

## **Measuring Urban Sustainability: Developing a Conceptual Framework for Bridging the Gap Between theoretical Levels and the Operational Levels**

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**ABSTRACT:** The issue of sustainable development has been widely acknowledged and spread rapidly after United Nations conference on environment and development in Rio in 1992. Considerable attention is given to urban settlement areas. Thus, role of urban development is seen as a challenging issue under circumstances. Outcomes of the current patterns of world population growth and industrial development are agreed and reported as major causes of un-sustainability in long term. Whereas by turn of century almost half of the world's population is lived in urban areas; it is expected that this figure will reach to 8.1 billion -60.5% of world population- by year 2030. This is twofold; on the one hand cities are the places of the excessive use of energy and resources, of production of waste and pollution, of crimes and deprivations and socio-cultural un-stability, and so forth. However, some question will arise: is there a simple and universal model of sustainable urban form? How would decision makers be able to assess the rightness of their programs and actions in terms of sustainability of urban forms? And to what extent the concept of urban sustainability can be translated to some measurable elements? This paper therefore, aims to develop a conceptual framework within which the notion of urban sustainability-as a broad conceptual term - can be translated into some quantities which can be measured and evaluated with more assertion. Through this model, characteristics of sustainable urban form, systematically are defined and translated into some indicators. It is hoped that this model can provide easement and clarification for researchers and decision-makers in their assessment of cities' form and function towards achieving sustainability.

**Key words:** Urban sustainability, Conceptual model, Development, Sustainability measurement, Sustainability indicators

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### **INTRODUCTION**

There are critical questions that need to be clarified in our path towards achieving sustainability. The issue of sustainable development has been widely acknowledged and spread rapidly after United Nations conference on environment and development in Rio 1992 (UNCED, 1992). Sustainable development was defined as "development that meets the needs of present generation without compromising the ability of future generation to meet their own needs" (WCED, 1987). Although, there has been many definition of sustainable development and un-sustainability thereafter, outcomes of the current patterns of world population growth and industrial

development are agreed and reported to be the major causes of un-sustainability in long term (ibid). It has been agreed that the current patterns of urban development and human activity have led to environmental degradation, and have created serious problems for natural resources and the quality of life particularly in urban areas.

These issues were supported by the Rio conference in 1992; which concluded that such patterns of development are not sustainable in the long term without some significant changes. Consequently, it is suggested that cities should act as a locus for solving global environment problems

in the direction of sustainable urban development. There are some arguments that the issue of urban sustainability is closely linked with the question of sustainable city/urban form (Jenks, *et al.*, 1997). The idea has been supported strongly by the two later conferences: HABITAT International (1997), and Rio+10 in Johannesburg (2002). Under circumstances some questions have been raised: What are the characteristics of sustainability? How do they relate to the urban form? And how can they be scaled and tested? These, leads to a need for devising methods or formulating techniques for the measurement of urban form in terms of sustainability.

This paper therefore, aims to create a tool to operationalise the idea in definite measurements; and to develop a framework within which the notion of urban sustainability - as a broad conceptual term - can be translated into some workable quantities which can be measured and evaluated with more assertion. Throughout this model, characteristics of sustainable urban form, systematically are defined and translated into some measurable indicators. It is hoped that this model can provide some tangible features to the general public and can be manageable to decision-makers, and also provide researchers with easement in their assessment of cities role towards achieving sustainability.

It is discussed that sustainable development idea is based on a comprehensive view of systems which are open, dynamic and integrated. This view aims to make goals of sustainability simple and flexible so that, multiple interpretations and applications can be afforded in variety of situations (Trraga and Ngel 2006). Contemporary approach in sustainability is tacking into account interactions and feedbacks between social, economics and environmental dimensions. However, the way in which these dimensions should be evaluated whether solely, or in combination, has not been well defined yet. At the same time, there has been many definitions given for of sustainable development after Brundtland report (1987), each reflect levels of values and assumptions (Beratan, *et al.*, 2004). These create a challenging situation. There is no consensus over a single precise term with which to facilitate measuring progress towards sustainability (Dahl, 1997, in Trraga and Ngel 2006). To some researchers, it has been seen

as something that cannot be easily scaled or measured (Trraga and Ngel, 2006). Therefore, it is suggested to begin from an articulated vision of sustainable development and clear goals which represent that vision (Hardi and Zdan, 1997). Therefore, the development of an instrument for sustainability indicators within a wider framework of analysis is necessary. Agenda 21 defined the importance of sustainability indicators (in Chapter 40) where, it urges for the development of methods and techniques at multiple levels for measuring sustainability (RDED, 1997).

Within the context of sustainability considerable attention has given to the role of urban form. Many organizations such as UN, EU and even World Bank have now sustainable cities programmes (Newman 1999). This shows the current importance of urban areas. This importance led to the discussion about necessity of a simple and universal model of sustainable urban form which could be sought and identified; and its features can be generalized across the world (Guy and Marvin, 2000:9). However, there is a risk of overestimating about alternative urban form and its universal legitimacy without thorough investigation of local conditions and geographical situation. The argument appeared to be in contradiction with the earth summit motto: Think globally, Act locally urging the recognition of local socio-cultural and environmental aspects as vital elements in sustainability domain. Therefore, it is argued that the continued search for a simple and universal model of sustainable urban form can blind researchers and policy makers to the multiplicity of the innovations that may contribute towards building a more sustainable urban future (*ibid*). It is agreed that Rio Declaration or Agenda 21 has provided a broad framework for global sustainable development (CAG, 1992). This may suggest to develop or invent models based on locality and availability of resources (materials, data, technology, etc...) that are put together to contribute into the framework of Rio Declaration or Agenda 21.

## **MATERIALS & METHODS**

Given the fact that measuring sustainability is coupled with sustainability indicators, there is a need for urban sustainability indicator systems that reflect the integration of relevant dimensions in

terms of social, economic and environmental factors. According to De Kruijf and Van Vuuren (1998) The integration process for measurement of sustainability could be done through at least five tools namely: 1) Integrating conceptual framework; 2) Integration by selection of specific indicators; 3) Integral presentation methods; 4) Aggregation of indicators; and 5) Mathematical models.

To develop sustainability indicators through first tool (integrating conceptual framework) six frameworks has been addressed. Domain – based frameworks; Issue – based frameworks; Goal – based framework; Sectoral framework ; Causal framework ; Comparative framework; Ecologic frameworks, and finally Combination frameworks (McLaren, 1996). Further details of each framework have been given by McLaren. There are strengths and weaknesses with each of frameworks. He suggested that before choosing an appropriate indicator framework to assess urban sustainability, it is necessary to define the pros and cons of each (ibid). Since, they can be used in accordance with the case study requirements in different situations. Combination frameworks thus, can be used to overcome disadvantages of above-mentioned individual frameworks.

While it is used as an integrated framework, Combination framework brings together two or more of described above frameworks. In this study, Domain–based framework and Goal–based framework are combined together to overcome disadvantages of above-mentioned individual frameworks; and to present a new framework which aimed to be appropriate for measuring urban sustainability. These frameworks are described in brief in the next section.

Domain–based framework is defined by the key dimensions of sustainability which are including: environment, society, and economy. It identifies indicators for each, and ensures for the coverage of the dimensions of sustainability. However, it suffers from the fact that it does not take into account links between indicators and sustainability goals. Thus, a Goal-based framework is used in conjunction with the former framework to provide appropriate link between goals (which are qualitative terms) and indicators (as the quantitative terms) of sustainability. The

ultimate goal here is to translate an idea or theory into indices and indicators that enable us to measure or assess urban sustainability. Thus, the proposed conceptual framework is divided into two major levels; each of which associated with a multiple stage process as follow:

1-THEORY LEVEL: this is involved theoretical aspects of the concepts through literature review, to define concepts in terms of study goals and measurement techniques. It includes three stages comprising of

- a) conceptual level;
- b) conceptual components; and
- c) conceptual definitions.

2-RESEARCH LEVEL: having defined the levels, components and definitions of concepts, in the Research level we are to define components for empirical research which are indicators. Two stages are to include:

- c) operational definitions; and
- d) observational level;

the process and methodology for transition from conceptual level to observational level and identification of indicators is discussed through the rest of paper.

The major concepts in the context of this study are to include: urban form, sustainability, environmental sustainability, and social sustainability. They were systematically derived from the theories of town planning, urban design and development in the framework of sustainable development. Before going further on with these concepts, one point should be made. Although concepts or constructs are of central importance in theory building, there is a certain limitation with their nature. Because they are abstractions (e.g. in this study- social sustainability, social class, environmental sustainability, household, urban form and so forth) they cannot be seen because they are not things which are observable (O.U. Block 1:83). Therefore, as a symbol of the phenomena, they are not measurable; but a concept can be defined in such a way that the rules for observations can be laid down. It is argued that concepts should be indicated by something that can be observable. Therefore they have to be linked to indicators, which by definition are observable (O.U. Block 3:15), where by the linking rules are called operationalization (O.U. Block 1:83).

In a similar position, Nachmias pointed out that any scientific discipline is necessarily concerned with its unique set of concepts or vocabulary to constitute its language. He argued that the scientific research comprises of two levels and five stages. The first level is called the Theory level, which consists of three stages, a) conceptual level, b) conceptual components, and c) conceptual definitions. The second level is called the Research level, this includes the two stages, a) operational definitions, and, b) observational level. For example see the Fig. 1.

Therefore the importance of definitions becomes apparent. To have proper functions, concepts should be clear and precise; Although in the process, many concepts were invented, used, refined, and discarded; many concepts remain ambiguous and inconsistent (Nachmias,1992). Clarity and precision in using concepts are achieved by definitions. Two types of definitions are important in social science research: conceptual definition, and operational definition. Conceptual Definitions are definitions that describe concepts by using other concepts.

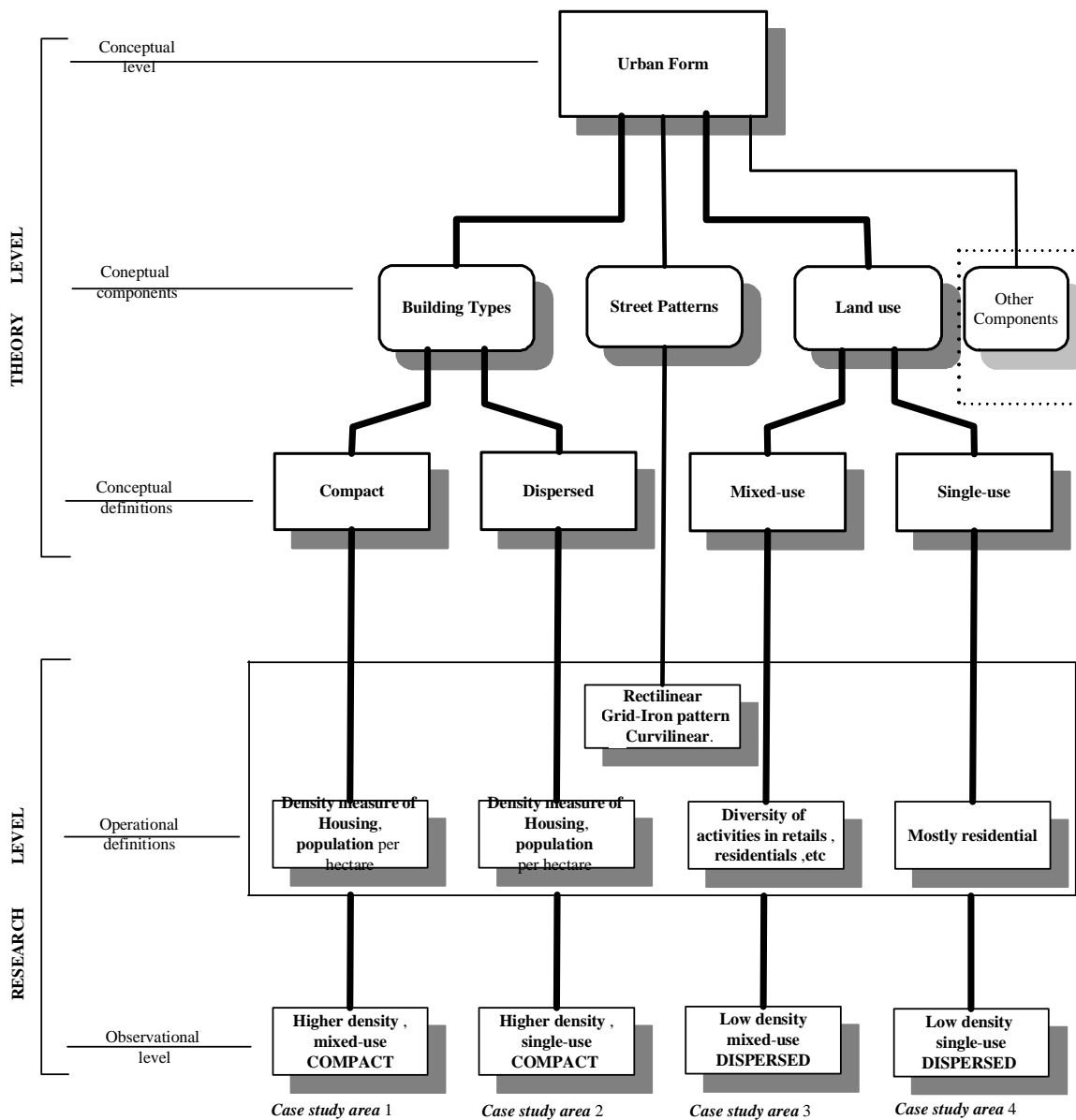


Fig. 1. Transition from the conceptual to observational level, the case of urban form

## RESULTS & DISCUSSIONS

If concepts such as *urban form*, *environmental sustainability*, and *social sustainability*, that are the very broad major concepts of this study, need to be measurable and observable, they have to be explained or be defined by several conceptual definitions.

Thus as a result of the literature survey, a wide range of conceptual definitions were used to describe each of those concepts. Although there were many conceptual definitions, it has to be recognized that investigation of all those indicators is not possible in research at this scale. To be realistic and considering the time factor, budget and the limitation of the study, the research needs to focus amongst the most influential indicators that are suggested by the theoretical framework of the study (Fig. 3). These are to be selected systematically for a deeper investigation. Accordingly the conceptual definitions of the study were as follows:

Urban form firstly was defined by conceptual components such as *Building types*, *Street patterns*, and *Land use*, although it is not restricted to these, and some other component). Then each of these concepts was described by the conceptual definitions.

*Building Types*, referred to the urban buildings and their physical forms, heights, and the number of storey which represented the Compact, and Dispersed building forms. The compact forms, is referred to as “three or four-storey urban blocks”; (Elkin, *et al.*, 1991).

Environmental sustainability was indicated by concepts such as global warming, greenhouse effect, depletion of the Ozone layer, Biodegradation, change in the Ecosystem and life cycles, depletion of energy and resources, and so forth (Talbot, 1993. Cooper, 1993) (Fig. 2). These are mostly due to energy consumption, and pollution and waste production. However recognizing the impact of all those factors in the case of this research, there has been an effort to detect the major factors. Thus, *environmental sustainability* here is referred to the impacts of:

“*Transportation energy consumption*”, that is including energy used by different modes of transport, private car, public transport, and walking/cycling, and also

“*Air pollution*” resulted from the “harmful emissions of automobiles”, particularly the “use of private car”, on the urban environment.

These conceptual definitions then would lead to operational definitions which will be discussed in the later section.

Social Sustainability refers to a series of concepts (Fig. 3) which include:

“*Social Interaction*”, according to Lang(1987) and Rapoport(1977) meaning the amount of “*Social contact*” between the people in the neighborhood’s open spaces, streets, local park, and recreational space.

“*Neighborhood satisfaction*”, referred to the level of satisfaction of quality of living in the neighborhood, relation with neighbors, and neighborhood facilities.

“*Safety and security*”, referred to a series of questions about walking trips and traffic accidents, and crime and attack during the walking trips.

It might argued that there were other indicators for the three concepts *urban form*, *environmental sustainability*, and *social sustainability* as well as those above mentioned, or one might not totally agree with the above conceptual definitions. But it has to be realized that these conceptual definitions were firstly, derived from the literature search, and - as mentioned earlier- were the major concern of this study. Secondly as discussed in previous section, one major function of definitions, is for Communication. Therefore there is no point in disputing a conceptual definition; as is pointed out by Nachmias (1993).

“Conceptual definitions are neither true nor false. Concepts are symbols that permit communication. Conceptual definitions are either useful for communication and research, or they are not. Indeed one may criticize the intelligibility of a definition or question whether it is being used consistently. But there is no point in criticizing a conceptual definition for not being true; the definition is what the definer says it is” (emphasis is the author’s).

However in order to move from the conceptual level to the observational level, and having these

conceptual definitions, in the next stage they have to be expressed in terms of operational definitions which will enable them to be measurable and observable (Fig.1).

It has been established that, is most often the case that the empirical attributes or events that are represented by the concepts cannot be observed directly, for example the concepts such as, buildings forms “neighborhood satisfaction”, or “safety and security” or particular “contact between people”. What has to be done in such cases? The solution lies in conceptualization of aspects of any personal or group behavior in a precise manner and in such a way that they can be measured (O.U. Block 1:83). Sometime the empirical existence of a concept has to be inferred, and inferences of this kind are made with operational definitions (Nachimas, 1992).

In the context of this study, operationalization is made through the following operational definitions. In the next section some operational definition are presented. Note that these are not a comprehensive list and there are many other operational definition; however we need to exemplify some for our purpose of model.

*Compact city*, as defined by Elkin, 1991 & Jenks *et al.*, 1996, ‘it must be a form and scale appropriate to walking, cycling and efficient public transport, and with a compactness that encourages social interaction.’ For a practicable model of compactness it is suggested that: ‘housing densities in towns and cities ought to be at a level equivalent to the typical three-and-four storey urban street’; this could be found in most of British inner-city urban areas and is a density at ‘a level at which it is still possible to provide each dwelling with its own front door to a public street, and to provide gardens for all family dwellings. *Mixed-use development*: Diversity of activity, means placing retail functions and local industry in residential areas, and residential functions in retail areas.

*Single-use development* refers to the suburban and urban areas where most of the buildings are residential, and commercial activity is separately concentrated in the town/city centre or in retail parks.

*Accessibility* refers to the distribution of the city facilities and the ease of access to the most

destination points within the city/town (Handy, 1992). In the context of this study they were classified under nine major groups of activities.

*Overall Population Density*, population density of the whole urban area, tightly defined, and including all other land uses- expressed as persons per hectare (Keeble, 1969. Cited in Breheny, 1995).

*Gross Housing Density*, is equal to dwelling units per hectare, calculated over the whole of a residential neighborhood, including roads, schools, workplaces etc., expressed as gross dwelling units per hectare (Breheny, 1995).

*Residential buildings* refer to the “three-and-four storey residential urban building blocks” with entry from a common staircase.

*House type* refers to “Block of flats”, “Tower block”, “and Detached house”, “Terraced House”, and the ‘other’ types.

*Density*- the number of people or housing per acre or hectare. In this study it refers to two levels, the higher density (Compact city), and lower density (Sprawl, dispersed).

*Average Household size*, refers to the average number of persons within the dwelling.

*Energy consumption*, rather than measurement of just fossil fuel consumption. by vehicles, particularly by private cars. It refers to their outcome, which is explained by the frequency of use of private car, the length of journey. Therefore the more the frequency of use of a private car, and the distanced traveled, the more energy used, and the more air pollution produced. *Social contact* refers to a series of question about contact with neighbors, and visiting friends and family.

*Neighborhood satisfaction*, is described by a series of question on the level of satisfaction about the privacy, and communal space, and quality of outdoor spaces in the neighborhood.

*Safety and security*, refers to a) being safe during the walking and strolling in the neighborhood, from crime and attack and b) being secured from traffic accidents in doing so.

*Shopping trips*, were refers to trips to high street, shopping centers/mall, city/town centers, local shops, and food stores.

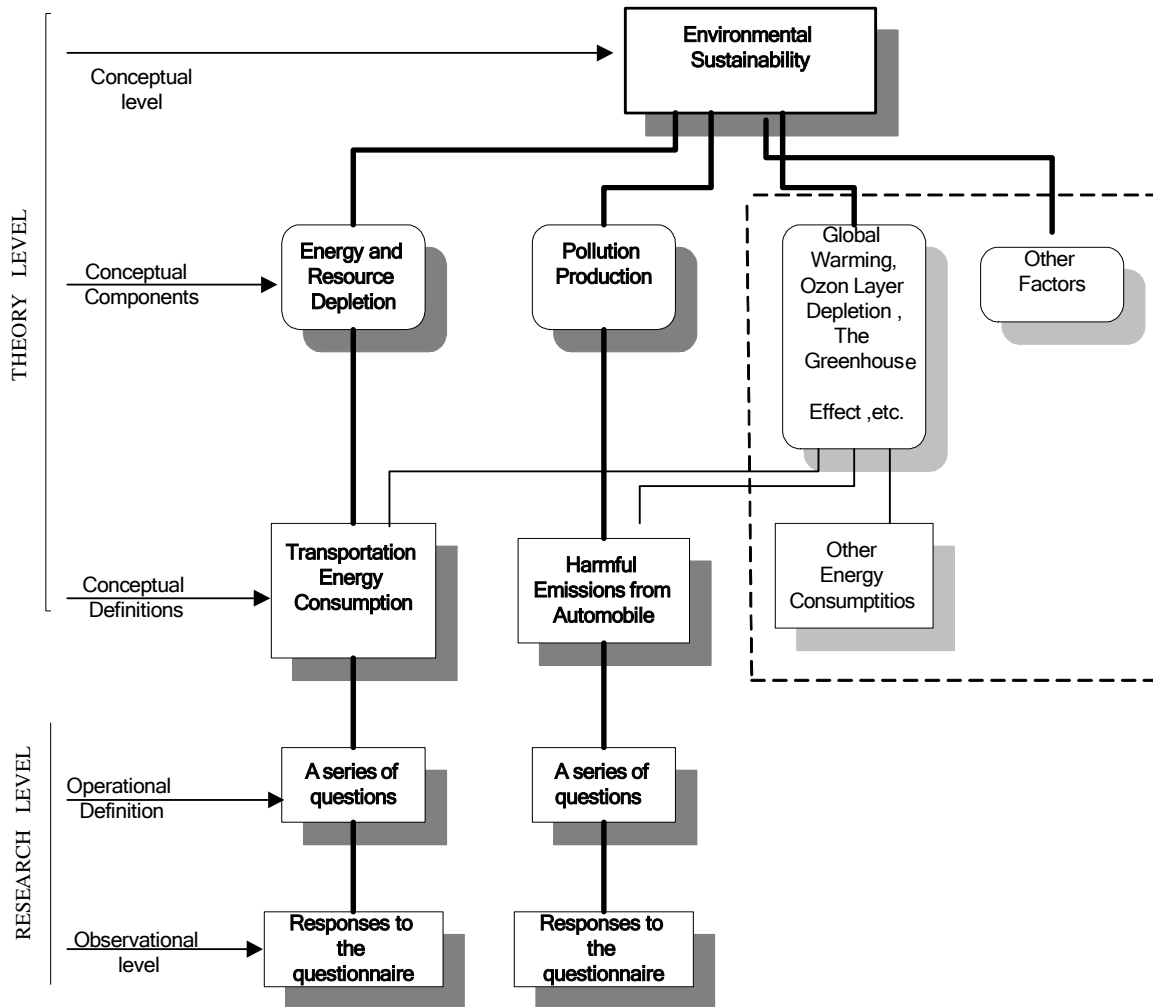


Fig. 2. Transition from the conceptual to observational level, the case of environmental sustainability

*Non-work trips*, are explained by all journeys by public transport, private cars, and walking, for the purposes of other than work. They are classified in this study, under nine major categories. In order to achieve consistency between respondents, the activities have been classified as in the National Travel Survey Census.

The statement of the research problems utilizes a set of concepts. As discussed earlier in the chapter, concepts are abstractions or interpretations of the real world, and do not actually exist as empirical phenomena. Thus, in order to move to an empirical level from the conceptual level, it is necessary that concepts be converted into something that is measurable and observable; into *the variables*. Variables eventually become the means of testing the hypotheses. According

to Nachmias (1992), a variable is an empirical property that takes two or more values. There are three major variables that should be distinguished in the research. The dependent variable, independent variable, and control variable. The independent variable is explanatory, and explains the changes in the dependent variable. It is suggested that in the real world, variables are neither dependent nor independent; the researcher decides how to view them, and the decision is based on the research objective. An independent variable in one investigation may be a dependent variable in another (ibid). One point should be made here, that in most urban research, the independent variable cannot be manipulated by the investigator to observe the effects on the dependent variables.

However at this stage the two major independent variables are: a) The Density, and b) The Land use. It was propositioned that these two variables would have an effect on the variables such as “transportation energy consumption”, “use of private car and distance traveled”, “the social contact”, “the patterns of activities”, “neighborhood satisfaction”, and “accessibility to the city facilities”. Consequently the second groups of variables are called dependent variables of the study. They are outcomes of the Density and the Land use variables. It has to be mentioned that having the two independent variables and several dependent variables in a study makes it much complex and needs much effort to investigate the individual relations and interaction between the variables relationships. The author was aware of this potential problem, and deliberately aimed to examine the impact of single variable as well as multiple variables and their interaction on the dependent variables). The major reason was that of the complexity of the urban form, and existing the multi-dimensional factors in the urban-social

research. The importance of this issue was explained well by Nachmias (1992), where he points out that most of the phenomena investigated by the social scientists call for the assessment of the effects of several independent variables on one or more dependent variables Both the independent, and the dependent variables were referred to a series of observable questions . The control of compound variables of the study will be discussed in detail in the next section. The aim is to measure both the quantitative and qualitative aspects of the urban forms. The two scales that are employed to measure the variables of the study in our conceptual model are: quantitative and semi-qualitative. Most of the variables of the study of urban sustainability could be measured in the quantitative scale. Considering the different levels of in a quantitative measurement, some variables might be measured in the *Categorical (Nominal) level*; some might be in *ranked order (ordinal)*, while there are many in the forms of *Continuous (ratio) level* of measurement.

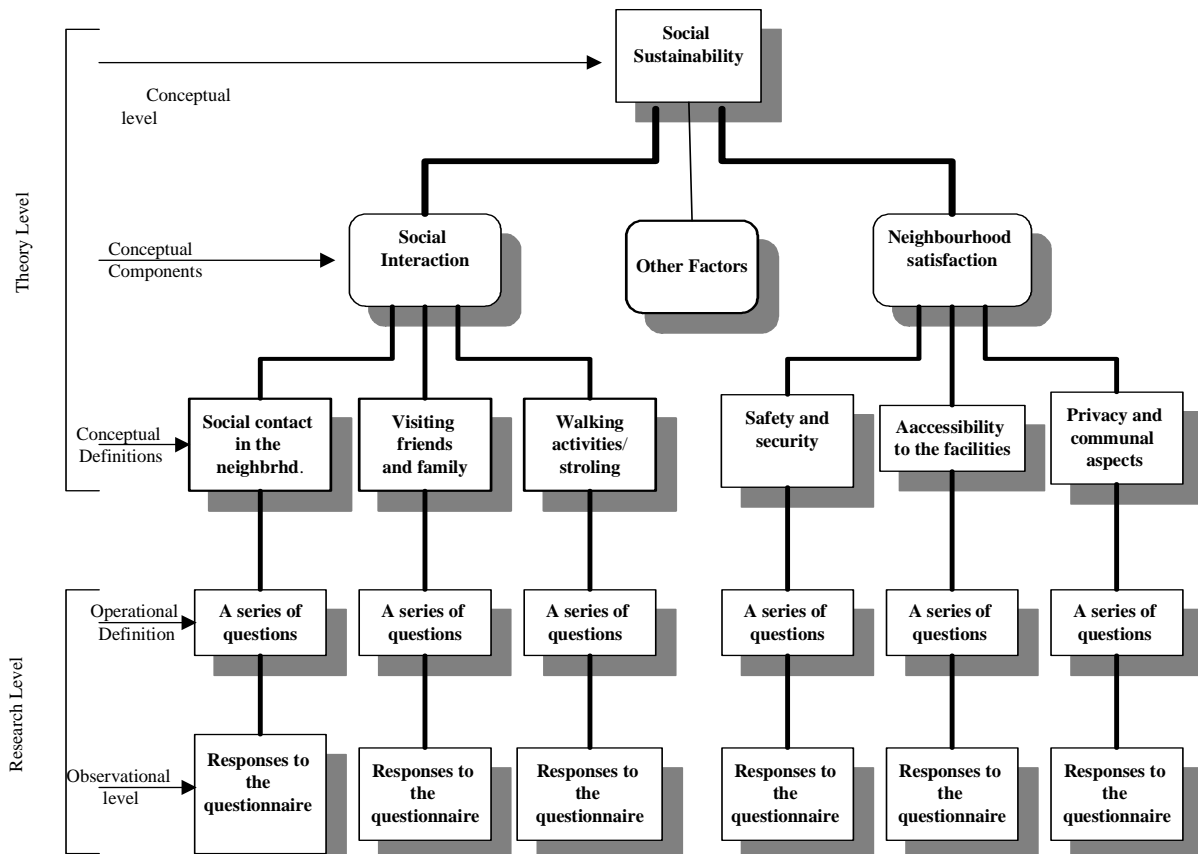


Fig. 3. Transition from the conceptual to observational level, the case of social sustainability



## CONCLUSION

The influence of particular urban form on the environmental and social sustainability is the main debate and of central importance to this study. The review of the literature led to the two central propositions that have to be examined. The major propositions suggested that the compact city form with an overall higher density and the mixed use of land, is more environmentally, and socially sustainable, compared with the low density, single-use city form. Therefore, it can contribute towards achieving sustainability. However, a framework is needed in order to assess urban sustainability. To achieve an appropriate method for measuring sustainability, several conceptual frameworks were discussed with their advantages and disadvantages. A multiple stage conceptual framework was formed by combination of *Domain-based* frameworks and *Goal-based* frameworks. In order to assess urban sustainability, the major indicators for *Environmental sustainability*, and the *Social sustainability*, have to be identified in the first instance. According to the literature review, the transportation energy consumption is regarded as a potentially important factor for the former, while social interaction was considered as the potentially important factor for the latter. To determine the effect the variables such as density, and land use on the transportation energy consumption, and the social interaction, some other variables were discussed. Finally the appropriate measurement scales and data collection method for the provision of *primary data* and *secondary data* were specified for those variables of the study.

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