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Introduction

Decision makers across groups, organizations and societies are frequently involved with the process of judicious allocation and apportioning of resources. The primary objective of this activity is to ensure uniform and holistic growth for all the constituencies. The root for which is the identification of development and growth patterns across the population of interest. The recognition and assessment of these growth patterns is based on socio-economic indicators associated with a particular constituency. Since the socio-economic indicators themselves are a function of a particular constituency's access to resources, the measurement of access becomes a vital feature of the whole exercise. The present paper reviews some of the most widely used measures of access and proposes a methodology that takes into consideration the other relevant but unexplored dimension(s) of accessibility. The study also presents a proof of concept using the data related to health-care with a specific perspective for policy decisions.

Relevance

Existing research indicates that the concept of accessibility has found application in studies related to deprivation (McIntyre, Muirhead & Gilson, 2002; Higgs & White, 2000), transport networks (Taylor, Shekhar & D'Este, 2006), public policy (Pirie, 1981; White, 1979), social inclusion & justice (Farrington & Farrington, 2005; Higgs & White, 2000), unemployment (Parks, 2004) and access & utilization of resources (Field, Cart & Briggs, 2001). In a review of geographical studies Hay (1995) argues that "accessibility" has got tremendous implications on the concepts related to societal equity, fairness and justice. Consequently, the treatment of "accessibility" across different spheres of human development indicates its pertinence for welfare and developmental decision making. This assumes greater significance in scenarios characterized by the paucity and/or unequal distribution of resources.

Accessibility: Definition & Determinants

Farrington & Farrington (2005) define accessibility as "The ability of people to reach and engage in opportunities and activities". While Pirie (1981) observes accessibility as being similar to reachability and convenience, Gulliford, Figueroa-Munoz, Morgan, Hughes, Gibson, Beech & Hudson (2002) consider the accessibility from two different perspectives

viz. “having access” that refers to availability of services and “gaining access” that refers to individual’s ability to utilize the available services.

The literature highlights various other approaches that have been pursued to conceptualize and define access. In one of the early works focused on access to healthcare, Aday & Anderson (1974) propose a framework that identifies the financial, informational and behavioral aspects of accessibility. The authors distinguish between socio-economic and spatial perspectives of accessibility and relate different aspects of accessibility to system level and individual level factors. Penchansky & Thomas (1981) also differentiate between individuals and the system and suggest five different conceptual dimensions of access viz. availability, accessibility, accommodation, affordability and acceptability.

Amongst other early works Moseley (1979) has emphasized that both spatial as well as non-spatial dimensions should be considered to determine accessibility. More recently, Farrington & Farrington (2005) in their conceptual paper reflect on the non-spatial dimensions (means of access) as integral part of accessibility. The authors consider both travel and communication as means of access thereby highlighting the relevance of information to accessibility. This dimension of information is different from that considered by Aday & Anderson (1974), who have accentuated the extent of information dissemination at the interpersonal level. Martin & Reggiani (2007) despite operationalizing access using spatial measures have also emphasized the relevance of non-spatial (communication) measures of accessibility.

Accessibility: Measurement & Operationalization

While the aforementioned scholars have highlighted different aspects of accessibility, the recent years have witnessed a significant amount of literature where the accessibility has been operationalized using the spatial component. Such literature has predominantly used GIS based measures of accessibility (see Higgs, 2004 for a detailed review). While recognizing the importance of spatial component, this paper proposes a related but more holistic dimension of “mobility”. “Mobility” as understood and employed in this text is related to movement, where distance is an underlying constituent. The relevance of mobility is highlighted in several studies that are oriented towards deprivation/access and is also underscored in studies that have taken spatial dimension under consideration.

Following articles that have found mention in previous section and writings in policy and economics, the present text argues that the accessibility goes beyond the spatial dimension to

include socio-economic and other non-spatial dimensions. Consequently the present paper proposes two other dimensions of accessibility viz. information (Aday & Anderson, 1974; Martin & Reggiani, 2007; Preston & Raje, 2007) and development (Hay, 1995; Sen, 2001).

Further, pursuing the works of Mosely (1979), Penchansky & Thomas (1981) and Hay (1995), the study distinguishes between the available and the utilized access. This is also in accordance with Higgs & White (2000) who suggest two constituents of deprivation viz. availability of provision and access to provision. Unlike Mosely (1979) who has emphasized on the provision/availability (termed as "opportunities") than utilization (termed as "behavior"), the present study contends that both provision as well as capacity for utilization are integral part of access. It is also claimed that the "provision" is a system/provider level construct while the "capacity for utilization" or the "behavior" is a user/individual level construct (Higgs & Field, 2000) and as established by Hay (1995) and Farrington & Farrington (2005) the absence of any or both of these may result in insignificant or zero access to the constituents.

The three dimensions (mobility, information and development) suggested above contribute at both the systemic and the individual level and a minimum basic quantity of all these dimensions at both the levels is deemed necessary for meaningful access. The final model proposed in this paper can take the form of a 2 * 3 matrix consisting of 2 levels and the three dimensions (see figure 1).

Figure 1- Conceptual model for accessibility Index

	MOBILITY	**INFORMATION**	**DEVELOPMENT**
YSTEM INFRASTRUCTURE	e.g. Road, Rail	e.g. Post, Telegraph	e.g. Education, Healthcare
INDIVIDUAL	e.g. Vehicles	e.g. Telephones, TV	e.g. Literacy

Studies which have considered the spatial perspective of accessibility argue that the distance is an extremely important variable affecting the access to resources. The present article also suggests a method to incorporate the measures of distance (as the spatial component) along-with the accessibility index. This will help obtain a more comprehensive measure of accessibility to facilitate better informed policy decisions.

Data

This article principally uses census-based measures to study accessibility. One of the primary reasons for using these measures is the policy perspective which mandates aggregated data representing sizable constituencies (Shucksmith, Roberts, Scott, Chapman & Conway, 1996). Contrary to arguments by Higgs & White (2000), the present essay endorses the view of Walford (1986) and stresses that in the context of developing economies aggregated data rather than individual data would help in making more efficient, informed and assessable policy decisions.

Method

The following steps outline the procedure followed for developing a composite index of accessibility.

Step 1. Data and Aggregation

The present study uses census based measures to develop the accessibility index. The census data for each village is available from the government of India in digital format. Accordingly, a primary requirement was to combine all the village level census data (collected by the Government of India). Given the volume of data, the aggregation task for more than .6 million villages on more than 100 different measures was executed using Statistical Analysis Software (SAS 9.1).

Further, as stated earlier, the authors decided to work on district level 'rural' data because nationwide policy or resource allocation decisions are unlikely to be based on data available at lower level of aggregation (i.e. village or individual level). However, given the judicious identification of variables and data availability, the methodology demonstrated can also be used for decision making at lower levels (block, village, household & individual) of aggregation.

Step 2. Choice of Variables/Measures

Systemic/Infrastructure

Different measures (around 80 in total) were recognized by the researchers as representing aspects of the three dimensions of mobility, information and development (see appendix 1 for details). Infrastructure measures representing mobility and development were taken primarily

from literature while the infrastructure measures representing information were selected in consultation with experts.

Taking cue from literature (Mor, 2005; Sen, 2000) education, healthcare and finance were identified as primary measures of development infrastructure. Further, availability of power and drinking water were also taken as key measures to assess development infrastructure.

The data on these variables is available for each village. To ensure meaningful interpretation and consistency with the data on the individual level, this data was converted into household level data.

Individual

Following the earlier premise of using census data, the measures that indicate the resourcefulness of individuals (and not the system) were selected as individual level measures corresponding to each dimension (see appendix 2). The selection of measures at the individual level was prompted by earlier studies (e.g. Filmer & Pritchett, 2001; Mckenzie 2004) that have focused on the development of asset index using individual level measures from the census data.

Similar to systemic variables, a total of 11 indicators (3 each for mobility and information and 5 for development, see appendix 2 for details) were identified as representing the components of the three dimensions of mobility information and development. Many of these variables represent the assets owned by a household and are therefore shared by each member of the household. Consequently, to ensure relevance and meaningful elucidation, this data was considered on a household basis rather than for each individual.

Since the objective was to conduct the study at the district level, both systemic and individual level data were aggregated at that level.

Step3. Combining measures (Deciding Weights)

The present paper uses the principal component analysis (PCA) to calculate weights for accessibility index (Filmer & Pritchett, 2001; Vyas & Kumaranayake, 2006). The authors have used both the single stage PCA and multi-stage PCA (Sharma, 1995) to achieve the objective. In this procedure, the eigenvectors corresponding to the first principal component are taken as weights (Mckenzie 2004; Vyas & Kumaranayake, 2006). This is based on the rationale that the first principal component accounts for the maximum variance. While other

principal components can also be considered the results have been found (Filmer & Pritchett, 2001) to be robust to the inclusion of other higher order principal components.

Single Stage PCA: This procedure involves applying PCA to calculate weights for all the measures/variables. Filmer & Pritchett (2001) & Mckenzie (2004) have followed a similar procedure for developing the asset index. For the present paper, this includes all the variables identified under information infrastructure, mobility infrastructure and development infrastructure.

Multi Stage PCA: In the first step of the multi-stage procedure, the PCA is used to develop individual indices for each of the constructs identified. The result is a set of three separate indices each corresponding to one of the infrastructure constructs (viz. Information Infra structure Index, Mobility Infrastructure Index and Development Infrastructure Index). In the second step the PCA is used on the three indices to obtain relative weights, which are subsequently used to develop the accessibility index for each unit of analysis.

Analysis and Result

In the following section we discuss the results of the principal component analysis of the three dimensions of accessibility and the validation of the indices. The patient inflow data at the Sadguru Netra Chikitsalaya (SNC), Chitrakoot and the employment data obtained from National Rural Employment Guarantee Scheme (NREGS)[1] were used for the validation of the indices.

Principal component analysis.

As discussed earlier, we have used PCA for weight calculation for the variables considered for the accessibility indices. Table 1 presents the summary of the results of the PCA. The variance explained by the first component ranges from 0.3839 to 0.9629. The five most important variables for each of the indices have also been reported. Among the variables which have the highest contribution to the single stage accessibility index, the most important are literate, hand pump and drinking water availability, commercial banks and approach road. Though the development related variables appear in the top five but the information related variables are also very important (see appendix 3 for Eigen vectors for all the indices).

[1] The National Rural Employment Guarantee Scheme (NREGS) is an initiative by the Government of India to provide employment to the households in rural areas. Under this scheme the Government provides at least 100 days of employment in every financial year to every adult in a household. The nature of employment provided is voluntary unskilled manual work.

Table 1 -Summary results of the Principal Component Analysis for index construction

Name of the index	**Single Stage**		**Mobility**		**Information**		**Human development**		**Multi- stage**	
	Variable	**Eigen vector**	**Variable**	**Eigen vector**	**Variable**	**Eigen vector**	**Variable**	**Eigen vector**	**Variable**	**Eigen vector**
1	Literate households	0.1536	Approach mud road	0.3380	Telephone	0.3865	Literate households	0.1879	Development	0.5803
2	Hand pump households	0.1526	Approach pucca road	0.3377	Paper magazine	0.3734	Hand pump households	0.1871	Mobility	0.5798
3	Household drinking water	0.1524	Approach foot path	0.3342	Radio	0.3696	Drinking water household	0.1868	Information	0.5719
4	Commercial banks	0.1522	Bicycle	0.3341	Television	0.3531	Commercial banks	0.1845		
5	Approach road	0.1502	Car, jeep	0.3213	Telegraph office	0.3462	Power supply household	0.1838		
Eigen value	38.64729		7.600999		5.825112		25.7183		2.888737	
Proportion	0.4294		0.6334		0.6472		0.3839		0.9629	

Other important variables are approach road, telephone and literate households for the mobility, information and the development index respectively.

Internal coherence of the accessibility index

We calculated the index for each of the three dimensions of the accessibility and also at the multi stage. Table 2 shows that the correlation between the independent indices and the single stage and multi stage indices are significant.

Table 2 – Summary correlations results of the indices

Correlations

		Development	Mobility	Information	Singlestage	Multistage
Development	Pearson Correlation	1	.971**	.932**	.996**	.986**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	64	64	64	64	64
Mobility	Pearson Correlation	.971**	1	.930**	.983**	.985**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	64	64	64	64	64
Information	Pearson Correlation	.932**	.930**	1	.954**	.972**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	64	64	64	64	64
Singlestage	Pearson Correlation	.996**	.983**	.954**	1	.996**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	64	64	64	64	64
Multistage	Pearson Correlation	.986**	.985**	.972**	.996**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	64	64	64	64	64

**. Correlation is significant at the 0.01 level (2-tailed).

High correlation of the individual dimensions of the accessibility with the single stage accessibility index would validate the accessibility index. High correlation between single stage PCA index and multi-stage PCA index point that they are in agreement with each other.

Validation of the Accessibility Index using SNC patient inflow data

The patient records were examined to get the residence details of the patients who visited the hospital from 1 April 2007 to 31 March 2008 for treatment. The district reported was taken as the district of residence for the patient. This helped us in obtaining the patient inflow form each district.

To perform the validation, a regression analysis was conducted with accessibility index and distance as independent variables and the number of patients from respective districts as dependent variable. The outcome of the regression indicates that the model to explain the patient inflow is significant (F-statistic and p-value) and explains about 40 % variation in the inflow. Further, both the distance and the accessibility index (unadjusted for distance) as the independent variables have got significant influence on the patient inflow. The negative influence of distance is according to expectations and is well documented in literature. The observed negative influence of the accessibility on the inflow may appear counter intuitive at the first glimpse because greater accessibility may imply greater capability to move and thereby utilize geographically dispersed resources. It should, however be noted that a greater value of accessibility (index) for a particular constituency along with higher mobility also entails greater access to information and increased development. Taken together these three dimensions would indicate a constituency's greater and self-sustained access to resources as well as its ability to utilize those resources. The upshot is a reduced dependence on external faculties that further causes deterrence to outward movement. A similar phenomenon is also evident with affluent regions and metros which are net recipients of migratory population both on a transitory and permanent basis.

Table 3- Summary of regression analysis*

Model	R	R Square	Adjusted R Square	F	Sig.	Independent variables	Standardized Coefficients	t	Sig.
1	0.618	0.382	0.362	18.572	0.000	Distance	-0.596	-5.835	0.000
						Development	-0.251	-2.455	0.017
2	0.627	0.394	0.374	19.483	0.000	Distance	-0.598	-5.907	0.000
						Mobility	-0.273	-2.695	0.009
3	0.622	0.387	0.366	18.926	0.000	Distance	-0.568	-5.619	0.000
						Information	-0.258	-2.551	0.013
4	0.624	0.390	0.370	19.173	0.000	Distance	-0.588	-5.813	0.000
						Multistage	-0.265	-2.616	0.011
5	0.622	0.387	0.366	18.929	0.000	Distance	-0.594	-5.839	0.000
						Single stage	-0.259	-2.551	0.013

***Number of patients from respective districts as dependent variable**

Validation of the Accessibility Index using NREGS employment data

Further validation of the index was done by comparing the accessibility index of each district (identified earlier) with cumulative number of Households issued job cards (till the reporting month of the year 2009) under NREGS. The job card contains the information of the adult members of the household who can apply for employment. The underlying rationale behind this validation is that if the district is more accessible then both the systemic and individual resources would be more. Consequently the government is able to create more opportunities and the individuals are in a better position to avail these opportunities.

Table 4: Summary of correlations

Correlations

		Cumulative Number of households issued job cards	Development Index	Mobility Index	Information Index	Accesibility Index (Two Stage PCA)	Accessibility Index (Single Stage PCA)
Cumulative Number of households issued job cards	Pearson Correlation	1	.452**	.434**	.263*	.391**	.423**
	Sig. (2-tailed)		.000	.000	.036	.001	.000
	N	64	64	64	64	64	64
Development Index	Pearson Correlation	.452**	1	.971**	.932**	.986**	.996**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	64	64	64	64	64	64
Mobility Index	Pearson Correlation	.434**	.971**	1	.930**	.985**	.983**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	64	64	64	64	64	64
Information Index	Pearson Correlation	.263*	.932**	.930**	1	.972**	.954**
	Sig. (2-tailed)	.036	.000	.000		.000	.000
	N	64	64	64	64	64	64
Accesibility Index (Two Stage PCA)	Pearson Correlation	.391**	.986**	.985**	.972**	1	.996**
	Sig. (2-tailed)	.001	.000	.000	.000		.000
	N	64	64	64	64	64	64
Accessibility Index (Single Stage PCA)	Pearson Correlation	.423**	.996**	.983**	.954**	.996**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	64	64	64	64	64	64

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The output shows a positively significant correlation between the indices and the cumulative number of households issued job cards.

Table 5- Summary of regression analysis*

Model	R	R Square	Adjusted R^2	F	Sig.	Independent variables	Standardized Coefficients	t	Sig.
1	0.639	0.408	0.378	13.767	0.000	Development Index	1.187	2.710	0.009
						Mobility Index	0.494	1.148	0.256
						Information Index	1.303	-4.540	0.000

***Cumulative number of households issued job cards from respective districts (May 2009) as dependent variable**

The results indicate that Development Index and Information Index have statistically significant influence on employment (measured by cumulative number of households issued job cards). It can be seen that development index has a positive effect whereas Information index has a negative effect on employment generated through NREGS.

Discussion

The present paper makes a case for inclusion of the information and mobility infrastructure both at the systemic and household level for constructing any accessibility index. The idea is to understand accessibility in three dimensions of mobility, information and development. The results show that the three dimension of the accessibility index can independently explain the patient inflow at SNC. Also, the indices have high correlations amongst each other which points to the internal coherence of the single stage main accessibility index.

The effects of distance and the accessibility index in facility utilization have to be understood for its policy implication. The effects of both- higher accessibility index as well as the distance to the facility- are negative on the patient inflow at SNC. Although the reduction in patient inflow from distant districts is supported by the extant literature but the role of increased accessibility on the decreased patient inflow needs more deliberation. One of the possible explanations could be embedded in the service provided at SNC. The most dominant service uptake was for cataract and we believe that this service would be generally available in the districts across country so the patients from the districts with higher accessibility index (implying higher scores on information, mobility and development) need not travel to SNC for its treatment. Thus, perhaps we need to validate the index with a service provision which is either very complex or very specialized hence not available in most of the districts around SNC.

The effect of various accessibility indices on employment generated by NREGS in the selected districts has to be seen with respect to the kind of employment provided through the scheme. This scheme aims at providing voluntary unskilled manual work. The positive coefficient of development index can be explained by the government's emphasis on creating rural development infrastructure through NREGS. The negative coefficient associated with information index points to the fact that information infrastructure may not be playing any role in determining the access to benefits of the scheme. The government also makes an effort to

provide employment in and around rural areas so as to benefit the local population and that might be the reason that mobility index is insignificant in explaining the cumulative number of households issued job cards.

Limitations and future research

There is a limitation about the timeliness of data as we have used census data for 2001 for the index construction. The indices could be further validated with other sources of data which were recently collected. Similarly, we did not particularly choose any specific set of indicator especially in the development dimension of the accessibility index which led to a preponderance of the development related variables in the overall accessibility index calculation. Based on the results given by the accessibility index, perhaps a smaller set of indicators might be chosen for further research and refinement.

The patients' records were examined for the district/ town listed in the residence information. It may be the case that the patient was a town or city resident in the particular district but we have only considered the rural values for all the census based indicators. Thus the frequency of the patients from the rural areas of the districts may be inflated.

We have not used the detailed sub-classification of the kind of employment provided through NREGS. Other indicators associated with use and benefits of NREGS may help to validate the index further.

Further exploration on the role of the nature of service delivered at the facility or the scheme and its impact on the utilization of the service by the end users would also assist the policy makers in designing the facilities and/or schemes.

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Appendix 1

List of systemic variables (Census of India, 2001)

Variable name	Explanation
Information	
POST_OFF	Number of Post Office
TELE_OFF	Number of Telegraph Office
POST_TELE	Number of Post and Telegraph Office
PHONE	Number of Telephone connections
PAP_MAG	News paper/Magazine (Y/N)
C_V_HALL	Number of Cinema/Video-hall
Mobility	
BS_FAC	Bus services
RS_FAC	Railways services
NW_FAC	Navigable water way including River, Canal etc.
APP_PR	Approach - Paved Road
APP_MR	Approach - Mud Road
APP_FP	Approach - Foot Path
APP_NAVRIV	Approach - Navigable River
APP_NAVCAN	Approach - Navigable Canal
APP_NW	Approach - Navigable water-way other than river or canal
Development	
P_SCH	Number of Primary School
M_SCH	Number of Middle School
S_SCH	Number of Secondary School
S_S_SCH	Number of Senior Secondary School
COLLEGE	Number of Collage
IND_SCH	Number of Industrial School
TR_SCH	Number of Training School
ADLT_LT_CT	Number of Adult literacy Class/Centre
OTH_SCH	Number of Other educational facilities
ALL_HOSP	Number of Allopathic Hospital
AYU_HOSP	Number of Ayurvedic Hospital
UN_HOSP	Number of Unani Hospital
HOM_HOSP	Number of Homeopathic Hospital
ALL_DISP	Number of Allopathic Dispensary
AYU_DISP	Number of Ayurvedic Dispensary
UN_DISP	Number of Unani Dispensary
HOM_DISP	Number of Homeopathic Dispensary
MCW_CNTR	Number of Maternity and Child Welfare Centre
M_HOME	Number of Maternity Home
CWC	Number of Child Welfare Centre
H_CNTR	Number of Health Centre
PH_CNTR	Number of Primary Health Centre
PHS_CNT	Number of Primary Health Sub Centre
FWC_CNTR	Number of Family Welfare Centre
TB_CLN	Number of T.B. Clinic

N_HOME	Number of Nursing Home
RMP	Number of Registered Private Medical Practiotioners
SMP	Number of Subsidised Medical Practitioners
CHW	Number of Community Health workers
OTH_CNTR	Number of Other medical facilities
DRNK_WAT_F	Drinking Water facility (A/NA)
TAP	Tap Water (T)
WELL	Well Water (W)
TANK	Tank Water (TK)
TUBEWELL	Tubewell Water (TW)
HANDPUMP	Handpumb (HP)
RIVER	River Water(R)
CANAL	Canal (C)
LAKE	Lake (L)
SPRING	Spring (S)
OTHER	Other drinking water sources (O)
COMM_BANK	Number of Commercial Bank
COOP_BANK	Number of Co-operative Commercial Bank
CRSOC_FAC	Credit Societies (Y/N)
AC_SOC	Number of Agricultural Credit Societies
NAC_SOC	Number of Non Agricultural Credit Societies
OTHER_SOC	Number of Other Credit Societies
POWER_SUPL	Power supply (A/NA)
POWER_DOM	Electricity for Domestic use
POWER_AGR	Electricity of Agricultural use
POWER_OTH	Electricity of other purposes
POWER_ALL	Electricity for all purposes
CANAL_GOVT	Government Canal
CANAL_PVT	Private Canal
WELL_WO_EL	Well (without electricity)
WELL_W_EL	Well (with electricity)
TW_WO_EL	Tube-well (without electricity)
TW_W_EL	Tube-well (with electricity)
TANK_IRR	Tank
RIVER_IRR	River
LAKE_IRR	Lake
W_FALL	Waterfall
OTH_IRR	Others
COMM_BANK	Number of Commercial Bank
COOP_BANK	Number of Co-operative Commercial Bank
AC_SOC	Number of Agricultural Credit Societies
NAC_SOC	Number of Non Agricultural Credit Societies
OTHER_SOC	Number of Other Credit Societies

Appendix II
List of individual variables (Census of India, 2001)

Dimension	**Variable**
Information	Radio
	Television
	Telephone
Mobility	Bicycle
	Scooter Motor
	Car Jeep
Development	Electricity available
	Latrine available
	Households availing bank facility
	Literate Household
	Household with drinking Water within premises