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Geographical Accessibility and Spatial Coverage Modeling of the Healthcare Centers in District Pulwama (J&K State)

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ABSTRACT

The study aims to measure the accessibility to public health centers when the environment remains stable and at the time of political instability. Land use/land cover, topography, road network, physical barriers, population coverage capacity, health facilities and ancillary data were used to model accessibility to health centers using AccessMod 4.0. Two travel time scenarios used by population to attend health centers were considered: Scenario 1 - walking at the time of political instability and Scenario 2 - walking as well as automotive passenger transport during normal situation. The result based on scenario 1 and scenario 2 reveals that 51.68 percent and 24.24 percent of population of the district are un-served respectively. To cover unattended population during normal situation it was determined that the study area required eight additional health facilities to cover up the estimated lag. The topography as well as the political unrest has greatly influenced the accessibility to health centers. The involvement of GIS provides more accurate analysis for establishment of new health centers by using multiple parameters.

Keywords : Population; Served; Accessibility; Health Centres; Time

I. INTRODUCTION

This Planning is the combination of location and layout. The former refers to where do we locate the facility whereas the latter corresponds to how we relatively locate the facilities inside a chosen location? Location-allocation analysis is a geospatial method that enables to minimize impedance for a given population to access a health center and also helps understand how a change in the allocation of existing resources would affect utilization. Since the 1960s, location-allocation models have been applied to a wide variety of problems but with a general form of structuring service facilities to satisfy demands in optimal ways (1). Location-allocation model is the process that selects the optimal location for facilities from a set of candidate locations and, simultaneously assigns demands to these locations in the most efficient manner, based on the distribution of demands (2). Location-allocation models can provide municipal planners and engineers a better view to choose the optimal locations of public facilities (3). Location-allocation models is not only important in the location of new facilities but also helpful to evaluate and improve the efficiency of past location decisions. (4). Access to healthcare services has an essential role in promoting health equity and quality of life. Knowing where the places are and how much of the population is covered by the existing healthcare network is important information that can be extracted from GIS and used in effective healthcare planning (5). The representation of health care demand in estimating accessibility is an important consideration since different spatial aggregations of demand have different consequences with regard to accessibility estimates (6). Spatial accessibility of health services is influenced primarily by travel distance or travel time and the spatial distribution of health service providers and consumers (7). Equity is an important criterion in evaluating health system performance. Developing a framework for equitable and effective resource allocation for health depends upon knowledge of service providers and their location in relation to the population they should serve (8). The capacitated P-median problem (CPMP) or minimum impedance problem is an initial and simpler form of the location-allocation modeling procedures. Numerous investigations have been attempted to find the optimum locations using mathematical programming. Minimize impedance problem is to determine appropriate locations for a number of specific facilities so that the total sum of weighted impedances is minimized (9). The maximal covering location problem (MCLP) seeks to find the optimal locations for fixed number of facilities that cover as many demands as possible within the impedance cutoff (10).

Both the classical models P-median problem and MCLP are taking Euclidian distance and do not take the barriers into consideration. Though the involvement of GIS location allocation model provide spatial decision support system and can support a wide range of spatial queries that can be used to support location studies but still it measures the accessibility to the facility along the roads thereby it does not measure the accessibility through other land use.

II. BACKGROUND OF STUDY AREA

The District Pulwama was formed in 1979 by separation of tehsils Pulwama, Shopian and Tral of District Anantnag and in 2007 it was bifurcated in two districts viz. District Shopian & District Pulwama. The study area is located between 33°.37’ and 34° 06’ North latitude and between 74° 33’ and 75° 14’ East longitudes. Administratively the district is divided into three medical blocks i.e. Pulwama, Pampore, and Tral (Map 1). Since 1979 the district has observed an increase of 101.58 percent in population but the number of health centers in the district has remained unchanged. This indicates that the district has been neglected in terms of establishment of new health care facilities.

Kashmir region is constantly under unpredictive events such as curfews, strikes; climatic instabilities etc. under such circumstances accessibility become totally disrupted. The dimensions of accessibility can be modeled in different ways to overcome or to solve the hindrances in the accessibility to health centers. But there are still some barriers which cannot be modeled either by GIS or any other tool. These barriers can occur at any point of time and can be very disastrous which include physical characteristics and political disruption.

a) Physical characteristics

The accessibility in the whole of Kashmir and Pulwama in particular has a strong inclination on seasonal changes giving rise to dynamic nature of accessibility. Kashmir enjoys four different seasons such as spring, summer, autumn and winter. Among these seasons winter is the most outrageous causing great impact on the overall situation of the region. Higher accessibility is enjoyed by the people during the non-winter seasons, while low accessibility is suffered during winter due to severe drop in the temperature making people disinterested to leave home. Snowfall and road blockades also add to increase the discomfort for people moving for health facilities thereby making the situation graver.

b) Political Disruption

Another factor which influences the accessibility to the health centers in Kashmir valley includes the political instability. Notwithstanding the fact that this issue dates back to the time when sub-continent got divided into India and Pakistan and since Kashmir valley which was a Princely state that is to say it was neither a part of Pakistan nor India remained a point of conflict between the two countries (11). The circumstances surrounding state’s accession to India have become a source of profound controversy and dissension. Many Kashmiris believe that the accession was contingent on a plebiscite that was never held. The recurrent conflicts between India and Pakistan over Kashmir and between Delhi and Kashmiri political forces, and the profoundly different views of the origins of and solutions to the disputes, have created an extraordinarily volatile political environment (12). The duo have since then been trying to make their stand and claims stronger to own the valley. But this geopolitics gave birth to mass uprisings, resulting in social disorders. Most of the time, due to this conflict, traffic and other vehicular services remain off the roads. This has direct impact on accessibility to the various essential services which includes health centers at large. The frequent mass protests in the Valley from past ten years have affected all spheres of life, touching an alarming level in 2008, 2010 and 2016. In July 2016 and lasted for five months medical field was even more badly affected sphere. It also affects all walks of life due to blockade of necessary services particularly in remote areas where people do not have an easy access to the lifesaving sources such as food and medical services. Another sub factor is chauvinism or favoritism of local politicians. They establish and construct the essential services mostly in the areas where they want to make their stand strong. This vote bank politics played so far does not make fair selection of places to be chosen for establishment of service centers which includes health centers as well.

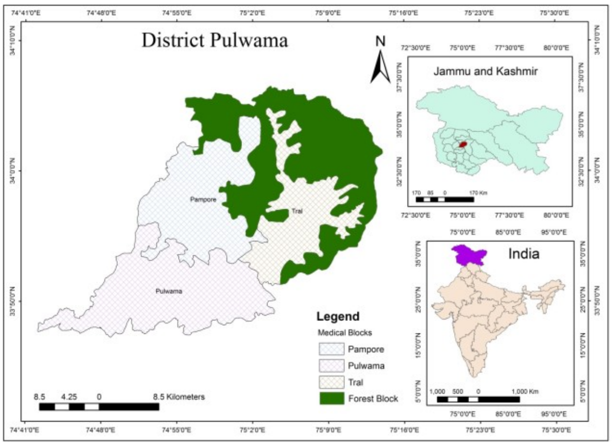
Curfew is another factor which influences the accessibility. During curfews it is harder to get essential supplies like food, medicines and milk. The only visible signs of a functioning administration were the hospitals but due to strict curfew and restrictions many people were unable to visit medical and other critical facilities.

Strikes are the events organized by the local Kashmiri political parties. The era of strikes started right from the inception of 1990, and the unresolved conflict has made Kashmir prone to negative economic shocks at regular intervals shattering each sector of its economy. These strikes continue normally for more than 4 to 5 months, concentrating mostly in the district of Pulwama which has now transformed into an epicenter of emanating unrest in the entire valley.

Kashmir also faces the problem of communication blockade regularly as and when the curfews get imposed. Under such circumstances phone and internet service are totally snapped off making people entirely incapable of providing immediate health care facilities as well as other related essential facilities.

As a result of the panic among the local inhabitants about the state of affairs on the roads, people normally stay away from going to the hospital, rather stay at home and wait for recovery which may lead to greater psychological unrest and frustration. Many times such incidences lead to death of the patients due to lack of medical care.

Since Kashmir is a region which is prone to curfews and strikes there is a necessity for a greater number of organizations which will cater to the cases arising in the form casualties. Local voluntary organizations and NGO's usually contribute medicines, food, milk, packaged water, cash, clothes, blankets and ambulance services to the injured persons, other patients and their attendants. International humanitarian and medical relief organizations such as Doctors without borders, Red Cross, Save the Children, Action Aid, UNICEF, MSF and others, usually are not giving any help during such critical moments. Emergency hospitals, ambulances and vehicles, life-saving drugs, medicines have to serve the injured people. But in Kashmir, during the times of emergencies the role of these international humanitarian and medical relief organizations has been disappointing.



Map 1

III. METHODOLOGY

In the present study, various parameters such as land use/land cover, topography, road network, physical barriers, population coverage capacity, spatial distribution of village settlements, spatial distribution of the population, location of existing health facilities, travelling scenario, direction of travel etc., were modeled in GIS domain using AccessMod 4.0 software package developed by World Health Organization (WHO) for measuring physical accessibility to healthcare network at global level. In the present study, the model was refined to suite local conditions by using a grid cell size of 1 hectare. Map 2 represents the input layers of model.

IV. GENERATION OF INPUT LAYERS

The following input layers were generated for running the geospatial model:

(a) Health facility

The list of health facilities in Jammu and Kashmir was provided by the state health service department, J&K government. GPS survey was conducted to generate the point data of health facilities of the district.

(b) Land Cover Grid

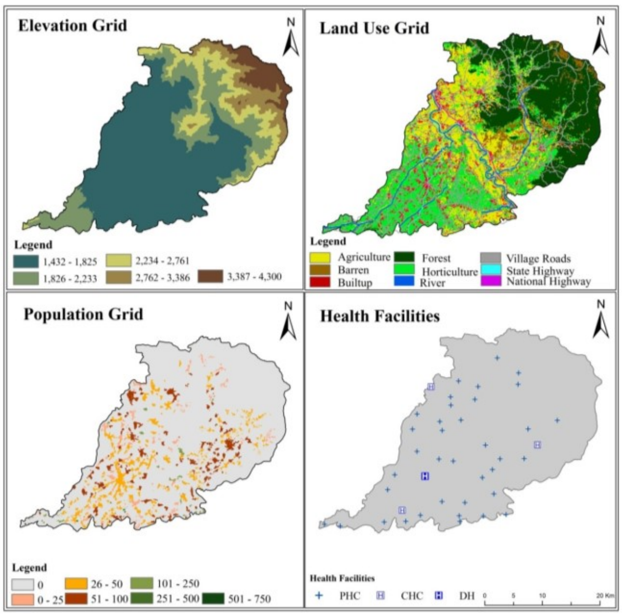
The LULC map of the area was generated from 2014 IRS LISS-III satellite images. Further a road network map of the area and physical barriers (River) were generated by digitizing features from the Google earth and for the accuracy assessment the data was cross checked with the topographical map of the area. The road network map was integrated with LULC map while as physical barrier map was masked out from it and a LULC grid of 100m x 100m grid size was generated with the classes of forest, scrubs, cultivated, river and snowfall. The road network and barriers has been integrated into the land cover grid using AccessMod 4.0 which automatically generates the travelling scenario text file for analysis.

(c) Population Grid

Census population when represented in the form of a spatial grid where each cell represents a value corresponding to its location on ground is called spatial census population grid. In the present study the extent of village settlements were digitized from high resolution Cartosat-1 imagery and integrated with geographically referenced 100m x 100m fishnet. The population value of villages as per 2011 census was tagged to the gridded vector layer. After verifying the population values of the village settlements randomly with the corresponding aggregate values of the cells in the gridded vector layer, the vector layer was rasterized using 1 hectare cell size.

(d) Digital Elevation Model

Digital elevation model (DEM) was generated using ASTER (30m) data. The DEM was converted into the grid format using same projection parameters and cell size as the LULC grid and population grid. The DEM was required for analyzing the movement of patients across the varying topography.



Map 2

(f) Travelling Scenario

While modeling physical accessibility to healthcare network, it is useful to incorporate the mode of transportation and speed of travelling of the patient through varying landscape features and topographical variations. For this, a travelling scenario text file was generated as one of the inputs for analysis in the model. The text file links in the type land cover grid with its associated speed of travel. For this, speed correction under the column, "Model", either NONE or WALKING is indicated in Table 1. In case of roads, no corrections owing to slope is applied because roads usually run along the contours.

Table 1: Travelling Scenario text File

		Automotive Passenger Transport		Walking	
Classes	Land cover type	Speed	Model	Speed	Model
1	Agriculture	3	WALKING	3	WALKING
2	Built-up	4	WALKING	4	WALKING
3	Forest	2	WALKING	2	WALKING
4	Plantation	3	WALKING	3	WALKING
5	Waste Land	4	WALKING	4	WALKING
6	Village Roads	25	NONE	5	WALKING
7	State Highway	40	NONE	5	WALKING
8	National Highway	50	NONE	5	WALKING

(e) Population Coverage Capacity (PCC)

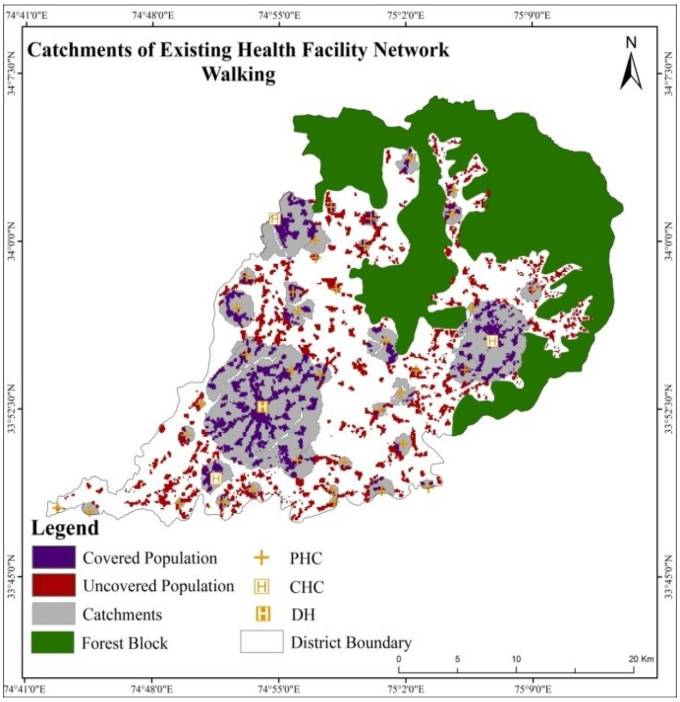
It refers to the capacity of health centers corresponding to the population it serves. The population coverage norms issued by the National Health Mission (NHM) recommends that a sub center should cover a population of 3,000, PHC 20,000 and CHC 80,000 in hilly/tribal areas. Further, the following assumptions were made to facilitate modeling exercise: the minimum population coverage capacity has been calculated in Table 2 by considering that a facility would still be cost effective if 70 percent of PCC was reached.

Table 2: Population Coverage Capacity

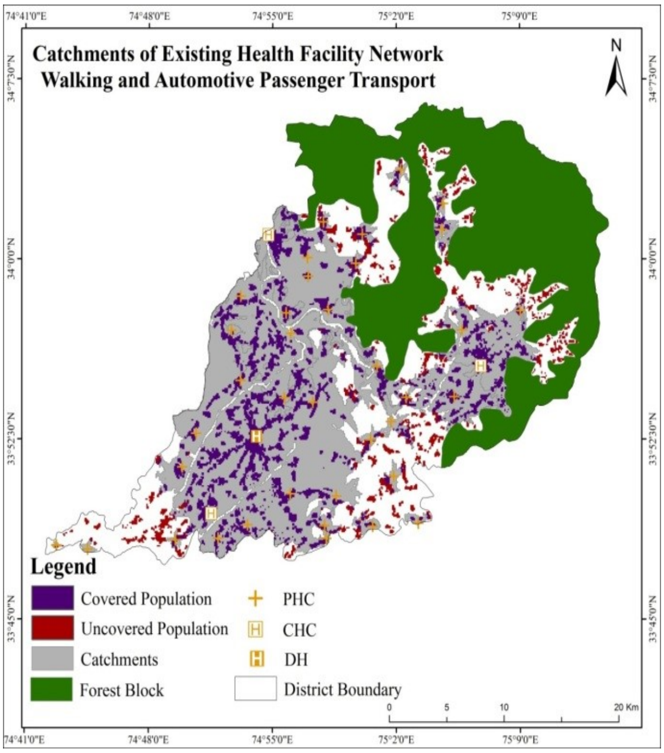
S. No	Health facility Type	Min. Population	Max. Population	PCC
1	PHC	0	56000	20000
2	CHC	56001	120900	80000
3	DH	120901	582550	172715

V. MODELING SPATIAL ACCESSIBILITY

The spatial modeling has been carried out to delineate the catchment areas of the existing health facility network. Input data for such analysis include existing health facility, population grid, land cover grid and travelling scenario table generated by model 1, digital elevation model and health facility population coverage capacity. The model calculates the population around each of the health facility type and measures its extent on the basis of travel time and population coverage capacity set in the health facility attribute table. The model processes all health facilities one by one during in which the model controls each health facility not exceeding the population coverage capacity of health facility with the predefined time and finally delineates the corresponding catchments. The catchment area of each facility determines the maximum carrying capacity of each facility. When the model completes its iterations, the results are displayed in the form of polygons representing catchment area for the existing health facility network and new population grid that depicts the population that is not yet covered by the existing health facilities.



Map 3



Map 4

Table 3: Population Coverage Scenario

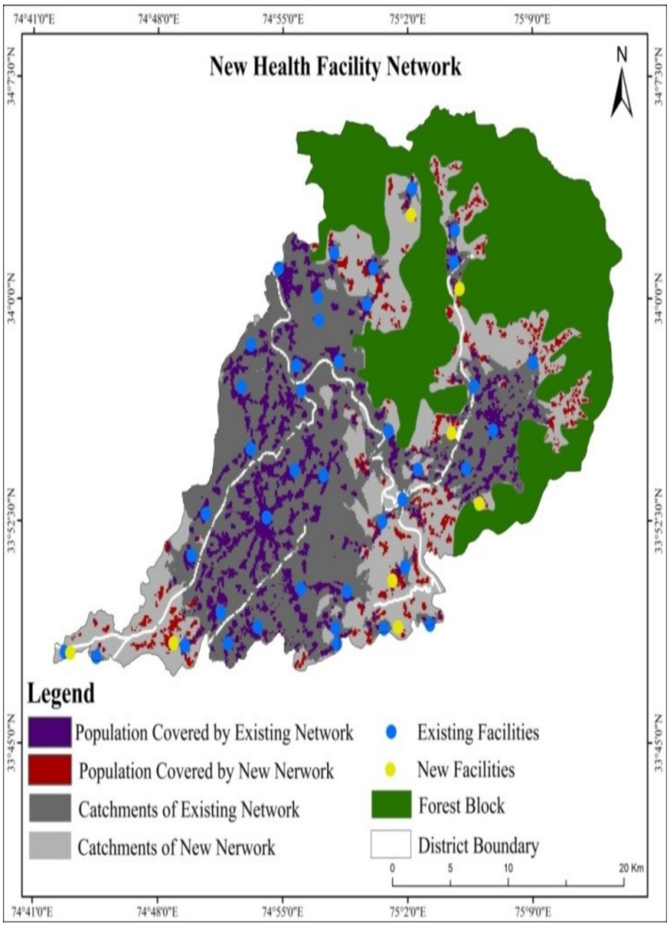
Medical Blocks	Percentage of Covered Population	Percentage of Uncovered Population
Scenario 1 - walking		
Pulwama	20.07	21.95
Pampore	17.58	14.73
Tral	11.01	15.01
Total	48.32	51.68
Scenario 2 - walking and Automotive Passenger transport		
Pulwama	30.61	10.61
Pampore	28.4	4.12
Tral	16.75	9.51
Total	75.76	24.24

Table 3 presents the population coverage scenario which reveals that the accessibility to the nearest health facility based on walking scenario reveals that 51.68 percent of population of the district is still un-served (Map 3). Among blocks large proportion of unserved population (21.95 percent) is from Pulwama followed by Tral and Pampore with 15.01 and 14.73 percent respectively. The unserved population or new population grid generated by model 3 in walking and automotive passenger transport scenario reveals that 24.24 percent of population of the district is still un-served (Map 4).

Among blocks large proportion of unserved population (10.61 percent) is from Pulwama followed by Tral and Pampore with 9.51 and 4.12 percent respectively.

VI. SCALING-UP ANALYSIS

This analysis was proceeded to meet the needs of the unattended population of the district generated by the software in model 3 in the form of new population grid. Like as model 3, the output of this model include new health facility, catchment areas of these health facilities, unserved population distribution in the form of new population in grid format and population coverage distribution as coverage. The schematics instructed in the model was repeated till it covered all unattended population and thereby the new population grid did not contain any population value. While doing so to cover all unattended population within the travel time of 60 minutes the study area required additional eight health facilities as shown in Map 5. Out of that four facilities are to be established in Pulwama, three facilities in Tral and one in Pampore.



Map 5

VII. CONCLUSION

It is significant to consider physical barriers and capacity of health care facility while demarcating the service area, and also to avoid the negative effects of politically motivated allocations on accessibility to essential service centers in any particular region; political favoritism needs to be taken care off. In particular during non-ideal situations, the people have to travel by walk to access the facilities, for that purpose mobile healthcare facility need to be established in the areas during such situations. It would not be practically feasible for people to access health service centers which are beyond walking travel time of 60 minutes. All such catchment areas fall in the list of unserved areas. The performed analysis also revealed that more than 50 percent of land area is unserved. However, when walking and the use of automotive means of transport are conjointly taken into consideration, there occurs a significant fall in the proportion of unserved area to less than 25 percent. The planning of setting up health centers in such unserved areas is highly required. AccessMod provides more accurate analysis by taking multiple parameters into consideration. Most of the models take geographic accessibility into consideration in terms of time. There are many determinants which influence the travel time while measuring the physical accessibility of existing health facilities. Travel time is not the sole factor to determine all aspects linked with health facility but the landscape features, spatial distribution of population, terrain, road network, and health facility capacity should also be taken into consideration. The scaling-up model available in AccessMod may be useful in many ways of healthcare planning, health management, governance of health facilities.

VIII. ACKNOWLEDGEMENT

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