Review on the Evaluation System of Public Safety Carrying Capacity about Small Town Community

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Abstract Recently, small town community public safety problem has been increasingly highlighted, but its research is short on public safety carrying capacity. Through the investigation and study of community public safety carrying capacity, this paper analyzes the problem of community public safety in our country, to construct index evaluation system of public safety carrying capacity in small town community. DEA method is used to evaluate public safety carrying capacity in small town community, to provide scientific basis for the design of support and standardization theory about small town community in public safety planning.

Key words Small town community, Community safety, Public safety, Safety carrying capacity, Evaluation system

In recent years, China's public security incidents frequently occur, such as Ya'an earthquake, northern haze, Kunming blizzard, Xiamen spontaneous combustion of bus and Qingdao chemical explosion in 2013. These disasters and accidents are the public safety issues that people are concerned about, and these issues also arouse people's attention to public safety. China has entered a stage of rapid development of urban-rural integration, and the public safety of small town community also receives much attention. The significance of researching the public safety carrying capacity of small town community lies in making up for the deficiencies in the current planning and design of small town community, and better promoting the the integration of urban and rural areas. Its role is to arouse designers, planners and managers' attention to issues concerning small town community public safety, thereby reducing the secondary disasters in the wake of natural disasters and public accidents in small town community.

1 Overview

1.1 Community safety carrying capacity The so-called community safety carrying capacity refers to the maximum limit of security system for environment, community and culture within the community to bear the unacceptable adverse impact caused by the disasters in the city over a period of time.

1.2 Small town community The small town community is the community mainly engaged in non-agricultural socio-economic activities with small scale of development and low degree of concentration. In China, the small town community is a middle part linking urban communities to rural communities, and a basic community type in modern society.

1.3 Community public safety planning Community public safety planning is designed to meet the security system and principles for living and production, recreation, health care, water, food, transportation, environment and education in the community. The purpose of community public safety is to provide effective measures for the construction and management of community public safety, in order to avoid losses and adverse impact within the community.

2 Research progress of community safety carrying capacity

2.1 Urban carrying capacity Carrying capacity is the capacity to withstand the maximum load without being damaged. Now it is used to describe the extent of limit to the development of things. In the 18th century, the rise of the industrial revolution in England brought the concept of carrying capacity into the field of ecological research. In1912, Park and Burgess[1] developed the concept of carrying capacity in sociology and held the opinion that the carrying capacity of one region can be determined by the amount of living space, nutrients, sunlight and food resources. The concept of carrying capacity was subsequently cited to many disciplines, such as demography, resources, environmental science and sociology.

The carrying capacity of a biological species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment. In population biology, carrying capacity is defined as the environment's maximal load, which is different from the concept of population equilibrium. For the human population, more complex variables such as sanitation and medical care are sometimes considered as part of the necessary establishment. As population density increases, birth rate often decreases and death rate typically increases. The difference between the birth rate and the death rate is the "natural increase". The carrying capacity could support a positive natural increase, or could require a negative natural increase.

Thus, the carrying capacity is the number of individuals an

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environment can support without significant negative impacts to the given organism and its environment. Below carrying capacity, populations typically increase, while above, they typically decrease. A factor that keeps population size at equilibrium is known as a regulating factor. Population size decreases above carrying capacity due to a range of factors depending on the species concerned, but can include insufficient space, food supply, or sunlight. The carrying capacity of an environment may vary for different species and may change over time due to a variety of factors, including: food availability, water supply, environmental conditions and living space. The origins of the term "carrying capacity" are uncertain, with researchers variously stating that it was used " in the context of international shipping" or that it was first used during 19th-century laboratory experiments with micro-organisms. A recent review finds the first use of the term in an 1845 report by the US Secretary of State to the Senate.

As of the 1980s, the concept of regional carrying capacity was proposed. With regional resources as the object, Mao Hanying[2] studies the relationship between the regional carrying capacity and human socio-economic activities, and applies the state – space method to the quantitative study of the regional carrying capacity. As for the concept of urban carrying capacity, it was raised by *Notice on Strengthening Revision and Approval of the Overall Urban Planning* at home in January 2005. In China Urban Innovative Economic Development Forum (2006), Chen Huai pointed out that the urban carrying capacity mainly refers to the capacity of one city to sustain the maximum limit of urban population, economy, society and life by its resource endowments, ecological environment, infrastructure and public services.

2.2 Safety carrying capacity For the study of safety carrying capacity, Yang Jingping and Lu Jianbo[3] stated that the regional ecological safety carrying capacity was the capacity of regional resources and ecosystems to ensure human economic and social activities in 2002.

In 2005, Yang Xiujie[4] believed that the ecological safety carrying capacity means the capacity of regional resources and ecological environment to sustain a certain population under certain standard of living and corresponding economic and social aggregate, when ensuring sustainable use of resources and virtuous cycle of ecological environment within a certain range of time and space.

In 2008, JinLei[5] maintained that the urban safety capacity could be further defined as urban carrying capacity, namely the maximum limit of urban disasters inflicting no unacceptable adverse impact on the urban environment, community, economy, culture and other security systems over a period of time, which could be quantified as the city's biggest disaster tolerance.

3 Study on the planning of public safety carrying capacity of small town community

3.1 Domestic community public safety

3.1.1 Various natural disasters. There are various kinds of natural disasters occurring in China, covering and affecting a large area, causing serious casualties, collapsed and damaged houses. From the losses caused by natural disasters in 2011 and 2012 (Fig. 1), it can be seen that the losses caused by floods, earthquakes and typhoons have a larger proportion among all disasters, and the losses of population and houses arising from floods and earthquakes are more outstanding.

There are a lot of small towns in the earthquake or flood-prone areas, so it is necessary to carry out rigorous data analysis of siting, planning and design of small town community. These factors will have an impact on the public safety of small town community.

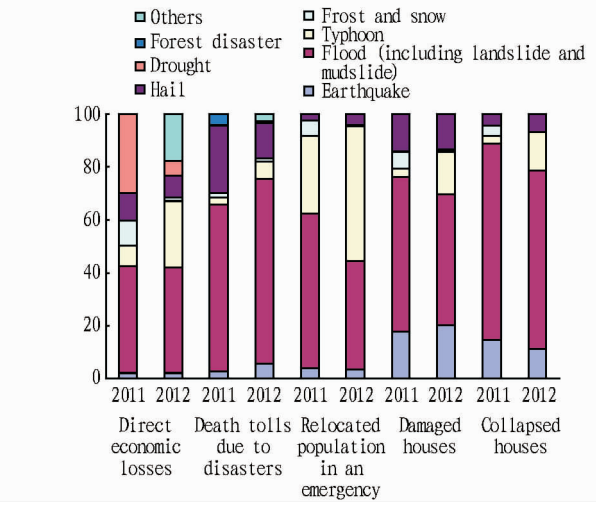

Fig. 1 The scale diagram of losses caused by natural disasters in China during 2011 – 2012

3.1.2 Earthquake disasters. In recent years, the occurrence of earthquakes has been more frequent. From the losses caused by earthquakes from 2003 to 2011 (Fig. 2), it can be found that the curve of earthquake casualties is most similar to the curve of losses of housing. It is found from the survey that the houses in the earthquake-stricken areas mainly have the mud and wood structure, with low seismic performance.

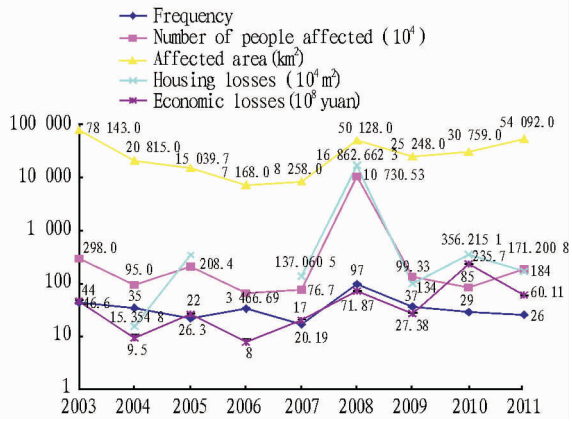

Fig. 2 The curve of impacts of earthquake in China from 2003 to 2011

The quality of construction materials is poor, and the housing

structure is irrational, so there are greater casualties. In addition, the damaged houses are also affected by site conditions, thereby increasing the amount of post-disaster reconstruction projects.

3.2 Establishment of evaluation indicators According to the above-mentioned domestic community public safety, we consider the characteristics of safety carrying capacity, to establish the indicator system for the public safety carrying capacity of small town community, including 6 first-level indicators and 21 second-level indicators (Table 1).

Table 1 Evaluation indicators for the public safety carrying capacity of small town community

First-level indicators	Second-level indicators
Residential areas (A_1)	Building density (B_1)
	Floor area ratio (B_2)
	Sunshine spacing coefficient (B_3)
	Gross population density (B_4)
Houses (A_2)	Gross density of residential building set(B_5)
	Net density of residential building set(B_6)
	Gross density of residential building area(B_7)
	Net density of residential building area(B_8)
Public service facilities(A_3)	Gross density of kindergarten building area(B_9)
	Ratio of the number of kindergarten classes to total land area(B_{10})
	Gross density of primary school building area(B_{11})
	Ratio of the number of primary school classes to total land area(B_{12})
	Gross density of medical facility building area(B_{13})
	Gross density of civil air defense facility building area(B_{14})
	Gross density of building area of other supporting facilities(B_{15})
Roads(A_4)	Parking rate(B_{16})
	Ground parking rate(B_{17})
	Gross density of road area(B_{18})
Green space(A_5)	Green space rate(B_{19})
Business services (A_6)	Gross density of business service building area(B_{20})
	Net density of business service building area(B_{21})

3.3 Building of the evaluation model C2R model in DEA is used to analyze problems, and we build the following CCR(C2R) model[6]:

$$\begin{cases} \min\left[\theta-\varepsilon\left(\sum_{j=1}^{m}s^{-}+\sum_{j=1}^{r}s^{-}\right)\right]=\upsilon_d(\varepsilon) \\ s.\ t. \\ \sum_{j=1}^{n}x_j\lambda_j+s^{-}=\theta x_0 \\ \sum_{j=1}^{n}y_j\lambda_j-s^{+}=y_0 \\ \lambda_j\geqslant 0 \\ s^{+}\geqslant 0,\ s^{-}\geqslant 0 \end{cases}$$

The optimal solution is θ^0, λ^0, s^{0+}, s^{0-}.

Note: if $\forall a>0$ and $\forall a>0$, $N\times\varepsilon<a$, then ε is non-Archimedean infinitesimal[7].

With the efficiency index of DMU_{j_0} as the goal and the efficiency index of all DMUs as the constraints, λ_j makes all effective points connected together to form an effective frontier; nonzero s^+ and s^- make the effective frontier extend along the horizontal and vertical directions, to form enveloping surface.

In practice, the study of slack variables is significant, because it is pure excess amount (s^-) or insufficient amount (s^+), then represents a radial optimizing amount or "distance" between DMU and the efficient frontier surface or enveloping surface.

Let $\hat{x}_{ij0}=\theta^0 x_{ij0}-S_i^{-0}$, $\hat{y}_{yj0}=yr_{j0}+S_r^{+0}$

where s_r^{+0}, s_i^{-0}, θ^0 are the optimal solutions of linear programming (D) that DMU_{j0} corresponds to, then $(\hat{x}_{ij0}, \hat{y}_{ry0})$ is the projection of x_0, y_0 that DMU_{j0} corresponds to on the relative effective surface of DEA, then it is DEA efficient.

3.4 Trends Safety issues has become a hot topic now, and the public safety of small town community is the focus of attention, so the small town community planning in terms of safety will also be a focus of future planning and design, and also become one of the considerations in planning and design. Its role can be equated to the status of sunshine analysis in the detailed construction planning and design.

Through the reasonable scientific analysis, this paper aims to provide a theoretical basis in terms of safety for the planning and design, with the purpose of better creating a safe, comfortable and ecological environment of small town community.

4 Conclusions

The community is the carrier of our basic daily activities, and the public safety of small town community is the focus of our attention. To create a safe environment for small town community, it is necessary to take into account various factors. The planning and design is the cornerstone of safe community, so it needs scientific and rational scientific foundation as the theoretical basis for safety planning and design. Through the establishment of evaluation system for the public safety carrying capacity of small town community and detailed calculation, this paper gets a relatively reasonable planning and design pattern of small town community public safety, and avoids the purely subjective planning and design of small town community.

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