Spatial Expansion in Islamabad's Rural Area: Patterns & Causes

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1. Introduction

Spatial growth of human settlements is a universal phenomenon linked to increasing human needs and activities. As a result of it, the un-built land is gradually converted into built-up environment containing buildings and related physical structures. Since the past century, cities have transformed from isolated locations to interconnected centers of physical, social and economic activities (Hathout, 2002). Population data are considered the principle source of information on growth of cities (Cohen, 2006). It is used because it is directly related to spatial expansion of built-up areas (Hammer et al., 2004). Researchers have used a number of analyses to examine the processes of spatial expansion. Spatial analyses of population dynamics, such as population density and population per unit built-up area, are the most frequently used approaches to identify the nature of growth (e.g. Bofeng et al., 2003; Fonseca, and Wong, 2000; Wang and Zhou, 1999). This study tries to explore the spatiotemporal dimension of population expansion using point based data interpolation. Zone IV, the study area is one of the five planning zones of Islamabad Capital Territory. It spreads to approximately 287 km^2 of land covering National Park Area (220 Km^2) and a part of Islamabad rural periphery (67 km^2). It is bounded by the cities of Islamabad and Rawalpindi from south-eastern sides (Fig. 1). Agriculture and vegetation are the dominant land use of Zone IV and it is the best source of vegetable supply to the hotels and residents of neighboring areas.

Fig 1. Location of the study area (Source Islamabad Master Plan, 2000)

2. Materials and Methods

This paper attempts to describe the nature of spatio-temporal growth in ICT Zone IV by exploring the changes in population density and Population Rank Mobility Index of the study area. Village population data (year 1972, 1981, 1998 and 2007) was used to identify the nature of spatial growth in Zone IV (Fig. 2). SPOT Panchromatic Satellite image and Islamabad Master Plan has been used as base map for demarcation of existing villages and administrative boundary whereas the physical features of the study area (e.g. major road

network and water channels) have been delineated through 2.5 m pixel resolution SPOT pan sharpened imagery of the year 2007.

Using ArcGIS software, population data of three census years was attached to the point location of the village. Population Rank Mobility Index (RMI) was identified for intercensal periods and ArcGIS Spatial Analyst toolset was used for spatial interpolation of population density and RMI surfaces. Historical changes in population density have been analyzed in terms of their intensity, area, shape and direction of expansion. Whereas, RMI surfaces explain the changing hierarchy of village ranks showing areas with increasing, decreasing or constant ranks.

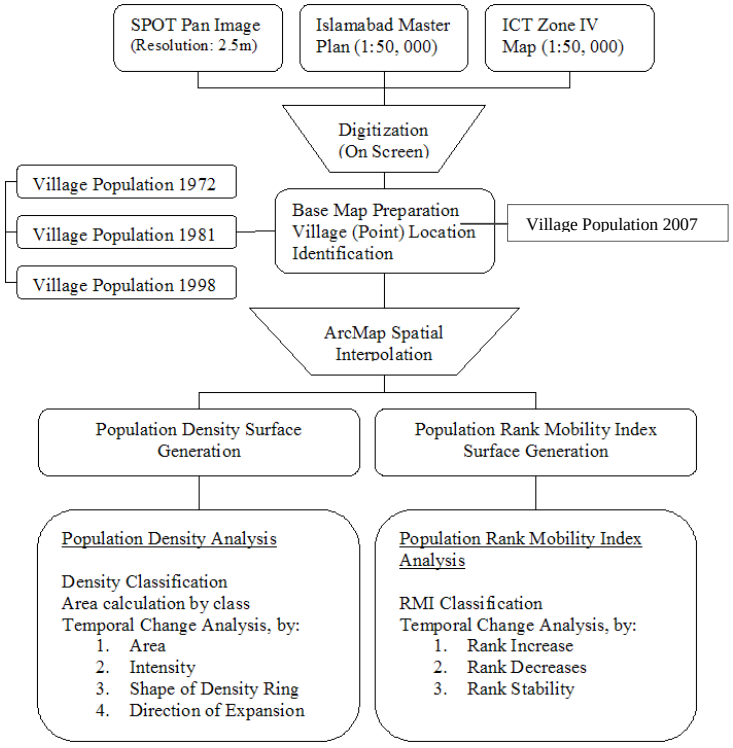

Fig 2. Methodological approach adopted in the study

3. Data Analysis

3.1. Patterns of Population Density Expansion

Kernel density function of ArcGIS Spatial Analyst has been applied to create population density surface for Zone IV. The resultant population density surface was classified (Fig. 3) for year (a) 1972, (b) 1981, (c) 1998 and (d) 2007. The analysis highlights the trends of rapid increase of densities around the middle resulting in continuous densification. In 1972, the maximum population density was 330 persons/km^2 (Fig. 3(a)), till 1981 it decreased slightly to 315 (Fig. 3(b)), reached 655 in 1998 (Fig. 3(c)) and increased to 1800 persons/km^2 till 2007 (Fig. 3(d)).

The figure also highlights that direction of population density concentration changed with the passage of time. GIS analysis highlights that the areas around Park Road experienced highest population densities. It has been identified that, presently densities are increasing more rapidly at the areas with higher densities, thus creating the process of densification. Historic density clustering in Fig 4 displays an elongated shift of higher densities towards the Murree road and Islamabad Highway. The oval shaped area of high densities (in 1972) stretched from centre to *Murree* Road (at *Bara Kau*) on northeast and towards *Islamabad* Highway on southwest. Higher density rings did not meet *Faizabad* interchange because a number of farming schemes (P&V Schemes, *Kuri* agro farming scheme etc.),

institutional allotments (NARC, NIH, IRDP etc.) control the population densities of this highly accessible spatial location. The bow wave like effects of densification (Fig 4) weakens out gradually towards the south eastern side.

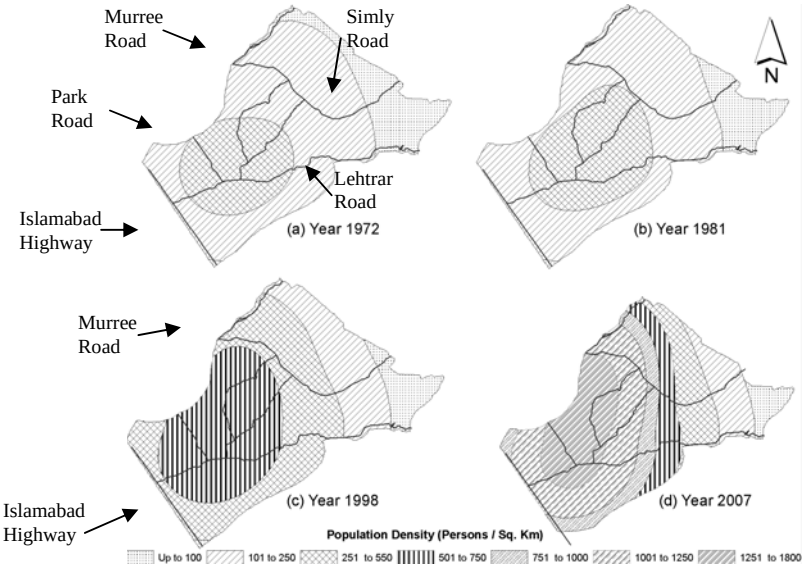

Fig 3. Population Density surfaces for year (a) 1972 (b) 1981and (c) 1998 and (d) 2007
Data source of village population see Government of Pakistan, 1998.

The results of changing areas of each density ring are summarized in table below.

Population Density (persons/km^2)	Area Change (Km^2)		
	1972 to 1981	1981 to 1998	1998 to 2007
Up to 100	- 15.9	- 10.7	- 7.4
101 to 250	- 2.5	- 115.0	- 24.3
251 to 550	+ 18.4	+ 23.7	- 74.0
501to 750	-	+ 102.0	- 67.0
7512 to 1000	-	-	+ 36.7
1001to 1250	-	-	+ 79.2
1251 to 1800	-	-	+ 56.8

Note: Negative values mean decrease while + value shows an increase than the previous census data

Table 1: Population density analysis of Zone IV

The table shows that, since 1972, lower density areas reduced while higher density areas increased gradually. Results of the analysis highlight that the area having population density less than 100 persons/ km^2 reduced from 46 to 12 km^2 (i.e. from 15.9 per cent to 4.1 per cent land of Zone IV). Spatial extent of this area, having population density of less than 100 persons / km^2, squeezed from entire eastern boundary to only the eastern corner of ICT Zone IV (see Fig. 3).

3.2. Patterns of Population Rank Mobility

Population Rank Mobility Index (RMI) is a measure of a city's change in population rank among a group of cities (Greene and Pick, 2006), and is calculated as;

$RMI = \frac{(R1-R2)}{}$

(R1+R2)

Where, R1 = Village population rank at time 1 and R2 = Village population rank later at time 2

An RMI value can change from -1.0 to +1.0. A negative RMI value indicates a decrease in rank, whereas a positive RMI value shows increase in rank. Index value of '0' indicates stability in rank position. RMI can be applied to any urban characteristics presented at nominal scale. A GIS analysis of Population RMI was carried out to identify spatio-temporal variations in village ranks. Village population for year 1972, 1981, 1998 and 2007 was used to create RMI of Zone IV for inter-censal periods (Fig. 4).

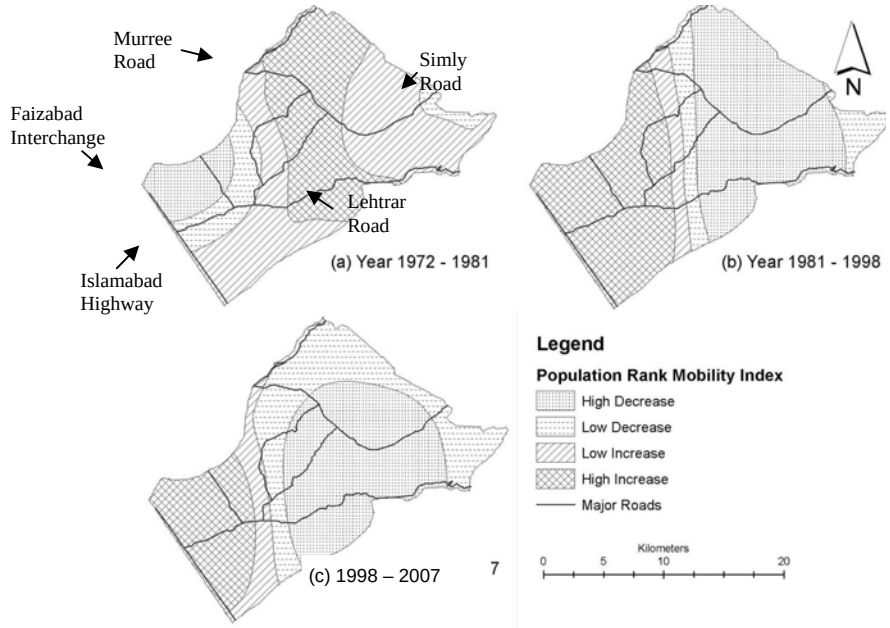

Fig 4. Population Rank Mobility Index surfaces for year (a) 1972-1981 (b) 1981-1998 and (c) 1998 – 2007

It allows for easy comparisons of population dynamics within the study area. It explains where and how population ranks are moving up or down in order of individual ranking. Figure 4(a) shows the spatial patterns of population RMI in the first intercensal period from year 1972 to 1981. The areas of increasing population ranks were located away from *Islamabad* Highway reaching north-south boundaries of the study area and covering the population centre of Zone IV in 1972. Figure 5(b) shows that during second intercensal period from 1981 to 1998, the trend of increasing RMI shifted towards *Islamabad* Highway. The areas of high increase were spread around Park Road in semicircular form covering its intersection on *Lehtrar* Road. The settlements away from *Islamabad* Highway experienced a decrease in population rank during this period. Figure 5(c) highlights RMI surface during third intercensal period from 1998 to 2007. It somewhat resembles RMI of the previous intercensal period. Increasing RMI spread to the areas around to *Faizabad* interchange, Park Road and the initial portion of *Lehtrar* Road. The temporal analysis shows that the population ranks of settlements have shifted from mobility to stability in spatial context. Increasing RMI area moved from north-south oriented central part of the study area to north-west oriented western part (towards urban areas) during the past thirty five years. It shows the trends of relatively faster population growth in the areas located closer to urban areas. The analysis predicts the effect of rapid urbanization in the areas located between Park Road and *Islamabad* Highway.

4. Discussion

As apparent from the GIS analysis of population and urban growth; the speed of urban processes and spatial expansion in Islamabad's rural area has been triggered by the element of accessibility to the better road infrastructure. For a fast track evaluation of urban phenomenon, GIS method of spatial interpolation provides a unique insight into the urbanization. Such 'fast forward' techniques are due for utilization in order to evaluate the hyper dynamic process of urbanization in developing countries. A fast forward planning paradigm is needed during this high speed change, in which the area should be re-accessed to deal with the challenges of present time (environmental, social). As per the findings of the study, the present scenario demands a revision in the zoning policy and management practices so as to preserve of fertile rural land along with the provision of affordable and sustainable urban growth of Islamabad. Methods of digital simulations and interpolation can greatly assist the planners to evaluate the dynamic process of urban growth and identify the agent of change needed to bring up a better world to live in.

Acknowledgements

The paper is based on the author's Master's thesis work carried out at the National University of Sciences and Technology, Islamabad, Pakistan. The author would like to thank the University, Higher Education Commission of Pakistan, Professor Umar Khattak, Mr. Mubushar Hussain, Mr. Ayub Tariq Shaikh and Dr. Ijaz Ahmad for their useful guidance. At the same time, many thanks to ISOCARP for the opportunity of presenting this work and their generous invitation to take part in Young Planning Professional's workshop at Perm, Russia.

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