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## Final Report

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# An Analysis of Urban Indicators Using Geographic Information Science

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We would like to thank the following for their invaluable contributions:

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**Botswana:** Branko Cavric, The University of Botswana

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**South Africa:** Randy Adrians and Phillip Romanowsky, Cape Town

Quality of life for urban dwellers within a given city widely diverges depending on the accessibility and quality of urban infrastructure available at their residential locations. This project has been focused on the visual exposure of these disparities, using GIS as a tool of exploration. Our goal has been to develop a web-based training tool that uses this analytical framework and can be used to expose spatial disparities as well as contribute to a greater understanding of these inequities. We hope, too, that this exposure leads to policy responses that incorporate this information.

This project has also been driven by a recognition that the city as a whole is not an effective unit of analysis. The inset box on page 5, which lists the uses of neighborhood-level indicators, gives an idea of the kinds of functions a more disaggregated set of indicators is able to address. The availability of disaggregated data at the intraurban level is key to assessing the current status of the quality of life for urban dwellers. This data would allow decision makers to formulate redistributive policies and programs to address some of the disparities that exist within third world cities.

We began our project by exploring the state-of-the-art with respect to urban indicators. We quickly confirmed our basic working assumption - that most urban indicators currently used are at the national or citywide level (UN Global Urban Observatory – GUO web site). There is a great need, then, not only to acquire disaggregated data on cities, but to incorporate this data in a decision-making framework that stresses the relevance of accessibility issues.

This is not an easy task. While geographic information systems (GIS) technology is a suitable tool to store, visualize, and analyze intraurban information, it is only effective for this type of analysis if the data is available to address the question of accessibility. The problem with using GIS in developing countries for this purpose, as we acknowledged from the outset, relates both to data and to local capacity, including availability of technology (hardware and software) and trained staff.

This report gives an overview of the tasks that we have been able to accomplish in a relatively short time period. Our initial project objectives were to use GIS data to assess quality of life at the intra urban level through measuring accessibility of urban infrastructure; to understand the relationship between data at the intraurban and aggregated urban levels; and to devise a web-based training tool on the necessary data, tools, and techniques for evaluating the accessibility of infrastructure. This report reveals success with 2 of these objectives in particular: organizing GIS data for 3 cities, and using some of that data in the development of a web-based training module for measuring accessibility.

The UNCHS Urban Indicators Program has developed a list of key urban indicators to assess development in urban areas. This list consists of 6 modules representing different aspects of urban living –

1. Socio-economic development
2. Infrastructure
3. Transportation
4. Environmental Management
5. Local Authorities and, Housing

Each of these modules or composite indicators is broken down into several components to measure the individual variables that contribute to the module as a whole. For example, the level of infrastructure development is measured through the following variables –

- Household connection levels: percentage of households connected to: a) water; b) sewerage; c) electricity and d) telephone.
- Access to potable water: percentage of households with access to potable water. Access is defined as having safe or potable drinking water located within 200 meters of the dwelling.
- Consumption of water: Average consumption of water in litres per day per person, for all uses.
- Median price of water: Median price paid per hundred litres of water in US dollars at the time of year when water is most expensive.

Indicators existing in the UNCHS database are global in nature, the most detail available is one value for select cities. However, disaggregation within the city has not been addressed. One of the objectives of this project has been to address the disaggregation of these indicators. This involves a movement from the conventional definition of the indicator in question, namely access to something more specific to each case study.

### UN Urban Indicators

Urban indicators currently do not exist for Cape Town and Kathmandu. The following are the list of indicators for Gaborone:

<b>UN Urban Indicators for Gaborone, Botswana</b>	<b>Values</b>
median household income per month	\$808.00
Households with access to water within 200m	100%
Child mortality (under 5 years)	10.50%
Reported crime rates	0.180 victims of homicide/'000 0.790 victims of rape/'000 0.850 victims of thefts/'000
% households below the locally-defined poverty line	54.09%
% women-headed households below the locally -defined poverty ine	22.97%
Gross school enrollment ratios	66.90% female 70.30% male
Literacy Rate	67.10 female 63.10 male
Life Expectancy at Birth	1.572
Population	3.50%
Population growth	239.00 liters per person per day
Water consumption	
Proportion of wastewater treated	0.00%
Solid Waste disposal	99.00% open dump 1.00% recycled
City Product	\$37.83 GNP/ capita
Unemployment	21.50%
Housing rights	
Urban violence	
Disaster Prevention and Mitigation	
Local Environmental Plans	
Public private partnerships	
Decentralization	
Citizens Participation	
Transparency and Accountability	
International Cooperation	

### Urban Indicators Used in UIUC Project

The project is devoted towards understanding disaggregated indicators of accessibility to infrastructure. The definition of access differs from that provided by the UN. The UN urban indicator of access refers to the percentage of population to which a particular infrastructure is available. The notion of access in this project is broadened to include physical access in terms of spatial location ~~as well as socio-economic access~~ determined by affordability or ethnic relationships. The following is the listing of data available for each city included in this project;. Those databases are used as the foundation for accessibility analysis.

Table 1: Data Available for Gaborone, Botswana

Name	Type	Description
Building Data	Vector(Polygon)	Building data like height, owner etc
Centralgaboronecontours	Vector(Line)	Altitude and terrain data
Carraigeway	Vector(Line)	Road network showing the major streets and roads
in the central part of the city		
Citycontours	Vector(Line)	Contains altitude and terrain data for the whole city
Propertydata	Vector(Polygon)	Land parcels or property boundaries in Gaborone
central		
Block 10	Vector(Polygon)	A new suburb of Gaborone
Township	Vector(Polygon)	The boundary of the Gaborone township
Proposedlanduse	Vector(Polygon)	Future area of development
Petrolstations	Vector(Point)	Location of all the petrol stations in Gaborone
Governmentenclave	Vector(Polygon)	Government Office area in central Gaborone City
Extents	Vector(Polygon)	Neighborhoods
Healthfacilities	Vector(Point)	Hospitals and clinics
Civic	Vector(Point)	
CBD	Vector(Polygon)	Central Business District
Central Gaborone	Vector(Polygon)	Extent of central Gaborone with respect to the
whole city		
Boundary	Vector(Line)	Boundary of the city
Grids	Vector(Line)	Grid reference system
Contours	Vector(Line)	Contains altitude and terrain data
Landuse	Vector(Polygon)	Landuse data for Greater Gaborone Area
Powerline	Vector(Line)	Major Powerlines
River	Vector(Line)	Main River
Sewer	Vector(Line)	Major Sewer lines
Railway	Vector(Line)	Railway lines
Telecommnetwork	Vector(Line)	Major Telecommunication lines
Roads	Vector(Line)	Major roads
Floodarea	Vector(Line)	Shows block 10
Gaboronecity	Vector(Polygon)	The extent of Gaborone and how does it relate
with the greater Gaborone area		
Greatergaborone	Vector(Polygon)	Greater Gaborone area
Railway	Vector(Line)	Major Railway showing the location of the main
railway		
Township	Vector(Line)	Built-up area showing places where there has been
urban development		

Table 2: Data Available for Kathmandu, Nepal

Name	Type	Description <i>Comments</i>
Addresses	MS Access database	Street names and house numbers <i>Can be used for geocoding (Nepal is developing a new system)</i>
Building footprint	Vector (polygon)	Footprints of buildings <i>The centroids of these polygons can serve as origin</i>
Road Center lines	Vector (line)	Single line road network for the city <i>Base data for network analysis</i>
KMC Roads	Vector (line)	Overall road network for the Kathmandu Metropolitan City
KMC Wards	Vector (polygon)	Metropolitan City Administrative Wards <i>Contain socio-economic and demographic data</i>
Landmarks	Vector (points)	Point location of landmarks <i>Can be subcategorized and used for accessibility analysis</i>
River Network	Vector (line)	River and stream network



Table 3: Data Available for Cape Town, South Africa

<b>Name</b>	<b>Type</b>	<b>Description</b>
1996 EA	Vector (Polygon)	1996 Enumeration Areas
1996 suburbs	Vector (Polygon)	Suburbs of Cape Town
Road Centerlines	Vector (line)	Single line road network for the city
Schools	Vector (points)	Location of schools
Fire Stations	Vector (points)	Location of fire stations
Bus Stops	Vector (points)	Location of bus stops
Police Stations	Vector (points)	Location of police stations
Parks	Vector (Polygon)	Location of parks in the city
Vacant Lands	Vector (Polygon)	Location of vacant land in the city
1999 T.B. areas	Vector (Polygon)	Locations in areas with endemic tuberculosis
Sewers and hydrants	Vector (points)	Location of sewer holes and hydrants
Education level	MS Excel data	Attribute data about level of education in each EA
Population	MS Excel data	Attribute data about population in each EA
Median household income	MS Excel data	Attribute data about median household income in each EA
Unemployment	MS Excel data	Attribute data about unemployment rates in each EA
<b>Ethnicity</b>	MS Excel data	Attribute data about ethnic composition of each EA

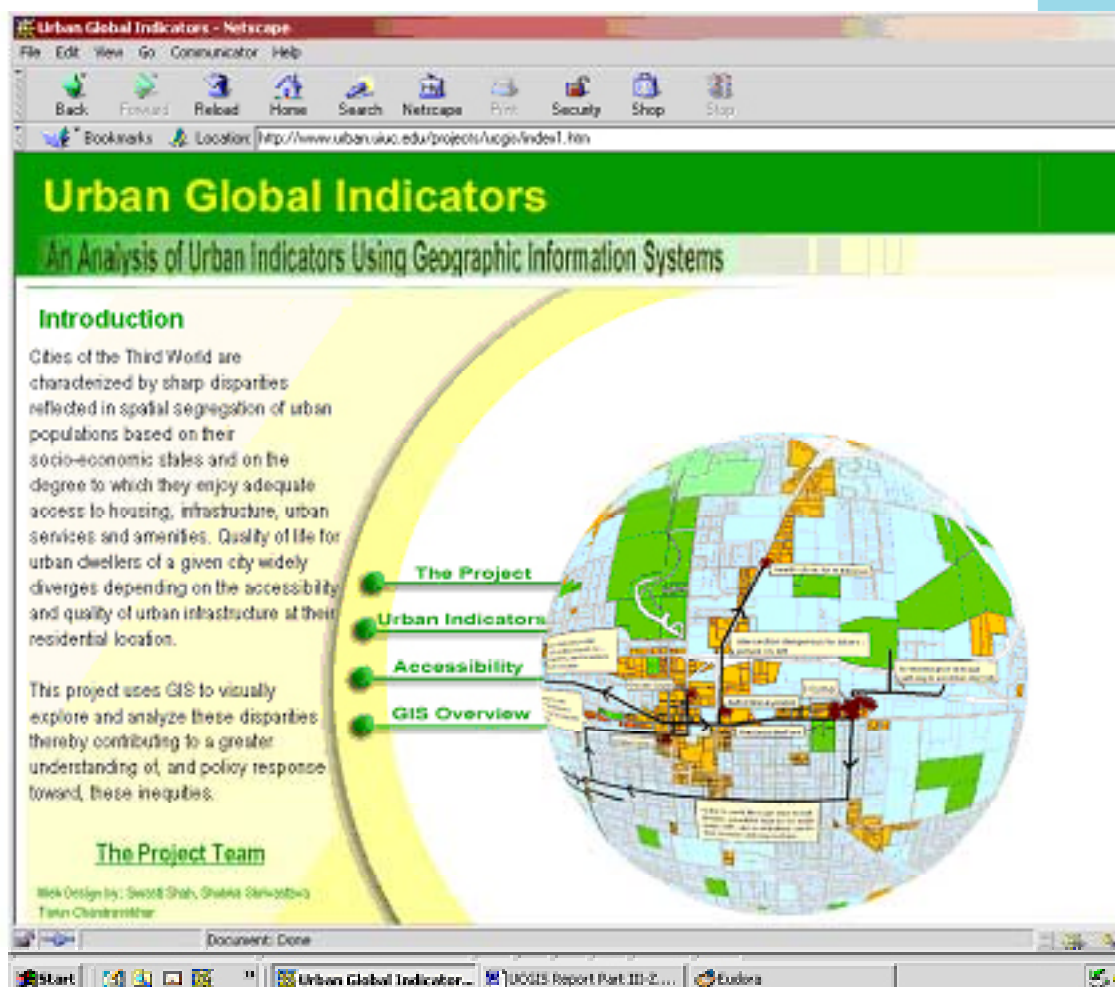
## Description of project website

The focus of the effort in developing a training module was on deriving and visualizing the distribution and access to urban infrastructure and services. The World Wide Web was the main outlet for the project products. It is located at:

<http://www.urban.uiuc.edu/projects/ucgis>.

The homepage of the website consists of an introduction to the project and participants. The opening screen (HOME) has been captured in figure 1:

Figure 1: Project Web Page



The Web outlet was structured into the following organizing units:

- PROJECT. General Information on the project background, rationale and objectives.
- INDICATORS.

- a) Definitions
- b) Types of urban indicators, their functional and geographic scope
- c) Link to UNCHS Urban Indicator Program
- d) Issues arising in the use of indicators: data quality, data relevance

- ACCESSIBILITY.

- a) Accessibility as quality of life component (factors)

- b) Accessibility measures
  - Description of five GIS-based methods for measuring access
  - GIS exercises with steps-by-step introduction to each of the five methods (based on ArcView, ArcGis, and ArcIMS)

- c) Technical requirements for conducting the exercises

- Data
- Specification of skills needed
- Specification of technology

- GIS OVERVIEW. Link to [www.gis.com](http://www.gis.com) as one of the sources for basic information on GIS.

### Development of the Training Module

The training module consists of a set of HTML based exercises and associated data that can be downloaded from the project website. The exercises were developed for ESRI's ArcView GIS. Prior familiarity of GIS, specifically Arcview is recommended. However, the exercises are designed such that, users not proficient in GIS can follow the easy step by step directions. However, prior knowledge of computing is a pre-requisite.

The inherent shortcoming of a web based training module is that it is not possible to cater to varying level of understanding or prior knowledge on GIS. Hence, the module had to be developed assuming that the user is a novice in GIS, thus enabling a variety of users to explore the possibilities of analyzing accessibility using GIS.

Another component of the training module is a live Internet Map Server (IMS) that allows the users to interact with the data and ~~view the results, before they perform~~ the analysis. This makes the user aware of the output created by each type of exercise besides providing information on the input data and its attributes. IMS helps visualize potential scenarios. Technical development of the IMS website involved certain complications. Issues pertaining to compatibility of the web server (IIS 5.0) and the version of the servlet engine (Tomcat) with the spatial server (ArcIMS).

Future development envisions migrating the module to ArcGIS and further customization of the internet map server.

institutional, legal, social, economic, political, and other factors are recognized to exert significant influence on the nature of infrastructure and service delivery and consumption. Access is defined as the quality of having interaction with, or passage to, a particular good, service, or facility. It is understood in terms of physical accessibility measured as distance, time, and mode of travel; in terms of socio-economic accessibility measured as affordability; and in terms of other cultural and institutional determinants of accessibility.

Table 4: Framework for Accessibility Analysis

<b>Factors</b>	Places / Origins	Location / Place Characteristics Type of Infrastructure / Service Attributes of Population at Origins Quality and Quantity of Infrastructure / Services Other factors characterizing the origins (cultural, institutional, legal etc.)
	Places / Destinations	Location / Place Characteristics Type of Infrastructure / Service Attributes of Population at Destinations Quality and Quantity of Infrastructure / Services Other factors characterizing the destinations (cultural, institutional, legal etc.)
	Mode of Travel	Pedestrian Bike Public Transit (Bus/Van/Rail etc.) Automobile
	Travel Route Characteristics	Quality of Route Sidewalks Design Speed Safety Other factors characterizing the routes (cultural, institutional, legal etc.)

### Training Module Examples

The training module is developed around the measures of accessibility that are compatible with standard GIS functionality of Environmental Research Systems Institute's (ESRI) software products ArcView and ArcGIS. Only a portion of the procedures can be demonstrated in ArcIMS context. The five accessibility measures include: container analysis, covering, minimum distance, travel cost, and gravity potential. Exercises are developed for each except the last method that is deemed more suitable for analysis of access to markets and goods based on competition and consumer preferences, and is therefore considered inadequate for analysis of provision of public goods in the context of developing countries. The exercises are all based on examples from Cape Town, as its dataset was the most complete (Figure 2).

Figure 2: Cape Town Metropolitan Area and Its Administrative Units

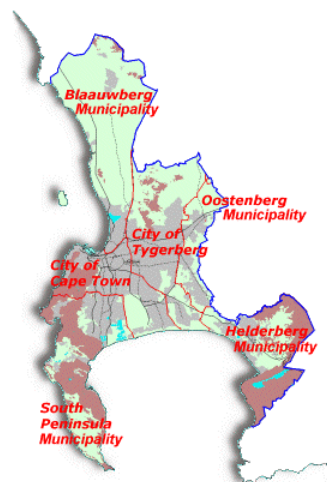


Table 5: Approaches to Measuring Access

### Different Approaches towards Measuring Access

Measurement Approach	Definition	Exercise	Data
Container	the no. of facilities contained within a given unit (e.g., census tract)	Exercise 1	Download
Covering	the no. of facilities within a given distance from a pt. of origin	Exercise 2	Download
Minimum Distance	the distance between a pt. of origin and the nearest facility	Exercise 3	Download
Travel Cost	the average distance between a pt. of origin and all facilities	Exercise 4	Download
Gravity	an index in which the sum of all facilities (weighted by size) are divided by the "frictional effect" of distance	Work in Progress!	

## Container

*Container Analysis* allows for identification of the number of facilities contained within a given spatial unit (e.g., census tract, city, country, etc.). In the conceptual example below this analysis helps count the number of schools within each of the three villages (Figure 3).

Figure 3: The Concept of Container Analysis

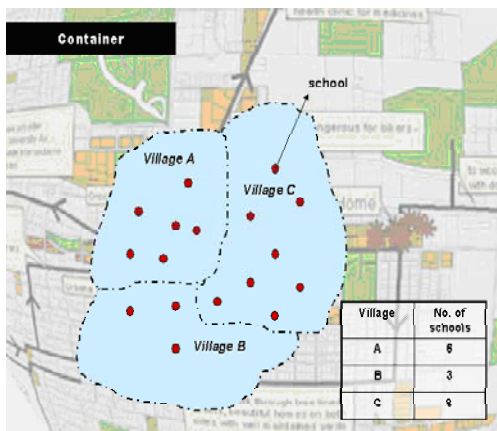


Figure 4: Distribution of Schools and Educational Attainment in Cape Town by Enumeration Area

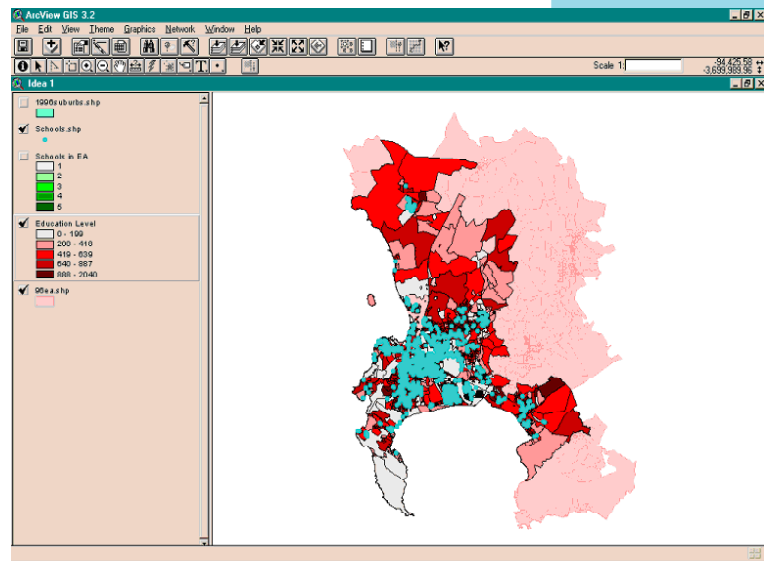
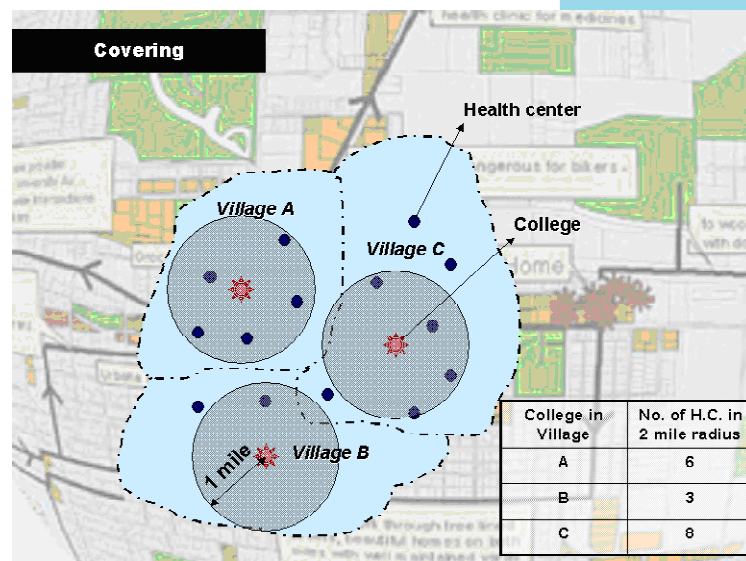


Figure 5: The Concept of Covering Analysis

A similar example is used for the GIS-based exercise developed to demonstrate this method. The exercise uses a sample of data from Cape Town to understand the distribution of schools relative to census enumeration areas (EAs), and to compare this pattern with the educational attainment data by EA (Figure 4).





*Covering* method identifies the number of facilities within a given distance from a point of origin. In the conceptual example below the educational centers within three villages are assessed with respect to their access to health facilities. The area of covering is defined by the user based on the substantive knowledge about the expected level of service. In the example below, a radius of one mile is applied to search for health facilities within that distance (Figure 5).

The GIS-based exercise applies this method in examining the adequacy of fire service. Assuming a 3-mile radius as reasonable distance to allow for emergency response, the exercise helps enumerate how many fire stations are located within the 3-mile radius of the population centers. The population centers are represented with centroids to allow for this analysis, which requires point designations of objects of interests. The following graph illustrates the outcome of this analysis. It shows the number of fire stations within and outside the buffered population centers, along with the number of people served by fire services or deprived of them (Figure 6).

### Minimum Distance

*Minimum Distance* is the distance between a point of origin and the nearest facility, based on traversing a real network. The conceptual example below shows a table and a graphic output generated from the minimum distance procedure (Figure 7). The highlighted table column displays the distance between each school and its nearest health facility. The graph illustrates that the minimum distance based on existing transportation network sometimes yields results different from what may be expected based on casual observation. Namely,

a facility that appears closer in aerial distance, may be further away in terms of network distance and/or time needed to reach the facility.

Figure 6: Number of Enumeration Area and Population Accessible to Fire Services

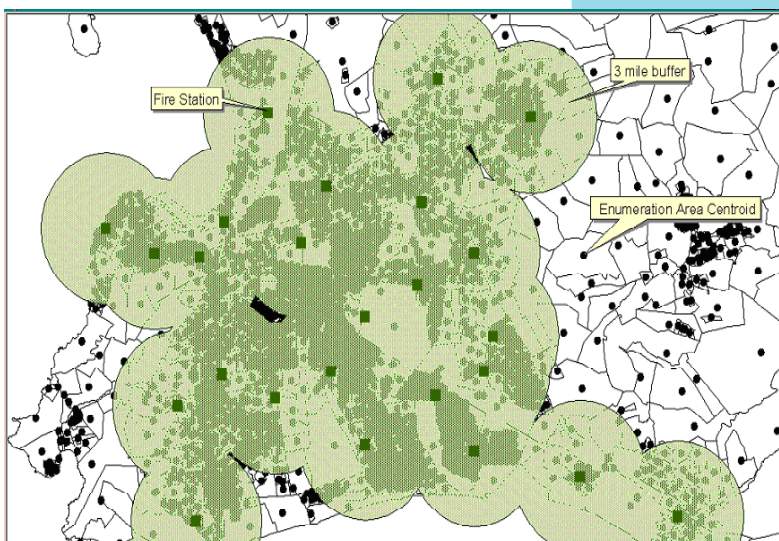
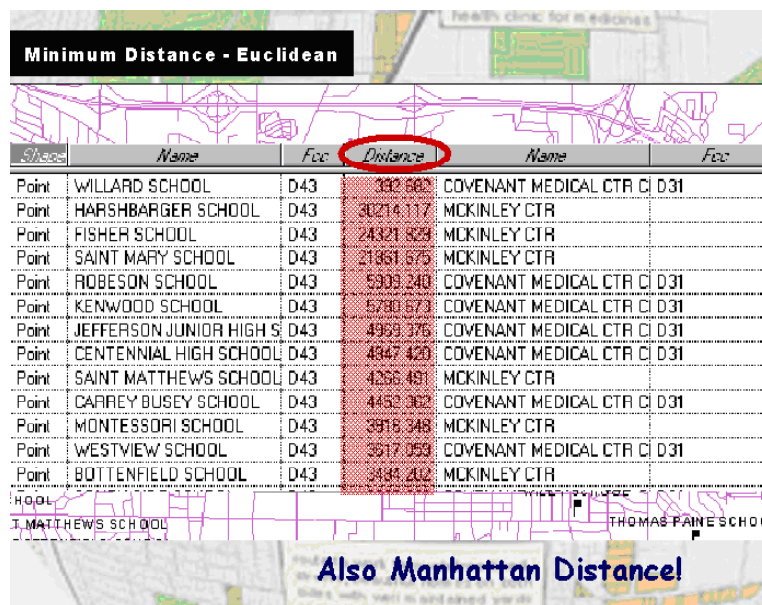


Figure 7: The Concept of Minimum Distance Analysis



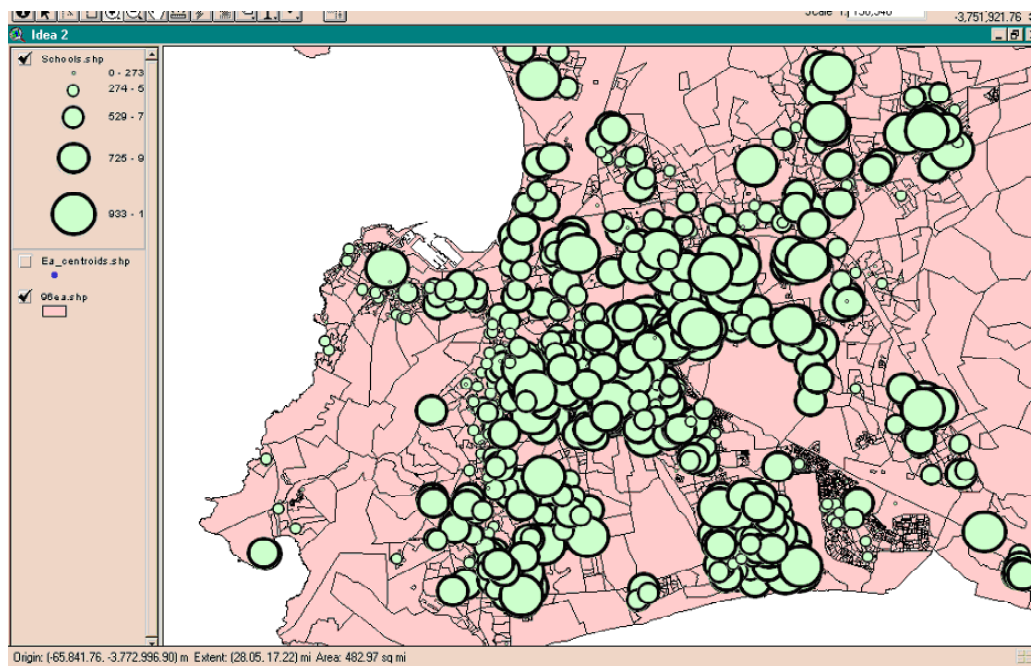


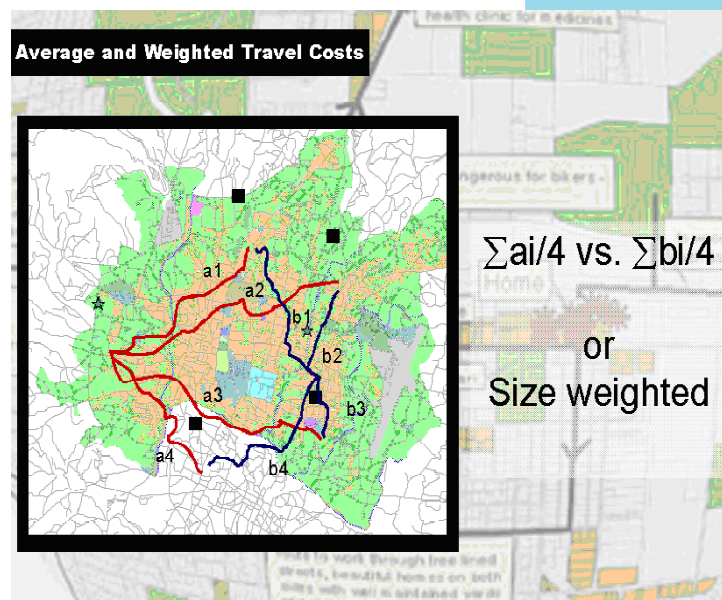
Figure 8 : Service Potential of Schools Relative to Closest Population Centers

The exercise illustrating this method uses the school locations and the centroids of enumeration areas to identify the schools closest to those areas (assuming that this proximity increases the likelihood of school being used by the population of the nearest population center). The service potential of schools in one section of Cape Town Metropolitan Area is displayed in Figure 8.

Figure 9: The Concept of Travel Cost

### Travel Cost

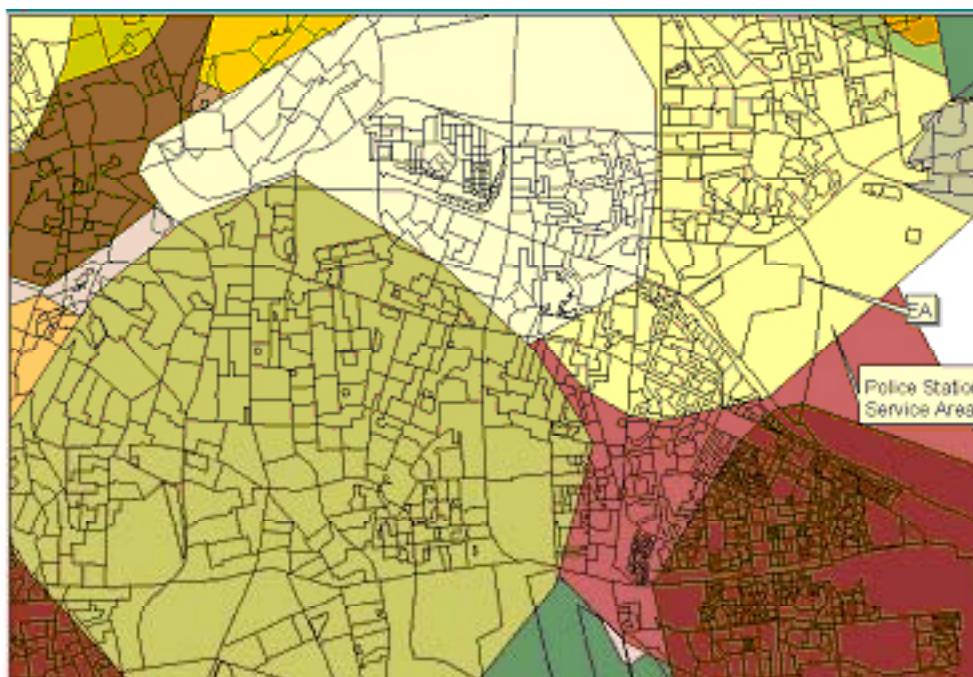
*Travel Cost* is expressed as the average distance between a point of origin and all facilities in the area. Using the example of health care facilities, this approach would explore the access to all facilities from a point (household, population center, central transportation facility, or another facility) in terms of distance and/or time, and calculate the average value (Figure 9). Preferences, transportation options, or other factors can be used as weighting factors. If this accessibility value is calculated for many points of origin, those points can be used to interpolate an accessibility surface for a given facility type or all types.





The exercise developed for the travel cost method calculates the number of population centers (i.e., enumeration ~~area centroids~~) ~~that are~~ within 3 miles from each police station. The distance is measured through the transportation network (Figure 10).

Figure 10: Overlay between Enumeration Areas and Three Mile Service Area around Police Stations



## Web Application Assessment

Keeping in mind that the development of exercises, web contents, and web interfaces is still work in progress, we can make several observations about the work accomplished so far:

Clearly, the readiness for use of local data received from Cape Town partners was crucial for our progress. The variables taken for analytical exercises coincide partially with the UN indicators. The analytical potential is there, however, to help visualize important information about inter-urban conditions and access opportunities.

Socio-economic data crucial for understanding the segregated nature of access has only been obtained recently. The information on age and racial distribution will be incorporated in the final versions of this training module. In addition to schools, fire stations, and police stations, the exercises will be complemented with information on other community facilities and utilities (access to water and sewer, for example), and open space.

Reliance on only one site prevented our observation of the complexities specific for other urban environments in developing countries. The improvement in data contents from Katmandu and Gaborone will compensate for this, and exercises with data from those regions will also be included. The feedback from the partners point to significant contextual differences in terms of community problems, issues, and their manifestation.

While the GIS exercises and hard data will capture some of those contextual differences, it seems that in order to accurately depict the

local conditions, it may be necessary to obtain or develop conceptually diverse databases. For example, the coincidence between the level of income and access to services that is shown in Cape Town, would not hold true in Gaborone or Katmandu. The access inequities are more of a micro scale and more peculiar in environments that are not experiencing as high socio-economic segregation. The contextual nature and differences will pose new methodological challenges and will certainly offer new learning.

Finally, going back to the original project purpose and objectives, the development so far was clearly geared toward providing GIS training. With our specific focus on accessibility, the general purpose of the project is achieved. The question of who would ideally be the users of this module is important to resolve. The project partners already have GIS capabilities and skills that the module exercises are trying to demonstrate. For example, reports from Cape Town City Planning and Information Services units offer comprehensive profiling of their communities. (The reports are referenced below.) Similarly Katmandu Regional Valley Authority has issued a similarly comprehensive GIS-based report. (Reference also provided below.)

The exercises focused on accessibility promise to be useful for the employees in those government agencies, as well as the community groups and organizations that are interested in taking advantage of available technologies and information streams. The technology transfer component was only indirectly addressed during the course of this project. However, in the still forthcoming final phase, we hope to gain additional insights about the utility and usability of the training module.

## GIS-based Reports Available (or Produced) by the Partners

Information Services, CMC Administration, Urban Policy Unit, Cape Town Administration, and City of Cape Town. 1996. THE PEOPLE OF THE CITY OF CAPE TOWN, A socioeconomic profile of the metropolitan area. Summary data from 1996 census.

Urban Studies, Surveys and Land Information Branch, City Planner's Department, City of Cape Town. 1996. LEVELS OF LIVING IN THE CAPE METROPOLITAN AREA – The social health and well-being of the communities of the Cape Metropolitan Area.

Information Services CMC Administration. 1997. CAPE METROPOLITAN AREA 1997. October household survey.

### Technology transfer and local capacity building

Important aspect of the technology transfer and capacity building in this project has been the variations that exist in technical capacity, needs, and professional composition of our international project partners.

Firstly, technological local capacity and needs is uneven amongst our partners. While the partners from Cape Town and Katmandu have a highly developed database for their urban indicators at different levels of disaggregation; the project partner from Gaborone lack the basic GIS data for the city. Secondly, the local levels of technical capacity are quite distinct among our project partners. Cape Town Metropolitan Council is staffed with highly qualified and GIS capable professionals and technicians. However, this level of local technical capacity is not present in other cities. Thirdly, the professional composition of the international partners is diverse. The project partner in Gaborone is with an academic institution and in Katmandu with an internationally funded unit, both able to enjoy certain degree of autonomy in their engagement with the UCGIS project. The partners in Cape Town, however, are practitioners that have to justify their engagement in the UCGIS project to their senior officials by their ability to demonstrate certain “deliverables” as project outcome.

These variations in local technical capacity of the partners clearly influence the distinct needs and priorities of the project partners in terms of capacity building. For Cape Town, which participated in

this project with a reliable database and qualified staff, the priority need was in application of the tools that could measure levels of accessibility for different urban indicators. But for Gaborone the value of the project was in creation of an operable database on urban indicators and training of their staff in basic use of GIS and accessibility measures.

The particular case of Bandung, however, is worth mentioning here. As it constituted one of the initial international partners listed in the proposal, but their data was not included in the exercises developed for the training modules. This was for several reasons including the inoperability of their data set and the heavy load of the team to work with the data set available from the other partner cities. We will, however, work with the Bandung partners at the final stage of the project by seeking their feedback on the web-based training module and evaluation of its utility.

Lastly, as to this final stage of the project, except for Cape Town, other project partners are yet to receive the ESRI software packages, which was to be the basic step towards technological transfer and improved local capacity.

### Evaluation of the training module and project interaction

In each country context target groups are currently testing the training modules developed by this project, to assess the clarity of the training instructions and improve those accordingly. The UIUC team members will also participate in this as they each have different strength and insight into the substance or technical development of the training

material and exercises involved. Although the Indonesian data set was not used for development of the training exercises, their input will be sought to assist us improve the clarity of the training material. A combination of these feedbacks, to be received within the next two weeks, and the subsequent improvements to be made to the site, is hoped to optimize the effectiveness of the project's web-based training material as its final output.

To evaluate the effectiveness of the project output and process, we will conduct a formal project evaluation among all participants. The evaluation forms will be circulated to international partner institutions (including Bandung) as well as the UIUC team members. The evaluation form will include questions about the project in respect to the following:

- The strength and weakness of the project process:

I.e., how permeable was the process of the project; did the process of the project allow them include their views, needs, and priorities as oppose to a donor-driven agenda; did the process of project participation in itself (i.e., meeting other partners and working with an international team) had any positive contribution at personal and professional/technical levels?

- The strength and weakness of the project outcome:

I.e., how far did they find the outcome of the project of relevance to their current needs and priorities; the fit between the training material and the needs and technical capacity of the targeted trainees in their institutional

or other environments (e.g., other agencies, governments in other cities, or other community groups); the clarity and usefulness of the exercises; in specific the clarity of the training material in respect to the site organization, intended audience, ease of downloading, (how easy they are to follow); downloading - vs web-based (ArcIMS)?

- The project's influence on their ongoing activities and local projects.

I.e., has this project dove tailed with any other of their activities or allowed them to mobilize other projects that needed the particular tools or data facilitated through this project; did the focus of this project on urban indicators and data disaggregation open new avenues in ways in which urban issues were framed, questions were asked; did the project work as a catalyst to help them develop certain data set that otherwise would not have been collected or registered?

- The project's influence on internal dynamics of their organization.

I.e., has it worked as a catalyst to bring different units or staff within their organization together; has it helped the individual's status within their organizations; has it provided a medium to push for collection of disaggregated data within their organization?



Working from the initial framing for the project and our experience in Phase 1, we see opportunities for substantial refocusing for Phase 2. Our partners are each in distinct circumstances with different needs and opportunities related to their immediate tasks and demand for training opportunities. Distance education modules alone are not sufficient. Local benefits from use of indicators require closer integration with devising, choosing, implementing, and monitoring particular urban development strategies. Indicators focused on cross sectional snapshots are useful in allocation formulas for funding; they are of less use in figuring out what to do and whether it is working. We, therefore, suggest that Phase 2 funding focus on 1) close collaborative enhancement of tools and capabilities in use rather than on creation of fixed training modules, and 2) using indicators to assess infrastructure services as evolving capabilities during urbanization.

Our partners in Phase 1 were in very different stages of implementation of GIS and of use of urban indicators. Capetown and Kathmandu have well-established databases, which they have begun to use for planning and management of development. They continue to have difficulty in attracting and keeping high quality GIS staff, but a few specialized modules of distance based GIS training may have little impact.

Distance based modules are insufficient and seen as less credible in credentialing and enhancing careers or employee capabilities. Many providers of GIS training already exist, including services with highly developed on location and distance learning modules. Organizations that provide such training expend significant sums creating and maintaining course materials and we cannot match

their economies of scale. Our partners, however, lack funding to provide these educational materials to their staff, including web access for distance education materials.

Funds might better focus on training placements and task specific “over-the-shoulder” consulting, rather than development of course materials. The mix of UCGIS project teams will be more effective by working as partners on specific tasks with local colleagues. Skills and knowledge would be transferred by mentoring and mutual learning rather than by training materials. Such opportunities would complement the already available training opportunities, which partners could be funded to attend.

We need to move beyond indicators as static measures. Even if we measure current levels of services, and could measure whether these improve, we cannot devise strategies for achieving improvements without considering how situation change. We need to consider the dynamics rather than comparative statics. In considering dynamics, indicators will have to take into account changes in—and therefore attributes of—institutional technology and physical technology, supply and its costs, demand and its price and ability to pay, and realized behaviors.

Serving an informal settlement with water is likely to involve combinations of household connections, shared taps, and vendors. Similarly an area of new urban development is likely to occur on a landscape that already includes rural and village systems (institutions and physical systems) of water supply, waste disposal, and transportation access. These existing systems will persist, perhaps for a long time, while new systems are created, sustained, and achieve complete coverage. In Kathmandu, for example, even after several attempts over

more than 25 years, there is still no functioning sewage treatment plant, much less general coverage for the urban area. The actual system in place is a combination of legacy systems and failed components of newly introduced technology. It will be more useful to formulate scenarios of change from existing circumstances rather than to imagine, completely transformed future states.

The water supply system could be described as a piping network, but much of the network carries no water. Further, distinct populations in the same spatial neighborhoods rely on very different modes of services for water supply, sanitary waste, and travel. Thus spatial disaggregation alone is insufficient. Disaggregation by population groups and change over time is essential. Changes are likely to occur in stages. Even if a piping system is installed, some households will not be able to afford or establish legal status to connect to it. Cultural norms may determine that different groups access services in distinct ways. We cannot simply assume that supply is or will be used if available, much less used by everyone with spatial accessibility.

Our partners in Kathmandu are interested in transportation questions. We might look at describing accessibility changes for various population groups based on scenarios of changing vehicle types, pricing, public sector supply, and road capacity networks. Or, we might look at scenarios of water supply for informal settlements based on strategies for regulating such settlements. Or, we might assess strategies for sanitary waste disposal in newly urbanizing areas given realistic expectations based on the record of sustaining externally designed sewage collection and treatment systems.

Tools should be developed to assess changes in the capabilities of impoverished persons to access water, sanitary waste disposal, solid waste disposal, and transportation (or communication) access to jobs, schools, health and other services. These tools will help to devise, choose, implement, and monitor urban development strategies that may reduce poverty by increasing the capabilities of the impoverished.

The following suggests possibilities for a continuation proposal. We identify our primary interests and what we see as opportunities, rather than a scope for the entire UCGIS effort. We assume that an overall proposal would be prepared by UCGIS and then sub-contracted as in the first round.

The three objectives of a continuation grant would be:

1. Provide funding so that partners can take advantage of existing training opportunities, including online and programs in country and in the US. For example, the University of Illinois already runs a summer training program focusing on information technology for urban development professionals in developing countries. Participants must have a funding source to be able to afford to attend. NGOs and universities in Nepal run GIS training programs aimed at agency personnel; we have participated as instructors in these programs. Funds to acquire up to date software and hardware for these training programs rely almost entirely on external funding of attendance fees.

2. Support over the shoulder collaboration of staff and US partners to work on specific tasks and problems that arise in trying to put GIS to work for human development. This would include remote

interaction through email and internet and onsite interaction by bringing people to the US and sending people to partner sites for short periods of focused work.

3. Focus on developing analyses and tools to devise and assess strategies for improving 1) accessibility and 2) water supply and its relationships to drainage. We will have to negotiate this focus with partners so that we can sustain both a focus and relevance to partners' needs. Such focus is essential, however, to developing sufficient expertise to contribute significantly to the work of partner agencies.



