Locating Residential Land use in Urban Transportation planning by the Application of GIS and Mathematical Emission Modeling of Air Pollution

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Introduction

Transportation, as a facility, has made movements easier for humans. Over time, developments have contributed to better transportation. With increasing demand for better transportation systems, which is capital intensive, research and study have to be conducted to minimize costs and maximize benefits. In the development of urban network, one of the most important and critical problems encountered is locating land uses and existing route network. In other words, the layout of urban transportation network plays a significant role in urban landuse development. Some land uses are more sensitive to transportation environmental impacts. Therefore, there is a complex and dynamic relationship between landuse and transportation. Many researches were carried out in the past to visualize the desirable and undesirable situations of transportation in the field of urban landuse locations. Some researches had focused on individual fields, such as transportation, urban planning, accessibility and air pollution; while others were carried out involving more than one field.

This research focuses on the issue of developing a spatial and mathematical model in optimizing distance of residential area from road (urban network). It requires understanding the main effective factors to develop this model. Different models of urban landuse and transportation contribute to this study. Urban models give expressions separately about urban landuse structure on which there is a significant influence by transportation planning. Useful models can be classified into several groups based on different criteria such as context, time, methods and tools. In this research, the relevant models on transportation and land-use were classified into: accessibility models (maximum distance) and air pollution models (minimum distance).

In this study, air quality is chosen as a key element with respect to its critical roles in the quality of life and urban health. The overall objective of this study is to develop a mathematical model to plan appropriate locations for residential land uses and urban transportation network development to address one issue- air quality. Arak, a developing city in Iran has been chosen as a case study. The methodology of this study helps to select suitable sites for the development of urban transportation network and residential zones. It covers reducing air quality by the definition of optimum distance between residential zones and roads based on mathematical model and good establishment of urban transportation network in proportion to residential zones. GIS as a powerful tool is applied for overlaying layers and interpretation of several scenarios. The results show the mathematical model, with acceptable accuracy, can be applied for the establishment of urban transportation network in proportion to residential zones. Based on the suitability maps, approximately around all main roads, there are non-suitable residential zones located in potential polluted areas. It will be dangerous for human health of residents.

This research has successfully managed development of a scientific approach for current and future model development that can be employed in transportation planning and residential landuse suitability assessment at both local and national structure plan levels.

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Methodology

The main component of this study is a mathematical model to incorporate air quality and quantitative interpretation of accessibility associated with the residential zone development. This mathematical model was adopted to incorporate accessibility and air quality associated with residential zone development. It included the spatial and quantitative parameters relevant for the emissions and effects of pollutants in relation to urban transportation. Arc GIS 9.1 and ArcView GIS version 3.1 were used to provide the framework for the operation of the model for mapping air pollution. The availability of spatial data types and functionalities of the software influenced the model design and plan. Designing the decision model and plan was the major task of this research. The basic conditions in finding a good location were expressed under two questions:

ii) What are the positive and negative effects (i.e. benefits and costs) of urban transportation network on its surrounding environment?

ii) How are the good and bad locations (i.e. benefits and costs) of the residential zone related to the above-mentioned effects and surrounding affected environment?

The basic idea behind these two questions is to examine the interactions of landuse and urban transportation network. Urban transportation network is defined as a mathematical representation of the physical transportation infrastructure in the city. This mathematical process is shown in Fig. 1.

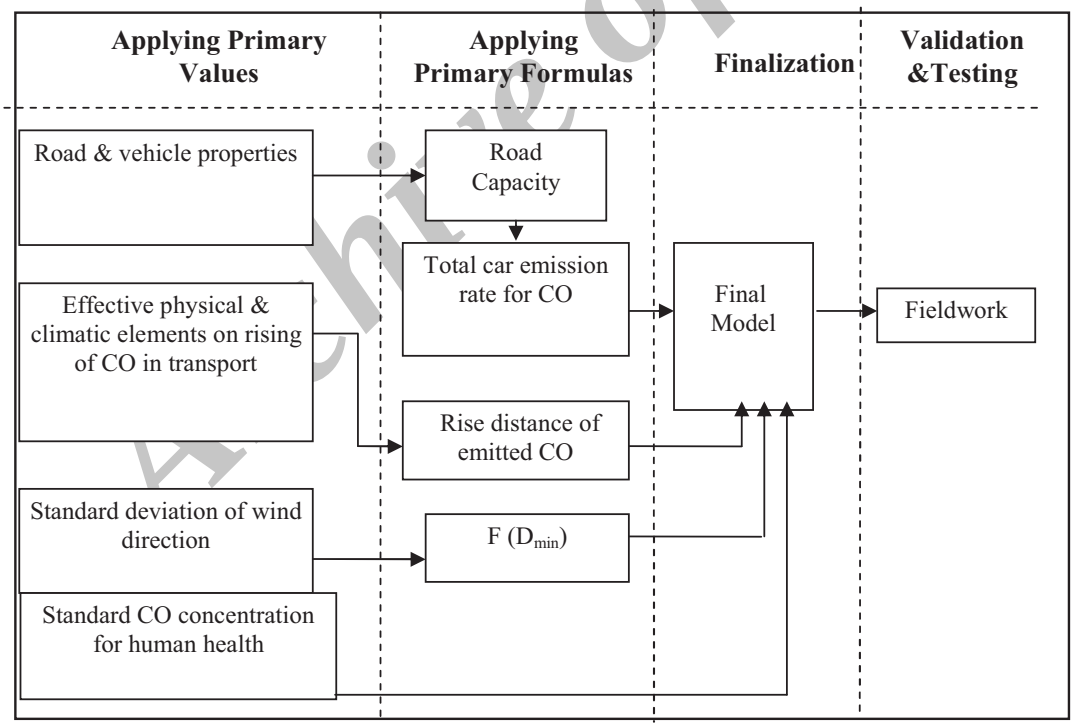

Fig. 1: Process of Modeling to Find Safe Distance of Air Pollution

Location of urban transportation network, largely determines how much area of urban land use can be accessed easily from origin to destination. It is considered a high-activity land use, as it attracts people and activities, resulting in higher environmental pollution around it, such as noise and air pollution. With the consideration of these characteristics, the urban transportation network should not be located close to residential land use, which requires a safe environment around it. So, residential land uses and transportation parameters should be considered in a balanced way, to get a suitable location for an urban transportation network which meets the transportation requirements of residents optimally.

This decision making process has both spatial and non-spatial dimensions. In this study, a plan were developed, by mathematical and spatial approaches, which incorporated spatial and non-spatial criteria arranged to answer the two basic questions on the influence of transportation on the environment of surrounding land uses. With arranging these criteria to search for suitable locations of residential land use and urban transportation network, objectives and sub-objectives of the study could be obtained. It was also necessary to evaluate the plan and model through fieldwork, statistical tools and interview.

Result and Discussion

The research outputs include mathematical model and its accuracy, potential locations for residential land use development, and existing suitable developed locations for residential land use. It shows how the developed mathematical model is utilized to achieve the objectives and sub-objectives of the research to finally identify the suitable locations for the residential land use. The mathematical model developed in this study comprised most of the criteria. Individual formulas and models of each criterion may not meet the objectives of the research individually. However, their preferences were incorporated in the final model. The structure of the developed model enables interactive modification by changing the weights and properties of the parameters. With respect to the scenarios analysis, economical and technical limitations, future development of residential land use and urban transportation networks in the study area will be possible based on the following priorities:

a. Re-designation of transportation networks (with more replacing local road types by arterial roads) in existing non-suitable locations of residential land use,
b. Development of residential land use and urban transportation networks in suggested locations for the future development of residential land use,
c. Removing some unnecessary roads in existing non-suitable locations of residential land use, and
d. Changing some of the residential land uses in existing non-suitable locations of residential areas.

The research strategy is able to support urban planners with a range of options. However, for selecting the best or most suitable sites, more comprehensive model and plan can be developed, from which choosing the sites from the alternatives will be the main purpose. Several urban land uses and environmental impacts of transportation are not placed in the model and plan, because they are exclusive for the choice phase of the study. Implementation of method and scenarios analysis suggests that some areas can be more suitable for residential land use and urban transportation network development than others, if performances and criteria are considered carefully. This suitability largely depends on the goals of the transportation projects; however, the importance of the main elements (air quality) cannot be ignored in all transportation projects.

The method developed in this study is not suitable for exact site selection purpose. It may be used as a generalized spatial decision support tool to support decision-making for locating residential land use and urban transportation network. Development and implementation of methods in the study area have materialized the following results:

a. Illustration of a new implementation using spatial method in urban transportation planning. Innovative GIS utilization in urban transportation can explain air quality.
b. Development of a complex mathematical spatial decision support model for determining the location of residential land uses, in proportion to urban transportation network.
c. Exploration and arrangement of a number of criteria or factors which could be interpreted to predict suitable land uses and urban networks location in quantitative framework.
d. Illumination of the parallel important role of environmental and economical sectors and users impacted by urban travel and land use activity in spatial framework.

Key words
Air Pollution, Transportation Network, Mathematical Model, Urban Development and GIS