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Spatial Variability in Human Development Patterns in Assiut, Egypt

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***Abstract*—**Given the motivation of maps impact in enhancing the perception of the quality of life in a region, this work examines the use of spatial analytical techniques in exploring the role of space in shaping human development patterns in Assiut governorate. Variations of human development index (HDI) of the governorate's villages, districts and cities are mapped using geographic information systems (GIS). Global and local spatial autocorrelation measures are employed to assess the levels of spatial dependency in the data and to map clusters of human development. Results show prominent disparities in HDI between regions of Assiut. Strong patterns of spatial association were found proving the presence of clusters on the distribution of HDI. Finally, the study indicates several "hot-spots" in the governorate to be area of more investigations to explore the attributes of such levels of human development. This is very important for accomplishing the development plan of poorest regions currently adopted in Egypt.

***Keywords*—**Human development, Egypt, GIS, Spatial analysis.

I. INTRODUCTION

HUMAN development is a process of enlarging people's choices. The most critical ones are to lead a long and healthy life, to be educated and to enjoy a decent standard of living. Additional choices include political freedom, guaranteed human rights and self respect - what Adam Smith called the ability to mix with others without being "ashamed to appear in public" [1]. Very importantly, *human development* provides the basis for a paradigm shift in development goals, moving from needs to opportunities. This last point has important implications in terms of information and communications technology (ICT) for development, such as proactively seeking to open up opportunities and doing so by promoting local talent and capacities in addition to directly helping to satisfy needs [2]. The *human development approach* arose in part motivated by growing criticism to the leading development approach of the 1980s, which presumed a close link between national economic growth and the expansion of individual human choices. The need for human development paradigm as an alternative development model was urged by many factors e.g., growing evidence that did not support the then prevailing belief in the "trickle down" power of market forces to spread economic benefits and end poverty; the human costs of structural adjustment programs became more apparent; social ills (crime, weakening of social fabric, etc.) were still spreading even in cases of strong and consistent economic growth; and a wave of democratization in the early 90's raised hopes for people-centered models [3], [4], [5].

Human development has become a major policy issue in both developing and developed nations. First human development report (HDR), launched in 1990 by United Nations Development Programme (UNDP), produced human development index (HDI) to rank countries by level of human development. The human development index is a composite one that measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, as measured by life expectancy at birth; knowledge, as measured by the adult literacy rate and the combined gross enrolment ratio for primary, secondary and tertiary schools; and a decent standard of living, as measured by GDP per capita in purchasing power parity (PPP) US dollars [6]. However, the development of indicators for the measurement of human development has been subject to intense debate recently (for the review of the problem, see, e.g., [4], [7], [8].

Since most of socioeconomic data used in human development studies are associated with geographical locations and aggregated to areas such as census tracts, maps are a natural way of portraying local social and economical conditions [9], [10]. In this way, the perception of human development status is enhanced with the visualization of problem areas "hot spots," which, more often that not, tend to exhibit some type of cluster patterns. In recent times, concern has been growing about monitoring spatial inequalities of human development components to target and prioritize deprived areas effectively [11], [12], [13], [14]. One of the arguments in favor of geographically targeted policies is that they are justified because of the increased polarization between deprived and more affluent areas [15].

Given the unique features and importance of the subject, the World Institute for Development Economics Research of the United Nations University (UNU-WIDER) launched a major research project on spatial disparities in human development in 2002 [16]. The project investigates spatial disparities in countries and regions that are attracting considerable professional and political attention, such as China, Russia and Central Asian countries. As a dimension of overall inequality, spatial disparities have added significance when combined with regional divisions and political and ethnic tensions that can undermine social and political stability. The accurate

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measurement of spatial disparities and the analysis of their causes and consequences are therefore of particular importance.

Henninger and Snel [17] analyzed the correlation of some *human development indicators* surrogates with the marginal condition factors using point and polygon overlay analysis functions in Arc/Info and Arc/View GIS software. For each HDI sample point, a geographically referenced value was extracted from each thematic layer. The study concludes that maps may be needed to show that certain regions are disadvantaged, to rapidly assess options for food emergency interventions, to target public investment to areas of greatest need, or to investigate specific causes of poverty.

Graves [18] cited a review of research literature on health disparities associated with healthcare access and health outcomes from a geographic perspective. The study digs on three research questions: first, GIS sue in healthcare; second, GIS effectiveness; third, implications for future use of GIS technology in healthcare. The literature reviewed shows effective integration and analysis of health data using GIS technology. As a type of information technology, GISs are potentially powerful assessment tools for the investigation of healthcare access, health outcomes, and the possible resulting health disparities. Their ability to integrate health data with mapping functions allows for visualization, exploration, and modeling of health patterns. The study concludes that applications of GIS and spatial techniques using health data can help in describing and explaining disparities in healthcare access and health outcomes.

Collection of Gulson and Symes [19] draws, within the sociology of education, on the 'spatial turn' in contemporary social theory. The contributors work a spatial dimension into the consideration of educational phenomena and illustrate its explanatory potential in a range of domains: markets and school choice, regional and rural settings, and youth and student culture. The premise of this work is that drawing on theories of space allows for a more sophisticated understanding of the competing rationalities underlying educational policy change.

Cervera, Lizárraga, and Sánchez Guillén [20] analyzed the results of the first National Assessment of Academic Achievement for Scholar Centers (ENLACE, acronym in Spanish) applied during the year 2006 in the Municipality of Juarez (State of Chihuahua, Mexico). Spatial analysis was conducted to make a georeferenced database by joining all related variables to a point representing a school. Apparently there is a high spatial correlation between ENLACE's results with the socioeconomic level of people. In this way, results going from good to excellent were spatially located over the sectors more developed of the city. Poor results going from insufficient to elemental were spatially located at places with higher deficits of infrastructure and low socioeconomic levels.

Regarding the standard of living, the third basic dimension of *human development*, poverty maps have emerged as important tools for targeting aid and development resources [21], [22], [23], [24]. Advances in data collection and technology make it possible to depict poverty with greater spatial detail than ever before, helping to better target poverty alleviation policies and programs. In particular, poverty mapping provides a means for integrating biophysical information with socioeconomic indicators to provide a more systematic and analytical picture of human wellbeing and equity.

However, whereas many studies employ spatial techniques for investigating each of the three basic dimensions of human development separately, few studies handle such a complex phenomenon comprehensively. The current study is a trial to look at different aspects of human development simultaneously, taking into account the multidimensional nature of welfare and development indicators. In addition, despite the importance of maps in promoting awareness about the quality of life, the role of space in the patterns of human development indicators has received considerably less attention in Egypt. This work is the first trial that map human development patterns in an Egyptian governorate using GIS and spatial techniques. Typically, the study is designed to inquire: Are the patterns of human development conditioned by factors that are spatially dependent? In other words, why are these spatial patterns there, and how will they change if we intervene in a particular way? Answering these questions requires using statistical methods that are spatially explicit; it also requires handling data sources at different levels of spatial aggregation and using different ways of depicting spatial information.

To accomplish its questions, the study goes through the local human development report carried out in Egypt to uncover developmental achievements targeted to improve people's living conditions in Assiut governorate's villages, districts and cities. Most concerned parties believe that the local report, which is a microscopic analysis of human development in every minute spot inhabited by the people (village, city or district), will be more capable of delineating a distinctively chiseled picture of the human status. People's actual realities are betrayed rather than blurred amidst the general averages of the governorate or the state larger picture in world and national reports. Accordingly, an unbiased vision of governance and policies is expected from this study to produce, hence, to act as a roadmap for local development decision-makers and citizens.

II. METHODOLOGY

Most approaches to the calculation of human development indices presume that the status of human development in a country or a region is made up of separate domains, where each domain is made up of a number of components that cover aspects of human development as comprehensively as possible. To investigate the spatial patterns in the three dimensions of human development, the study draws on the results of the poverty mapping work [11], [25], spatial analysis of health indicators [9], [26], and mapping educational inequalities [20], [27]. Human development index

used in the Egyptian local human development reports was adopted to capture the quintessence of human development in Assiut governorate and its constituent components namely, villages, cities and districts. Each component is tackled separately as an independent unit and is then compared to other units in the governorate. Assiut governorate presents an important challenge to developmental planners, a governorate that is simultaneously one of Egypt's largest (3.4 million), Egypt's poorest (60% poor persons of total population), and the one that of consistently lowest ranking five governorates in Egypt (as measured by human development index, HDI=0.681 in 2008). To allow for a common geographical basis for the different data sets, the study used the official division of Assiut governorate in 247 census tracts. The data sets used include: (a) life expectancy at birth as a measure for long and healthy life indicator, (b) adult literacy rate (with two-thirds weight) and combined primary, secondary and tertiary gross enrollment ration (with one-third weight) as a measure for knowledge, and (c) GDP per capita in purchasing power parity (PPP) terms in US dollars as a measure for decent standard of living. This methodology was used to produce a map of human development for Assiut governorate.

Taking the map of human development of Assiut as a basic data set, the study has set out to explore a number of questions regarding the role of space in the human development patterns. The first concern was to address the nature of spatial dependence in these patterns. As a starting point, it was necessary to determine the possible existence of regional trends in the data based on regression model. The next step was to estimate the global spatial autocorrelation in the human development index, by using Moran's *I* index:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (1)$$

Where, n is the number of areas, x_i is the value of the attribute in area i, $\bar{x}$ is the mean value of the attribute for the whole region, and the weights w_{ij} are such that they are $1/neigh_i$ if area i and area j are contiguous and $zero$ otherwise, where $neigh_i$ is the number of neighbors of area i. The Moran index is a global correlation coefficient, where a value of 0 would indicate no spatial correlation and a value of 1 a complete spatial dependency.

Given the existence of a strong global pattern of spatial association for the human development index in Assiut, the next question to be asked concerns the regional distribution of this index: Are there "pockets" of local variation where human development differs significantly from the overall trends in the governorate. The idea is to find clusters of local variation where the human development index has a stronger association than the overall trends in the governorate. To address such questions, two exploratory data analysis tools have been used: the Moran scatterplot and the Local Moran spatial autocorrelation index.

The benefit of applying *Moran scatterplot* is to compare the spatial distribution of an *attribute* and its *local mean*. To perform this analysis, both variables are *normalized*, subtracting values from the global mean and dividing by the standard deviation. Anselin [28] describes this as "the spatial lag of the variable on the vertical axis and the original variable on the horizontal axis" -the spatial lag refers to the values of a location's neighbors. The resulting normalized variables will have a mean of 0 and a standard deviation of 1. This study refers to normalized variables as HDI and to its local mean as W_HDI, where W is the normalized weights matrix, as described in (1).

Local Moran index is a tool to find clusters on the distribution of human development index. It is calculated using the following matrix:

$$I_i = \frac{(x_i - \bar{x})\sum_{j-1}^{n} w_{ij}(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (2)$$

Where the terms are defined as in (1).

III. RESULTS AND DISCUSSION

Data available from 2003 local human development report of Assiut governorate have been used to produce the map of human development [29]. The map shows a significant gap between regions of Assiut in terms of human development index, Fig 1. About 16% of Assiut's villages and cities have low human development index (HDI=0.466~0.529). The same percentage is found for villages and cities with high human development index (HDI=0.591~0.681). The majority of constituent components (68%) have moderate value of human

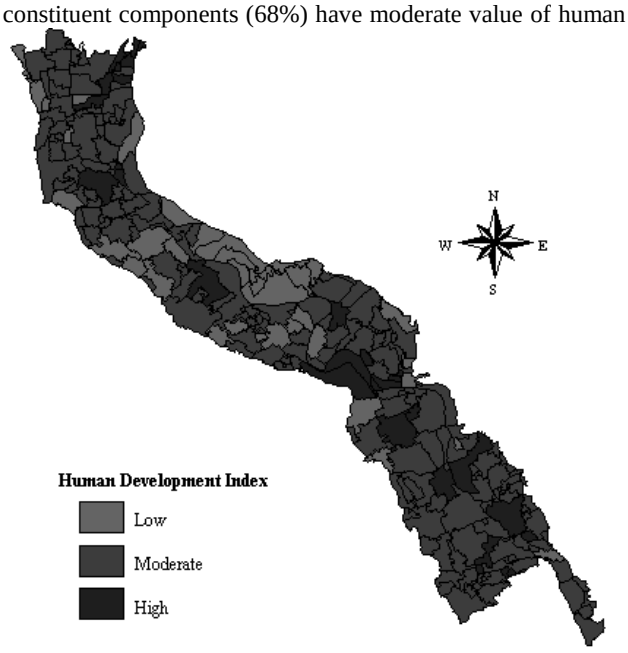

Fig. 1 Human development map in Assiut, 2003

development index (-1 Std. Dev. ~ 1 Std. Dev.). An important but logic result is that high values of HDI are found in cities and some neighbor villages, while periphery villages have often low values of HDI. Such result may assist policymakers and development agencies in designing interventions to improve the quality of citizen's life in such worse-off areas. Typically, the study suggests 40 of 247 census tracts of Assiut governorate where resource budget allocation and compensation for inequalities can be more effective. The location of worse-off villages assures the need for decentralization policies to achieve sustainable development in Assiut. However, Egypt has started the adoption of such policies through Egyptian Decentralization Initiative (EDI), but it still needs to further expansion.

Building upon the map of human development, a regression model was applied to determine the possible existence of regional trends in the data. This estimation is necessary, because, if the data exhibit a trend, it would cause the indices to be naturally spatially autocorrelated [30]. However, the regression fit for the trend surface was poor ($R^2 = 0.24$), and it can be inferred that there are no strong spatial trends in the data. Estimation of global spatial autocorrelation in the human development index resulted a Moran's I index of 0.674, with less than 1% likelihood that this clustered pattern could be the result of random chance.

To determine whether there are pockets of local variation where human development differs significantly from the overall trends in the governorate, Moran scatterplot was applied. By constructing a graph of HDI versus W_HDI (Fig. 2), four types of spatial association were expressed:

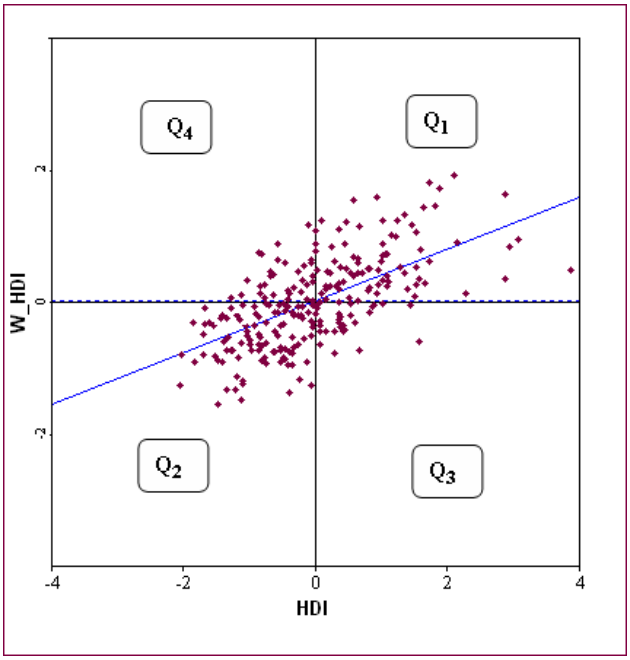

Fig. 2 Moran scatterplot for the human development index of Assiut 2003

- Quadrant Q1 ("High-High"), showing areas where both normalized values and local mean are positive;
- Quadrant Q2 ("Low-Low"), showing areas where both normalized values and local mean are negative;
- Quadrant Q3 ("High-Low"), with positive values and negative local means; and
- Quadrant Q4 ("Low-High"), with negative values and positive local means.

A map of Moran scatterplot has then been created, Fig. 3. In this map, each constituent component of Assiut governorate is labeled according to quadrant occupied by its human development index in its Moran scatterplot. The interpretation of the Moran scatterplot map in this context is that most of villages of Assiut are located in quadrants Q1 and Q2, which are areas of positive spatial autocorrelation. However, a significant number of villages are located in quadrants Q3 and Q4 and can be considered as transition regions between regions of the "high-high" and areas of the "low-low". Such a map shows that Q1 ("high-high") areas are located in the center as well as far northern and far southern parts of Assiut governorate. It is to be noted that Assiut city, the capital of the governorate, is located at the center and attracts the majority of investments oriented to improve the quality of citizen's life. Areas of Q2 ("low-low") are mostly located in the north of Assiut governorate with some areas in the south. Areas in quadrants Q3 ("high-low") and Q4 ("low-high") are distributed between areas in quadrants Q1 and Q2 especially in the center of the governorate.

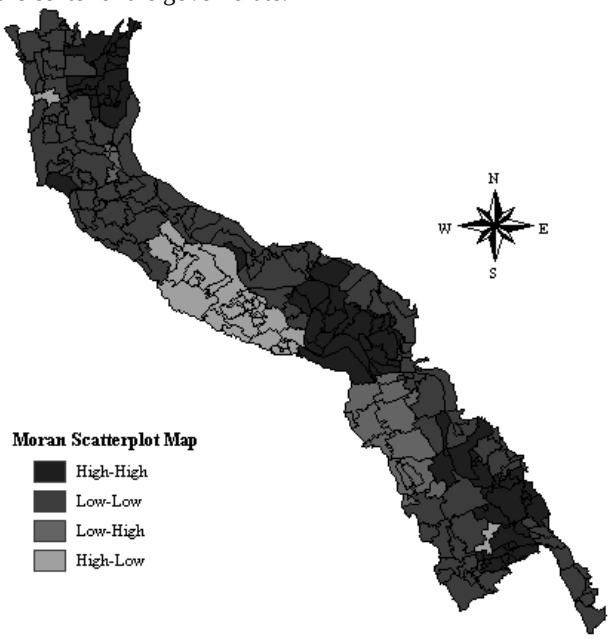

Fig. 3 Moran scatterplot map for human development index for Assiut, 2003

The Moran scatterplot map indicates strong patterns of spatial association and, therefore, suggests the presence of clusters on the distribution of human development index. As a result, local Moran index was used to find out such clusters. The significance of local Moran index has been established by simulating a pseudo-distribution by permutation of the attribute values among the areas. Local index values with

significance of 95 percent and 99 percent were then mapped and posited as "hot-spots" of local non-stationarity. Fig. 4 shows hot-spots of human development in Assiut governorate. The map identifies four "hot-spots" of high human development located in the south, center, near north, and far eastern north of Assiut. On the contrary, there are three "hot-spots" of low human development distributed in the south, near north, and far western-north of the governorate. Those "hot-spots" should be area for more investigations to explore the causes stand behind such levels of human development.

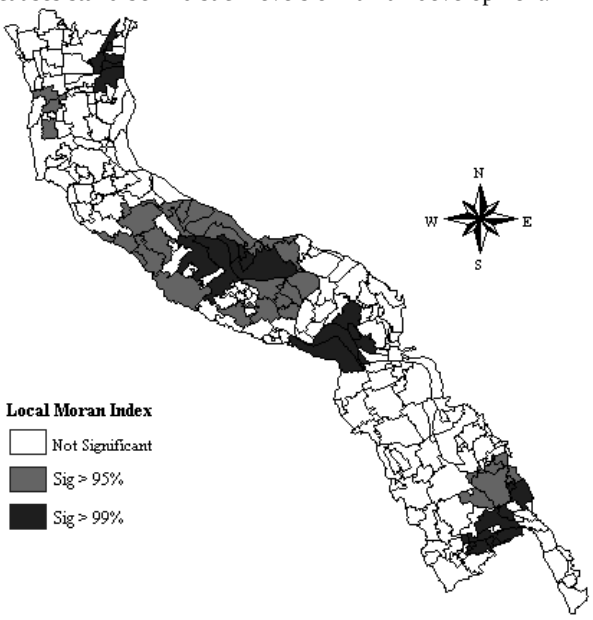

Fig. 4 Significant values of local Moran index for human development index for Assiut, 2003

There is no doubt that identifying hotspots of human development among rural and urban areas could help developmental decision makers effectively allocate resources towards reducing the disparities between different regions of Assiut governorate, which would contribute in achieving social equality. However, through in-depth investigation of human development data with its various dimensions, as well as through knowledge of the living conditions and the distribution of power structure in the governorate of Assiut, the most important reasons that lead to the existence of such hotspots can be reported. In this regard, areas of higher levels of human development are represented in the cities of Assiut (at the center of the governorate), Sedfa city in the south and Dairout city in the north. The high level of human development in the city of Assiut may be traced to a combination of factors including: the concentration of social services and cultural infrastructure since it represents the capital city of Assiut governorate. Another important factor is the concentration of economic activities in Assiut, which would raise the average per capita GDP that in turn leads to higher gross human development index in that city. High level of human development in the other cities, Sedfa and Dairout, may be attributed to the high index of average per capita GDP since both of the two cities is famous for commercial businesses. In addition, high rates of emigration of the two cities, which could benefit economically upon the remittances, would increase investment in these areas.

On the other hand, concerning areas with significant low human development index, evidently they are rural areas. Returning to the attributes that could be behind this significant decline, there are key factors in this respect: the decline of the life expectancy at birth, which indicates the low level of health of these sites; another reason is that it is the low rate of literacy than the rest of the province.

IV. CONCLUSION

Investigations of human development status in a country or a region require social and economical data that tend to be space-related. Due to the inherent spatial methodology in the composition of the HDI, this paper introduces the use of geographic information systems tools in hopes of better capturing the differentials of human development patterns in Assiut, Egypt. The paper explicitly addresses the nature of spatial dependence in these patterns. The research draws on previous local human development reports conducted in Egypt to portray developmental achievements targeted to improve people's living conditions. Results assure that exploratory techniques such as global and local Moran indexes and Moran scatterplot maps are very useful to indicate the existence of global trends of spatial autocorrelation for human development patterns and to point out regions where this trend was significantly weaker or stronger. While spatial analysis per se is crucial to better understand the nature of human development differentials in a region, the presence or the absence of spatial autocorrelation also points the potential role played by diffusion mechanisms. The study concludes that mapping human development patterns in Assiut governorate is essential to rapidly assess options for policy interventions, hence, to target public investment to areas of greatest need. However, this is the first paper, which looks at mapping human development patterns within Egypt, using geographic information systems tools. The value of this paper is seen on three levels: first, the original arguments made which highlight the importance of space for human development discourse or the so-called the genius loci, second, the manner with which these contemporary insights are then contextualized with reference to the wider literature, and third, the way in which this research adds to the calls to rethink policies toward developing different regions of Egypt. This research is expected to influence social policy measures in the governorate and to raise general awareness about the value of spatial analysis in human development studies.

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