Economic Land Use Theory and Land Value in Value Model

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***Abstract*—**The paper explores the relationships between land use, land price, and land value. It draws on the value model with explaining and analyzing the relationship between land value and land use, especially each type of use. The paper starts with an overview of a limited number of economic theories on the land market and subsequently introduce some well known land use models of economic theories on the principles. Later, the paper analyzes the variables affecting land use functional structure of the city namely: geographical, economic, urban, laws and legislation , political, environmental, social, public interest, and demographic variables. Finally, the integrated value model will be developed in this study. The value model is a mathematical based model for simulating future land use, especially in valuable lands; that has a foundation in economic equilibrium theory.

***Keywords*—** Economic theories, land use models, land price, land use, land value, variables, value model.

I. Introduction

Land use is considered one of the essential factors influencing the pattern of urban development. The limited space within cities combined with the growing space requirements for various purposes outlines the framework of the struggle for land for different purposes and by different vested interests. The difficulties in land use planning result from the contradiction between the rapid technological changes which influence urban growth and the slows process of planning which allocates land use. Land use in the city has a unique structure, mostly due to the interactions between its spatial configuration and functions, developing into a patchwork of functional regions of different forms.

Governments use land use planning to manage the development of land within their jurisdictions. In doing so, the governmental unit can plan for the needs of the community while safeguarding natural resources. To this end, it is the systematic assessment of land and water potential, alternatives for land use, and economic and social variables in order to select and adopt the best land use options. Through this process, governments need to use some tools like computer and mathematical models to guide land use to the optimal use.

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Past decades showed strong advancements in the development of operational land use models. Geographic information technology, faster computers, besides the availability of better data made it possible to draw a comprehensive models. Advances in theoretic development went a bit lower. Theoretic underpinning of models still in many cases a problem and models rely on statistic analysis to model relations between land use and all kinds of variables.

According to all above, the study focuses on developing an integrated model in order to get a better understanding of land use in terms of land value named the value model. The value model is mathematically based model for simulating future land use, especially in valuable lands; that has a foundation in economic equilibrium theory.

II. Analysis of Development Policy in Existing Urban Areas

The development policy of the existing urban areas is considered one of the policies of the urban development strategy of the state, which is based on two parallel axes of the schematic thought:

A. Axis 1

It concerns about developing the desert areas and establishment of new cities.

B. Axis 2

It includes improving the existing urban structure through using empty spaces inside urban centers, to reduce district accumulation, to deal with pressure problems on infrastructure

Figure (1) shows urban development strategy in Egypt.

Fig. 1 Urban Development Strategy , Source: Abdel Kader, Lamea, PhD thesis.

and public services, and to manage future urban growth trends on agricultural land through preparing strategic plans for existing cities. This may help to improve the urban environment , reducing the population density , providing services and infrastructure ,and limiting the spread of informal areas throughout the country.

III. Frame Work

A. Problem Identification

According to all the above, the main problem is in the lack of an integrated system to guide the functional and spatial change in land uses and the absence of controlling regulations that must be adopted to direct land to its optimal use, primarily in the case of ignoring the land value as a significant variable affecting the spatial change of uses.

In this context, any-project for guiding the spatial change of land-uses comes at a crucial stage not only as a reaction to solving the existing problems of traffic congestion, pollution, and informal urbanism, but also as a step towards improving the Greater Regions to face the future and restore its vitality, cultural flame , and civilizational position.

B. Research Objectives

The goals of our study are to compare the economic theory behind the land use with the working of the land market in reality. This can be done through a value model to conceptually define the role of the land value as a tool to control land uses and their impact on the development process as a whole. This approach aims to reach the sustainability of land development by identifying the most significant variables that are affecting the land use structure through the value model.

C. Research Hypothesis

The study proposes a developed methodology called value model which may achieve the required balance that is resulting from the interactions between land value, land uses and other variables through building a model that translates these interactions.

D. Research Structure

Fig. 2 shows the concept map of the study to achieve the previous objectives.

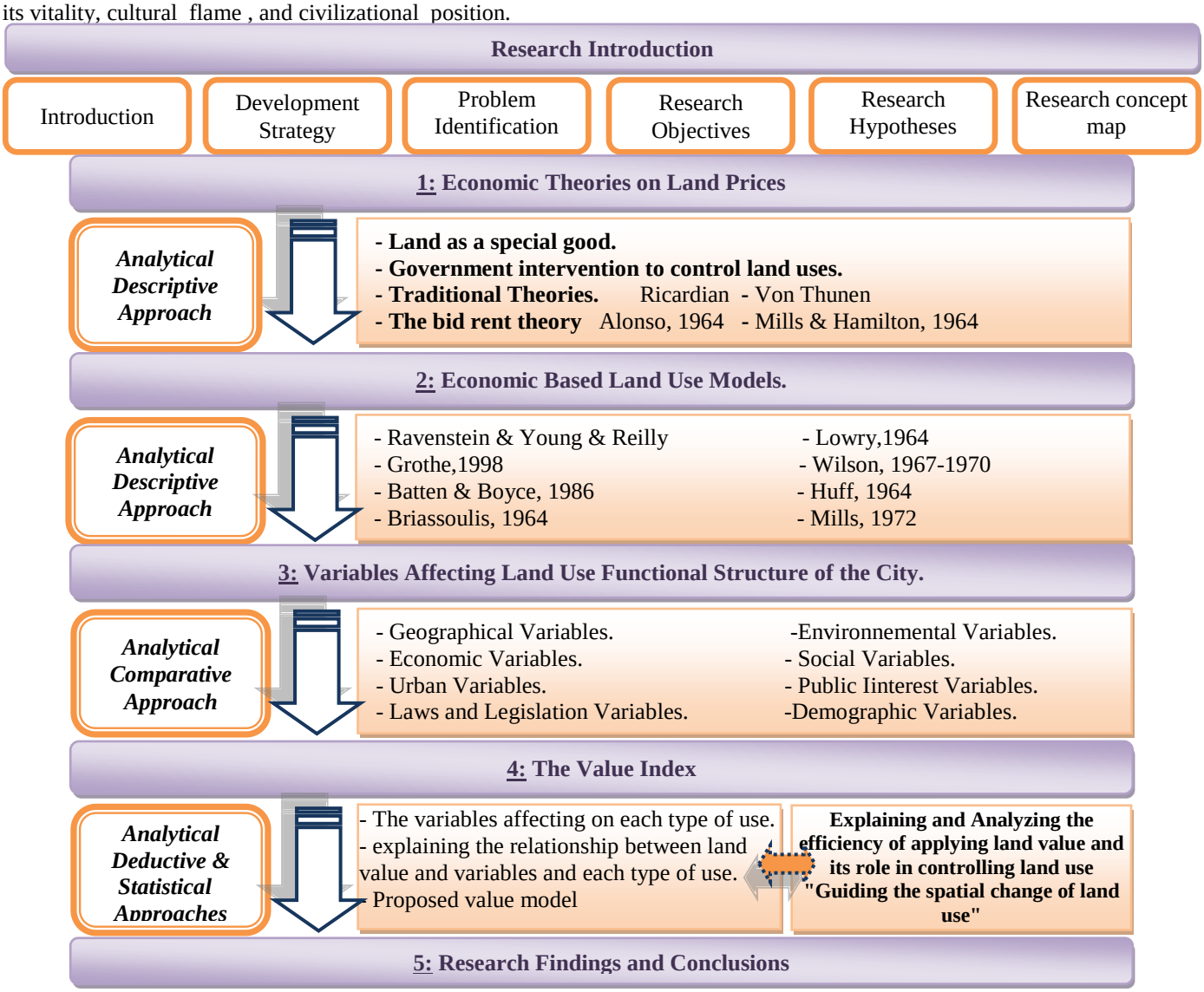

Fig. 2 The concept map of the research – source : Researchers

IV. Economic Theories on Land Prices

The main focus of urban economic theory is, of course, land. But in economic terms, land is a complex object endowed with dual characteristics. First, land is a commodity in the usual economic sense. But, second, unlike other commodities, land is completely immobile. Hence, each piece of lands is associated with a unique location in geographic space. These dual characteristics of a land induce strong no convexity in consumers' preferences. The spatial characteristics, the externalities, and intervention make an analysis for the land market rather complicated.

The attention for land in economic theories have changed over time. The theory of economic rent was first propounded by the English classical economist David Ricardo (1773-1823). David Ricardo in his book "Principles of political economy and taxation", defined rent as that: "portion of the produce of the earth which is paid to the landlord on account of the original and indestructible powers of the soil, Ricardo in his theory of rent has emphasized that is a reward for services of land which is a supply. Secondly, it arises due to unique qualities of land which are indestructible". The primary indestructible powers of the soil include natural soil, fertility, mineral deposits, climatic conditions etc…..

All the units of land are not of the same grade. They differ in fertility and location. The application of the same amount of labor, capital and other cooperating resources give rise to differences in productivity. This differences in productivity of the surplus which arises on the superior units of land over the inferior units is an economic rent.

The main results of the economic theory have unified in terms of the bid rent functional approach. The origin of this approach is quiet old. Indeed, Von Thunen 1826, created his original model of agricultural land use, which stands as a cornerstone of land use theory, using this approach. But surprising, the approach is closely related to the duality approach of modern microeconomics. Consequently, by employing it, one can develop modern land use theory in a manner that is not only intuitive

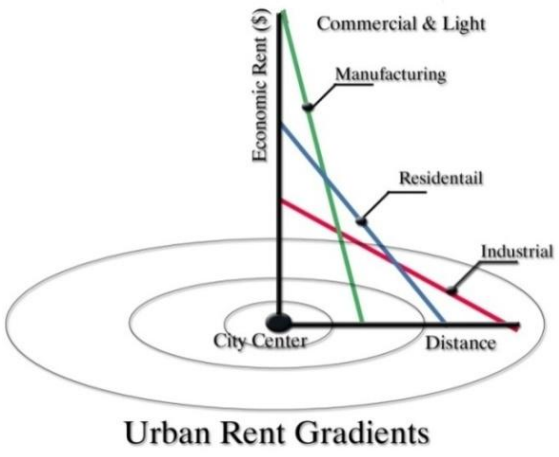

Fig. 3 Shows land uses' general form of Van Thunen
Source: Hartshorn, 1989

The bid rent theory is based on microeconomic theory and was basically developed in the context of urban land uses and urban land values. The bid rent function in the theory explains the relation between urban land uses and urban land values. In a very simplified view, households and companies make a tradeoff between land price, transportation costs and the amount of land they use. This output in a convex land price curve with the highest land prices close to the city centre. The derivation of agricultural and rural land values in the bid rent theory owes more to Von Thunen's theory than the work of Alonso. The crop that produces the maximum revenue at a particular location will be able to make the highest bid and then will be cultivated on that parcel. The land is sold to households, or firms in case their bid is higher than the bid of agriculture; this situation which defines the limits of the city.

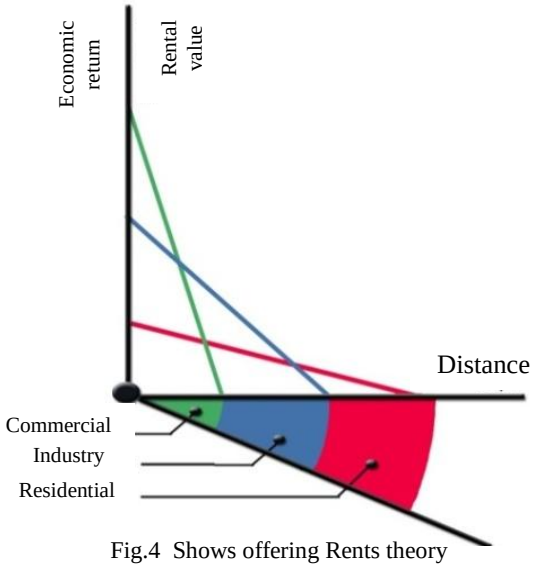

Fig.4 Shows offering Rents theory
Source: Hartshorn, 1989

The bid rent theory does not directly end with an operational model of land use and land prices. It relies strongly on an analysis of the market, market prices and bids actors. In reality, however, the land market is not transparent and market information is often hard to get. However, other values than the market price for land can exist, like social land value or non-revealed values as a result of zoning restrictions. Other methods, like the hedonic pricing method which values the various amenities of a parcel of land for an actor, can be used to actually choose land prices.

Following the pioneering work Isard 1956, Beckmann 1957, and Wingo 1961, Alonso 1964 succeed in generalizing Von Thune's central concept of bid rent curves to an urban context. Since that time, urban economic theory has advanced rapidly, inspiring a great deal of theoretical and empirical work. Prominent among the efforts in this area are the works of Muth(1969), Mills (1972), Henderson (1977), Kanemoto (1980), and Miyao (1981), to name a few.

V. Economic Based Land Use Models

Most of land use models that have incorporated economic theory in its framework have its origins in the family of spatial interaction models. Spatial interaction models are based on Newtons gravity theory. Geographers as Ravenstein, Young and Reilly, described migration in analogy with this theory in the last part of the 19th century and the early 20th century. They assumed that the interaction between two entities relies on their respective size and mutual distance. Lowry further expanded the concept in 1964 when he linked two partial gravity models (for residential location and service location) into a general urban model.

Wilson (1967,1970) revised the gravity model by applying entropy-maximizing principles from yet another theory of physics. The entropy-maximizing producer aims to reveal the most probable state of interaction of the urban system that corresponds to the largest number of possible microstates.

People like Huff (1964) attempted to derive the gravity model on the basis of economic principles of utility maximization. Huff's model of trade area attraction is used to determine the probability that a customer residing in a particular trade area, the trade area's multiplied by this probability. Finally, all of the calculated trade areas sales forecasts are aggregated to estimate total sales from all of the areas. As with other gravity models, the ability of a shopping center to attract customers is in direct proportion to the size of the shopping center(relative to competing shopping centers) and in inverse proportion to the distance or travel time to the shopping center (relative to competing shopping centers). According to Francica (2002), " The Huff Model is widely regarded as the industry standard for determining the probability of a retail location to attract customers.

Employing the micro-economic theory of consumer behavior, the optimal allocation of origins (consumers) to destinations (shops), is obtained by postulating a utility function which reflects the relative preferences of people at the origin zones for the attributes of the destination zones (Briassoulis,1999). This approach is based on the description of individual choice behavior and subsequent aggregation to the level of a market segment. The same utility maximization framework was applied by Alonso (1964) to describe the urban land market. He built his model on an idea whose essence is based on land uses installation in the city as a reflection of differences in land uses rents. These uses are just a translation of lands prices and rents variation. This means that several activities that constitute uses structure vary according to intensive competition between lands prices and rents. His treatment of the land market inspired many (urban) land use models (Mills,1972 ;Fujita,1989) that, applied to mono-centric cities, provide a well known concentric land use patterns.

The above-mentioned models that apply utility maximization all have a micro-economic focus on the behavior of individuals. A more general, macro-economic approach is used in the equilibrium models that consider the balancing of supply and demand. Models that concentrate on more than one market (housing and agriculture) and more than one region are referred to as spatial general equilibrium models. The development of operational, computable version of these theoretic models is difficult, since a lot of detailed information is a must on demand and supply side of the various considered markets. It is even more difficult to make these models spatially explicit.

VI. Variables Affecting Land Use Functional Structure of The City

The previous sections have presented all the economic theories and economic based land use models which explain the relationship between land use, land value and other variables.

Consequently, this section will be mainly concerned with determining the different variables constituting the list of variables affecting land use functional structure of the city, based on all the previously introduced concepts. The variables that are affecting land use, land value and other variables are classified into geographic, environmental, economic, social, urban, public interest, laws and legislation, demographic, political variables.

A. Geographic Variables

Experts agree that geographic factors clearly control the type of uses; however, they disagree on the extent of this control and its form. Some of those experts approach the geographical factors – especially climate – as being the controlling factors in population distribution and type of uses. Such geographic variables have a clear influence on the type of use, but this effect may appear overtly on both the world and the country levels, and , at the same time, this effect may not appear clear inside the city or the district. So, the importance of these geographic variables decreases in the local levels.

B. Environmental Variables

Environmental impact is defined as any change in environmental characteristics or the emergence of new ones due to the project, or the activity suggested. This impact may be positive, reflected in the improvement of the environment, or negative as appears in the damage that happens to air, water, or the decrease of land fertility.

C. Economic Variables

Spatial change for land uses can be understood in the light of the economic variables , especially variables that are related to the population density that represents the utmost capability of using the place as an economic source as long as it has an infrastructure suitable for use. So, changing the type of use is the direct outcome of the change of land prices, ability to pay, and the extent of exploiting the piece of land.

D. Social Variables

Social variables are considered a double-edged issue; the first, and essential part is the social human entity that is offered in inhabitants, and the second is presented in the urban materialistic entity. In this connection, the social perspective tackles non-materialistic entity by applying some social concepts, and elements related to the vital variables

participating in the distribution of density. Such social concepts include the reasons of movement, the code of ethics and its impact, and understanding the motives, and behaviors existing in the background of such behaviors.

E. Urban Variables

Land value is one of the fundamental tools used in urban management and the quality of the urban environment as it has an essential role in evaluating and improving the land needs. A group of urban variables (roads ,traffic network, buildings and public services ……) has a great relation with the land value as a result of the exchanging relations among them. As well as the modality of developing these areas as every group contains a set of subsidiary variables that interact with each other to change the land value. Subsequently, we can distribute the urban variables into three significant groups: the roads and transportation network, development density, and public services in the area and land uses.

F. Public Interest Variables

Public interest considerations are a consideration's group involving values , principles, standards, concessions and restrictions that are taken by the community itself from its reality and economic, social, political, urban and religious concepts to achieve its public goals. So, public interest values are related to economic and social values of individuals and groups. It also includes an additional dimension, which is how effectively intervene "by law" to achieve overall objectives and its impact on structuring and restructuring of land use, including significant five key elements, namely: Public Health /Safety / Convenience/ Economy/ Amenity.

G. Laws and Logistic Variables

The role of domestic, or central government appears overtly in all the decisions related to locations and land values; this is reflected through its policy concerning taxes or laws. For example, this factor appears in such matters as spaces, green belts, open spaces, maintenance, transportation, traffic-jam problems, housing, schools, universities or public utilities.

H. Demographic Variables

Their impact appears in dimension form or "demographic factor" in the light of population increasing and through its urban structure and its uses required to satisfy different age groups' needs. In the light of this development, we can say that population concentration is based on the elements that have an impact on urban structure transformation of the city.

VII. Value Model

The land use model is mathematically based model that simulates future land use and which offers an integrated view on all types of land use. It deals with geographic, economic, urban, social, environmental, public interest, political, demographic, laws and logistic variables, usually distinguishing seven or more different land use categories, residential , commercial , educational ,medical , social , recreational and cultural. The model is a variables based, covering all types of uses, where each type of use is affected with group of variables.

Unlike many other land use models, the objectives of the value model is not to forecast the dimension of land use change but rather to integrate and allocate future land use claims from various sectoral models. The results of the model should not be interpreted as a fixed prediction for a particular location but rather as a probable spatial patterns.

The land use model employs the equilibrium principle to balance the need for various land use functions with the supply of suitable land.

A. The Variables Affecting Each Type of Use

Residential uses

Variables affecting site chosen for residential uses are:

- soil and subsoil condition.
- ground water level.
- freedom from surface floods.
- freedom from topographic accident hazards.
- availability of utilities and protection services.
- freedom from local hazards and nuisances: accident hazards, noise, vibration, noise, smoke, dust, disease hazards and moral hazards.

Commercial uses

Variables affecting site chosen for commercial uses are:

- flat land , preferably not more than 5% so as not cost much when settled.
- the possibility of choosing the right location for shops is in the heart of city, or neighborhoods or on its outskirts.
- sites contact directly with the main streets and transportation both for receipt of the goods for shops or for delivering goods to customers.
- parking areas.

Educational uses

Variables affecting site chosen for educational uses are:

- accessibility from houses.
- children mustn't cross any major streets.
- quiet places.
- suitable area for playgrounds.
- flat and dry sites.
- site for schools must be far away from the noise, factories, and railway stations.

Medical uses

Variables affecting site chosen for medical uses are:

- soil.
- infrastructure.
- neighboring land use.
- transportation network.

Cultural uses

Variables affecting site chosen for cultural uses are:

- accessibility
- some planners think that a library must be placed near to parks and open areas in quiet amazing environment.
- parking areas.

Social uses

Variables affecting site chosen for social uses are:

- the site of the social center is different from a neighborhood to another, it is enough to set the social center

with the primary school to share with the school buildings like the theatre, conference hall and bathrooms.

Recreational uses

Variables affecting site chosen for recreational uses are:
- linking to residential uses.
- safety, to prevent children from crossing any major streets.
- protect visitors from the dangers of the terrain.

B. The Relation Between Variables and Each Type of Use

The previous section has introduced all variables, and factors affecting each type of use namely: residential, commercial, educational, medical, cultural, social, and recreational uses. Hence, this part is interested in trying to determine and classify all variables affecting each type of use, based on all the previously presented concepts. table 1

Table 1 Relation between variables and different type of uses

Type of uses	Variables affecting land use type	X
Residential uses	Geographic variables Environmental variables Public interest variables Urban variables	X1 X2 X6 X5
Commercial uses	Geographic variables Urban variables	X1 X5
Educational uses	Geographic variables Environmental variables Urban variables Public interest variables	X1 X2 X5 X6
Medical uses	Geographic variables Environmental variables Urban variables Public interest variables Demographic variables	X1 X2 X5 X6 X8
Cultural uses	Environmental variables Social variables Urban variables Public interest variables	X2 X4 X5 X6
Social uses	Geographic variables Environmental variables Social variables Urban variables Public interest variables	X1 X2 X4 X5 X6
Recreational uses	Geographic variables Environmental variables Social variables Urban variables Public interest variables	X1 X2 X4 X5 X6

C. Explaining the Relation between Land value and Variables and Each Type of Use in Terms of Value Model.

- The first step of the model is to divide the groups of variables which affect land use functional structure of the city, on the different types of uses, as we did in the last point (5.2) and order them according to their importance and effects.

- City is constructing and dynamic structure. Land uses in any city are, in fact, the outcome of individual actions that occur daily in every area of the city's lands. The factors that contribute in the functional structure of land use in the city are interdependent, interrelated and interacted with one another constantly, and these interactions end to find what is really happening in actions of facilities form or change in use.

- Figure (4) shows that every type of services and uses affects with some variables, which determine the optimal use of land. As we said before" city is a dynamic structure" , these variables are applicable to change continually and the land value change too. Under the changing power, we have to change the uses.

The Figure explains the relationships between the variables affecting land use functional structure of the city and uses ; we can translate these relationships into mathematical equations.

- Every cell in fig (4) describes one type of uses and its affecting variables.

- Each equation describes the relative proportion of every present land value for each type of uses. The cell may contain more than one type of uses.

- Regional projections of land use change are used as input data to build the theoretical back ground of the proposed model for every valuable area. These projections are derived from the sectoral models of specialized institutes.

The different land use claims are located to individual grid cells based on their suitability. Suitability maps are generated for all different land use types based on location characteristics of the grid cells in terms of physical properties , operative policies and expected relationships with nearby land use functions.

This model focuses on explaining spatial patterns in land use according to its value (land value) in valuable areas. Therefore, a large set of data must be collected and analyzed to run the model.

Hence, it will be enough to present the resulted equations to explain all land use relations and the research will initially present the residential uses as an example.

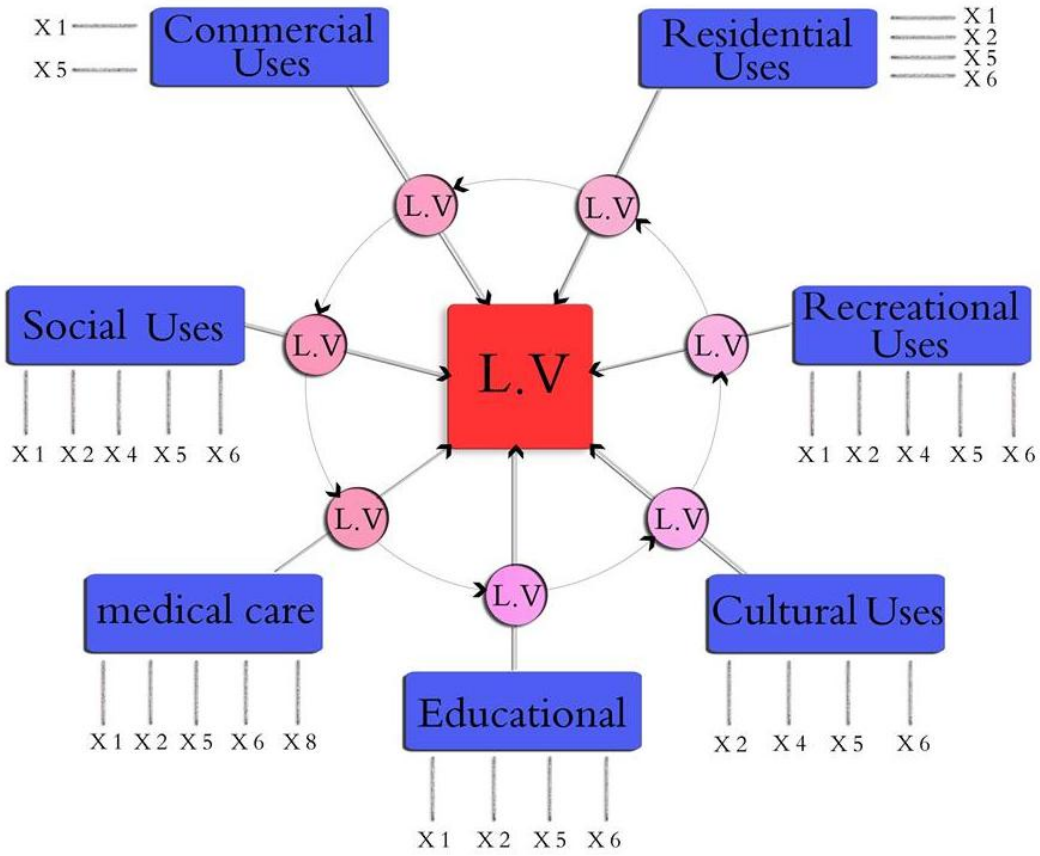

Fig. 4 The change of land use according to variables affecting the land and land value

Example : Residential uses

$$L.V\ Residential = f(x1, x2, x5, x6)$$
$$L.V\ Residential = x1 + x2 + x5 + x6$$

This equation display the land value for the residential use , which equal the value added from every sub-variable connected to the land.

$$L.V\ Residential = f1x1 + f2x2 + f5x5 + f6x6$$

In other words, we can express the land value for residential uses through the last equation whereas (f1) is the effect of the variables (x1) in land value for residential uses.

$$x1 = a1ya + a2y2 + a3y3 + \cdots \ldots \ldots ETC.$$

This equation express the constituted sub-variables which are part of the main category (geographic variables).

$$\frac{\partial \text{ residential land}}{\partial \text{x1}} = \frac{\partial}{\partial \text{x1}} (\text{x1} + \text{x2} + \text{x5} + \text{x6})$$

This equation expresses the change of the rate of residential land value according to geographic variables(x1) in the case of x2, x5, and x6 are constant.

$$\frac{\partial \text{ residential land}}{\partial \text{x2}} = \frac{\partial}{\partial \text{x2}} (\text{x1} + \text{x2} + \text{x5} + \text{x6})$$

This equation expresses the change of the rate of residential land value according to environmental variables (x2) in the case of x1, x5, and x6 are constant.

$$\frac{\partial \text{ residential land}}{\partial \text{x5}} = \frac{\partial}{\partial \text{x5}} (\text{x1} + \text{x2} + \text{x5} + \text{x6})$$

This equation expresses the change of the rate of residential land value according to urban variables (x5) in the case of x1, x2, and x6 are constant.

$$\frac{\partial \text{ residential land}}{\partial \text{x6}} = \frac{\partial}{\partial \text{x6}} (\text{x1} + \text{x2} + \text{x5} + \text{x6})$$

This equation expresses the change of the rate of residential land value according to public interest variables (x6) in the case of x1, x2, and x5 are constant.

From all above the study can express the Land value as:

$$L.V = F(L.V\ residential\ , L.V\ Commercial\ , L.V\ educational\ , L.V\ medical, L.Vsocial, L.V\ cultural, L.V\ recreational)$$

Finally, If we apply this model in lands with high urban value, we can get a highly disaggregated description of the entire valuable lands.

VIII. Results and Conclusions:

- Land has special characteristics compared to other economic good: the supply of land is fixed (with the exception of land reclamation), every parcel of land has a fixed area, which is a unique property, and the use of a parcel of land affects the use and value of adjacent parcels.

- Spatial distributions of land uses are not linked to the primary principles of the site theory (Alonso Model), but otherwise is connected to a number of factors which have similar direction in general, including many variables working together and are different in their impact and direction; such variables affect and are affected by each.

- Land market is not transparent and market information is often hard to get. Moreover, other values than the market price for land can exist, like the social land value or non-revealed values as a result of zoning restrictions.

- Land value with all its economic, social, and urban dimensions control the spatial and functional change of land use.

- Economic Theories on Land Prices constitute mainly the theoretical economic framework related to the land market in most land use models.

- Economic Based Land Use Models that apply utility maximization all have Generally, a micro-economic focus on the behavior of individuals. Generally, macro-economic approach is used in the equilibrium models that consider the balancing of supply and demand.

- The variables that are affecting land use, land value, and other variables are classified into geographic, environmental, economic, social, urban, public interest, logistic, demographic, political variables.

- The land use model is mathematically based model that simulates future land use and which offers an integrated view on all types of land use. The model is a variables based, covering all types of uses, where each type of use is affected with group of variables.

- The objective of the value model is to integrate and allocate future land use claims from various sectoral models. The results of the model should not be explained as a fixed prediction for a particular location but rather as a probable spatial forms.

- If we apply the value model in lands with high urban value, we can get a highly disaggregated description of the entire valuable lands.

Acknowledgment

I would like to express my deep gratitude and respect to my advisors at Cairo University Prof. Mohamed El Barmelgy, and Associate. Prof. Ahmad Shalaby for their valuable suggestions, advice, and comments. Thanks go also to my supervisor Assistant Prof. Usama Nassar, for his patient guidance, encouragement and support. They have provided throughout my time as a student. I have been extremely lucky to have supervisors who cared so much about my work, and who responded to my questions and queries so promptly. I would like also to thank all the faculty members of the department of architecture at Cairo University for their continued guidance, encouragement, and support.

Thanks go also to Dr. Osama Sharaf, assistant professor at Power Mechanical Department, Faculty of Engineering, and Suez Canal University- for his support and guidance in mathematical issues.

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