Land Resource Carrying Capacity

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Developing a Model of City's Land Resources Carrying Capacity

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Abstract

One of the most popular and widely applied method of the environmental carrying capacity assessment is the Ecological Footprint–Biocapacity Account (EF-BC Account). The ecological footprint is defined as the amount of biologically productive land or sea area required to renew the biological resources consumed and to absorb the biological wastes produced, by a given human population or activity. The biocapacity measures the amount of useful biological resource production and waste absorption within a defined geographical area. A such area can be defined as an ecological deficit if the ecological footprint amount is exceed its biocapacity. It means the carrying capacity of this area is exceed.
EF-BC account has some advantages such as it has a single figure indicator that is easy to understand and to make comparison among other period in the same area or among other areas. However, this method has some disadvantages such as it only covers natural capital calculation and not suitable for assessing carrying capacity at the local level, especially for assessing carrying capacity of a city. By using this method, carrying capacity of any city would be exceed, since a city is characterized as an area with limited natural capital, especially land resource. Land available in the city is very limited and constant in amount. Moreover, the land in the city is usually used for housing and other buildings for socio-economic purposes and not as biologically productive land. This fact would make the biocapacity of a city is small, while the ecological footprint is very wide in line with its high population and high consumption of resources per capita. By using the EF-BC method, the result of assessing carrying capacity of city would be biased.
Therefore, this paper would discuss and develop a model of land resources carrying capacity for a city by considering not only its natural capital but also other community capitals that are human capital, social capital and built capital. The model developed can be used to assess the land resources carrying capacity in terms of the quantity and of the quality of land resources available in the city. The methodology used in developing the model is the description analysis with a mathematical approach as well as spatial analysis. The model of city's land resources carrying capacity is a functions of all the community capitals. This model would be useful for government to make the planning which focuses on achieving the sustaining city.

Keywords: Carrying Capacity, Sustaining City, Land Resources.

I. Introduction

The environmental problems around the world is accelerating in line with the population growth and the increase of resources consumption per person. In the early 1990s,

half of the world's urban population was located in 394 cities, each containing over half a million inhabitant. The population of urban areas is currently growing at 2.4 percent annually, over three times as fast as the 0.7 percent rate for rural areas, affecting over 60 million people are added to urban populations each year. In 1997, United Nation predicted that by the year 2030, 61 percent of the world's population will live in cities and towns and an estimated 90 percent of this increase will occur in cities of developing countries (Leitmann, 1999). At the same time, urban areas are more and more the engines of national and regional economic growth, following their functions as the centre of manufacturing and services. Consequently, the cities become the biggest consumers of resources and generators of waste. This fact brings the important of exploring on how to achieve sustaining cities.

By use of the carrying capacity approach, Wackernagel et al constructed a method to measure the sustainability that is called Ecological Footprint and Biocapacity Account (EF-BC Account). This method has been globally used and became one of the most popular method. However, this method has more appropriate to be used for global and national level, since it assumes that the resources consumed in the region can or must not be imported from outside the region. Meanwhile, according to Graymore, 2005, unlike the global sustainability, small region do not necessarily have to remain within the region's carrying capacity in terms of the resources that are available, since much of what is consumed may be sourced from outside the region. If this idea of ecological footprint and biocapacity method was used for small regions, the fact many of the resources consumed in the region are imported would suggest that the area is not sustainable as the population is living outside its own carrying capacity.

Moreover, if the EF-BC Account was used for a city which is characterized as a small region with a limit of land resources, the result would suggest that all city in the world is not sustainable since the land available in a city is used for non agricultural purposes. The fact,

the city has a regional economic function as the centre of manufacturing and services, and there is no other way, so most of resources consumed for the population is imported.

Hence, the main purpose of this research is to develop carrying capacity assessment method that is appropriate and effective as a tool to measure the sustainability of a city. This model will focus on the sustainability of land resources which are quantitatively limited in the city and cannot be imported from the outside region. The model developed would be based on the approach used in EF-BC account that is carrying capacity approach that assesses the demand and the supply of land resources for sustaining the city development.

Firstly, the paper reviews the Ecological Footprint – Biocapacity (EF-BC) Account as the base approach for developing the model. Then, it follows by the review of the city's function and the consequences to the land use pattern in order to understand the characteristics of a city on using the land resources. The methodology used in developing the model is the description analysis with a mathematical approach as well as spatial analysis approach. The mathematical approach will be used especially to assess the quantity aspect, while the spasial analysis approach will be used to identify the quality of the land available.

II. E F – BC Account as the Method of Carrying Capacity Assessment

Basically, the account of this method are divided into two parts: the demand on nature (or ecological footprint) and ecological supply (or biocapacity). The demand on nature or Ecological Footprint is a quantitative measure of how much ecologically productive land and water a defined population unit needs to support its current consumption and to take care of its wastes. Meanwhile, the ecological supply or biocapacity refers to the capacity of a given biologically productive area to generate an on-going supply of renewable resources and to absorb its spillover wastes (GreenFacts, 2006). The calculations takes into account the

following resources:1) Arable Land; 2) Pasture Land; 3) Forests; 4) Oceans; 5) Infrastructure needs; 6) Energy costs. (Wackernagel et.al, 2005).

A comparison of the Footprint and Biocapacity reveals whether existing natural capital is sufficient to support consumption and production patterns. A country whose Footprint exceeds its Biocapacity runs what we call an ecological deficit and that means its development is not sustainable. Vice versa, if the EF is smaller than the BC, it is called an ecological reserve. A national ecological deficit can be compensated through trade with other nations that process ecological reverses or through liquidation of national ecological assets. In contrast, the global ecological deficit cannot be compensated through trade and is therefore equal to overshoot (Global Footprint Network, 2006). The global ecological deficit might be minimized by minimizing the global EF. Since the EF will decrease in line with the population size, the consumption per person and the resource efficiency, the global EF could be minimized by controlling population growth, decreasing consumption per person and prevailing technology to improve resource efficiency.

The advantage of the EF – BC account method is that it has single figure indicator that easy to understand and to make a comparison of ecological condition between one nation to the others or of nation in different periods. Meanwhile, this method also has some disadvantages since it 1) is only taking into account natural capital and ignoring the social and human capitals; 2) excludes some demands such as fresh water consumption, soil erosion, toxic pollution of air, water and land, industrial and domestic wastes, in the calculation; 3) is required a large amount of the data that are beyond what is available for a small region and some of which is difficult to obtain; 4) ignores the impacts of varying This led to many estimations used in the calculations and 5) calculates the resources that mostly are not available in urban areas. This fact makes the method is not suitable to be used for

assessing sustainability of city. Hence, Graymore (2005) stated that this method is not suitable for assessment of sustainability of small region, including city area.

III. The City's Functions and Its Consequences

Generally, a city plays economic and social roles as the centre of manufacturing industry, and or of public services. As the centre of manufacturing industry, the linkage between cities and its hinterland is growing mostly related to the production process. As the centre of public services, a city provides the services that facilitate not only for its inhabitant but also the people surroundings. There are three categories of services provided: 1) Consumer Services; 2) Production Services.; 3) Public and Goverment Services.

Though the existences of cities have significant roles for the regional growth even national scale, in fact, cities are not self sustaining. They are usually most use resources inefficiently compared to rural areas. A city is a complex system greatly dependent on outer resources (Figure 3.1.). In order to sustain city's life, it takes air, water, energy, food and other resources and produces wastes as these resources used. Most of these resources is imported from near and distant farmlands, forests, mines, and watersheds. Most of wastes produced is also discharged into or end up in air, water and land outside the boundaries.

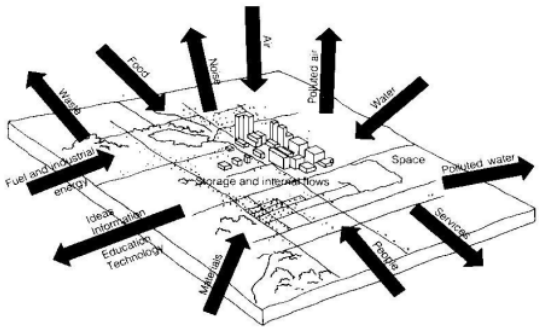

Figure 3.1. Crude model of major inputs and outputs of an urban area (Source: Miller TJ., 1990)

Though some resources need for city life could be imported to the city, there is only one resource that cannot be imported and is confined within the city boundary. In line with city's population growth, the land available is becoming scarcity. Meanwhile, affecting by the push factors as well the pull factors of a city, the city's population growth cannot stop to increase, then it becomes overcrowded and or expands upward. Then, the environmental problems will arise when the existing population and its activities exceed the maximum load that can be supported by ecosystem, in other words, the city carrying capacity has exceeded. Therefore, the land resource carrying capacity is necessary to identify and to use as the base of making city planning decision.

As mentioned before, the land available in a city is usually very limited and relatively finite in quantity. However, the city's life is very dynamic, in all aspects, demographic, social and economy of inhabitants as well development policies, by which they will affect the land use changes. Basically, the availability of land in the city can be divided into two category, protected areas and usable areas. Protected areas include unsuitable areas for development such as sloppy land, flooding areas, etc., and areas that have ecological functions such areas surroundings lake or pond, areas along riverside, areas along coastal line, etc. All the protected areas can not be used for any development purposes. The total protected areas exist in a city is influenced by the physical condition of that city that is constructed naturally depend on the form, structure and condition of the watershed in where that city is located. The hydrological interrelation between a city and the watershed in where that city is located reflects the natural capital of that city.

The real available of land is usable areas that can be divided into existing built areas and un-built areas. The existing built areas comprises the land for all activities purposes such housing, industry, trade, social facilities and public facilities. All building and service facilities existed in a city is the built capital that the city has. The existing pattern of the land

uses is influenced by the specific function of a city, the number of population and the social economic level of inhabitant It means that the need for land per person of a city is reflected by the specific city function (social capital) and the social economic level of inhabitant (human capital).

The un-built area available in a city is the remaining area that can be used for the future development. Simplify, from quantitative aspect side, the land carrying capacity of a city exceeds if the un-built area is not available for any other development. However, the land carrying capacity cannot only be seen from that aspect, it also must be analyzed in term of its quality.

The quality of the protected area is poor when its condition does not function ecologically as it should. Sometimes, that areas are existed in a city, but there are no trees or occupied illegally by some people. In that case, the land carrying capacity of the protected areas can be said as in poor condition. Similarly to that principal, the quality of the usable areas, built and un-built, is poor if their conditions does not reflect comfortable areas for life. The conditions of usable areas can be seen from social economics aspect of inhabitans, the level of crimes, the level of air and water pollution, the crowding index, the availability of public facilities and infrastructures, etc.

IV. Developing the Model

Based on the theoretical reviews, discussed earlier, it can be mentioned that it is needed to develop the land carrying capacity model that is suitable for city environmental characteristics. Systematically, the concept of the model can be seen in Figure 4.1. Quantitatively, the mathematical function of the land carrying capacity is

$$Y = f(S, D)$$

Where :

Y = Land Carrying Capacity Status

S = Supply (Availability) of land which depends on the natural capital and the built capital
D = Demand of land which depends on the social capital and the human capital
If S>D = the land carrying capacity does not exceed
If S<D = the land carrying capacity exceeds

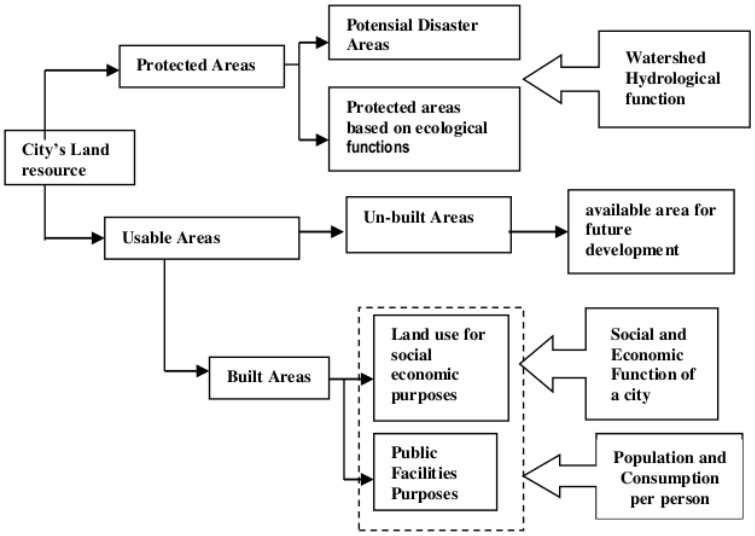

Figure 4.1. Concept of Land Carrying Capacity Model

Meanwhile,

S = TA – PA – BA, and

D = HA + SEA + PFA

Where:

TA = Total Area of a city
PA = Protected Area
BA = Built Area
HA = Area needed for the development of housing purpose
SEA = Area needed for the development which depends on the city function
PFA = Area needed for the development of public facilities purposes

As mentioned earlier, the quality of land available in the city is also needed to be assessed. The assessment of the land quality is needed for identify whether the conditions of area properly supports the functions or not. The method of the land quality assessment is the spatial analysis methods. It is needed to constructs all parameters for each type of land use functions that reflects the adequate standard required to support the functions. After data

related to the parameter are collected, they are plotted into a map. This map will show where the area is in poor, moderate or good conditions. If a such of city dominantly has poor areas, it means that in term of land quality, the carrying capacity has exceed. Then, the priority action program of development is not to expand but is to repair and to increase the quality, such as by conducting revitalization, providing more adequate public facilities, etc.

V. Conclusion

A city has significant roles on the economic and social development of the wider region. The environmental quality of cities must be sustained in such conditions that can optimally support that regional social economic function. That condition can be achieve only if the land carrying capacity of a city does not exceed. In addition, the pattern of land use and the quality of land is appropriate with the function. Hence it can be said that, urban land use decisions are critical determinants of environmental quality.

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