ASSESSING THE AVAILABILITY OF PRIMARY HEALTH CARE SERVICES IN CHAMARAJANAGARA DISTRICT USING KERNEL DENSITY ESTIMATION

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Abstract

Accessibility is the term which geographers and planners use to describe the ease or difficulty of reaching services in another place. It is an important element of the health care system and is the proportion of the given population expected to use specified facility and services in an area. This paper analyses the details to assess the availability of Primary Health Centers in Chamarajanagara District using Kernel Density Estimation (KDE) for assessing population coverage of health services. This paper describes an approach to calculating accessibility ratios such as Population to Primary Health Centre (PHC) and Population to Health Workforce using Kernel Density Estimation (KDE). KDE disperses discrete phenomena across continuous space and is unrestrained by administrative boundaries. Therefore it provides a better representation of the spread of people and services within the district.

Key Words: Accessibility, Kernel Density Estimation, Health Workforce

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1. Introduction

Primary Health Care is recognized as the most important form of healthcare for maintaining population health because it is relatively inexpensive, can be more easily delivered than specialty and inpatient care, and if properly distributed it is most effective in preventing disease progression on a large scale. Recent advances in the field of health geography have greatly improved our understanding of the role played by geographic distribution of health services in population health maintenance. However, most of this

knowledge has accrued for hospital and specialty services and services in rural areas. Access to primary healthcare is recognized as an important facilitator of overall population health (Guagliardo 2004). The concept of health care accessibility is one of the more analyzed and debated concepts in public health (Joseph and Phillips 1984; Guagliardo 2004; Chayovan et al.1984). Researchers have framed the debate on economic, structural, infrastructure and behavioral pattern of healthcare facilities. This paper is concerned with geographic proximity, which is a form of potential spatial accessibility (Joseph and Phillips 1984; Guagliardo 2004). Quantifying adequate availability of health services to a population group is a challenging endeavor. The factors that shape the health care landscape are very complex and not easily modeled or even fully understood. In addition to the conceptual difficulties associated with measuring health care accessibility and availability, there is the technical challenge of finding and employing a method or technique that is robust enough to adequately model the health system. Kernel density estimation is an approach that has been in use for many years, but it has not often been applied to assess health accessibility, though that is changing as the value of KDE becomes apparent. Guagliardo (2004) describes a modification of an approach used by Guptil (1975) that employs KDE when assessing the availability of primary care physicians in Washington, DC. The work presented in this paper seeks to build further still and includes multiple types of accessibility to assess population coverage of services.

2. Study Area

Chamarajanagara is the Southern district in the state of Karnataka, India. The study area lying between 76° 24´ and 77° 43´ East longitudes and 11° 32´ and 12° 16´ North latitudes. It has Geographical area of 5101 Sq. km. Chamarajanagara district is consisting of 4 taluks: Chamarajanagara, Gundlupet, Kollegala and Yelanduru with 16 hoblis. As per 2011 census, the population of the district is 10, 20,962. It was constituting 845669 rural and 175293 urban population in 2011. The district is ranked 17th in area and 26th in population of the state. It contains 1.82 percent of the total population of the state, and it was 1.96 percent in 2001.

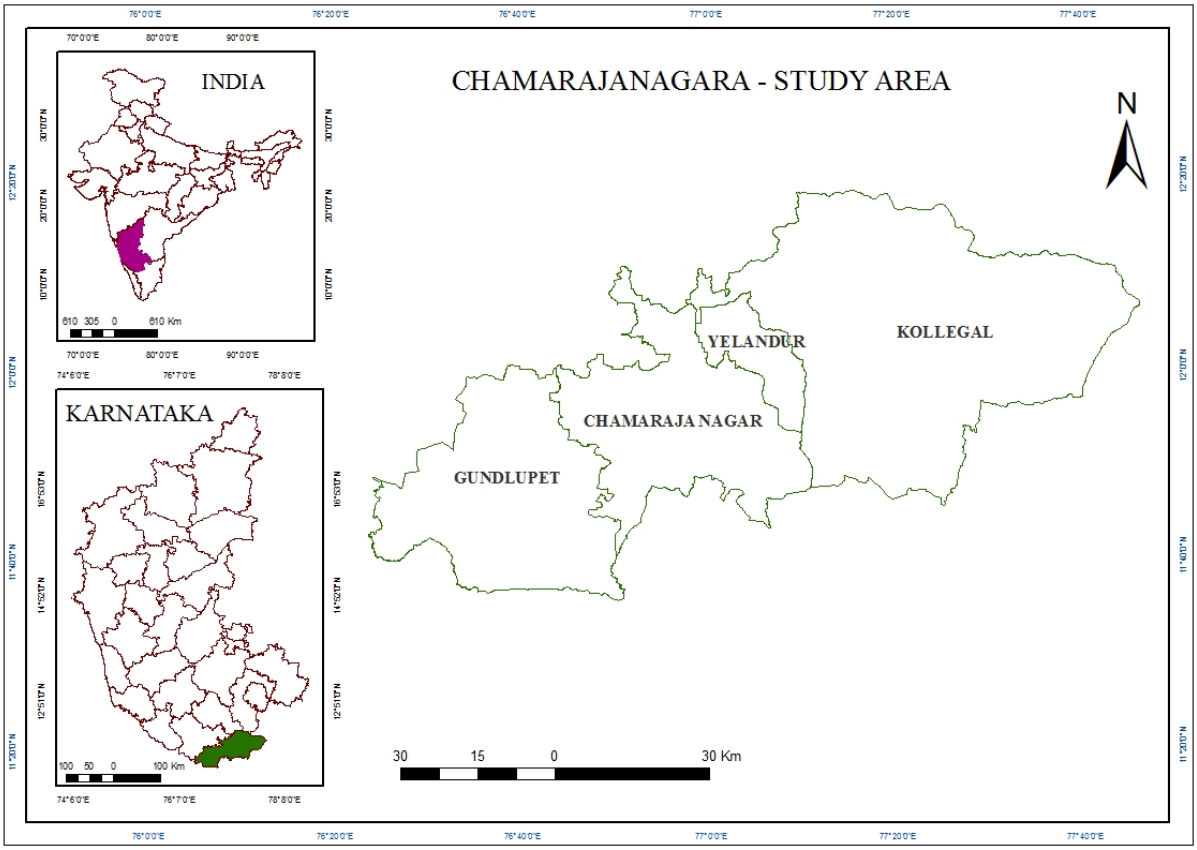

Fig. 1

3. Methodology

This paper analyses to assess the Primary Healthcare service availability in Chamarajanagara district. The study is based on secondary data collected from District Census Hand Book (DCHB) 2010-11, District Health Office and Health Facility Survey to present the results of an exploration of the use of a technique known as Kernel density estimation (KDE) for assessing population coverage of health services. Initial attempts to map accessibility relied on the use of simple Euclidean buffers to define service areas with inadequate health services. However, while the results were useful, there were limitations and shortcomings that prompted the investigation of alternative approaches. After investigating several options, KDE was employed to assess the availability of health services in Chamarajanagara District. KDE techniques effectively showed the distribution of Health Centres and Health Workforce in relation to the distribution of the population and helped to identify imbalances between availability of services and population.

4. Discussion and Results

4.1 Buffer Analysis

This paper first attempts to assess accessibility through the use of buffers around health centers, to identify villages within a given number of kilometers from center. It is a regular method to establish a health facility area of influence where a simple Euclidean buffer is drawn around each Primary Health Center. The number of villages located within the buffer can easily be determined. A village within the buffer was considered to have access to a facility, while those outside the buffer were assumed not to have access. The areas where there is an abundance of overlapping buffers, represents areas of over service, while areas without any buffer or those with a dearth of buffers is indicating the shortage of service. Figure 2 provides an illustration.

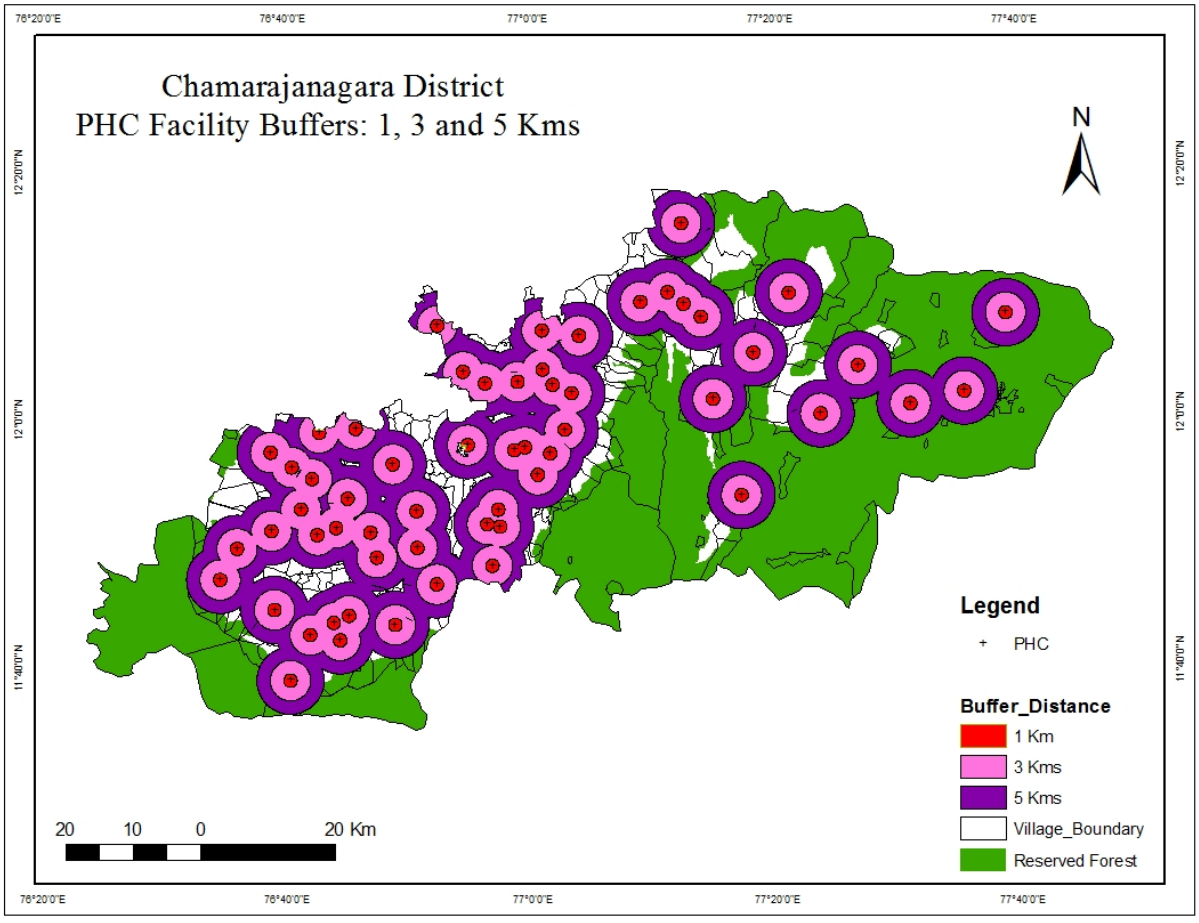

Fig. 2

This approach has its own strength and weakness. Conceptually it is easy to understand. A facility has a service area (here we've produced buffers of 1, 3 and 5km to define different service areas), and if a village is in the buffer, it is served. If a village is outside, it is not. Strength of this technique is the fact, it is a very simple procedure to

perform in GIS and can be done even outside GIS on a paper map. It can produce facility-to-population ratios when population counts village are available.

The limitation of this technique is that, it does not take into account staffing or capacity of the facility, the geographical distribution of the population of the villages or the relationship between the two. Facilities with small number of staff on duty will be treated the same as larger facilities that have many care providers. The Euclidean buffer approach is a binary approach, it does not accommodate such a multidimensional approach to the analysis. Another important limitation is that distance is not controlled for. All locations within the buffer are considered equally serviced by the facility. In reality, villages nearer to the center of a facility buffer are closer to the facility than villages at the perimeter, which could alter the level of influence of the facility have on otherwise similar villages. (J Spencer & G Angeles 2007).

To overcome from these limitations we have employed KDE model, which consider the relationship between people and facility effectively.

4.2 Kernel Density Estimation

KDE takes the value of the data assigned to a specific point and spreads it across a predefined area. The result is a more diffuse representation of a phenomenon, one that is not represented by a series of discrete points, but rather by a continuous surface. KDE was originally used to evaluate histograms and their density (Levine 2004; Silverman 1986), but it can be adapted to spatial distributions as well. It is a more sophisticated illustration of the services and population.

Kernel density estimation is an approach that has been in use for many years, but it has not often been applied to assess health accessibility, though that is changing as the value of KDE becomes apparent. For instance, Guagliardo (2004) describes a modification of an approach used by Guptil (1975) that employs KDE when assessing the availability of primary care physicians in Washington, DC. The work presented in this paper seeks to build to assess population coverage of services (Fig 3).

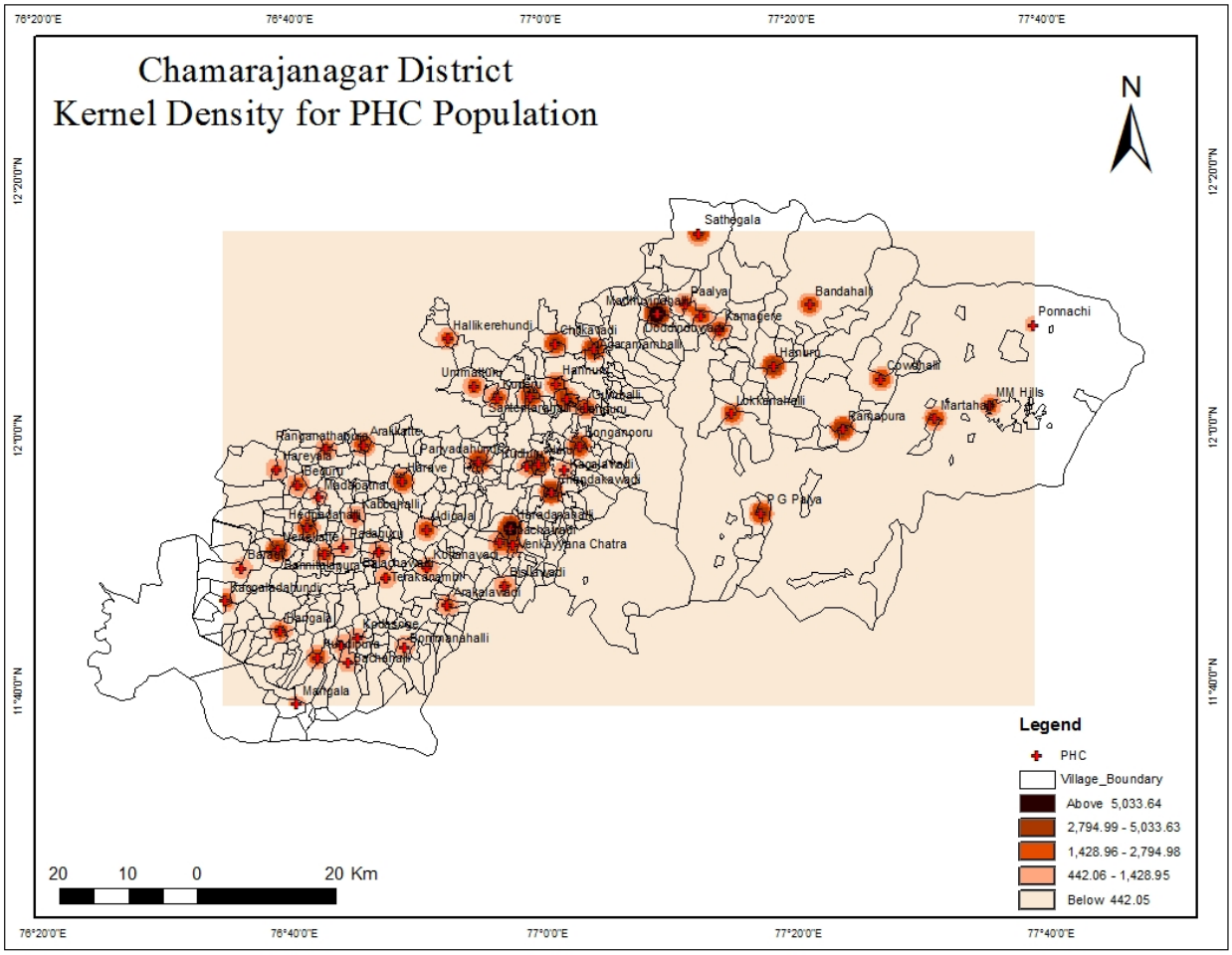

Fig. 3

It is not hard to portrait how transforming discrete data to continuous data can be applicable to health accessibility. First consider the health facility. It has a service area from which it serves people. The size and shape of this service area will be dependent on a variety of factors such as the staffing levels at the facility, the supplies and equipment the facility stocks. Population distribution across space is an important consideration. For instance, if a point on a map represents a community, that community's population has been assigned completely to that single point. In reality that community's population is dispersed throughout an area and is not concentrated within a single point. Information on the extent and boundaries of the area occupied by a community, however, might not be available to the analyst. In the face of this information limitation, one might consider dispersing this population spatially by other means in order to provide a better approximation to reality. There are multiple ways one might disperse the population spatially, KDE provides one of the simplest way to accomplish this (J Spencer & G Angeles 2007).

Fig No 3 explains, the population distribution from the health center for every 2236 square kilometers. As the distance increases from the health center, the population covered by the health centers decreases. Madhuvinahalli and Amachavadi PHC serving more people at its surrounding area. The population of our above-mentioned villages could be dispersed evenly across space or its distribution could vary depending on distance from the center of the buffer. Different probability density distributions are available to represent different options for distributing the population across the buffer. If one considers that the population is equally distributed across the kernel, the appropriate density distribution to use will be the uniform distribution. The use of this distribution indicates that a higher percentage of the village population will be assigned to areas near the center and a lower percentage to areas in the edge of the buffer. Distance from the center is thus conceptualized as having a diminishing influence on population concentration. In the case of health facilities, this approach ought to reflect the diminishing influence of a health facility as distance from it increases. For populations, it assumes that most people in a village will live near the identified center, while as travel further from the center of a village, the number of people present will decrease.

The responsibility of healthcare Centres is two-fold, (i) Providing skilled medical staff in the hospitals and (ii) Realization of Millennium Development Goals of improving healthcare facilities to reduce the different kinds of diseases. One of the pivotal factors to sustain the projected growth of the healthcare industry in India would be the availability of a trained workforce, besides cheaper technology, better infrastructure etc. worldwide shortage of doctors, nurses and paramedical staff has led to an exodus of such manpower from India. Health workforce refers to health professionals - for example, physicians, nurses, dentists, and pharmacists - who work in health service settings (Karen Matherlee 2003). Health workforce can be defined as “people engaged in the promotion, protection or improvement of the health of the population (Adams et al., 2003; Diallo et al., 2003). Fig No 4 shows the population served by Doctors, Nurse and Ancillary Nurse (DNA). DNA ratio illustrates the staffing available to people. When the number of people at the DNA thresholds are calculated, the results are the inverse of the facility ratio.

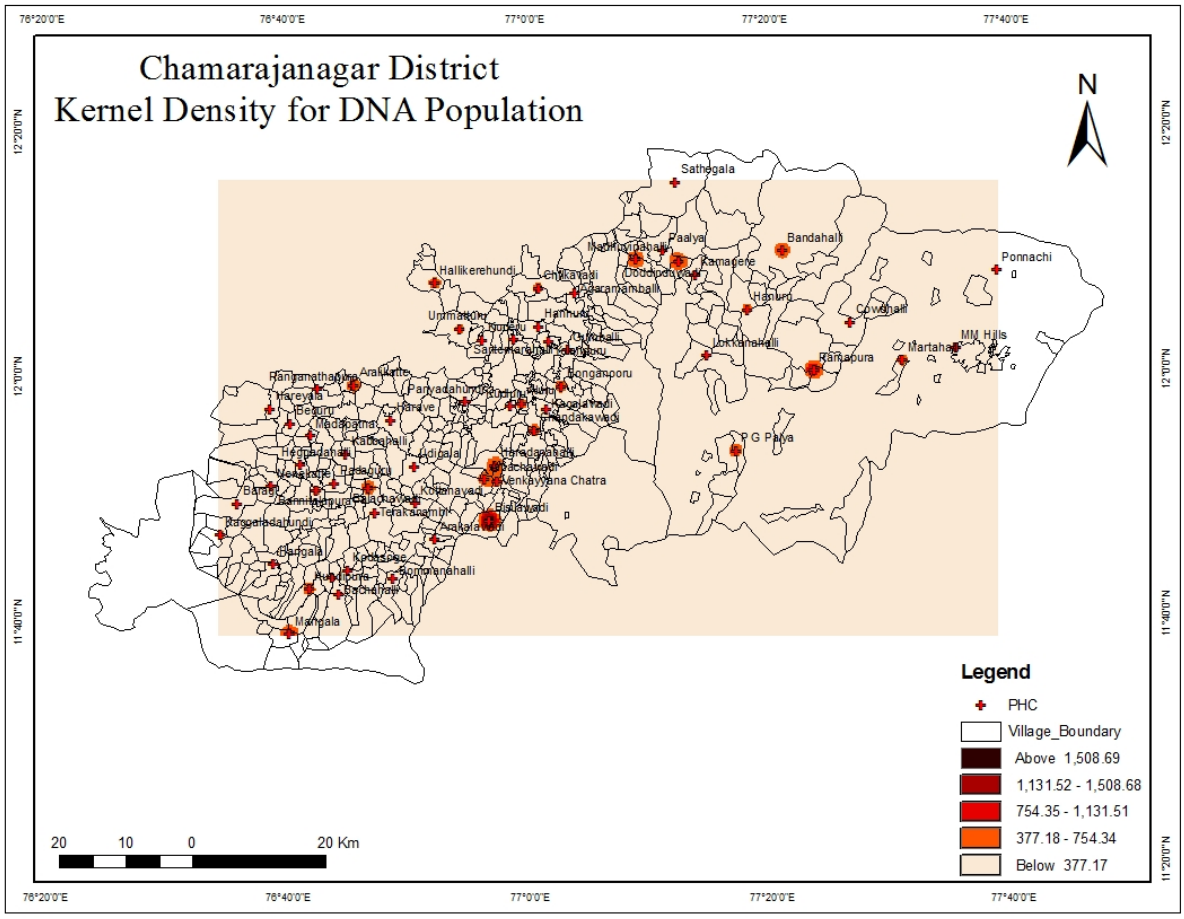

Fig. 4

Performing a KDE calculation on the data resulted in a map showing the phenomenon per square kilometer. For the village data, this was population per square kilometer; for facilities, it was either facilities per square kilometer or number of staff per square kilometer. Inside a GIS, map algebra could be performed on these maps. Map Algebra is a technique in a GIS where mathematical calculations are performed on the data in a map or multiple maps.

The values of each cell in the population per square kilometer map were divided by the values in the corresponding cell of the facilities (or staffing) maps. The results were a raster surface showing people per staff count. These provide an indication of the availability of health services based on not only the population of the villages being served, but also the staffing and capacity of the facilities serving them. This is an improvement over the more traditional buffers or straight division of aggregate numbers for population and staffing because distance

can be better controlled for and the results are not constrained by artificial administrative boundaries.

5. Conclusion

Access might be describe either the potential or actual entry of a given individual or population group into the healthcare delivery system. The method presented in this paper can be useful as a way to measure potential access. Firstly simple Euclidean buffer has been employed, it is a binary approach and it does not accommodate such a multidimensional approach to the analysis. To overcome from these limitations we have employed KDE model, which consider the relationship between people and facility effectively. Kernel density estimation provides a way to spread both the population and the facilities across space, thereby allowing the ability to calculate basic population to facility or staffing ratios. These ratios can be used to help assess potential accessibility which will be useful information for health care service planning and represent an improvement over methods that rely on discrete points.

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