Explore Urban Flood Vulnerability based on Spatial Pattern in Taiwan Ecological City Viewpoint

Chin-Hsien Liao, Hsueh-Sheng Chang

(Chin-Hsien Liao, Ph.D student, Department of Urban Planning, National Cheng Kung University, 70101 Tainan, Taiwan, krien3082@hotmail.com)

(Hsueh-Sheng Chang, Assistant Professor, Department of Urban Planning, National Cheng Kung University, 70101 Tainan, Taiwan, changhs@mail.ncku.edu.tw)

1 ABSTRACT

This paper introduces the theory of ecological city and province thinks the respond to the impact from urban flood. The contemporary of urban and nature conditions are facing basically variation that not to stand in opposed perspective. The new urban development condition is to inspire the new challenge from the urban spatial plan. The urban flood issues between ecological city and compact city discuss complicated dialectical perspective from adaptation spatial plan.

The methodology has been tested in principle by using Tainan County in the Taiwan as a case study. This paper allows users to understand the spatial pattern of urban flood with vulnerable land use types. First, utilizing the FLO-2D models to simulate four urban flood situations from water resources bureau. Second, using the geographic information system to compare the four urban flood situations. Third, utilizing explore spatial data analysis (ESDA) to discuss the spatial pattern of urban flood and simulate the land use vulnerability area or levels from different situations. Finally, forecasting the results to urban flood with land use plan.

2 INTRODUCTION

In 2005, the World Bank issued Natural Disaster Hotspots – A Global Risk Analysis, which indicted that Taiwan may be the place on Earth most vulnerable to natural hazards, with 73 percent of its land and population exposed to three or more hazards. According to the Central Weather Bureau (http://www.cwb.gov.tw/V4e/, CWB), approximately 3.5 typhoons on average hit Taiwan every year. There is a population of 23 million people in an area of about 36,000 km2 of the main island of Taiwan. This level of population lives density makes Taiwan one of the most crowded areas in the world. According to the CWB there was a total loss of 589 million dollars every year could be attributed to typhoon induced flood hazards. As mentioned above, these are the general phases usually considered in conventional planning processes failure in Taiwan. The contemporary of urban and nature conditions are facing basically variation that not to stand in opposed perspective. The new urban development condition is to inspire the new challenge from the urban spatial plan. The urban flood issues between ecological city and compact city discuss complicated dialectical perspective from adaptation spatial plan.

Flood is among the most severe risks on human lives and properties, and has become more frequent and severe along with local economical development. As the Taiwan's city has been compact rapidly and more stress is put on the land to support the increased population. In turn, floods that once occurred infrequently during pre-development periods have now become more frequent and more severe due to the transformation of the watershed from rural to urban land uses and urbaniziation phenomenon is one of the main research topics in the last decade. A comprehensive plan addressing flood hazard management is therefore, necessary. This plan should combine land use strategies for each zone with the careful consideration of certain structural controls. This can be achieved by the minimal disruption of natural environments. These strategies could serve as basic components in a comprehensive flood management plan in Taiwan.

The eco-city a well-known concept in the western world is new to the Taiwan context. While east connotations of eco-cities should core concerns vary significantly for obvious reasons(Surjan, 2008). These may be ascribed to different land use structure from ecological city and compact city spatial plan. However, the urban planner recognition to choice suitable to prevent flood of land use plan that the process of improving the environment will not be easy. However difficult it may be, cities are at risk to both deteriorating local environment and increasing disasters. In recent years, efforts have been made to use remote sensing and geographic information systems (GIS) for creating national-level flood hazard maps for Bangladesh (Islam and Sado, 2000; Sarkar, 2008). Population density and other socio-economic data have been integrated with hydrologic information to identify priority zones for implementing anti-flood measures

(Islam and Sado, 2002). Therefore, the forecast and simulation of floods is therefore essential for planning and explore urban flood vulnerability based on spatial pattern.

The methodology has been tested in principle by using Tainan County in the Taiwan as a case study. This paper allows users to understand the spatial pattern of urban flood with vulnerable land use types. First, utilizing the FLO-2D models to simulate four urban flood situations from water resources bureau. Second, using the geographic information system to compare the four urban flood situations. Third, utilizing explore spatial data analysis (ESDA) to discuss the spatial pattern of urban flood and simulate the land use vulnerability area or levels from different situations. Finally, forecasting the results to urban flood with land use plan.

3 'ECO-CITY' VISION: THE DEVELOPMENT PERSPECTIVE

Roseland (2001) mentions that the term ''eco-city'' is relatively new, but is based on concepts that have been around for a long time. It is based on acknowledging the complexity of every urban process and trying to tackle this complexity by focusing mainly on the interrelationships among different fields and sectors, but without neglecting the necessity of appropriate, sector-specific solutions. With the city as the main object of analysis, a very important aspect is to adopt a practical and accessible framework for its description. This requires a clear identification of elements of urban analysis which allows both straightforward linking of the planning objectives and criteria to these elements and the assignment of tasks to the different disciplines involved. A closer look at such western initiatives usually reflects priorities, as summarized in Fig. 1. These aspirations, although also relevant to the Taiwan context, vary significantly with regard to core concerns for obvious reasons. In a country like Taiwan, which is predominantly defined by vastness and diversity, an eco-city vision should reflect an awareness of history and society, relate the human, built, and natural environments, and respect the cultural and social use of space. In the ECOCITY project, the structure adopted for analysis and evaluation was based on the following elements: context, urban structure, transport, energy and material flows, and socio-economy. Other alternative structures, based for instance on the scale of approach (territorial, metropolitan or urban) might have a similar role in an integrated planning process.

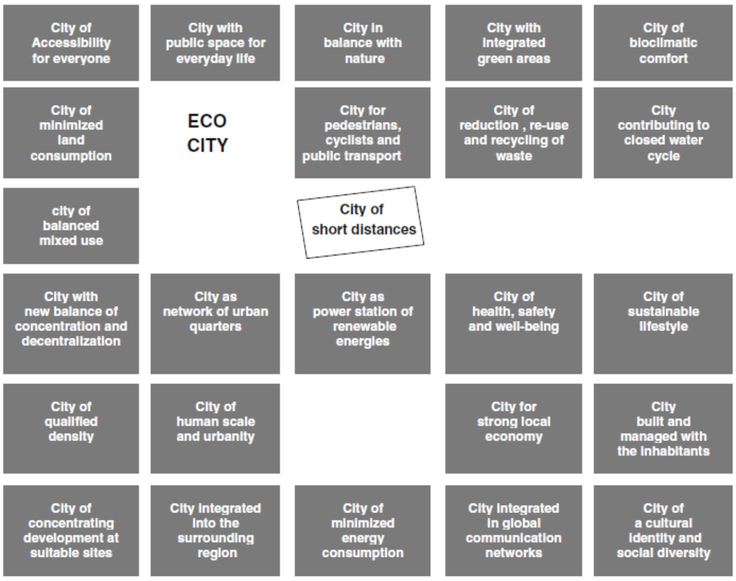


Fig. 1 Developed countries' aspirations for an 'eco-city' (source: http://www.ecocityprojects.net/ index_public.php)

4 METHODOLOGY

4.1 Study area

Located in the southeastern corner of Eurasia Taiwan sits in the middle of the Western Pacific festoon of islands. It faces the East China Sea to the north (600 km from the Ryukyu archipelago), the Bashi Channel to the south (350 km from the Philippines), the Taiwan Strait to the west (averaging 200 km from the Chinese mainland), and the Pacific Ocean to the east. Situated at the western rim of the Pacific Basin, the island plays an important role as an East Asian crossroad.These study area Tainan is the forth-grade city in Taiwan, but it's the oldest city which has abundant cultural heritage, as the cultural style presented. The methodology will now be described in greater detail, taking as an example its pilot application for Tainan in Taiwan, which is a town in which there is present risk from flood hazard. The extent of the flooding suffered by the inhabitants of Tainan in 2009 is illustrated in Fig. 2.

Fig. 2. Tainan, Taiwan, in the floods of Auguster 2009(source: http://www.flickr.com/photos/kyo4890x115/3807860280/)

4.2 Flood governing equations

The Taiwan government has developed various flood data for mitigation of natural hazards. The two-dimensional finite difference model FLO-2D was conceived for routing non-Newtonian flood flows on alluvial fans(O'Brian, et. al. 1993). The objective in designing this model was to estimate the probable range of flow properties (velocity and depth), predict a reasonable area of inundation, and simulate flow cessation. The model has been applied to a variety of flooding problems. The advantage of this model is embodied in its versatility to route channel flow using variable area cross sections, predict channel overbank discharge, and simulate floodplain flow over complex topography. Simulation of urban flooding on developed fans and floodplains became plausible when model components were designed to evaluate street flow and account for flow path obstructions, such as buildings.

(1)The two-dimensional constitutive equations include the continuity equation:

$$\frac{\partial h}{\partial t}+\frac{\partial hV_x}{\partial x}+\frac{\partial hV_y}{\partial y}=i \quad (1)$$

(2) The two-dimensional equations of motion

$$S_{fx}=S_{ox}-\frac{\partial h}{\partial x}-\frac{V_x}{g}\frac{\partial hV_x}{\partial x}-\frac{V_y}{g}\frac{\partial hV_y}{\partial y}-\frac{I}{g}\frac{\partial V_x}{\partial t} \quad (2)$$

$$S_{fy}=S_{oy}-\frac{\partial h}{\partial y}-\frac{V_y}{g}\frac{\partial hV_y}{\partial y}-\frac{V_x}{g}\frac{\partial hV_y}{\partial y}-\frac{I}{g}\frac{\partial V_y}{\partial t} \quad (3)$$

in which h = flow depth; and Vx and Vy = depth-averaged velocity components along the x and y coordinates. The excess rainfalI intensity i may be nonzero on the alluvial fan or the flood. The friction slope components Srx and Sly are written in (2) and (3) as a function of bed slope Sox and Soy, pressure gradient, and convective and local acceleration terms. A glecting the last three acceleration terms of (2) and (3). Further, by neglecting the pressure term, a kinematic wave representation is derived. These approximations are valid for steep alluvial fans. The option of using either a kinematic wave or diffusive wave equation is available in FLO-2D.

4.3 Utilizing explore spatial data analysis

4.3.1 Spatial autocorrelation analysis

Spatial analysis is examining hazards and their impacts. Spatial analysis provides a means of understanding the nature of hazards and their social, economic, or ecological impacts. The value of Moran's I, is positive when nearby objects tend to be similar in attributes; a positive Moran's I suggests a natural hazard distribution, with Moran's I = 1 as the worst natural hazard distribution. On the contrary, the value of Moran's I is negative when it tends to be more dissimilar than what is normally expected. With respect to natural hazards, a negative Moran's I suggests a natural hazard distribution, with Moran's I = -1 as the best natural hazard distribution. Moran's I = 0 when attribute values are arranged randomly and independently in space. They were also implemented in a number of software packages, including SpaceStat, Geoda, and the analytical toolbox for ESRI's ArcGIS.

$$I(d) = \sum_{i} \sum_{l} w_{il} z_i z_l / S_0 m_2 \qquad (1)$$

Where

$$S_0 = \sum_{i} \sum_{l} w_{il} \text{ , } m_2 = \sum_{i} z_i^2 / I \text{ and } z_i = x_i - \bar{x} \qquad (2)$$

A weight matrix W has elements xi representing the connections in a set of spatial unit i. The xi may assume any value, but in this paper we shall confine ourselves to a binary weight matrix consisting of ones (connected) and zeros (not connected). The diagonal elements of W are zero. The variable X is mapped onto the I spatial units. The spatial autocorrelation analysis coefficient, Moran's I, is Zi is the value of equity for each zone. i = 1,2,. . ., I. The value of Moran's I, is positive when nearby objects tend to be similar in attributes; a positive Moran's I, suggests a natural hazard distribution, with Moran's I, = 1 as the worst natural hazard distribution. On the contrary, the value of Moran's I, is negative when they tend to be more dissimilar than what is normally expected. With respect to natural hazard, a negative Moran's I, suggests a natural hazard distribution, with Moran's I, = -1 as the best natural hazard distribution. Moran's I, = 0 when attribute values are arranged randomly and independently in space. They were also implemented in a number of software packages, including SpaceStat, Geoda, and the analytical toolbox for ESRI's ArcGIS.

5 ANALYSIS AND RESULT

5.1 Explore spatial data analysis of flood area

This paper through a cases studies in where natural hazard happened areas and the analysis used the data from Tainan in 2009. The method integrates GIS techniques, spatial autocorrelation analysis (SAA) and local indicators of spatial association (LISA) to analyze the process of disaster scale and decision making is guided by examination which may vary from large regions. The disasters mapping of locations with significant LISA statistics, together with an indication of the type of local spatial association as given by the quadrants in the Moran scatter plot, provide the basis for a substantive interpretation of spatial clusters or spatial outliers. Show in figure 3.

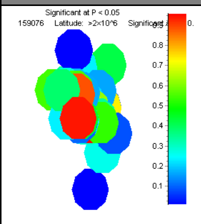
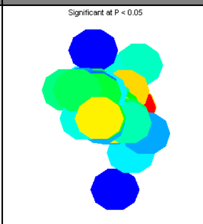
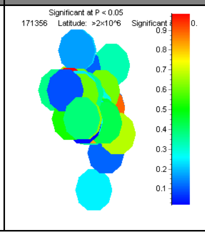
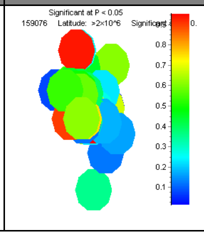
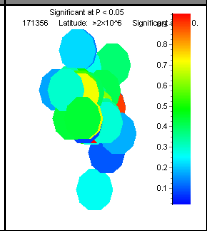
Flood Area	A	B	C	D	E
Explore spatial data analysis					

Fig.3 The SAA and LISA analysis

The result of the SAA analysis on Tainan the value of Moran's I is positive 0.52, and refers to the random and independent distribution in region. LISA provides information on the relative important of four types of spatial association: (1) high–high, high values (above the mean) associated with high risk values such as A, B D areas; (2) low–low, low values (below the mean) associated with low risk values; (3) low–high, low values associated with high risk values; and (4) high–low, high values associated with low risk values. In the future, the land use planning suggests strengthening prevention such as Yong Kang district, Sinying district and Madou district.

5.2 Land use vlunerability assessment of flood area

The hazard data used for flooding is from the flood map compiled by the water resourse agency (2004), which provides the probability of occurrence of three scenario flood areas: 1 day 600 mm rainfall assessment land use vulnerability area. Show in Fig4.

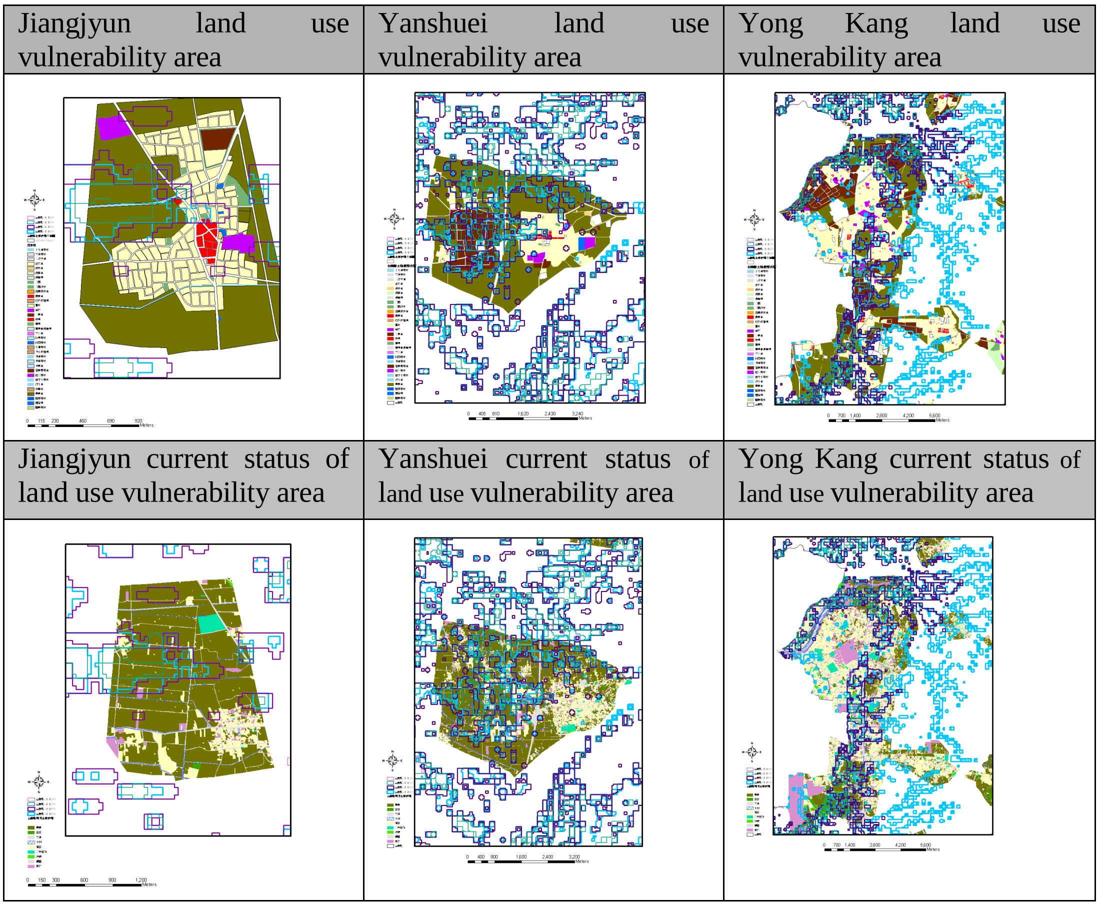


Fig 4 Land use vulnerability area of Tainan

Results indicate that the land use type and degree of urban development of disaster shifted from the natural event towards the development processes that generated different levels of vulnerability. Vulnerability reduction began to be advanced as a key strategy for reducing disaster impact. For a particular class of severity, the variation in vulnerability of the land use situation affected will result in a range of vulnerability values. Let us discretize land use vulnerability as well into a set of classes. A damage value needs to be found for each class of vulnerability in each class of severity. The general scheme is illustrated in Table 1.

		The simlation of flood				Vlunerability level
		I	II	III	IV	
Land use planning type	Residential	27(2)	21(3)	17.3(3)	6.1(2)	10
	Agriculture	88(4)	71(4)	77.2(4)	6(1)	13
	Open space	59(3)	2.8(1)	2.2(1)	25(4)	9
	Wetland	13(1)	4(2)	2.6(2)	8.2(3)	8
Current Status of Land Use type	Residential	77(4)	82(4)	3.7(3)	11.4(2)	13
	Agriculture	33(2)	21(3)	13.6(4)	23.6(4)	14
	Open space	20(1)	0.7(1)	0.02(1)	2(1)	4
	Wetland	46(3)	2(2)	0.4(2)	23(3)	10

Table 1 Format of look-up table for assessing vulnerability values from classes of use vulnerability

Results indicate that Tainan area will be vulnerability by flooding at minimum and maximum inundation 4 to 13 levels, respectively. The most severely impacted sectors are expected to be the residential areas, agricultural land. The urban flood issues were discussing water retention by land use from ecological city. Potential strategies to balance the impact of water retention by land use include: wetland preservation; open space build stormwater planter; and the afforestation of dunes.

6 CONCLUSION

It is clear that the focus of flood as well as disaster initiatives has to be people-centric and inclusive. This paper concludes that even the most daunting problems have simple solutions. Recognising the complex multilayered land use planning of a traditional Tainan city like Taiwan, a explore urban flood vulnerability based on spatial pattern in Taiwan ecological city viewpoint., long-term and balanced development. The synergy of environmental and disaster disciplines blended with the hidden potential lying within communities needs to be maximised to ultimately achieve the objective of sustainable development.

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Central Weather Bureau (http://www.cwb.gov.tw/V4e/, CWB)

fig3. source: http://www.flickr.com/photos/kyo4890x115/3807860280

fig2. source: http://www.ecocityprojects.net/ index_public.php