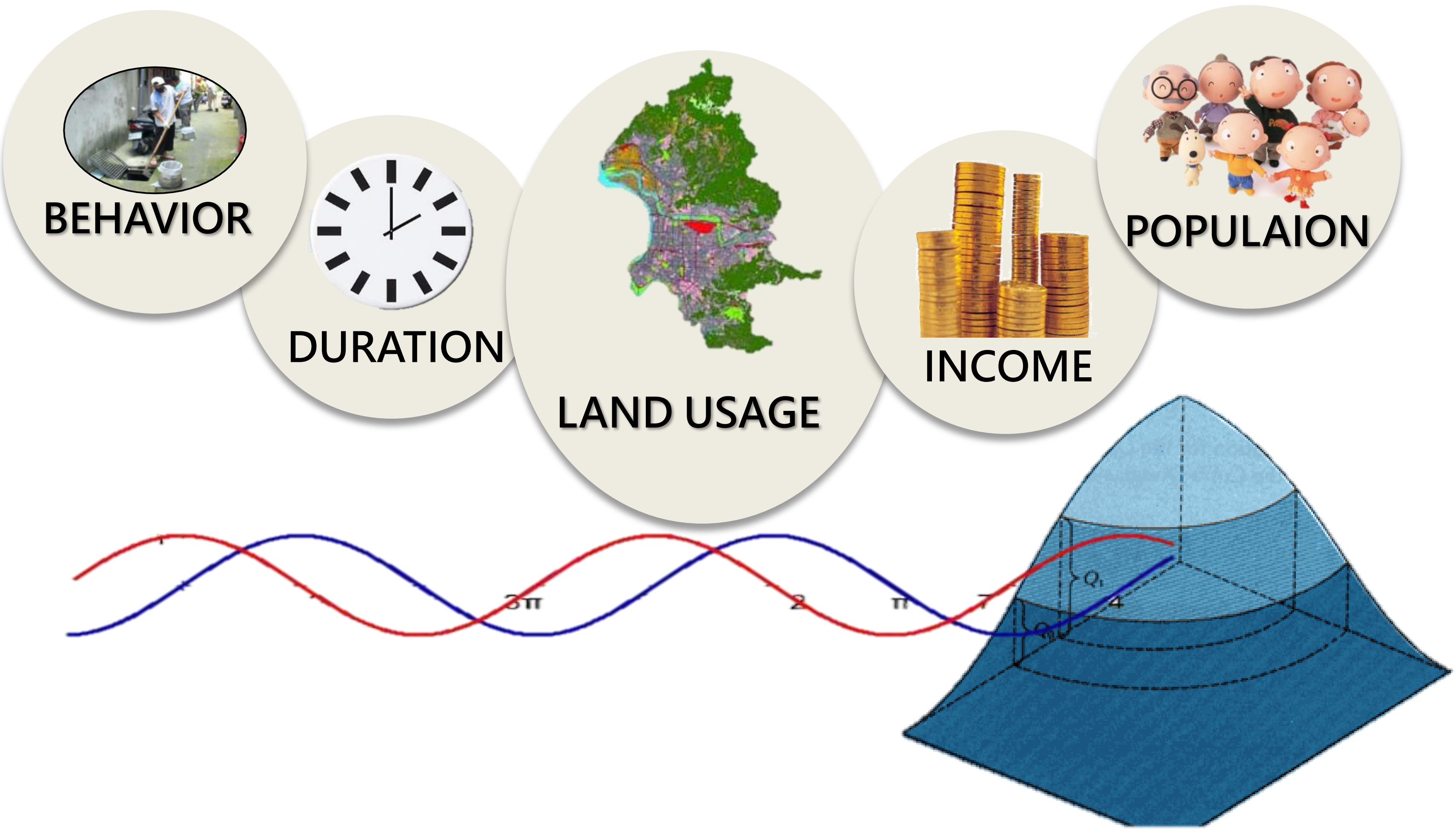
Reduce Peak Runoff



LAND-USE PLANNING



PREPAREDNESS



ONE more
household preparedness

21 % Loss reduce

EVACUATION

Drill and Operation

27 % loss reduce

DOUBLE

36%

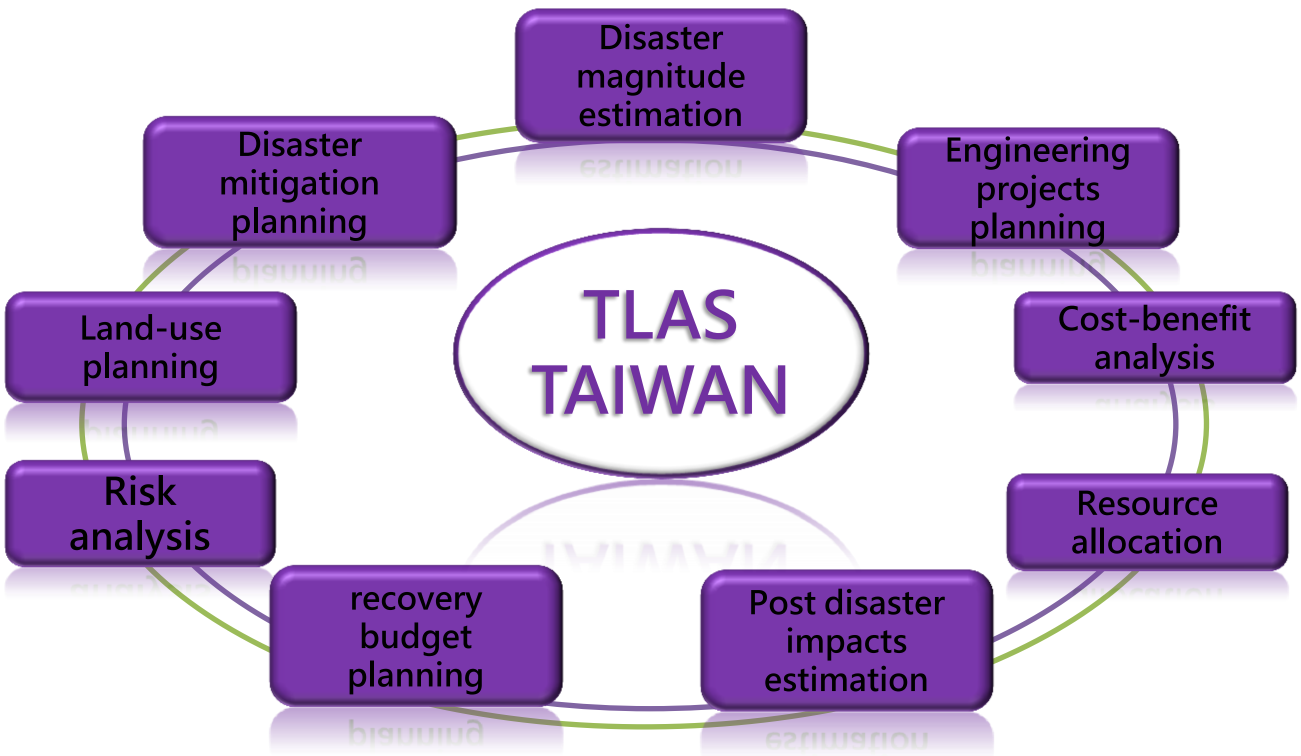
FLOOD DEPTH

1m LOWER

53% Loss reduce

Difficulties and future applications

- To Keep updating Land-use information from government
- Upgrading Loss estimation models and updating social-economic parameters



Thanks for your attention