Assessment of New Towns Self Sufficiency Based on Working and Non-working Trips by Mathematical Models

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Abstract

There are many researches about new towns around the world one of these fields is about new town's self sufficiency. In many studies about new town's self sufficiency researchers use many different criteria to evaluate this task but there is a gap between these criteria and get a whole result it means in usual way they produce a table with some number and present without a model that can combine all of them and give a specific amount. In this paper we use mathematical models for combining all criteria and get a whole result that consider all aspect of cities functions. TOPSIS model is implemented on data of Hashtgerd 's new town as a case study for illustrating is implemented for assessment of new towns self sufficiency based on working and non-working trips by mathematical models.

Keywords: TOPSIS Method, Self sufficiency, New Town, Working trip, Non-working trip

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1   Introduction

In many countries around the world, building new towns has been a long-standing policy of managing urban growth in rapidly growing urban areas. The garden cities idea was introduced by Ebenezer Howard in 1989. The British experience was essentially developing garden cities and new towns [16]. They present, however, a part of new towns immense entity appearing in the course of activity advancing urbanization process. In other counties the idea of new towns developing has been accepted, whereas it is realized much slower than the British islands [15]. The new towns emerged through a political decision [17], and they are considered to serve three main purposes:

- New towns are answers to ”megalomania”, or the excessive concentration of people and economic activities within great cities.Decongestion of the central city has long been the primary purpose of new towns [7].

- New towns are ways of organizing the vast volume of new development which will occur anyhow, along more beneficial lines. One of the primary benefits of the new towns programming is to enable planners to more appropriately channel economic development to reduce congestion and decentralize the territory's population and job base.

- New towns are built to be ”balanced communities” [8], and create a self sufficient new town, avoiding the ”bedroom town” role of new town [17].

One of the most emphasized principles of new town design is self sufficiency and a main purpose from beginning of new towns programs around the world. Diamond suggested that self-sufficiency is stressed in the development of new towns in post-war British [20]. It is found that despite the idealistic visions embodied in the planning principles of new towns, the reality fell short of expectations and for various reasons these new towns have failed to become a self sufficient town. New towns were planned to be independent but in reality were often forced to operate as insufficient and dependent towns and in many cases, new towns are not as self sufficient as planners intended, therefore commuting between new towns and established urban areas hence becomes necessary [7]. Commuting is a big issue around the world. Every day millions of people travel between the new territories and urban areas, planning new towns in the new territories stems a large scale trips for different purposes. Usually self sufficiency is understood as balance between jobs and housing in a community, thus in a balance community residents can both live and work [5]. Many researchers suggest that good population-job balance should minimize the need to commute in search of border opportunities while fully protecting the opportunity to do so [19]. Cevero, Newlan and Stewart come to conclusion that the jobs- housing balance have significant impact on working trips [21, 6].

Hui and Lam believe that many people travel between new towns and urban areas mostly for going to work and school [19].

The link between jobs-housing balance and self sufficiency is not that clear [5]. In a border framework, self sufficiency refer to a built form that allows people to live, work, shop and recreate within a community [10]. There are some studies arguing that jobs-housing balance might not induce minimization of commuting of new towns' residents. Burby and Weiss suggested the concept of self sufficiency contains more than a jobs-housing balance with in a community [10]. Richardson and Gordon determined that non-working trips constitute approximately three-quarters of all trips in large American metropolitan areas. They argue that jobs-housing balance does not have much effect on the fastest growing travel segment of the new town resident population, the non-working trips [13]. Salomon et al. revealed similar figures in Europe [11]. Giuliano and Small concluded that jobs-housing dose not have a large influence on commuting pattern [9]. Giuliano,Downs and Cevero argued that jobs-housing balance have minimal impact on reducing commuting of residents and new towns' self sufficiency [12, 1, 2, 3, 4].

To sum up we can say there are two tendencies in research literature:

- Some balance on jobs-housing balance create self sufficiency new towns and insist on working trips as most important criterion on evaluating.

- The other suggest non-working trips are important more than working trips and in many cases are more effective in assessing new town self sufficiency.

The establishment of new towns in Iran goes back to the 1930s but it was institutionalized in the late 1980s with the establishment of the "New Towns Development Corporation" (NTDC) by ministry of Housing and Urban Development. The NTDC has already built 18 new towns [18]. New towns were developed in Iran primarily as a mean to alleviate the overcrowding conditions of established urban areas. The principle of creating Self sufficient new towns is also dominant in the planning of Iranian new towns.

New town of Hastgherd has been chosen for case study in this research based on its size, location and NTDC reports. Hastgherd new town is one of the largest new town in Tehran metropolitan area and Iran. the location of this new town provide a good potential to function as a independent town in addition NTDC reports shows that new town of Hastgherd is one of the most successful new towns projects in Iran.

In addition, the only data available for efficiency analysis will often be in the form of qualitative, linguistic data, e.g., "old" equipment and "good" service. Hwang and Yoon proposed the basic principle is that the chosen points should have the "shortest" distance from the positive ideal and the "farthest" distance form negative ideal solution. In their TOPSIS model, the measurement

of weights and qualitative attributes did not consider the uncertainty associated with the mapping of human perception to a number. The structure of paper is as follows:

In this paper, self sufficiency of Hashtgerd's new town is evaluated based on working and non-working trips. It is developed on 4 sections. In Section 2 some basic definitions and results are described. In section 3 ,methodology and mathematical model are brought. At the end of Section 3 a case study is done for illustrating. Conclusions are drawn in Section 5.

2   Preliminaries

Definition 2.1. *[7]* **New Town**, *A new town is a city, town, or community that was designed from scratch, and grew up more or less following the plan.*

Definition 2.2. **Type of New Town**, *New towns are categorized based on this functions and features as follows:*

(a) "Bedroom Towns": This kind of new towns are created only for resident purpose and they can not provide this own population with employment, "in situ".

(b) "Partially autonomous town-satellites", are formed providing for "in situ" employment for the part of its labor-capable population.

(c) "New town-Satellites", are created with "guarantee an almost complete employment with in the town for their inhabitants" and are able to provide for cultural-service facilities.

Definition 2.3. **Work Trip**, *Any trips of head of new towns' households for going to work place or going to school (kinder garden up to high school) for children's of resident households are called "Working trips"*

Definition 2.4. **Non-working Trips**, *Any trips new town residents' for accessing to goods and services is called "Non-working Trips" which consist of 3 levels:*

- *Daily shopping (groceries clothing, electronics/furnicture).*

- *Access to services (offical/banking/medical services).*

- *Leisure and entertainment.*

Definition 2.5. *,* *[15]* **Self Sufficient New Town**, *A self sufficient new town is functionally balanced and has full set of urban activities. The resident of these kind of new town require minimum work and non-working trips to other established urban areas.*

"Bedroom-Towns" and "Partially autonomous town-satellites" are considered "in sufficient"new towns and only "New town-satellites" are consider as "Self-sufficient".

Definition 2.6. *, [14]* **New town of Hashtgerd***, More than 18 planned cities have been developed or are under construction, mostly around Iran's main metropolitan areas such as Tehran, Isfahan, Shiraz and Tabriz in Iran. Hashtgerd is the largest of 18 Iranian New Towns and is being established to accommodate about 500,000 people by the year 2016, which has been planned as an overspilt city for Tehran metropolitan area and the emerging Megacity Karaj. This new town in the Tehran Province of Iran located at 68 kilometer west of Tehran. Over 8,850 residents settled in the new settlement city of Hashtgerd over the year 2000, at the end of the Iranian calendar year 1384 (2005-2006), the number of Hashtgerd's resident was raised to 32,000. Hashtgerd is an industrial city and possesses among others an industrial city, the Hashtgerd International Studios, a hydroponic farming complex, a Center for Agricultural Research and Nuclear Medicine and the Iranian Garden Museum. Line 5 of Tehran's metro will be extended to the new city of Hashtgerd in future.*

Definition 2.7. **TOPSIS***, the TOPSIS (Techniques for Order Preference by Similarity to an Ideal Solution) method which is a multiple criteria method to identify solution from finite set of points.*

3 Hashtgerd is a self-sufficiency new town or not?

The surveys were done on the summer of 1384 (2005). The numbers of questionnaires were 330 and filled by interview. The questionnaires contained groups of questions on household characteristics, prior addresses, and trips destinations for going to work, going to school (kinder garden up to high school) and three levels of goods and services consisting of daily shopping (groceries clothing, electronics/furnicture), access to services (offical/banking/medical services), and leisure and entertainment.Random sampling is done for choosing households. Survey areas include the 3 phases of Hashtgerd new town.

Since city as a place for living of people should be a complete set of functions so that it can cover all residents' need, also it should prepare good facilities and utilities, cannot be evaluated based on one or more than one homogeneous factors. In the research literature, authors have been emphasize on working trips or non-working trips as criteria for evaluation self sufficiency of new towns. In addition, there are various ideas about items of working and non-working trips. Some of researchers defined working trips as any trip for going to work place, and the others add trips for going to school to these criteria. There are

similar ideas about non-working trips. To sum up, there are various idea about criteria used in assessing a new town self sufficiency. We consider 5 criteria in two group of working and non-working trips by consultant and done adoptive study. Model which is defined in this paper consider the whole items and also is flexible to import new variables. By using this model each researcher can emphasize its point of view by choosing the appropriate weights.

3.1 Mathematical model

This mathematical model is constructed based on TOPSIS. Consider n cities $A_1, \ldots, A_n$ and m criteria $c_1, \ldots, c_m$. We want to determining the kind of $A_i, i = 1, ..n,$. To achieve this goal, we can rank them related to two ideals, positive and negative, which is the main idea of TOPSIS. Let x_{ij} denote the level of satisfaction of criterion c_j in A_i. Since this level can not be determined exactly, in real world, we are corresponding it to a bounded interval $[x_{ij}^L, x_{ij}^U]$ which, we know the exact value x_{ij} lie with in it. Then we have interval TOPSIS by following criteria which the reasons of choosing are described in previous subsection.

- C_1 : The number of any trips of head of new towns' households for going to work.

- C_2 : The number of any trips for daily shopping (groceries clothing, electronics/furnicture.)

- C_3 : The number of any trips to access to services (offical/banking/medical services.

- C_4 : The number of any trips to Going to school. (kindergarten up to high school)

- C_5 : The number of any trips to leisure and entertainment.

A systematic approach to extend the TOPSIS to use interval data is proposed as follows:
The normalized values n_{ij}^L and n_{ij}^U are calculated as

$$
\begin{aligned}
n_{ij}^L &= x_{ij}^L \Big/ \left(\textstyle\sum_{i=1}^m [(x_{ij}^L)^2 + (x_{ij}^U)^2] \right)^{1/2} \\
n_{ij}^U &= x_{ij}^U \Big/ \left(\textstyle\sum_{i=1}^m [(x_{ij}^L)^2 + (x_{ij}^U)^2] \right)^{1/2} ;
\end{aligned}
\tag{1}
$$

where $i = 1, \cdots, m, \ j = 1, \cdots, n$. The normalization method mentioned above is to preserve the property that ranges of normalized interval numbers belongs to [0,1].

The weighted normalized interval numbers decision matrix to notify the different importance of each criterion is constructed as

$$V_{ij}^L = W_j n_{ij}^L, i = 1, ..., m, j = 1, ..., n,$$

$$V_{ij}^U = W_j n_{ij}^U, i = 1, ..., m, j = 1, ..., n,$$

Where W_j is the weighted of the j-th attribute or criterion and $\sum W_j = 1$. Then positive ideal solution and negative ideal solution are defined as

$$A^+ = (V_1^+, \cdots, V_n^+) := \left[(\max_i V_{ij}^U | j \in I), (\min_i V_{ij}^L | j \in J)\right]$$

$$A^- = (V_1^-, \cdots, V_n^-) := \left[(\min_i V_{ij}^L | j \in I), (\max_i V_{ij}^U | j \in J)\right]; \tag{2}$$

Where I and J are associated respectively with benefit and cost criteria. After positive and negative ideal solution are considered as two interval vector with interval number as follows:

$$A^+ = [A^{+^L}, A^{+^U}],$$

where

$$A^{+^L} = (V_1^{+^L}, V_2^{+^L}, \cdots, V_n^{+^L}), \quad A^{+^U} = (V_1^{+^U}, V_2^{+^U}, \cdots, V_n^{+^U}),$$

and

$$V_i^+ = [V_i^{+^L}, V_i^{+^U}]$$

A^- is defined in a similar way

$$A^- = [A^{-^L}, A^{-^U}],$$

where

$$A^{-^L} = (V_1^{-^L}, V_2^{-^L}, \cdots, V_n^{-^L}), \quad A^{-^U} = (V_1^{-^U}, V_2^{-^U}, \cdots, V_n^{-^U}),$$

and

$$V_i^- = [V_i^{-^L}, V_i^{-^U}]$$

The separation of each point from positive and negative ideal solution calculated by using the n-th dimensional Euclidean distance as

$$d_i^+ = \left(\sum_{j \in I}[v_{ij}^L - V_j^{+^L}]^2 + \sum_{j \in J}[v_{ij}^U - V_j^{+^U}]^2\right)^{1/2}$$

$$d_i^- = \left(\sum_{j \in I}[v_{ij}^U - V_j^{-^U}]^2 + \sum_{j \in J}[v_{ij}^L - V_j^{-^L}]^2\right)^{1/2},$$

where $i = 1, \cdots, m$, v_{ij} is the element of under evaluation vector V.

A relative closeness coefficient (R_i) is defined to determine the ranking order of all points. To determining the relative closeness coefficient d_i^+ and d_i^- of each point A_j are calculated, then

$$R_i = d_i^- / (d_i^+ + d_i^-); \quad i = 1, \cdots, m$$

It is clear that

$$d_i^+ \neq 0 \Rightarrow (R_i \to 0 \ \ iff \ \ d_i^- = 0)$$

and also

$$d_i^- \neq 0 \Rightarrow (R_i \to 1 \ \ iff \ \ d_i^+ = 0)$$

By implementing the method on real data, we get the following result which show the Hashtgerd new town is a relatively a partially autonomous. The mentioned results about Hashtgerd can be obtained and concluded by mathematical method that is showed in table 1.

Table 1: data

$Cities/indexes$	C_1	C_2	C_3	C_4	C_5	d_i^+	d_i^-	R_i
$Hashtgerd$	$[0.3, 0.35]$	$[0.3, 0.35]$	$[0.1, 0.15]$	$[0.9, 0.95]$	$[0.35, 0.45]$	1.878	1.33	$.4145$
A^+	$[0.9, 1]$	$[0.9, 1]$	$[0.9, 1]$	$[0.9, 1]$	$[0.9, 1]$	0	$-$	1
A^-	$[0, 0.1]$	$[0, 0.1]$	$[0, 0.1]$	$[0, 0.1]$	$[0, 0.1]$	$-$	0	0

If we omit the criterion C_4, we obtain $d_i^+ = 1.877$ and $d_i^- = .65$ and $R_1 = .25$ which show that hashtgerd is a bedroom new town. So we should note to the weights which are assigned. At the present research we do not use the weighted distance because it needs to prepare a questioners which is filled by experts and the weights are obtained from it. It is considered in future research.

4   Conclusions

In this paper self-sufficiency of new town Hashtgerd is investigated. For this evaluation five criteria based on research literature and adoptive study are suggested. A mathematical model based on TOPSIS is used for disappear the role of individual point of view in assessing a new town. During this work is determined that despite of NTDC'reports Hshtgerd is a bedroom new town which is consistence with other experts' point of view. Also the role of weights of criteria is illustrated by an example i.e. Hashtgerd is far from a "new town-satellites" but its self sufficiency degree is decreased obviously only by omitting the number of trips by purpose going to School. But in fact dose have mentioned factor this level of importance or not? In future work are tried to give a mathematical model to do that.

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