# How to Prevent Urban Disaster by Using 3D GIS Technology in Taiwan

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## ABSTRACT

The urban growth is based on people living and industry need in Taiwan. Urban growth policy is provided more and more floor area for land development. Over-exploitation lead to excessive vulnerability for disaster especially flood in Taiwan. According to statistics, the flood disaster occurred in Taiwan caused by typhoon had damaged more than 49 thousand houses and killed almost 1000 people and direct damage more than NT$ 14 billion each year. The land use planning and application of space system tactic planning for the flood disaster treatments has become one of the major plan to against the disaster issues.

The major issue is the lacks of the use of the dynamic data especially for the prevention of urban disaster that cause the tragedy always occur ahead of our estimation. The objective of this study is to develop a platform base on 3D Web-GIS integrated flood model and online data to simulate the damaged of flood disaster.

This study wish to get the risk map include population、agriculture、business and industry . Then we use the four kind risk maps to overlap land use map. The result shows that some high risk area is also highly developed area, so we could be decided the policy that balance between economic development and urban disaster prevention。

**Keywords:** Geographic Information System (GIS), Disaster Prevention, Risk Map, Urban planning

# 1 Introduction

The flood disaster occurred in Taiwan caused by typhoon had damaged more than 49 thousand houses and killed almost 1000 people and direct damage more than NT$14 billion each year. Flooding is the most damaging catastrophe among all natural disasters in Taiwan. Historical statistics indicate that economic losses caused by floods is approximate ten billion NT dollars every year. Flooding mitigation measures have been implemented to reduce economic damages as well as losses of human lives. However, risk of flooding is increased owing to the effects of the climate change. Increasing number of people is threatened with frequent high-intensity extreme rainfall associated with sea level rise in coastal lowlands. Such situations are further deteriorated by improper anthropogenic activities such as groundwater overdraft, which resulting in serious land subsidence. Flooding related problems are still a concern in the future and become more sophisticated since the global warming and other anthropogenic factors. Coping with such problems, social assessment such as land planning is equally important with the engineering analysis, which is the initiation of this integrated project.

A natural disaster is the consequence of a natural hazard which affects human activities. Human vulnerability, exacerbated by the lack of planning or appropriate emergency management, leads to financial, environmental or human losses. The resulting loss depends on the capacity of the population to support or resist the disaster, their resilience. This understanding is concentrated in the formulation: "disasters occur when hazards meet vulnerability". A natural hazard will hence never result in a natural disaster in areas without vulnerability, e.g. strong earthquakes in uninhabited areas. The term natural has consequently been disputed because the events simply are not hazards or disasters without human involvement.

# 2 Research Method

## 2.1 Web-GIS and Integrated Flood Management

The research introduces in Web-GIS platform to evaluate and forecast economic losses of disaster. It could be compare the budget above that use to prevent floods and the budget from direct damage cost down. The research we integrated economics and flood management to development the policy of land-use planning for southwestern Taiwan. We introduce the concept of disaster risk prevention and control .It uses Web-GIS platform to develop the dynamic evaluation of prevention landslide area. The prevention landslide area could help us to improve social safety.

The sustainable and effective management of water resources demands a holistic approach - linking socio-economic development with the protection of natural ecosystems and appropriate management links between land and water uses. It is recognized that a river basin is a dynamic system in which there are many interactions between land and water bodies. In the light of this, attempts are needed and should be tried to improve the functioning of the river basin as a whole rather than simply fixing local problems.

This has called for the Integrated Flood Management (IFM), a new approach in which consideration is given to the positive as well as the negative aspects of flood waters and to the valuable resource that is represented by the flood plains that these waters occupy on occasions.

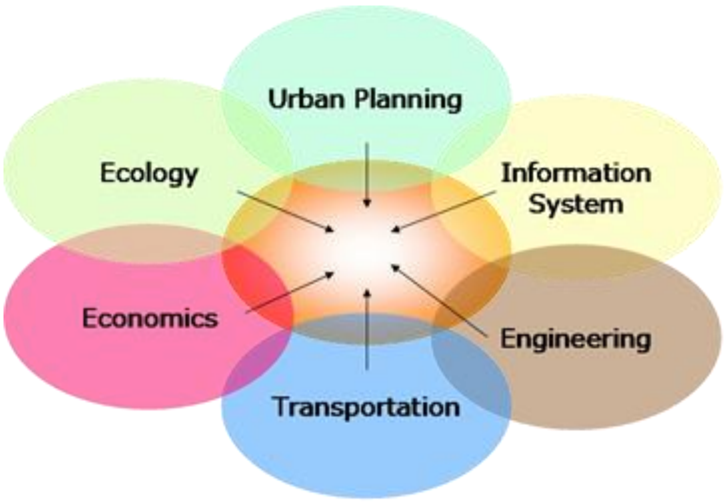


Figure1. IFM Concept

It integrates land and water resources development in a river basin, within the context of Integrated Water Resources Management (IWRM), with a view to maximizing the net benefit from floodplains and minimizing loss to life due to extreme hydrologic events. In traditional, we control floodplain management policy decisions is builds physical structures with which the residents have to live. The case is like GDFPP (Greater Dhaka Flood Protection Project) in Dhaka. It finds revealed that floodplain occupation was a result of overall reaction to the Government's structural adjustment policies that resulted from institutional, locational and socio-economic factors.

In addition to support for structural embankments, the study sample displayed a common concern and widespread environmental awareness. In terms of any 'trade-off' between the benefits (resources) from the embankments and costs (hazards) due to the detrimental impact on environment, the residents of Dhaka, despite some concern for sacrificing embankments for environment, tended to show a general consensus for embankments.

The new point is that the water is resources and disaster. We live with water so we are living with flood risk. It called FLOWS is an acronym for Floodplain Land use Optimizing Workable Sustainability. This means communities adapting to climate change and living with water. In the project we define prevention of flood is focus the resource point to manager the water.

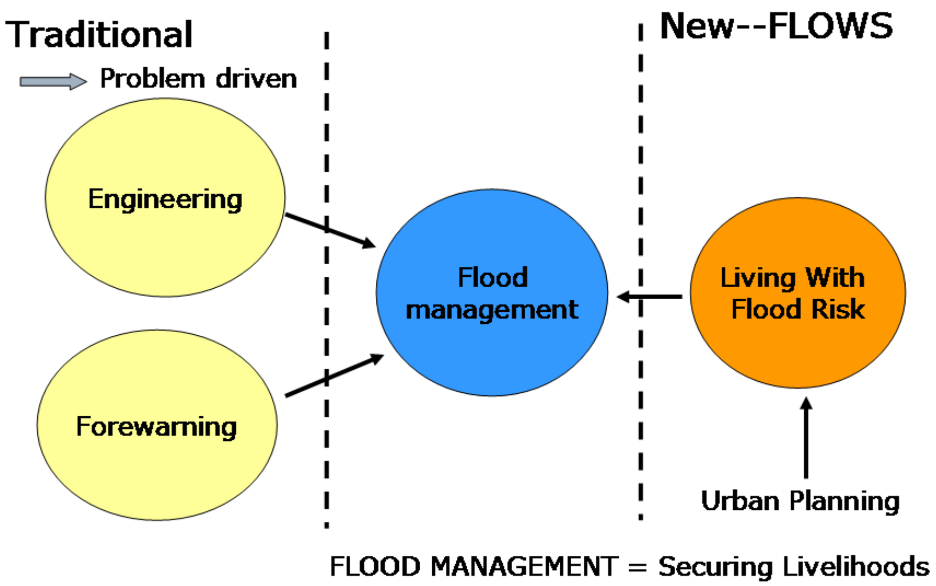


Figure2. Flooding Risk in Our Life

## 2.2.Development of IFM

Integrated flood management (IFM) is a new approach to flood management by

World Meteorological Organization. It co-ordinates the meteorological and hydrological services of 185 countries and territories and as such is the centre of knowledge about weather, climate and water.

In this platform we develop a Web-GIS platform, which collaborate sea level projection, rainfall projection, land subsidence, flood risk analysis and land uses settings for flood management in this project. The kernel part of Web-GIS platform is multi-discipline modeling, which deals with both climate change and human impacts on flooding.

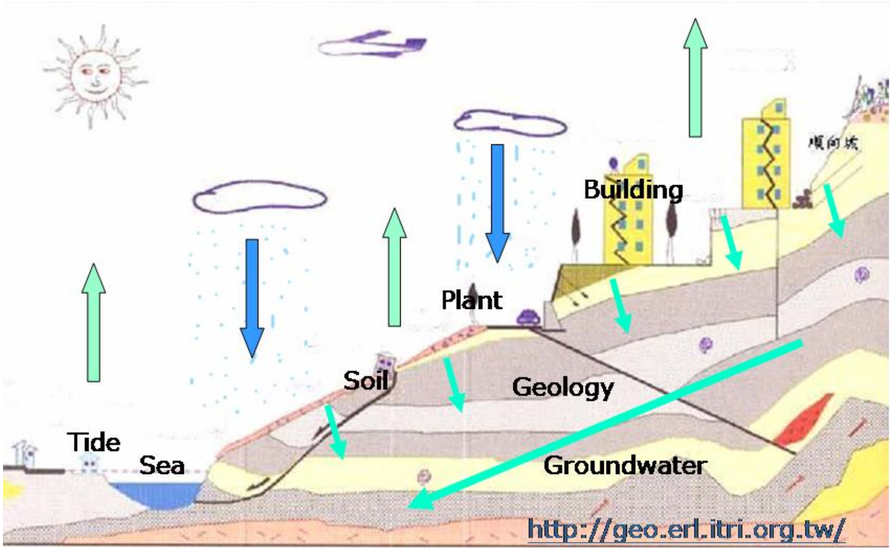


Figure3. The cycle of water system

## 2.2.1.Sea Level Rise

For example, We did the empirical study in the Cishan District in Kaohsiung developed the disaster prevention systems on urban planning project, sea level rise in the southwestern coastal area of Taiwan is 7.3cm in coming 20-years and 36.4 cm in coming 100-years. We use fixable value 36.4 cm in sea level rise variable.

## 2.2.2 Rainfall

This study also does on the rainfall empirical study in the Cishan District. It uses SVD downscaling system to forecast the rainfall in 2011 to 2100. In the project we use the two hundred years return period downscaling hourly rainfall. We use database to record the forecast data include 24 hours and 35 rainfall gauge stations records.

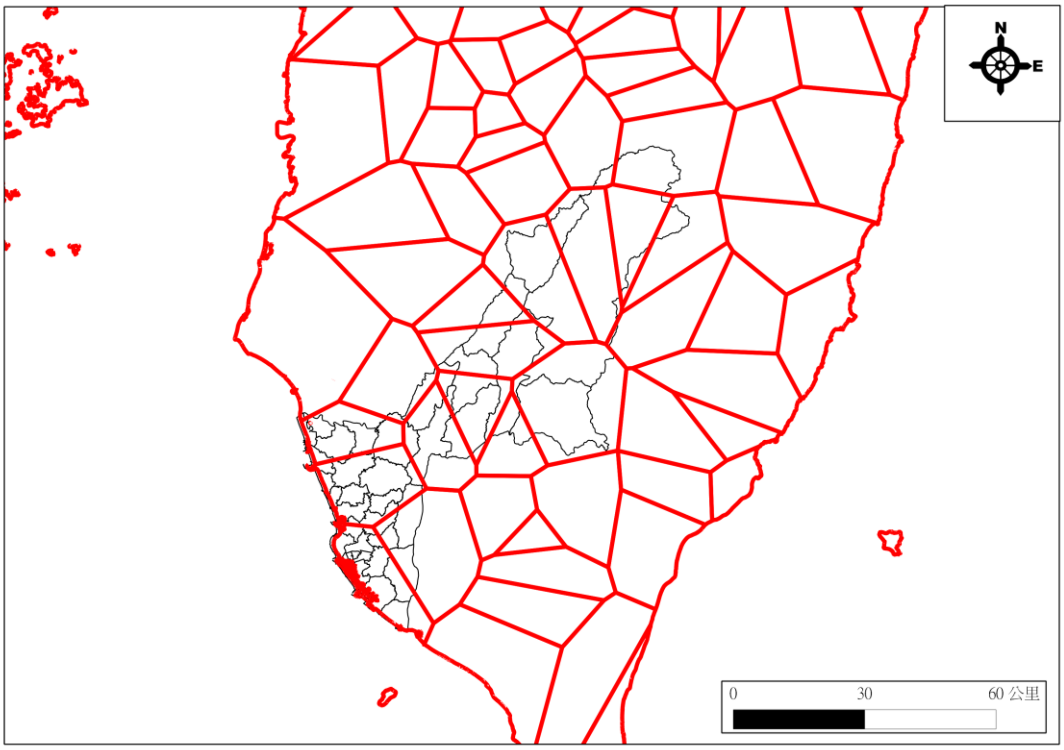


Figure4.  34 rainfall gauge stations location

### 2.2.3 Land subsidence

We use GM model and Pororlasticity model to forecast the value of land subsidence area in coming 100-years. We use database to record the forecast data include 272 land subsidence gauge stations records.


Figure5.  272 land subsidence gauge stations location

## 2.3 Web-GIS Software Engineering

To develop a Web-GIS platform collaborates sea level projection, rainfall projection, flood risk analysis and land uses settings for flood management. The Web-GIS platform can dynamically analyze the flood risk in southwestern coastal areas of Taiwan due to the climate change and propose land planning for flood prone area in the future.

The platform creates an interaction structure to tune and to verify the cooperative framework of the other six sub-projects as a whole dynamically. It will help each sub-project to re-examine the sensitivity of its own module response to the effect on flood disasters. Therefore, it is a platform able to fine tuning variables/parameters setting of each model for better results.

And the Web-GIS platform is an opened structure to input external data for model. The data format is included relational database (MySQL, Oracle, MSSQL…), TXT (csv , txt …) and GIS formats (SHP, TAB, …), so we can integrate the data provided by Construction and Planning Agency and Water Resource Agency of Taiwan and APFM/WMO's format as well. By which, the result of APFM/WMO and policy setting of flood management can be evaluated in the platform in terms of various disaster scenarios due to global climate change.

Finally the Web-GIS platform uses 3D render and Cloud technology to compare flood dynamic changed over the temporal dimension visually and can be interactively operated directly online.

(1) Model developing

The impacts of climate change on sea level rising, extreme rainfall, land subsidence, and ecology system are proposed for flood risk analysis. Scenario-based flood risk map will be further developed for southern coast areas of Taiwan.

(2) Web-GIS platform

A platform for visualizing interaction to improve cross-discipline dialog and cooperation in developing strategy for flood management is developing.

(3) Land planning strategy

The policy in land-use settings will be assessed based on Scenario-based flood risk map.

## 2.4 The Data of Contents

When we use the Web-GIS Model to develop the prevention of flood manager, we also need the data about topography include building, urban planning, land-use, floodplain area to draw physiographic diagram.

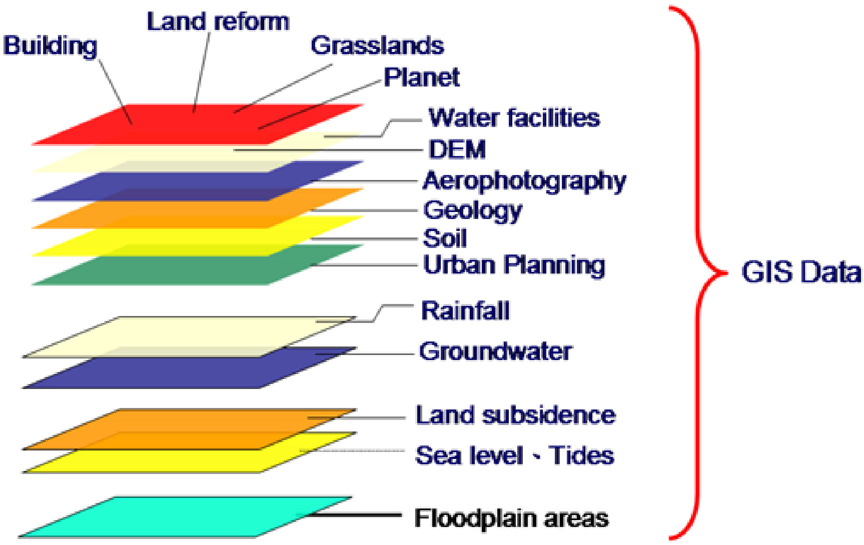


Figure6. The Data of Contents

# 3.The Contents of IFM Platform

## 3.1 Software and hardware structure

The whole idea of service is based on architecture of SOA (Service-Oriented Architecture) and integrates with back-end services. The operation architecture display is as below diagram. The connection services are all web service and adopt with SOAP (Simple Object Access Protocol). The protocol uses XML as base communications protocol, compile required internet service request and reply then send the compiled message to the internet.

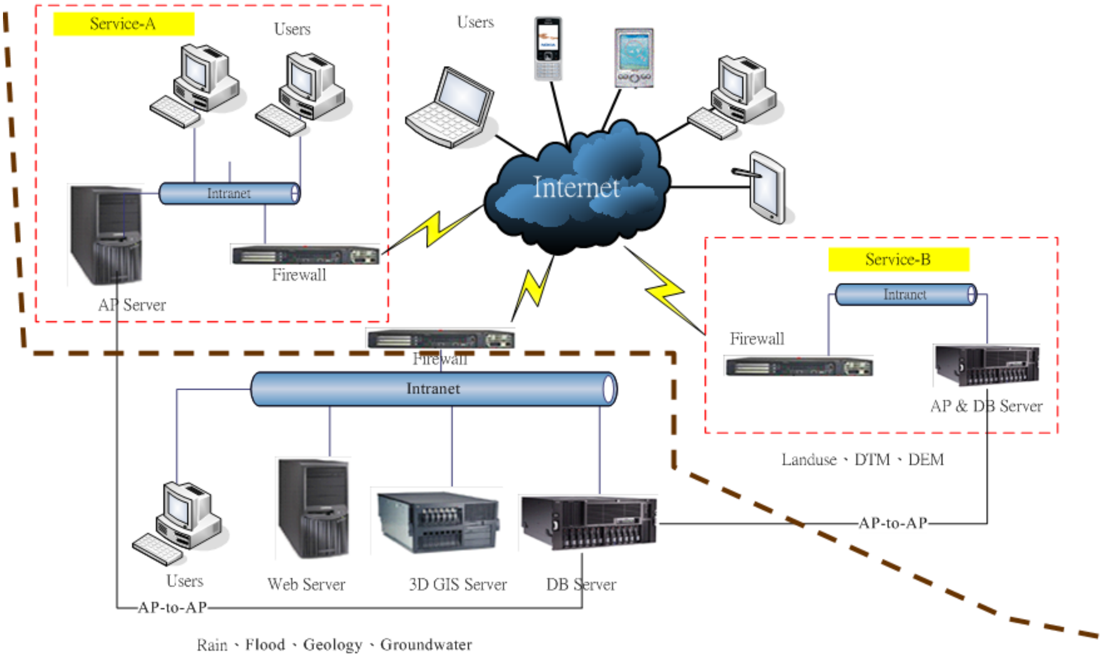


Figure7. Software and hardware structure platform

## 3.2 IFM system

For the goal is online and near real time dynamically analyze the flood risk. We must import the inundation model as a module for IFM system. In the project, we use Java to code the program online calculate the model

Java refers to a number of proprietary computer software products and specifications from Sun Microsystems, a subsidiary of Oracle Corporation, that together provide a system for developing application software and deploying it in a cross-platform environment. Java is used in mobile phones, Web servers and enterprise applications, and while less common on desktop computers; Java applets are often used to provide improved and secure functionalities while browsing the World Wide Web.

## 3.3 Physiographic Diagram

The project we want simulate the flooding plain area. We use the cell as the calculate unit. The cell is defined by study DEM, DTM. We define 6943 cell in study area(Figure 8). We use the GIS software ArcView to calculate.

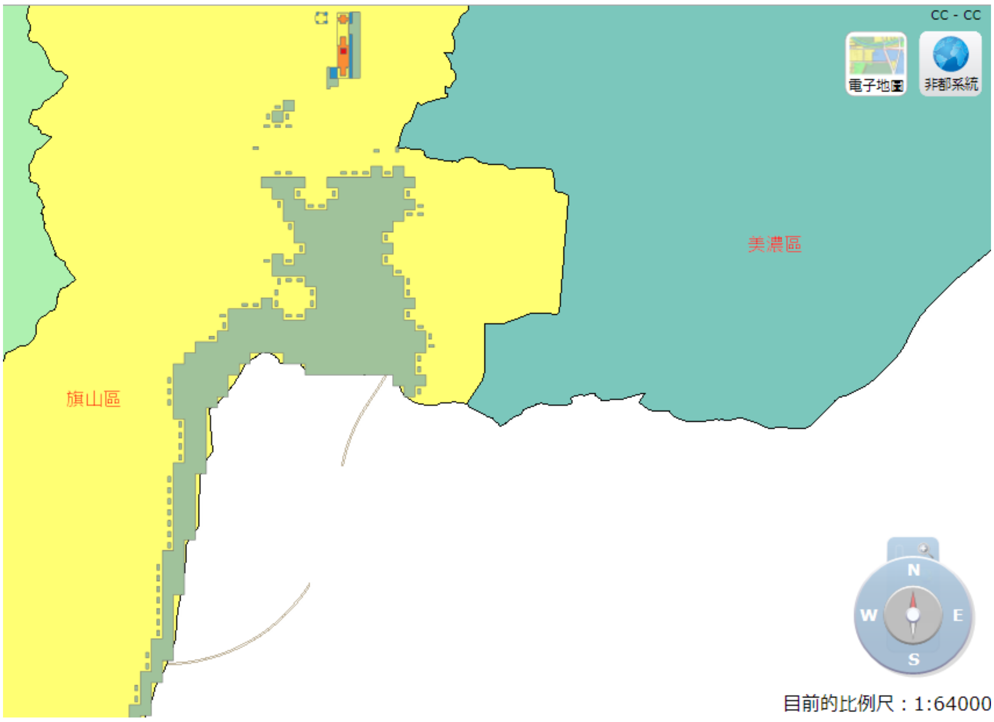


Figure8.  Computational cells of the study area.

# 4 Case Study of IFM System in Kaohsiung

## 4.1 The IFM System

The IFM system is developed by Active server page. In the server machine we use IIS as our web server engine. In figure 9, we estibalished the IMF system in Kaohsiung.

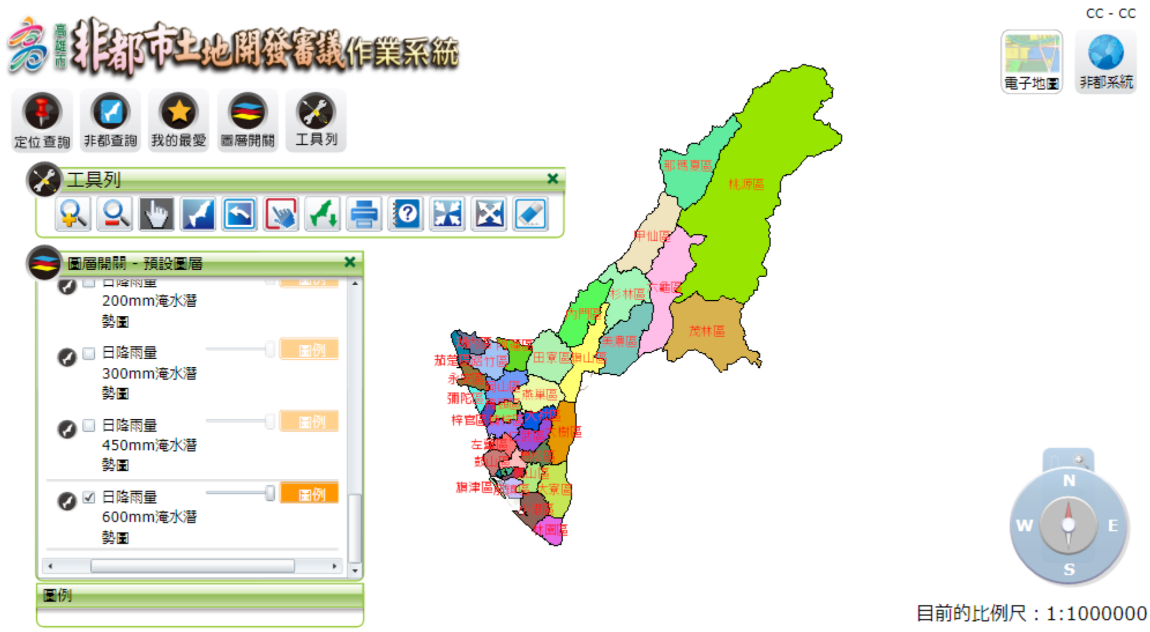


Figure9. The IFM System Main Page

## 4.2 3D&2D GIS Simulate Inside Page

We design the web page include 3D&2D and Setting screen.

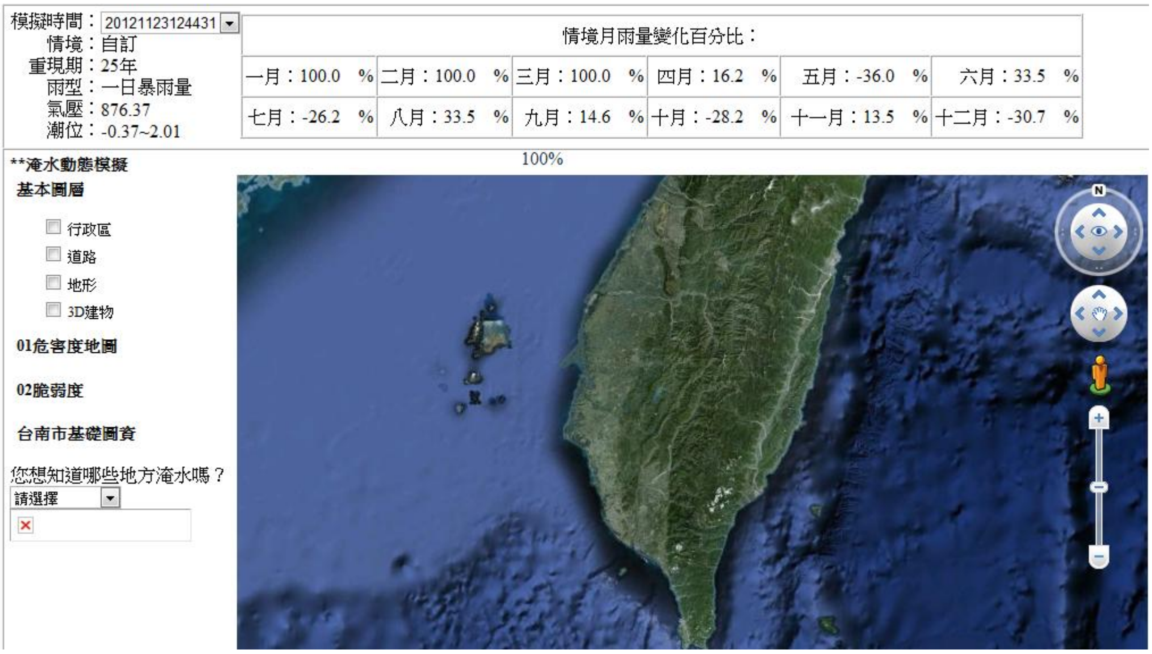


Figure10. Web Page in IFM System in Kaohsiung

## 4.3 Setting Page

Setting page is defined the setting of context. The contexts include sea level rise, rainfall, and land subsidence. See the Table 1.

Table 1. The setting of contexts

| Type | Setting | Notes |
|---|---|---|
| sea level rise | 100-years | Maximum |
| land subsidence | 100-years | Maximum |
| Rainfall | 200-years | Return period |

## 4.4 Using 2D GIS Page

Applicants is able to enter the apply information then send information out and lie between to online information transfer operation. The information includes sea level projection, rainfall projection, land subsidence, flood risk analysis and land uses settings.

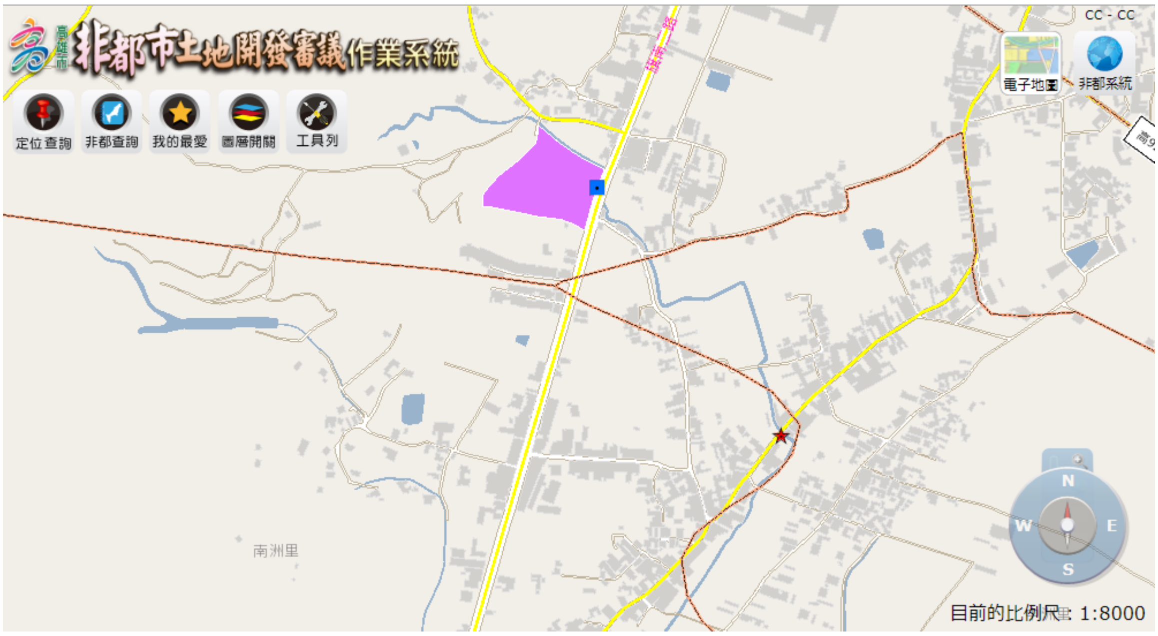


Figure11. The IFM System Web-GIS System

## 4.5 Using 3D GIS Page For Flood Simulation

Simulation events are one various recurrence intervals 200-year of 48-hour design rainfall. It introduces the dynamic evaluation in Web-GIS platform to evaluate and forecast economic losses of disaster.

The results showed that we use cloud calculate base on the 3D GIS platform to simulate the flood area dynamic. We could fast and correctly online simulate the region of the flood area each hour (total 48-hour). The flood simulated for the policymakers could be made the decision about disaster prevention and disaster Response.

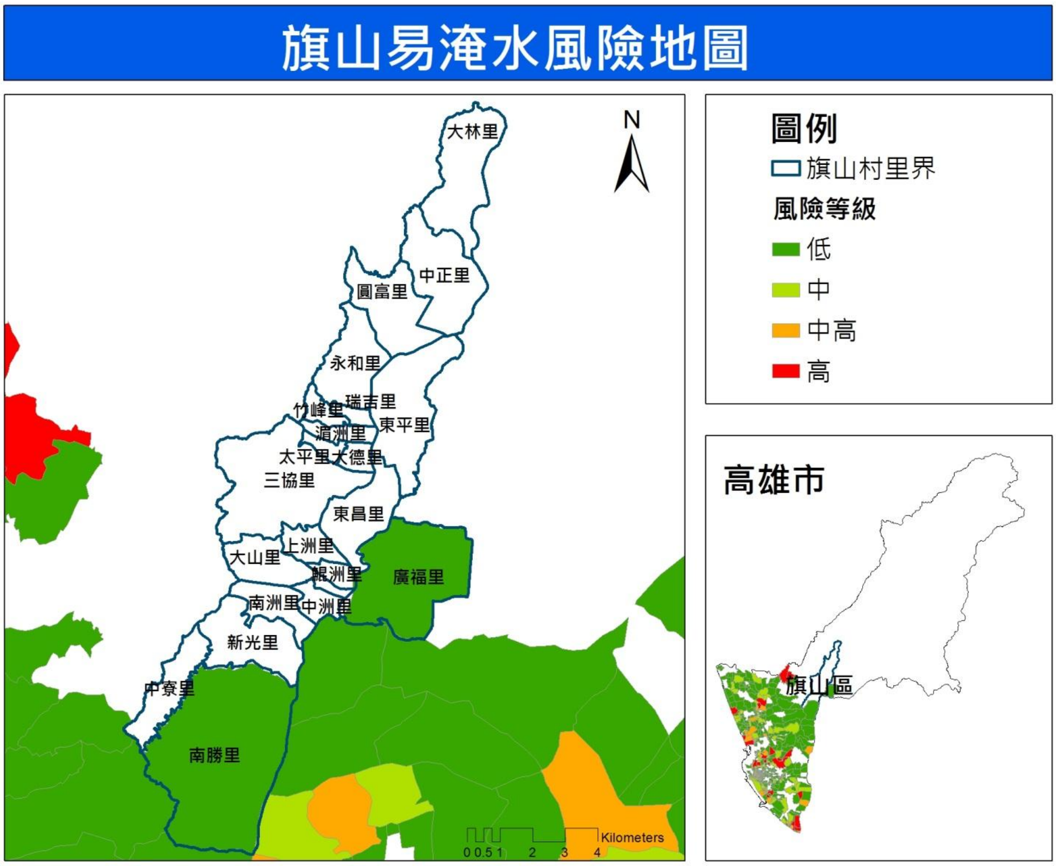


Figure12. The IFM System of Flood Simulated Result in Chi Shan in Kaohsiung

# 5 Conclusion and Suggestion

## 5.1 Conclusion

The project is used in the several domain research just like Operation System design, Business Model developed, Space etc. So the 3D WEB-GIS platform included Cloud to develop integrated flood management. The result list as blow.

1. To our model, we integrate more than five domain knowledge included collaborate sea level projection, rainfall projection, land subsidence, flood risk analysis and land uses settings.
2. To computate and simulated technology, we use 3D render and Cloud for online. The policy maker could get the results fast and correctly on line. They also simulate the region of the flood area each hour.
3. We will be seeking to know what's beyond the data and the policy makers could be made the decision about disaster prevention and disaster response in the future.

## 5.2 Suggestion

We can simulate the flooding plain area and the depth of the cell. If we have the water depth and cell area, we will get the heavy of the cell in the future. It will help us to analyze the kinetic from the heavy with the speed. The next we can advance research as following:

1. We could use the flooding plan area to help us calculate the financial loss.
2. We study the forecast tolerance when we design infrastructure for flood prevention.
3. Under the climate change, it will be more frequency disaster of flood and drought in Taiwan. We need to find the solution when we face the global warming.
4. We can develop another system to simulate the drought disaster.

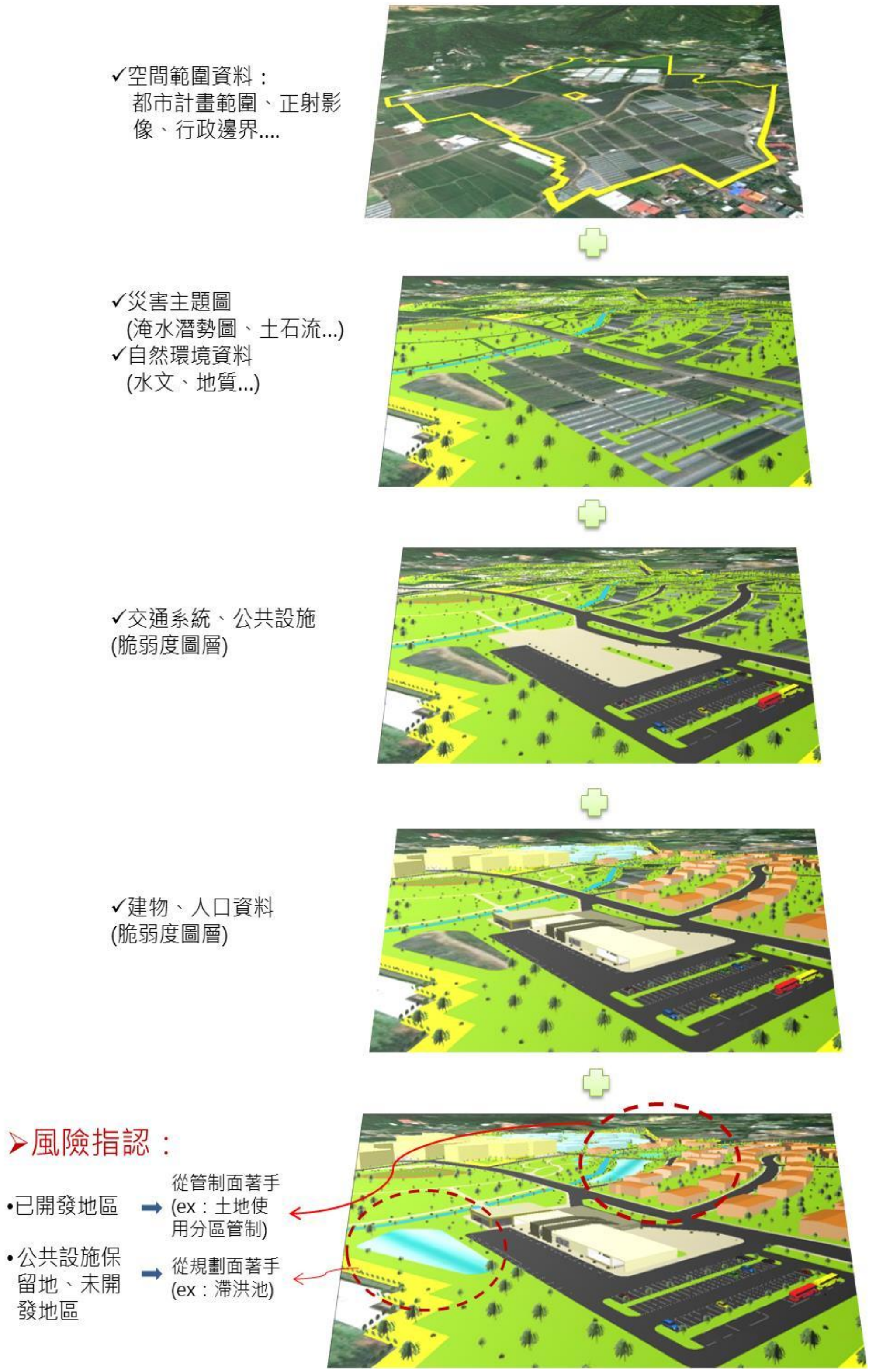


Figure13. The Disaster Prevention System of Urban Planning

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