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The Eco-efficiency Assessments of Hazards prevention in Urban Parks of Taiwan

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1 ABSTRACT

The development of urban led the area of green filed to be decreased. Also, the capability of pervious to water in the surface of the earth and water conservation was lower. These situations raise the probability of flood in urban and attack the environment of urban. Besides, the capability of regulating climate and reducing carbon oxide was lower in eco-efficiency. There were some researches investigate these problems, but most of them focused on the simulation of preventing disaster not eco-efficiency. This research aimed to investigate the eco-efficiency of urban disaster prevention and practice in real plan of urban.

The research investigated the real instance from parks in Chiayi city in Taiwan as subject. The instrument of this study combined CITYgreen model and GIS to assessment the value and eco-efficiency of reducing the hydraulics runoff in the parks of Chiayi city. Based on the results, this study provides some suggestions in conclusion.

2 INTRODUCTION

The improving project about urban environment is thought as the thershold of eco-city. Due to the perception of the importance of ecology and green space, the issue of urban parks gains more and more visibility recently. Whether on recreational, precautionary, or educational purposes, parks are oriented for multifunctional services. Besides, urban parks also play an important role on improving environment and landscaping. So green space becomes an essential part in cities. However, the ecological funtion ,one of the most major functions , of parks is often neglected, such as reducing rainstorm runoff, maintaining biodiversity, secluding carbon dioxide, decreasing the level of noise, lessening heat island effect, and increasing the bearing capacity of environment. The neglect of ecological function of parks can make parks lose its eco-efficiency gradually.

As the process of urbanization, the ability of water pervasion and water storage of earth surface is getting lower and lower. Cropland, grassland and forests are displaced by the impervious surfaces of streets, driveways and buildings greatly intensifying storm water runoff, diminishing groundwater recharge and enhancing stream channel and river erosion (Stone, 2004). One of the major environmental problems of urbanization is that the urban hydrological system has to cope with a highly fluctuating amount of surface runoff water which may become extremely high during periods of rainfall and remains low during the rest of the time (White, 2002). Green space in urban can be a key solution to reduce the rainstorm runoff. Although many studies relative to this issue was done from many aspects, in-depth discussions are still needed to clarify the effects of eco-efficiency of green space besides the general focus on the simulation of preventing disaster. The eco-efficiency of green space was discussed comprehensively through practice planning process by quantification way in this study

Parks in Chiayi city in Taiwan are considered in this study. A model established by CITYgreen combining GIS is used to evaluate the eco-efficiency of green space ,like parks, on reducing the hydraulics runoff of Chiayi city. Finally, the eco-efficiency and eco-value of the parks in Chiayi city can be determined and given through this model. It provides the planner and decision maker a reference solution on urban planning and green space planning.

3 METHODOLOGY

3.1 Principle of computing eco-efficiency using CITYgreen

CITYgreen is an extention module of Arcview GIS. The eco-efficiency of air pollution removal,carbon storage and sequestration,energy savings and runoff reduction can be determined using CITYgreen with

spatial analysis function in Arcview GIS. The major function of CITYgreen is to determine the eco-efficiency of every concerned variable by computing the data of area space and area property. Besides, growth modelling, prediction, and evaluation of eco-efficiency can also be considered in this model. Runoff reduction is taken as major variable to be evaluated and analysed in this study.

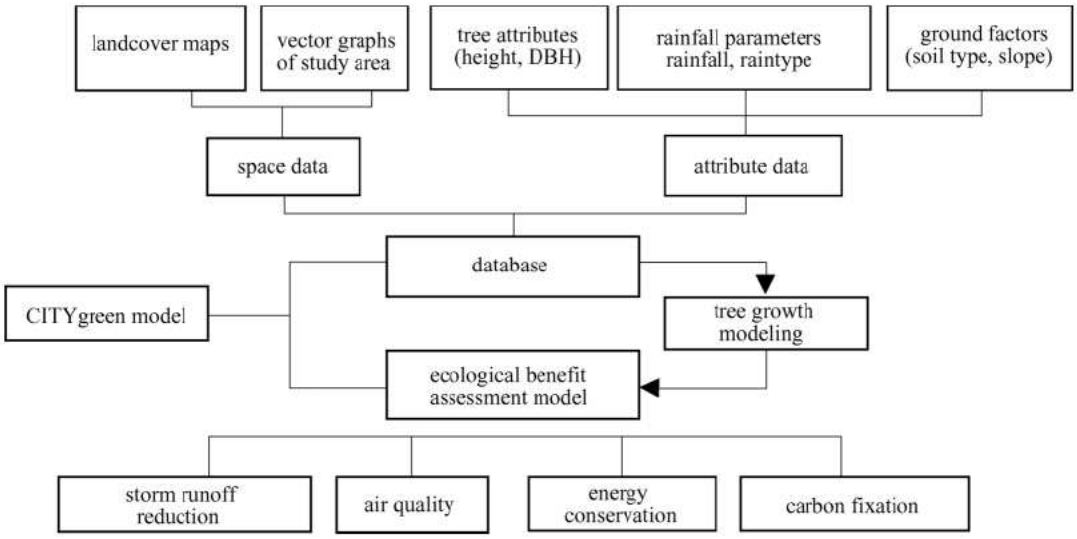

Fig. 7: Structure of CITYgreen

3.2 Principle of determining the eco-efficiency of reducing rainstorm-runoff

The major function of green space is to reduce the flood peak after rain-storm. It can delays the happening time of flood peak and modulates the water flow through cities rapidly. It will help to lower the occuring probability of flood disaster in cities. As the reason, green space plays an important role in water storage and replenishing groundwater. With reference to past researches, the effect of green space on water storage can be summed up into three approach method (Lihua PENG et al., 2008) :

(1) evaluating of rainfall interception of leaves,stems and other physical structure of trees

(2) water balancing methods : It is a method based on the balance of water of a forest zone to calculate the amount of water conserved by vegetation

(3) runoff curve comparison between forest land and non-forest land (Wang and Zhang, 2001; Jin et al.,2005).

Two different models ,with vegetation and without vegetation, were established using CITYgreen in this study. These models were used to simulate the path of water flow after rainfall. The eco-efficiency of vegetation on water storage and reducing rain-storm runoff can also be determined in this study. The result is presented as storage volume (Vs).

Four curves, Type IA,Type III, Type II, and Type I, were drawn by the U.S. Soil Conservation Service (SCS) as Fig. 8 according to 24 hours distribution record of rainfall. The meaning of the curves is listed below:

(1) Type IA represents the lowest intension rainfall with long time duration .

(2) Type III represents the higher intension rainfall with shorter time duration than type IA.

(3) TypeII represents the highest intension rainfall with shortest time duration.

(4) TypeI represents the lower intension rainfall with longer time duration than type II.

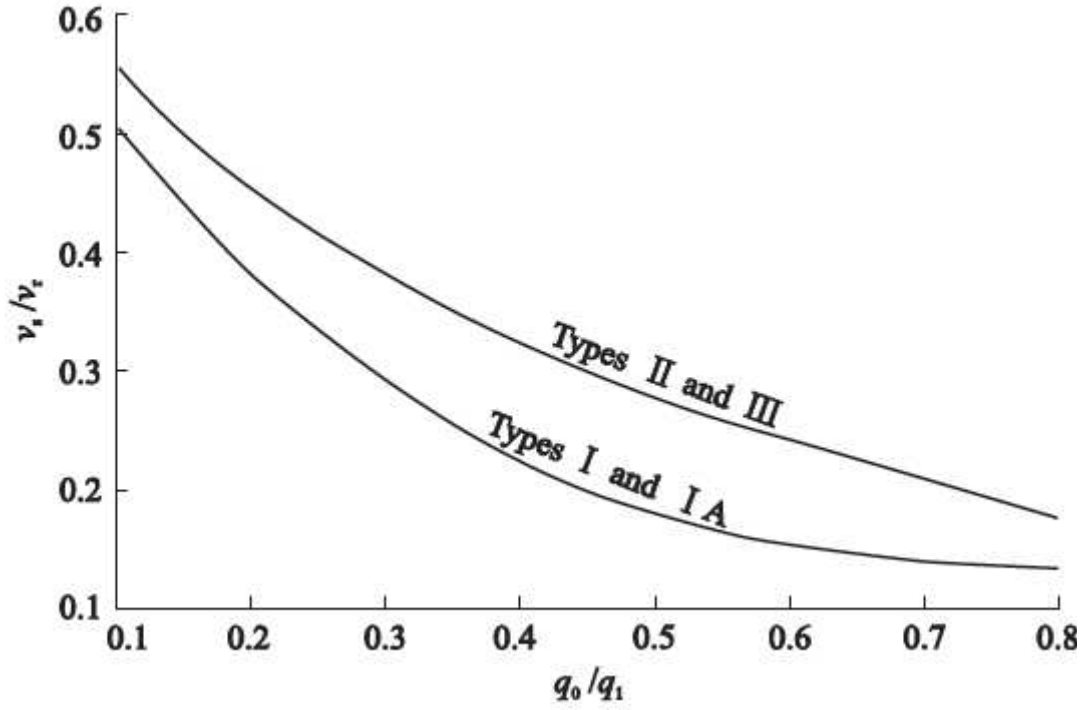

Fig. 8 Vegetation interception curves of rainfall types I and IA, II and III (redrawn from USDA 210-VI-TR-55, Second Ed., June 1986)

The meaning of four variables (V_r V_s q_0 q_1) mentioned in Fig. 8 was expounded respectively and the equation of total runoff volume(V_r) was given below:

1.V_r total runoff volume in a storm event with vegetation

2. V_s decreased volume of runoff with the vegetation removed

3. q_0 peak flow of runoff in a storm event with vegetation

4. q_1 peak flow of runoff in a storm event without vegetation

5.equation of total runoff volume V_r:

$$V_r = Q \times E \qquad \text{eq.(1)}$$

$$Q = (P - 0.2S)2 / (P + 0.8S)2 \qquad \text{eq.(2)}$$

$$S = (1000/CN) - 10 \qquad \text{eq.(3)}$$

Where:

E: the measure of the study area

Q: runoff of 24 hours duration storm

P: rainfall of 24 hours duration storm

S: potential maximum retention when runoff occurs

CN: CN is a value determined by the soil and landcover property under the path of runoff.

The total volume Vr can be computed through eq. (1). When the value of q0 and q1 is avaliable, the value of Vs can be determined through the relation of Vs/Vr and q0/q1 in Fig. 8. The economic value of the eco-efficiency of reducing runoff by the green space can be determined through eq.(4). It is taken into consideration in the CITYgreen model in this study. This model can be used or be references in urban planning project.

economic value Vs × M eq.(4)

Where M represents the cost of per unit water storage facility

3.3 Application on establishing model with CITYgreen

The aerial photograph is translated into grid file by the function of spatial analyst in Arcview. Through this process, landuse distribution can be differentiated into several types by different colors on the grid figure, such as green space, bussiness section, and industrial zone. Then the figure was taken to evaluate the eco-efficiency value after re-classification by CITYgreen model.

4 STUDY AREA

Chiayi city is selected to be analysed in this study. Chiayi city is situated on the Northern Chianan Plain(south-west Taiwan) and located at latitude 23*29' N and longitude 120*27' E, close to the tropic of Cancer 22.5*N. It covers a land area of 60.0256 square kilometers with width of 10.5 kilometers and length of 15.8 kilometers. Expect some of the eastern parts are belong to hill landforms, most parts of the city are fertile plain. The plain lays westward and descend slowly. Characterized by the subtropical monsoon climate,the city has an average temperature of 23.3 Celsius with the hottest in July and the coldest in January. Winter is the dry season and blows only the northwest monsoon. Summer comes the southwest monsoon and usually thunder rains. Because of location at the main path of typhoon passing, Chiayi city was usually attacked between July and September. Affected by thunder rains and typhoon ,the annual average rainfall of Chiayi city can be up to 2,000 mm.

The administrative area of this city (60,025 square kilometers) was divided as East and West districts. In each district, there are 55 Lis (sub-district), totaling 110 Lis. By May, 2003, the total number of households is 83,161 with a population of 268,755 including male 134,595 and female 134,160. Ths landuse situation of Chiayi city is shown in Fig. 9. The distribution of landuse structure includes agriculture and forest 40.5%(24.35Km2) , parks and green fields 2%(1.44 Km2) , industrial zone 3%(1.9 Km2) , hydrolic use 3%(2.1 Km2) , traffic use 12.8%(8 Km2), residential district 16%(9.7 Km2) , infrastructure 2%(1.2 Km2) , bussiness section 2%(1.3 Km2) , unused space 9%(5.28 Km2) , schools 4%(2.4 Km2) , government organization 1%(0.8 Km) , aquiculture 0.1%(0.04 Km2) , and others 2.1%(1.25 Km2)

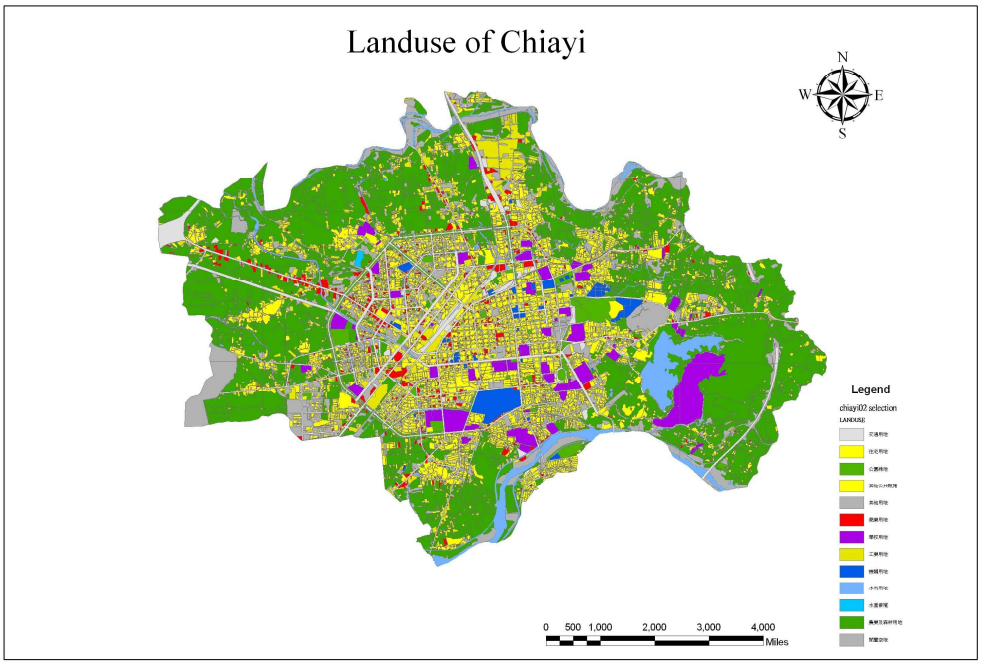

Fig. 9: Present landuse structure distribution of Chiayi city

5 VALIDATION WITH PRACTICE

The landuse grid file of Chiayi city was created using the aerial photograph by the function of spatial analyst in Arcview. And different colors represent the different landuse type of the area as shown in Fig. 9. This study re-classified relative landuse types into seven types: building, line, traffic, forest, school, government, and water and other. Then it is summed up by CITYgreen model into four categories to evaluate eco-efficiency value: Farmsteads, Impervious, Surfaces, and Trees (as shown in Table. 1).

Table. 1 Landcover Composition of Chiayi city

Percentage of the measure of area	measure of area（Km2）	Composition
33.44%	15.57	Farmsteads (Buildings, lanes, driveways and surrounding lots)
2.45%	1.14	Impervious Surfaces: Paved: Drain to open ditches
3.16%	1.47	Trees: Grass/turf understory: Ground cover < 50%
25.7%	11.96	Trees: Impervious understory
23.41%	10.9	Urban: Commercial/Business
11.67%	5.44	Urban: Western Desert: Natural Landscaping

The stormwater runoff control benefits of Chiayi city are determined through CITYgreen model (as shown in Table. 2). The figure of rainfall vesus time is drawn based on 2 years, 3.5 in rainfall of 24 hours storm. In hydropedology aspect, the soil of Chiayi city is classified as type B cause of its pervious property and easily affected by human activities.

Table. 2 Stormwater Runoff Control Benefits of Chiayi city

Control Factor	Results
Avg.	2-yr
24-hour Precipitation (in.)	3.5
Site Avg. Slope (%)	0
Rainfall Region	II
Hydrologic Soil Group	B

According to the computing result, the runoff depth of Chiayi city is estimated as 1.86 (in) and the runoff depth of green space in Chiayi city is estimated as 1.64 (in). The runoff volume of Chiayi city is estimated as 314,070.34 (cu. ft.) and the runoff volume of green space in Chiayi city is estimated as 276,521.65 (cu. ft.). Based on the cost of per unit water storage facility NT 51.31, the stormwater runoff control benefits of green space in Chiayi city is estimated up to NTD 14.2million.

6 CONCLUSIONS

The eco-efficiency of green space in Chiayi city on reducing rainstorm runoff is determined using CITYgreen model in this study. The stormwater runoff control benefits of green space in Chiayi city is estimated up to NTD 14.2 million. CITYgreen is developed and used extensively for the decision-making processes of urban planning in the United States. However, the CITYgreen model needs to be modify when it is used to analyse rainstorm runoff of cities in Taiwan. For precision result, some parameters of CITYgreen have to re-correct to suit the environment of Taiwan. It depends on the complete data collection by more further researches and studies. With CITYgreen model and local data information, the precision ecological benefits can be take into consideration and be references when the planner is making decisions.

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