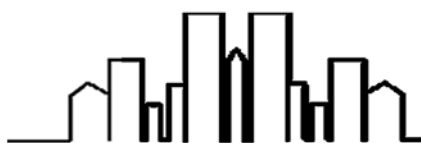


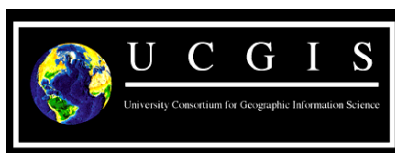
**Final Report
To
U.S. Department of Housing and Urban Development
Office of Policy Development and Research
HUD Project H-21260CA**

**Global Urban Quality: An Analysis of Urban Indicators Using
Geographic Information Science**



May 2002

**Kenneth Dueker, UCGIS Program Manager
and
Susan McDonald Jampoler, UCGIS Executive Director
University Consortium for Geographic Information Science
<http://www.ucgis.org>**



Participating Universities

**University of Illinois, Urbana-Champaign
University of Iowa
Virginia Commonwealth University
West Virginia University
University of Wisconsin-Milwaukee**



**HUD Program Manager: Alven Lam
HUD Government Technical Representative: John M. Geraghty**

The Office of Policy Development and Research, Department of Housing and Urban Development provided a grant to the University Consortium for Geographic Information Science (UCGIS) for a project titled “Global Urban Quality: An Analysis of Urban Indicators Using Geographic Information Science (GIS). The project supported five university efforts in the development of urban indicators at the sub-city level. Each university collaborated with academic institutions and government agencies in emerging nations to develop web-based training and analysis programs on the application of geographic information systems for urban indicator modeling.

The project complements the Urban Indicators Programme of the United Nation’s Global Urban Observatory, by use of UCGIS member institutions to develop programs to train personnel in developing countries on the application of geographic information systems (GIS) technology. GIS is used to disaggregate country and city indicator data to sub-areas within cities to help evaluate the spatial dynamics of urban quality within larger metropolitan areas. The project developed implementing strategies of: 1) forming partnerships; 2) adopting enabling approaches; 3) activating participatory mechanisms; 4) building capacity; and 5) monitoring progress through networking and modern information technologies.

An important finding is that regular monitoring of indicators is needed to identify emerging urban issues. The international partners stress the importance of capacity building and continuous monitoring, and analysis. Although, inter-city com

parisons are useful to assess comparative status and progress, intra-city monitoring and indicators are crucial to good practices for managing urban systems. The partnerships of UCGIS universities and their international collaborators emphasize the strengthening of local capacity, wherein issues are clarified and key stakeholders are involved to set priorities through an informed consultative process. Within the context of the mutual goals of HUD and UCGIS for the project, the unique perspective and approach of each university results in a broader set of findings than could be achieved by a single perspective and approach.

Now that the five university teams have experience with urban indicators at the sub-area level and with GIS-based instructional materials, it is time to compare experience and results to assess strengths and weaknesses of various measures and approaches. This will set the stage for exploring opportunities for increasing consistency in the development of the regular monitoring of GIS-based urban indicators.

The GIS and spatial analysis methods used in this project were applied in developing countries that are characterized by poor data and where local authorities have limited capacity to monitor urban growth and change. The emerging colonias settlements along the US-Mexican border mirror those of informal settlements on the urban fringe in developing countries in that they lack adequate infrastructure and other basic facilities or develop spontaneously without jurisdictional sanction and viable livelihood systems. Thus, the project may lead to additional applications for monitoring urban development.

In response to an unsolicited proposal, the Office of Policy Development and Research, Department of Housing and Urban Development granted \$340,000 to the University Consortium for Geographic Information Science (UCGIS) entitled “Global Urban Quality: An Analysis of Urban Indicators Using Geographic Information Science (GIS).

The mutual goals of the Office of Policy Development and Research and UCGIS are to:

- Gain knowledge on the state of urban quality within cities in developing countries that can be used to monitor change and assist in developing and evaluating policies and programs that intend to improve the quality of life in those areas.
- Establish a quantitative baseline of data that can be used in the future to evaluate the effectiveness of new policies and programs that are intended to improve economically distressed communities, increase homeownership, and reduce homelessness.
- Transfer expertise in evaluating urban indicators using spatial analytical techniques and geographic information systems from participating universities to paired organizations within the emerging nations. The transfer of knowledge will be through web-based training programs.
- Build a local capacity to collect and use policy-related indicators.

Develop long-term relationships between the UCGIS member universities and the paired organizations in the emerging nations to increase the capacity within the developing countries to continue urban indicator analysis on a long-term basis.

UCGIS Solicitation

The HUD grant enabled the University Consortium for Geographic Information science (UCGIS) to issue a solicitation for proposals. The proposals were reviewed and five universities were selected. The winning universities were:

- University of Illinois, Urbana-Champaign
- University of Iowa
- Virginia Commonwealth University
- West Virginia University
- University of Wisconsin-Milwaukee

Each university collaborated with academic institutions and government agencies in emerging nations to develop web-based training and analysis programs on the application of geographic information systems for urban indicator modeling. The project complements the Urban Indicators Programme of the United Nation’s Global Urban Observatory, by use of UCGIS member institutions to develop programs to train personnel in developing countries on the application of geographic information systems (GIS) technology. GIS is used to disaggregate country and city indicator data to sub-areas within cities to help evaluate the spatial dynamics of urban quality within larger metropolitan areas.

The **University of Illinois at Urbana-Champaign** team is headed by Drs Emily Talen, Farank MirafTAB, Lewis Hopkins and Zorica-Nedovic-Budic. The University of Illinois is collaborating with the Kathmandu Mapping Project in Kathmandu, Nepal, the Department of Information Systems Technology in Cape Town, South Africa, and the University of Botswana in Gaborone, Botswana.

Dr. Gerard Rushton and Michael McNulty head the **University of Iowa** team. The National Institute of Urban Affairs, New Delhi, India and the Department of Geography at the University of Ibadan, Nigeria are collaborating with the University of Iowa.

Drs Robert Rugg and Weiping Wu are heading the **Virginia Commonwealth University** team with Dr John Accordino. VCU is collaborating with the Center for Urban and Regional Studies and Faculty of Architecture at the University of San Carlos of Guatemala and the Open Research Laboratory of Remote Sensing at East China Normal University in Shanghai, China.

West Virginia University's team is headed by Dr. Daniel Weiner with Drs Gregory Elmes, Calvin Masilela and Dr. Brent McCusker as co-investigators. Dr. McCusker is the project administrator. West Virginia University is collaborating with the Universidade de Catolica de Mocambique in Beira, Mozambique.

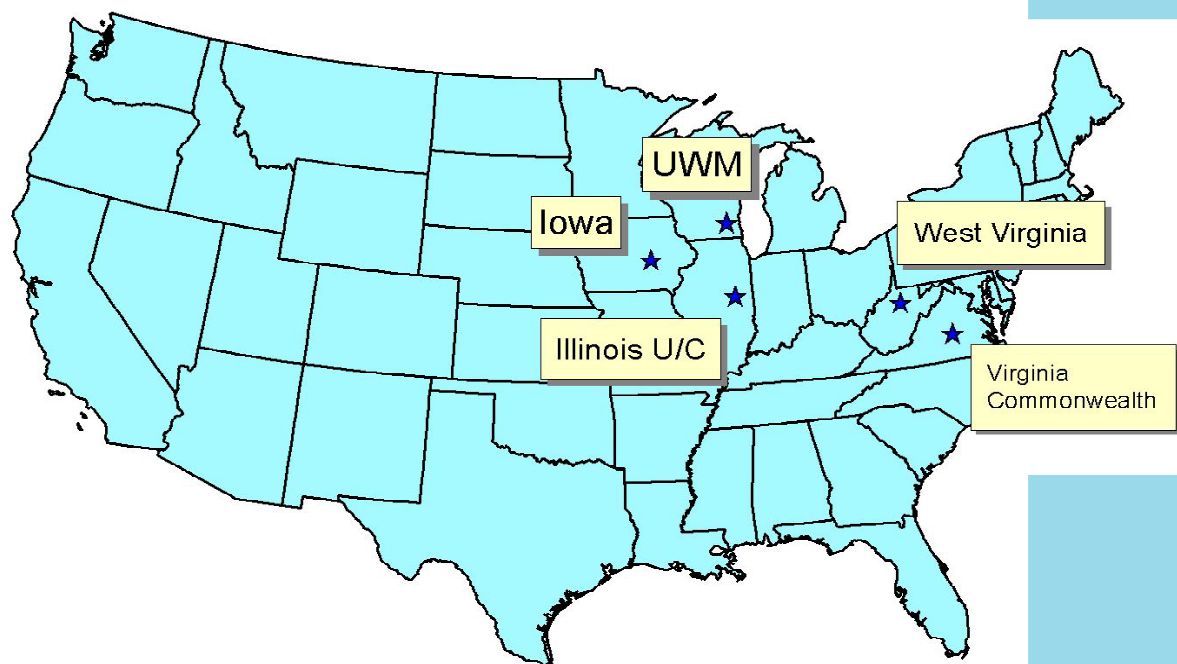
Professor William Huxhold, Cheryl Ajitrotutu, Jochen Albrecht and Dr. Laxmi Ramasubramanian are heading the **University of Wisconsin — Milwaukee** team. The City of Milwaukee, Wisconsin, the City of Dakar, Senegal, the Ecole Superieure Polytechnique and the University of Cheikh Aanta Diop-Dakar are collaborators on the project.

Dr. Kenneth Dueker is the overall project coordinator. His responsibilities include: providing oversight, intellectual support and peer review for the UCGIS participating universities, identifying possibilities

and techniques for linking the micro-level data developed through the individual projects to the macro data, coordinating and producing the final report, and working with the Advisory Board.

UCGIS private affiliate member **Environmental Systems Research Institute (ESRI)** is supporting the effort through donation of ArcIMS and ArcView software to participating universities. In addition, ESRI has provided GIS software to cities in developing countries cooperating on this project with UCGIS and the United Nations Centre for Human Settlements (HABITAT) and its Global Urban Observatory Urban Indicators Programme.

Figure 1: Map of the Five Participating Universities



Urban indicators are designed to measure the quality of life and the nature of development of an urban area. They can also be used to make comparisons over time and space to form the basis for urban development policies. The International Development Research Centre (IDRC) and the United Nations both emphasize the usefulness of indicators in policy making. IDRC describes indicators as “essentially pieces of information that reveal conditions and, over time, trends. These indicators can be used to make policy and planning decisions, to identify whether policy goals and targets are being met, and sometimes to predict change.” According to United Nations Centre for Human Settlements (UNCHS), “indicators are models that simplify complex subjects into a few numbers which can be used to determine policy.”

In developing countries the lack of good data and indicators severely constrains the ability to develop and analyze effective urban policy. A sustained and systematic appraisal of urban problems is needed to provide the overall picture of the city and how it functions and an indication of the relationships between the performance of individual sectors and broader social and economic development results (Leitmann, 1999).

The Global Urban Observatory is the UNCHS Habitat’s facility for monitoring and evaluating the implementation of the Habitat Agenda and Agenda 21. This body was created through a resolution by the 1996 UNCHS Habitat II Conference in Istanbul, Turkey, that “All partners of the Habitat Agenda, including local authorities, the private sector, and

communities should regularly MONITOR and EVALUATE their own performances in the implementation of the Habitat Agenda through comparable human settlement and shelter INDICATORS...” (Paragraph 240 of the Habitat Agenda). The Urban Indicators Program (UIP) and the Best Practice and Local Leadership (BLP) together make up the Global Urban Observatory. This Urban Indicators Program was born of the realization that many cities of the world (particularly the developing world) are faced with an information crisis, which seriously undermine their capacity to develop and analyze urban policy.

The meaning and role of indicators has thus been defined: “...a measure that summarizes information about a particular subject and may point to particular problems ... (and) provides a reasonable response to specific needs and questions...” (UNDP, 2000). Regardless of the definition, literature has demonstrated that various indicators based on easily obtained data can offer useful intelligence for making strategic choices about directing and managing future growth. Furthermore, while indicators primarily show trends, prioritize and define targets, provide qualitative and quantitative information etc, (Banerjee, 1996; Leitmann, 1999), they can also be more than pieces of information if designed in response to well defined policy objectives (Sawicki and Flynn, 1996). In a special issue of the Journal of the American Planning Association devoted to a discussion of indicators, Banerjee (1996:222) summarized the purposes of indicators as:

To measure performance of policies and programs; to examine trends; to monitor the condition of a city or a region; to inform decision-makers; to raise awareness of the public; to define targets; to set planning objectives; to compare localities horizontally (across space) or longitudinally (over time); to raise flags in an early warning system; to guide strategic investment choices; to challenge conventional wisdom; and so forth.

Sawicki and Flynn (1996) and Leitmann (1999) argue that indicators must be capable of affecting citizen action and public policy making, and hence must be formulated through a broad-based partnership approach involving all levels of decision-making and all stakeholders. However, it has been argued that stakeholder participation in this process has always remained questionable as experts dominate the scene (Leitmann, 1999).

Indicators can be used to measure conditions at varying geographical levels. For example, national indicators are used to measure and compare the level of development of different countries. Within a country, there can be indicators at the regional level or at the city level. Most indicators in current use are at the national or the city level. However city-wide indicators are not always a true reflection of the level of conditions – especially in the case of cities in the developing world that are characterized by stark

socio-economic differences amongst inhabitants. While the affluent enjoy a high quality of life and have access to quality services, the poorer inhabitants of these cities live in miserable conditions, often without basic services. These disparities are also reflected in the spatial segregation of the urban population based on the level of access to amenities and infrastructure (Portes and Johns, 1989).

Availability of reliable and appropriate data at the intra-city scale is a problem. There is a need to build national and local capacity to collect globally comparable and useful information on urban conditions and trends, to convert the information to knowledge through appropriate techniques, and to apply this knowledge in formulating and modifying urban policies and programs (UNCHS, 1999). Addressing this need will help to resolve information and knowledge gaps that blur the vision of city leaders and the hopes and aspirations of urban citizenry.

The spatial nature of urban phenomena prescribes the use of geospatial technologies in urban management. GIS analysis is mainly used during the informed consultation phase to generate physical and social information, including key correlations, and for monitoring the implementation of plans in cities. Sawicki and Flynn (1996) engaged a thorough conceptual and theoretical examination of the literature where they identify urban environmental indicators as the precursors of neighborhood indicators in the United States.

To illustrate the relevance of GIS, it is argued “With many records located in space, the GIS can then aggregate them to any level of geography: city blocks,

neighborhoods, census block groups, tracts, municipalities and counties (Sawicki and Flynn, 1996:166). Furthermore, the analytical capabilities of GIS have made the technology more than just a communicative visual tool hence most applicable in the development of indicators for evaluating urban policy and the quality of our cities. This way, the use of the technology would fall within the five geographic information science (GI Science) potential areas for planning as identified by Nedovic-Budic (2000:82): database development, integration of geospatial technologies with urban models, building of planning support systems, facilitating discourse and participation, and evaluating planning practice and technological impact.

Applications of GIS have recently disseminated to developing nations. Despite the rapid adoption, the use of the technology has tended to reside in externally funded projects or state agencies and rarely is it owned and used by people at the grassroots. Similarly, there has not been a coordinated style of adoption and use in many countries. Although local authorities in different countries have engaged GIS at different levels, enormous gaps in information and citywide data have become commonplace.

First Symposium

The project principal investigators met in Washington DC February 6-7, 2001 for a Symposium on Urban Indicators. The agenda for this symposium included: 1) demonstrations of the capacity of UCGIS member institutions to perform the analyses; and, 2) investigation of the availability of data in the developing countries for incorporation into the developed analytical models. The symposium consisted of invited presentations from UCGIS member universities describing work currently being done on urban indicators and on related GIS activities within developing countries, and presentations by interested government and international agencies. Presentations were also made by: UCGIS President, William Huxhold; UCGIS Executive Director, Susan McDonald Jampoler; Alven Lam (HUD); John Geraghty (HUD/International); David Chase (HUD/OPDR); Ann Johnson (ESRI); Richard Campbell (Cornerstone Concepts); and representatives of the UN Habitat, HUD, and the World Bank provided useful background on the general interest in Global Urban Indicators and the use of these Indicators in UN, World Bank, and US policy and planning contexts. These sessions provided a larger context for the present UCGIS grant and placed the work of the five universities in perspective.

Each of the participating universities made brief presentations at the Symposium, outlining their proposed activities, providing an introduction to their partner institutions, and current state of the project. Two or more persons represented each university. Several of the foreign partner institutions were also represented. The presentations highlighted the considerable

differences in interpreting and addressing the main purposes of the UCGIS/HUD RFP. The discussions and small group session that followed were helping in clarifying individual projects and further defined some of the common, and divergent, approaches.

Originally, the projects were to finish their work by September 30, 2001. However, it was decided at the Symposium that UCGIS would ask that this date be changed in view of the late start and the implementation plans of the projects. A time extension for the project has been approved with a new completion date of May 31, 2002.

UN Habitat (UNHCS) Conference

Susan McDonald Jampoler, William Huxhold, and Gerard Rushton participated in the UN Habitat (UNHCS) conference in New York, June 6-7, 2001 as a member of the HUD/UCGIS team. They participated in three meetings involving Guenter Karl, Coordinator of the Global Urban Observatory, Christine Auclair, Indicator Specialist, and their Chief, Ms. Nefise Bazoglu, Urban Secretariat, HUD Deputy Assistant Secretary Shannon Sorzano and HUD Secretary Martinez.

Other sessions included "Implementation of the Habitat Agenda", chaired by Ms. Bazoglu with panelists Guenter Karl, Jay Moor and Alven Lam of HUD. Participants were involved in discussions on two major Habitat projects: The State of the World's Cities and the Report of Urban Settlements.

These sessions were very useful in

examining the relationship between current urban indicator research and training in the UNCHS, HUD, and the several universities participating in the UCGIS Urban Indicators project.

Second Symposium

A second Symposium on Global Urban Indicators was held in New York City, January 8-11, 2002. The agenda for this symposium included: 1) presentations from the five university teams on progress during the first year; 2) assessment of progress and future directions by observers and participants; 3) recommendations by the international partners, functioning as an advisory board, and 4) discussion of GIS and web-based training materials. The symposium focused on presentation of research results and the description of training materials developed by the five university teams on urban indicators and on related GIS activities within developing countries. Presentations were also made by: UCGIS Project Coordinator, Kenneth Dueker; HUD Project Monitor, Alven Lam; UN Habitat observer Christine Auclair; software representatives from ESRI, Ann Johnson, Mike Phoenix, C.J. Cote, and Daniel Zimble; and Shlomo Angel from New York University. They provided useful assessment of progress and advice on development of GIS-based training materials and the use of these material and urban indicators in UN, US AID, and US policy and planning contexts.

Each project team presented a report on their activities that served to describe their focus and approach:

1. **The University of Iowa** described their focus on health-related indicators and analysis for use in policy analysis and the planning of health services and facilities. They are converting and adapting GIS-based analysis for use in medical geography classes in the U.S. for application in Nigeria and India. The Iowa team has well-established capacity-building connections in these two countries.
2. **The University of Illinois at Urbana-Champaign** team collaborating with the Kathmandu Mapping Project in Kathmandu, Nepal, the Department of Information Systems Technology in Cape Town, South Africa, and the University of Botswana in Gaborone, Botswana on the measurement of accessibility to urban services. This project uses GIS to visually explore and analyze disparities in access to housing, infrastructure, urban services and amenities. They are developing applications in ArcGIS, ArcIMS and ArcView. The focus is on developing measures of accessibility that are applicable in several developing countries. The capacity-building connections with international partners are moving from formative to an advanced stage.
3. **The Virginia Commonwealth University** team is collaborating with and focusing on the data needs of the Center for Urban and Regional Studies and Faculty of Architecture at the University of San Carlos of Guatemala and the Open Research Laboratory of Remote Sensing at East China Normal University in Shanghai, China. They are developing data resources and training materials in Spanish and Chinese. The training modules are for digitizing, map projections, scale, data integration, aggregation/disaggregation, map design, and analysis.
4. **West Virginia University** is collaborating with the Universidade de Catolica de Mocambique in Beira, Mozambique. Jointly they are developing a database that uses infrastructure as the focus for support of planning and decision making at the local level. They are developing web-based training programs on the application of GIS for modeling of urban indicators in Beira.
5. **The University of Wisconsin-Milwaukee** team is collaborating with the City of Dakar, Senegal, the Ecole Superieure Polytechnique and the University of Cheikh Aanta Diop-Dakar on the project of participatory action research and capacity building for Dakar. Participatory action research employs a partnership approach to map and subsequently analyze selected urban indicators using GIS. UWM has developed training modules. Selected staff based in Senegal will develop their skills to use GIS and analyze urban indicator data through participation in this research project.

The project team presentations and the ensuing discussion illustrated the difficulty in reconciling the need for uniform and consistent urban indicators from the top down or global perspective, while developing a bottoms-up perspective of developing useful data for local planning and policy analysis. With a high level of participation and influence by the international partners, the five project teams emphasized the bottoms-up perspective and developed data and training materials suited to local needs. Consequently, the objective to develop comparable indicators was compromised by this tailoring of activities to local needs.

Discussion of plans to continue the project addressed the need to generate comparable data while at the same time being responsive to the needs of the international partners, and their role in providing data and analysis on behalf of local planners and policy analysts. The project teams accepted the need for a common conceptual model of urban infrastructure and services with measures of capacity, demand, and stress (disparity in capacity and demand, in time and space, in relation to norms). The project teams will exchange approaches and measures on these dimensions toward more comparable indicators of conditions and trends. The amount of growth and change that was detected heightens interest in and the importance of the temporal dimension. More communication is needed between university teams toward increasing uniformity in mapping temporal change and in placing small-area indicators in a city, region, province and nation context.

The discussion of GIS software tools for the development of applications provided comparative information on what approaches were productive and what proved problematic. Applications that relied on the proven and stable technology of ArcView 3.2 were most successful although they did not achieve the objective of being web based. Several teams experience difficulty and limited success in working with ArcIMS. The difficulties stemmed from limited experience with the software, too ambitious expectations of it, and limitations of the early version of the software. A new version of ArcIMS should help, although bandwidth and limitations of hardware at the international client side may limit the application of web-based GIS applications. In the longer term, ArcGIS may be a more robust way of accessing data remotely for GIS analysis. The University of Illinois has already made this shift; three of their four exercises are now implemented in ArcGIS.

The contribution of GIS software by ESRI has been beneficial, particularly to the international partners. The announcement that ESRI has expanded its educational program by adding resources on the international side will serve the project well.

HUD's interest in the project continues to be strong. They see the strength of the varied approach of the five university teams, of the capacity building that is taking place, and the development of training materials. HUD is looking for a compilation of results from the development of GIS-based training materials, and development of indicators of urban infrastructure and services capacity, demand, and stress that will be of use by local governments in the U.S. and in developing countries.

This project serves HUD's agenda of working with the United Nations on monitoring progress in implementing the Habitat agenda. Implementing strategies of: 1) forming partnerships; 2) adopting enabling approaches; 3) activating participatory mechanisms; 4) building capacity; and 5) monitoring progress through networking and modern information technologies are addressed in this project. In addition to these contributions of capacity building toward comparative urban indicators, the project contributes to the capacity building for the building of environmental management information systems that focus on mapping and GIS analysis within urban areas.

With a common project focus, the unique perspectives of the five universities and their international partners enabled addressing a range of issues pertaining to urban indicators. This section of the final report identifies and assesses the diverse findings of the university teams from the perspective of the larger project.

Overall, the project provides support for the importance of regular monitoring of indicators for identifying emerging urban issues. Although, inter-city comparisons are useful to assess comparative status and progress, intra-city monitoring and indicators are crucial to good practices for managing urban systems. The partnerships of UCGIS universities and their international collaborators emphasize the strengthening of local capacity, wherein issues are clarified and key stakeholders are involved to set priorities through an informed consultative process. This process follows and confirms the local environmental action planning process used for sustainable planning (Leitmann, 1999).

Within the context of the mutual goals of HUD and UCGIS for the project, the unique perspective and approach of each university results in a broader set of findings than could be achieved by a single perspective and approach. The following summarizes the important findings from each university team.

The **University of Illinois at Urbana-Champaign** team used GIS to explore differences in accessibility to and quality of urban infrastructure for residential locations in selected cities in different countries. This effort demonstrates the importance of spatial analysis and GIS to measure accessibility. Measuring accessibility at the neighborhood level is an important issue in various countries. Further, this effort illustrates the need for and use of web-based training tools for GIS instruction and collaboration with partners.

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.

UIUC suggests that a Phase 2 continuation 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.

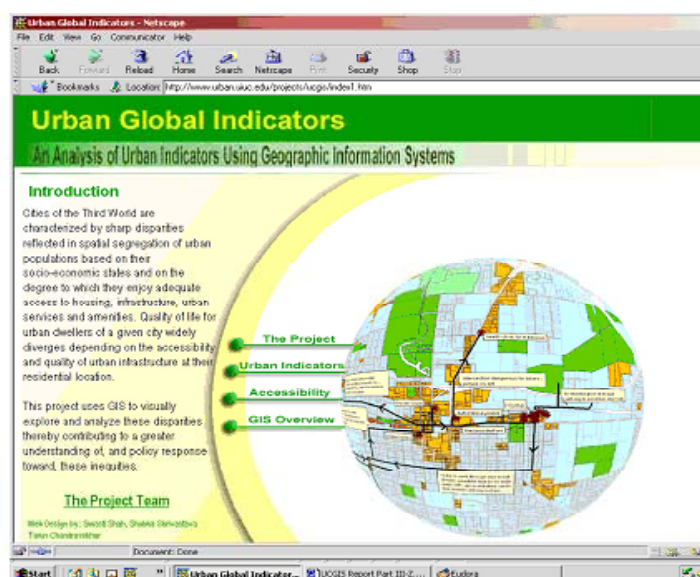


Figure 2: The University of Illinois at Urbana Champaign Web Site

The **University of Iowa** team effort demonstrates how a set of GIS instruction modules designed for domestic analysis of health indices and health care planning can be converted and adapted to web-based training tools and applied by international partners. The University of Iowa team is composed of persons who have worked together over a period of years allowing them to quickly focus on the substantive issues to advance the state-of-the-art of development of small-area indicators using socio-economic and health data.

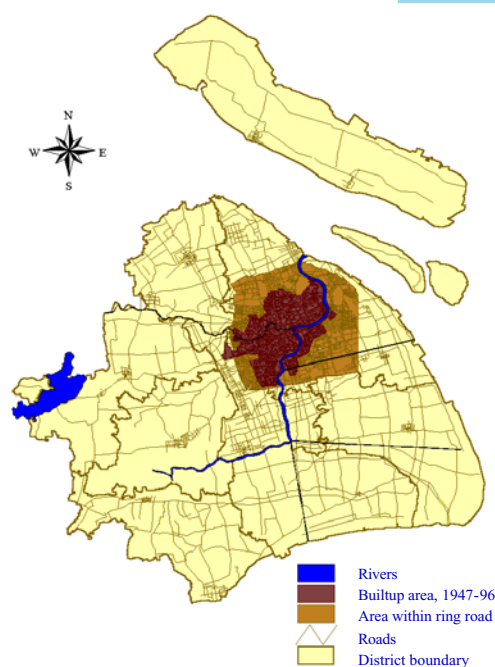
University of Iowa partners at the National Institute of Urban Affairs, New Delhi and the University of Ibadan are developing data sets for their respective areas to be incorporated into the Training Labs on the Website for use in their countries. In India, these data represent a sub-set of the more than 3000 slum areas in and around New Delhi where material and child health problems are known to be acute. In Ibadan Nigeria, data on environmental conditions and several relevant health variables are being collected for local neighborhoods within Metropolitan Ibadan.

The **Virginia Commonwealth University** team developed sub-city urban indicators in two quite different contexts – Shanghai and Guatemala City. The size and issue differences of the two regions reinforce the need for local collaborators and the development of different types of indicators. One set of indicators will not serve both regions. The mapping of indicators and the training modules for mapping serves to illustrate the importance of collaborative process of mapping for analysis of spatial patterns of urban indicators. This work lays the foundation for monitoring trends in the two regions. Monitoring change in the spatial patterns of urban indicators is of great interest in both regions.

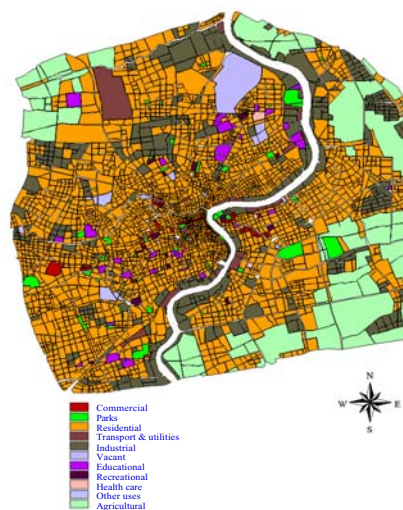
As a result of exchanges, the collaborative relationships with VCU international partners have strengthened significantly. Such relationships will continue and benefit future research. In the case of Guatemala City, the partnership has evolved into an institutional research exchange program between VCU and the Faculty of Architecture of the University of San Carlos, beyond the scope of this research. Efforts in transferring indicator research and GIS mapping expertise also have contributed to the building of local capacity. In the case of Shanghai, VCU will make the research results available to local planning policy-makers. The VCU research efforts in bringing together information from diverse sources are likely to help them overcome the lack of coherent and consistent data in their decision-making process.

Figure 3: VCU Maps

Metropolitan Shanghai



Land Use w/in Shanghai's 2nd Ringroad, 2000



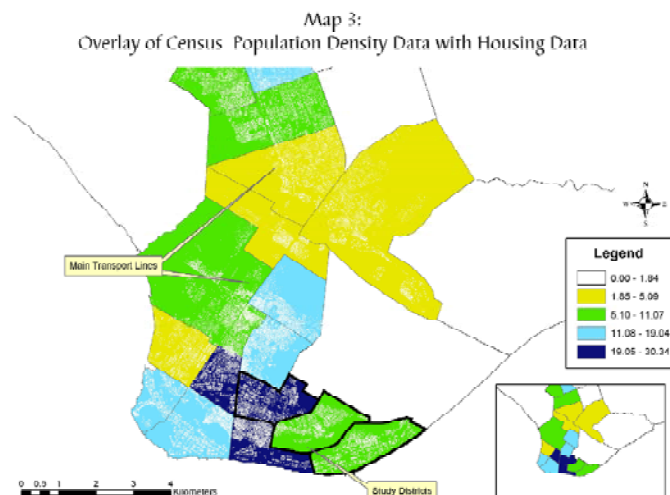
West Virginia University's team worked to gain knowledge on the state of urban quality in a very challenging region – Beira, Mozambique. They employed GIS, and transferred the technology locally to establish a quantitative baseline of spatial data to evaluate existing conditions and monitor change. They worked with stakeholders to evaluate the effectiveness of policies and programs intended to improve socially and economically distressed communities, increase home ownership, and reduce homelessness.

The initial assumption that pilot projects could draw/rely on the availability and applicability of UN derived urban indicators to develop a GIS for monitoring and analyzing urban indicators at the sub-city level was too ambitious and unrealistic for two reasons:

1. UN urban indicators, though providing a useful starting point, were intended for country comparisons rather than sub-city level analysis. Since urban problems are contextually based and solutions have to be developed locally, sub-city level analysis of indicators requires the generation of data that is situation specific. This is an important lesson from the Beira experience.
2. Unlike cities in other countries, data on key UN urban indicators were found to be either incomplete or non-existent. This was not surprising given that Mozambique only recently emerged from a long protracted civil war, and therefore faces major challenges on many fronts including reconstituting critical databases for urban policy analysis and institutional capacity building.

The conditions of a poor data environment presented both constraints and opportunities. Specifically, the need to generate new data forced an early decision concerning the choice of indicators and the methods of analysis. In this respect, the training modules developed both reflect the desire and need to familiarize the user with basic techniques for selecting appropriate indicators, data gathering methods, mapping as well as techniques for integrating disparate data sources to analyze and monitor urban indicators.

Figure 4: WVU Maps

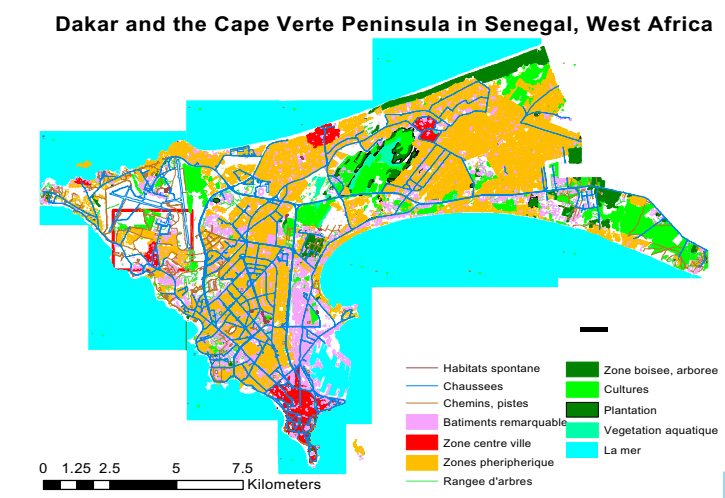


The **University of Wisconsin — Milwaukee** team operated in the context of a broader, but still developing relationship between UWM and a university in Senegal. Participatory methods and techniques were used to increase awareness among key decision makers of the advantages in using urban indicators and GI technologies to make policy decisions and day-to-day management decisions. This participatory approach facilitated a robust discussion regarding the selection of appropriate indicators to be used in sub-city analysis. The UWM team has developed an analysis template that allows decision-makers to examine large data sets with many variables in order to investigate a specific problem. This analysis template allows a range of users to examine the same data set to provide relevant information to address different problems such as to solve day-to-day management decisions, strategic planning, emergency services delivery, and for developing policy options.

The UWM participatory approach facilitated a robust discussion regarding the selection of appropriate indicators that can be used in sub-city analysis. The UWM team learned that decision-makers in different sectors (e.g., health, urbanism, education) require context-specific indicators that are sometimes not consistent with the indicators selected for use by the Global Urban Observatory. Decision-makers in different sectors expressed a strong desire to be equipped with advanced training (skills) in conducting analyses that integrate their conventional approaches using indicator data with the

appropriate use of GIS to better achieve their sectoral objectives.

Figure 5: UWM Map



The UWM research team investigated the potential benefits and limitations of using ArcIMS to facilitate urban indicator analyses in developing countries. Building on ArcIMS' strengths that lie on the server side, the UWM team recommends the following two uses of the software rather than generalized GIS training. These views are in concordance with the vendor's perspective.

- Development of active server pages-based functions that support urban indicator analysis. This will allow local decision-makers to analyze datasets with regular web browsers without any need for sophisticated hard- and software.
- Establishment of a regional spatial data infrastructure with variable access privileges to a multitude of datasets, which fosters collaboration among sometimes competing agencies

The project was originally envisioned as a three-year effort, but only the first year was funded. Consequently, the goals of the project have not been fully achieved, but this report represents evidence of considerable progress to serve as a basis for a decision for continuation funding.

The university teams and their international partners provided insights into monitoring urban change and local capacity building. This work illustrated the difficulty in reconciling the need for uniform and consistent urban indicators from the top down or global perspective, while at the same time developing a bottoms-up perspective of developing useful data for local planning and policy analysis. With a high level of participation and influence by the international partners, the five project teams emphasized the bottoms-up perspective and developed data and training materials suited to local needs.

As a result of different local needs and interests, the university teams worked independently and the resulting data, indicators, spatial analyses, and training materials are not very consistent. Future research will compare and evaluate these differences carefully to provide a basis for a more concerted effort, while at the same time allowing for addressing unique needs of local partners.

The instructional materials that have been developed by the five universities vary in content and form. They are referred to as Exercises, Labs, Modules, and Training Materials. Some are Internet-based exercises while others are support classroom presentations. Each set of instructional materials was developed from available resources at each institution and the local

needs of international partners. Consequently, GIS-based instructional materials lack consistent “look and feel” and content. The follow-on project will compare approaches and methods, and work toward a common look and feel of training materials, while at the same time allowing for unique features needed for different types of analyses and differing local needs. Similarly, the Project web pages for each of the universities have different content and formats. Follow-on research will strive for a common look and feel of web pages for the five universities. Both will have to be comparative and collaborative efforts to assess strengths and weaknesses of current training materials and web pages. These differences are illustrated by the list of training materials developed by the five universities.

The University of Illinois at Urbana-Champaign

Exercise 1	Container: Number of facilities contained within a given areal unit
Exercise 2	Covering: Number of facilities within a given distance from a point of origin
Exercise 3	Minimum Distance: Distance between a point and nearest facility
Exercise 4	Gravity - Network based facility service area
Exercise 5 –	Accessibility to linear infrastructure (Arc IMS implementation pending)

The University of Iowa

- Laboratory 1 Making a choropleth map in ArcView
- Laboratory 2 Geocoding by address using ArcView
- Laboratory 3 Spatial filtering using DMAP and ArcView
- Laboratory 4 Probability testing using DMAP and ArcView
- Laboratory 5 Data manipulation and spatial interpolation
- Laboratory 6 Spatial interpolation: Analysis of Iowa breast cancer patients
- Laboratory 7 Analysis of Iowa breast cancer patients: Distance to treatment facility
- Laboratory 8 GIS and health resources

Virginia Commonwealth University

Training materials

- Linking data sets with maps
- Digitizing
- Map projections
- Scale
- Data integration
- Aggregation/disaggregation of spatial data
- Map design
- Analysis

West Virginia University

- Module 1 Data preparation
- Module 2 Digital mapping
- Module 3 Introduction to GIS
- Module 4 Image analysis
- Module 5 Internet map server
- Module 6 Model building

University of Wisconsin-Milwaukee

- Laboratory 1 Introducing ArcView
- Laboratory 2 Digitizing
- Laboratory 3 Exploring different data sets
- Laboratory 4 Query/overlay/buffer
- Laboratory 5 Analysis Template
- Laboratory 5 Basic cartography

This project has provided experience with the transfer of expertise in evaluating urban indicators using spatial analytical techniques and geographic information systems from participating universities to paired organizations within the emerging nations. This transfer of knowledge utilized web-based training programs.

This project also enabled the building of local capacity to collect and use policy-related indicators. The relationship between the UCGIS member universities and their international partners increases the capacity within the developing countries to continue urban indicator analysis on a long-term basis.

Now that the five university teams have experience with urban indicators at the sub-area level and with GIS-based instructional materials, it is timely to compare experience and results. The task would be to assess strengths and weaknesses of various measures and approaches, and to explore opportunities for increasing consistency. Much can be gained by sharing experiences and approaches.

The GIS and spatial analysis methods used in this project were adapted to application in developing countries that are characterized by poor data and where local authorities have limited capacity to monitor urban growth and change. The emerging colonias settlements along the US-Mexican border are a case in point. The Office of Housing and Urban Development defines colonias as “rural communities and neighborhoods located within 150 miles of the US-Mexican border” (<http://www.hud.gov>). Their conditions mirror those of informal settlements on the urban fringe in developing countries in that they lack adequate infrastructure and other basic facilities or develop spontaneously without jurisdictional sanction and viable livelihood systems.

For regional and local authorities attempting to respond to this growth phenomenon, the various methods used in the context of this project offer possibilities. Remotely sensed data (air photography and satellite imagery) can be used to estimate the pace of colonias growth as well as to assess the threat of encroachment to ecologically sensitive areas and farmland. Second, an integration of remotely sensed data and resultant GIS coverages can be used both as a predictive and planning tool for infrastructure improvement, assessing housing conditions, and demand estimation of related basic facilities, for example: water access, electricity, sanitation, schools and recreation.

References

Leitmann, J. 1999. *Sustaining Cities: Environmental Planning and Management in Urban Design*. New York: McGraw-Hill.

Banerjee, T. 1996. Role of indicators in monitoring growing urban regions: The case of planning in India's national capital. Journal of the American Planning Association 66 (2): 222-235.

Nedovic-Budic, Z. 2000. Geographic Information Science implications for urban and regional planning. URISA Journal 12 (2): 81-93.

Portes, Alejandro and Michael Johns. 1989. The polarization of class and space in the contemporary Latin American city. In W. Canak (ed.), *The Lost Promises*, Westview Press, Boulder.

Sawicki, D.S and P. Flynn. 1996. Neighborhood indicators: A review of the literature and an assessment of conceptual and methodological issues. Journal of the American Planning Association 66 (2): 165-183.

UN Global Urban Observatory
(<http://www.urbanobservatory.org/indicators/>)

Additional Documents

Budget Statement

Individual University Final Reports

University of Illinois, Urbana-Champaign

<http://www.urban.uiuc.edu/projects/ucgis/index1.htm>

University of Iowa

<http://www.uiowa.edu/~gislhth/rev/>

Virginia Commonwealth University

<http://www.has.vcu.edu/usp/gis.htm>

West Virginia University

<http://beira.geo.wvu.edu>

University of Wisconsin-Milwaukee

<http://www.geog.uwm.edu/ucgis/>