

Urban Slum Monitoring¹

Jan Turkstra and Martin Raithelhuber

Abstract

One of the United Nations Millennium Development targets is to 'achieve significant improvement in lives of at least 100 million slum dwellers, by 2020'. To monitor progress on this target a first step is to develop an operational definition to identify slum settlements. The indicators selected are: access to water and sanitation, sufficient living area, a house with durable material on a non-hazardous location and with tenure security. This paper describes a methodology to identify slums at the sub-city level in different regions of the world. For each of the five indicators different data sets are identified, which includes the use of high-resolution satellite images. GIS models are presented to integrate the different indicators. The collaboration between ESRI and UN-HABITAT in the 1000 Cities GIS Programme and the methodology described in this paper are facilitating the use of GIS software for slum monitoring for cities in developing and transition countries.

Slums: The Urbanization of Poverty

Over 6 billion people currently inhabit the world and, despite a reduced population growth rate, this number is expected to increase to 8 billion over the coming decades (United Nations Population Division 2001, 2002). It is important to note that most of this growth will occur in cities of developing countries. Differences in income, living conditions, access to services and opportunities for development are seen as a major source of many conflicts facing today's world and can be observed at the global level (developed / developing countries), within a country (rich and poor regions) but also within cities where the gap between the wealthy living in gated communities and the poor living in intolerable housing conditions is expanding. In many developing countries, lack of employment opportunities in the rural areas contribute to urbanization, which is further accelerated by natural population growth. Often, however, cities do not offer sufficient employment opportunities for their rapidly increasing population. As a consequence, many cities are characterized by a high incidence of informal employment opportunities, which are unstable and yield only low incomes. The resulting poverty in combination with a lack of affordable housing are driving forces behind the formation of informal settlements commonly know as slums, which offer only sub-standard living conditions to their inhabitants. The term "urbanization of poverty" describes the process of cities becoming more and more the places where the poor of the world can be found.

It is a myth that the people in the cities are automatically better off compared to those living in the rural areas. Recent research (UN-HABITAT, 2003b) has shown that 924 million people, or 31.6% of the world's urban population, are living under unacceptable conditions, and this figure will increase unless development agencies scale up their efforts to improve the living conditions of current and future urban dwellers. The fight against poverty has to take place in both cities and rural areas or it might well be lost. Still, urban poverty as a topic receives relatively little attention from donor agencies. Why is that so?

Unmasking Urban Poverty

Aggregation of data at the city level hides the stark contrast of income and living conditions between better-off urban citizens and the urban poor by providing just a single figure. In Kenya, for example, rural under-five mortality rate, which is a major measure for lack of underdevelopment, lies at 113.0, while Nairobi city has only half of that rate (61.5). Without more in-depth analysis, the problem would

seem to be graver in rural areas, while the city is doing not so bad. A closer look, however, reveals that the 40% of Nairobi's population living in slums have an under-five mortality rate of 150.6, which is considerably higher than in rural areas (APHRC 2002, p. 87). The tradition of providing urban versus rural estimates has masked the crisis cities are facing. Figures for urban areas average out rich and poor, by providing a single number that overlooks pockets of poverty and destitution in cities. However, analysis of data at the intra-city level is fundamental for accurate policy information. To be able to take into account the needs and capabilities of a city, local policy makers need to be informed about the consequences of vastly different living conditions. In addition to that, the urban poor have to face a set of challenges, which is different from rural poverty. Urban poverty is characterized by e.g. a high reliance on the cash economy while income from subsistence agriculture is rare; living in overcrowded areas with an insufficient, overused water and sanitation infrastructure; exposure to hazards and crime, as well as social fragmentation. A single pit latrine can serve 200 households or more; a standpipe at the roadside may serve hundreds of people with water that does not even have drinking water quality.

Defining Slums

A first step to be able to quantify and locate the slum population is to develop an operational definition of the term "slum". Experts at a UN-HABITAT meeting held in 2002 agreed on the following definition: "A slum is a contiguous settlement where the inhabitants are characterized as having inadequate housing and basic services. A slum is often not recognized and addressed by the public authorities as an integral part of the city" (UN-HABITAT 2003c, p. 6). That is one of the reasons why little data on slum dwellers can be found. UN-HABITAT therefore developed a household level definition in order to be able to use existing household level surveys and censuses to identify slum dwellers among the urban population. A slum household is a household that lacks any one of the following five elements (UN-HABITAT 2003c, p. 7):

- Access to improved water,
- Access to improved sanitation,
- Security of tenure (the right to effective protection by the state against arbitrary, unlawful eviction),
- Durability of housing (including living in a non-hazardous location) and
- Sufficient living area (no overcrowding).

On the basis of this definition the slum population of the world was estimated by country using a total of around one million records of different household surveys. Figure 1 shows that many countries in Africa have a very high percentage of urban households living in slum conditions, which is mainly caused by the lack of access to improved water and/or improved sanitation. Sub-Saharan countries face an especially difficult situation as they host some of the fastest growing cities in the world. However, Figure 2 shows that some African countries such as Egypt and South Africa have made progress in reducing the slum population over the period 1990-2001.

Figure 1 Slums of the World 2001 (source: UN-HABITAT, 2003b)

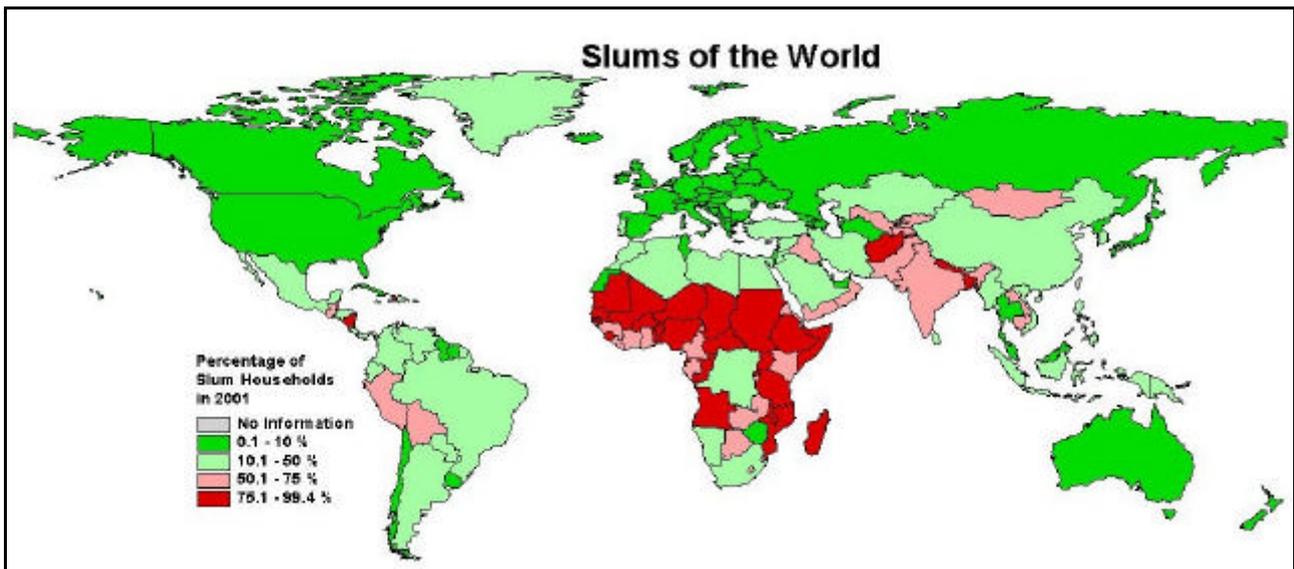
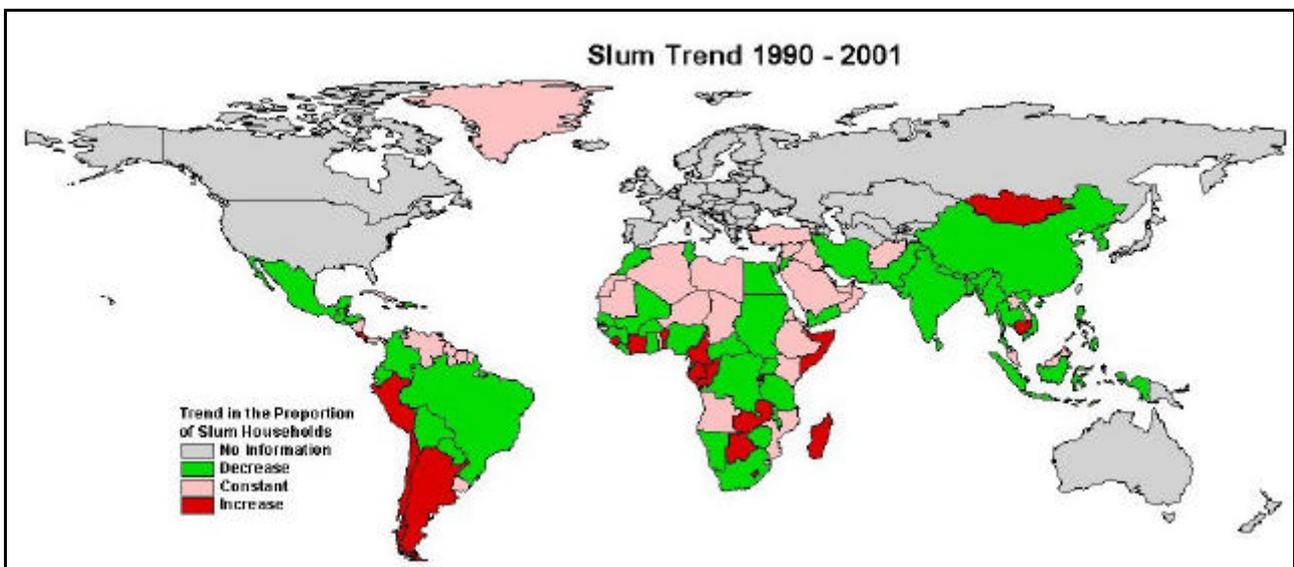


Figure 2: Slum Trends 1990 - 2001 (source: UN-HABITAT 2003b and Demographic and Health Surveys 1990)



UN-HABITAT took up the challenge not only to monitor and report on these slum developments by providing statistics for global and national policy making but also to develop methods to intervene at the local level. To be able to improve the living circumstances of the slum population it is required to identify, quantify, and locate slum dwellers at a detailed spatial level, analyse this information and formulate evidence-based urban policies and programmes. That is the one of the purposes, for which UN-HABITAT uses GIS.

Cities: places for the rich and the poor

Generally, the concentration of people and activities in cities is regarded as being economically beneficial for a country. This is supported by the fact that highly urbanized countries are often more developed, reach higher GNP and score higher on the UN Human Development Index. They also tend to have fewer slums. However, more complex factors determine slum incidence and interventions should be based on a thorough analysis of the local and national context.

Table 1: Urbanization and Slum Incidence (Source: State of World Cities Report 2004, UN-HABITAT)

Human Development Index	Urban Population	Slum Dwellers as % of Urban Population
High	78.5%	7.6%
Medium	42.6%	35.6%
Low	29.7%	79.7%

What the aggregate figures in Table 1 hide is the sharp contrast and unequal distribution of this relative wealth within cities. This paper uses two case studies from African cities to demonstrate the vast inequalities existing within cities of countries that both less developed and have a low level of urbanization. Figure 3 for example shows the differences in urban layouts (e.g. densities) of where the rich and the poor are living in Nairobi. Land is unequally distributed with 60% of the population of Nairobi living on only 8.7% (4490 ha) of the total area of the city of Nairobi.

Figure 3: A Small Format Aerial Photograph of Nairobi covering the Kibera Slum area sandwiched between adjacent formal settlements and a golf course. Courtesy: Paul Hofstee, ITC, The Netherlands.



In order to improve the living conditions of these slum areas, detailed spatial information is required. Local planners, infrastructure engineers and communities know best where these areas are located, what the living conditions are and what the daily hardship of coping with poverty is. But more knowledge is

required based on detailed information on the socio-economic characteristics of the households and physical conditions of the neighbourhood, including the geo-visualisation and mapping, before solutions can be developed. Traditional approaches such as physical infrastructure projects have had only a modest impact, especially when the projects were not integrated with other aspects of poverty such as employment. Slum policies should be integrated with urban poverty reduction policies, which have to go beyond the physical dimension of slums and address underlying problems.

In order to address the problems of slums and assess the difference between the living conditions of the poor and the rich, UN-HABITAT launched the "Monitoring Urban Inequities Program" (MUIP). MUIP was specifically designed to gain information and knowledge about inequality and intra-city differentials in development. The programme aims at filling gaps of information especially on the impact level thus contributing to monitoring of the Millennium Development Goals. Using the results of MUIP, development stakeholders will be in a better position to support local policy formulation and develop effective, locally embedded intervention programs to improve the living conditions of slum dwellers.

In the next paragraphs, two MUIP case studies (Nairobi and Addis Ababa) are presented, which illustrate the data source problems and corresponding data processing methodologies in a GIS environment. Recently (e.g. IKONOS since 1999, QuickBird since 2001) available high-resolution satellite images (Figure 4) were used as source of data and as backdrop images for 'putting the poor of the map', which is an important aspect for gaining political support and communicating results to non-technical audiences at the local level.

Figure 4: QuickBird Satellite image of Nouakchott- Mauritania, 2003, with distinct patterns of planned and the unplanned urban settlements. Courtesy MAPS Geosystems, © DigitalGlobe



Urban Poverty Mapping

In principal, there are three different methodologies of poverty mapping depending on the availability of data.

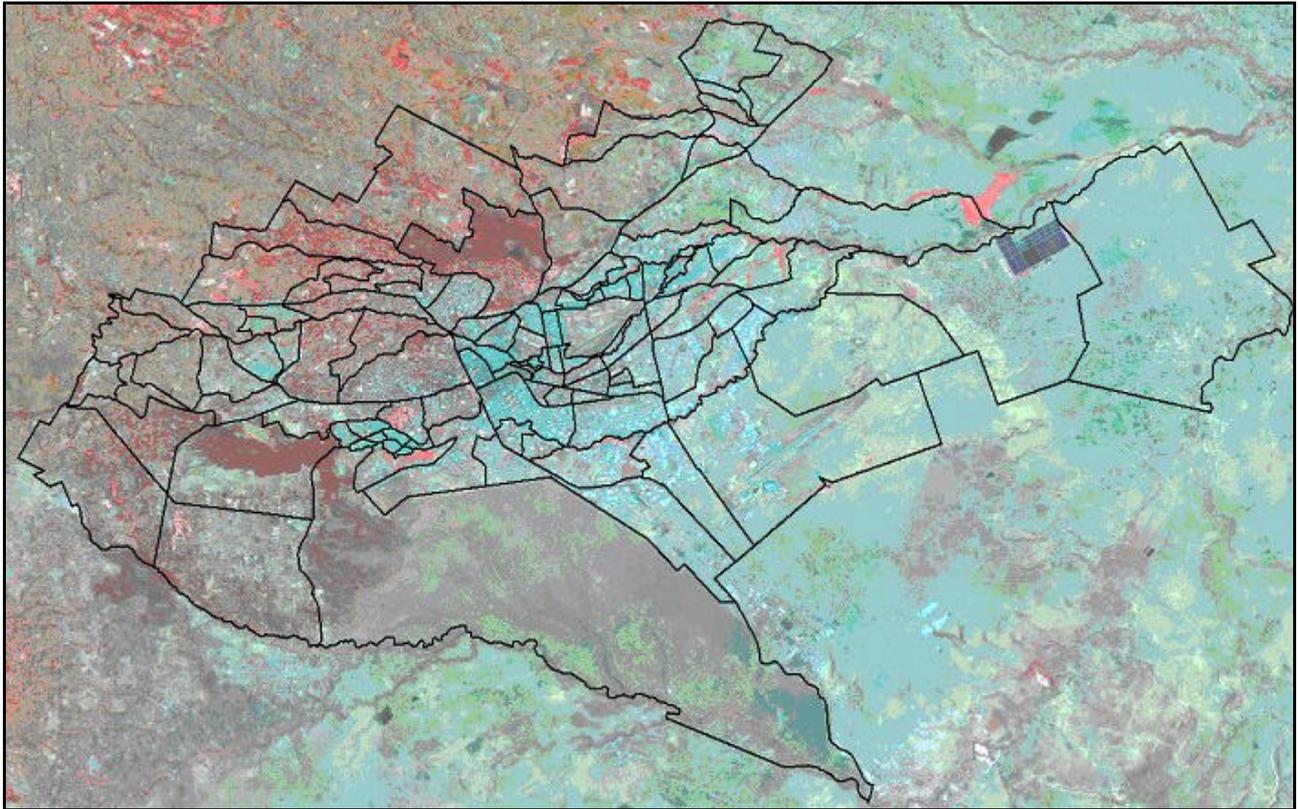
1. Full data coverage (case study Nairobi). When a complete, recent census dataset is available covering all the required indicators and the corresponding maps exist, the program can focus on data analysis, mapping and follow-up (policy support). In case a reliable, recent census is available these data are very useful. The crucial question is whether the variables included in the census are covering the information required for the specific needs of an urban inequity study or poverty study. In many cases, e.g. income data will not be available.
2. Sample Household Surveys (case study Addis Ababa). In case auxiliary data (such as old census data, social welfare records, municipal population registration, large demographic and health surveys) are available, these can be related to data obtained through a specifically designed sample household survey. By developing a model to identify the relationship between the survey and the auxiliary data more reliable estimates can be made and it is possible to extrapolate the information to areas not covered by the household survey.
3. Qualitative and secondary data. In case there is no capability / resources available for a household survey and there is neither an up-to-date census, alternatives are required for an urban inequities study. A possibility is to use a combination of local expert knowledge, high-resolution images and local records. This is sometimes referred to as the development of 'participatory poverty profiles'. Thematic layers (land use, location of slums, hazard zones, water coverage) can be developed using specific local knowledge supported by good base maps (or recent high-resolution images). An additional layer is the boundaries of administrative areas (enumeration areas, neighbourhoods) with local available records. The combination of these data sets in a GIS can generate a wealth of information on urban inequities and can easily deal with the so-called modifiable areal unit problem. The advantage that is locally generated, and thus easier for institutional embedding.

Case study Nairobi

Nairobi has grown rapidly over the last decades. While some 500,000 people inhabited the city in 1969, by 1999 this number had expanded to 2,1 million, around 40% of which were living in slums. The forecast is that Nairobi will be the home of over 3 million people in 2010.

The fourth (since independence in 1963) Population and Housing Census of Kenya was carried out in August 1999. For this study, a 5% sample of the households was drawn for Nairobi using a sampling method that made sure that all spatial sub-units of the city were represented in the sample. The spatial sub-units are the 110 sub-locations of Nairobi, which are on an average inhabited by 20,000 people. These sub-locations contain several census enumeration areas, which constitute the smallest spatial unit of a census. However, the boundaries of the over 4000 enumeration areas in Nairobi have not yet been digitised. Thus, the enumeration area level could not be used as for a spatial analysis. Still, on the basis of this relatively large sample (102,224 people) the large differences within the city as well as the spatial heterogeneity of living conditions could be analysed at the sub-location level.

Figure 5: Sub-locations in Nairobi (n=110) with a LandSat satellite image as a backdrop image



In the 5% dataset from the 1999 Census, each household of the sample was classified as slum/non-slum using UN-HABITAT's slum household definition. In addition to that, each Census Enumeration Area (EA) was classified as slum/non-slum using the results of a Slum Area Identification Survey jointly carried out by the Kenya Central Bureau of Statistic, the Ministry of Roads and Public Works/Department of Housing, and UN-HABITAT. Among the 4774 EAs, 1389 (29%) were identified as slum. Table 2 shows that 40,030 (39.2%) people out of a total sample of 102,224 people are classified as living in slum conditions. The table also shows that most slum dwellers live in areas classified as slums, while a minority lives in by-and-large non-slum areas. This indicates that EA's are not completely, although to a large extent, inhabited homogeneously either by slum or non-slum households. It is very likely that in many cases boundaries of slum areas are not exactly coinciding with the boundaries of the EAs. In addition to that, small clusters of slum households may exist in better-off neighbourhoods. Vice versa, a certain number of relatively well-to-do households exists in slum areas. The heterogeneity is even stronger at the sub-location level, which is the spatial unit we will use for the visualization of the variables and composite indexes.

Table 2: Distribution of slum population by slum – non-slum enumeration areas (Source: Kenyan Population and Housing Census 1999, own calculations)

		No. of Persons Living in		Total
		Slum Households	Non-Slum Households	
Slum EA	No. of Persons	27,413	4,135	31,548
	% within EA Slum type	86.9%	13.1%	100.0%
Non-Slum EA	No. of Persons	12,617	58,059	70676
	% within EA Slum type	17.9%	82.1%	100.0%
Total	No. of Persons	40,030	62,194	102,224
	% within EA Slum type	39.2%	60.8%	100.0%

Figure 6: Distribution of slum incidence across Nairobi's sub-locations illustrating that Enumeration Areas classified as slums are concentrated in a limited number of sub-locations (Source: Kenyan Population and Housing Census 1999, own calculations)

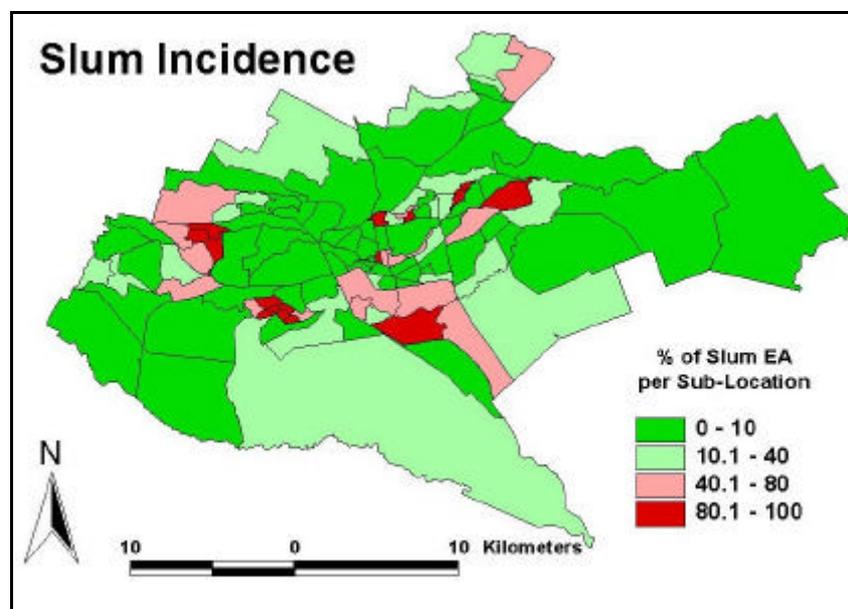


Figure 6 demonstrates the spatial inequality of living conditions in Nairobi using slum incidence, a combination of variables based on UN-HABITAT's slum household definition. Such thematic maps are useful to geo-visualise the differences across the sub-locations and can be rapidly produced for many of census variables or combination of variables. High-resolution satellite imagery, which has become available recently, is another important source of information especially in data poor environments. Figure 7 shows two data layers: the image is a QuickBird satellite image from 2002 depicting part of the Kibera slum area, the Nairobi dam, and surrounding areas. The second layer shows the sub-location boundaries, while Table 3 displays some selected attributes for three sub-locations. This area specific information especially at a detailed disaggregated spatial level will not only allow to visualise socio-economic or physical characteristics of the population and their dwellings but also facilitate the development of local policies addressing issues of poverty and geographic targeting of (public) investments and subsidies.

Figure 7: A Quickbird satellite image from 2002 with the boundaries of census areas (sub-locations) of Nairobi.

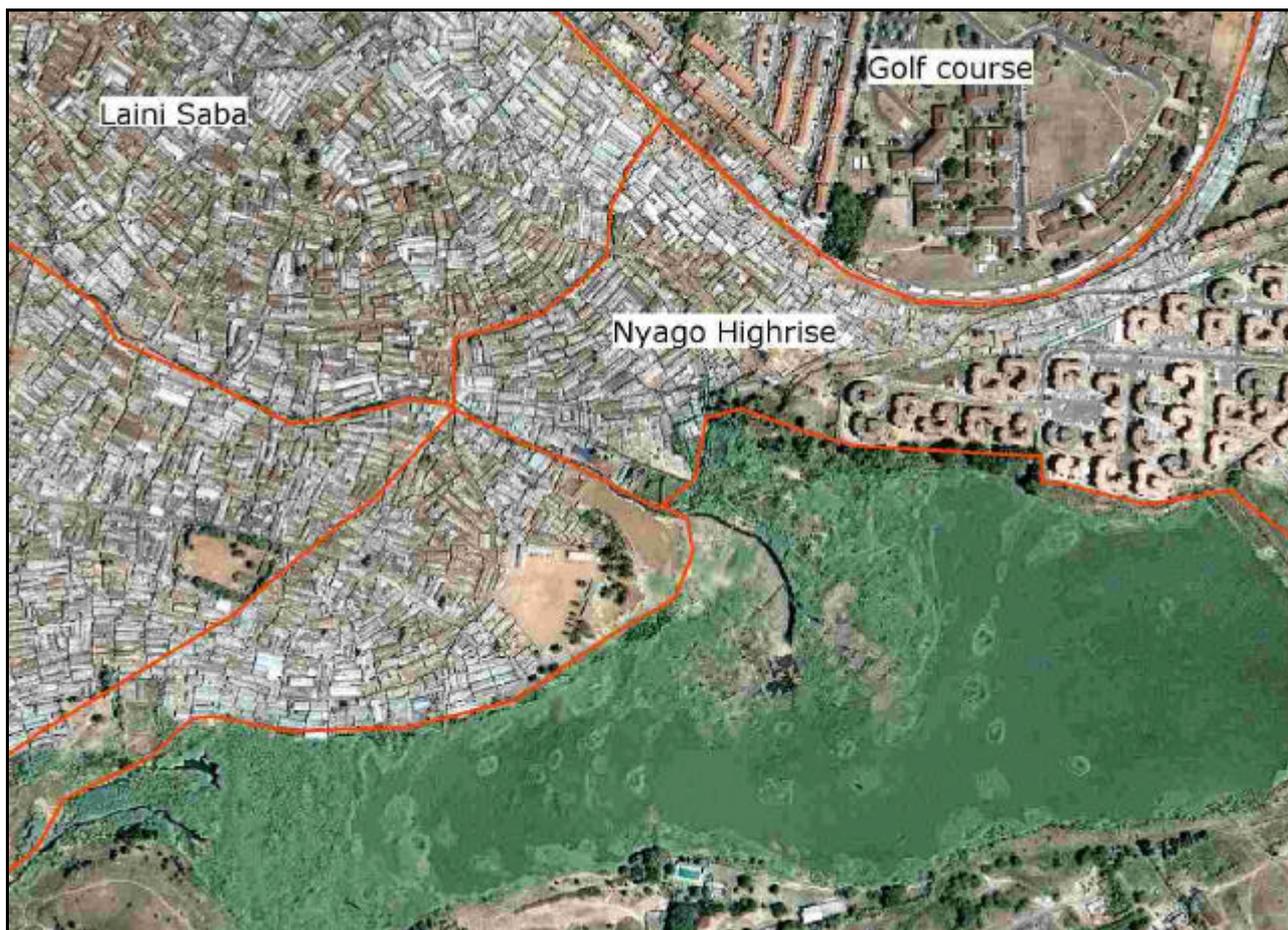


Table 3: Development differences in Nairobi at the sub-location level (Source: Kenyan Population and Housing Census 1999)

Sub-Location	Laini Saba	Golf Course	Nyayo Highrise
Population	26,800	10,260	25,440
Area	29 Ha	168 Ha	46 Ha
Population density	924 P/Ha	61 P/Ha	553 P/Ha
Slum Households	99%	10%	70%
Connected to main sewer or septic tank	1%	88%	29%

Case Study Addis Ababa

In Ethiopia, the last population and housing Census was conducted in 1994, which means that these data are too outdated to be useful for an intra-city analysis. In order to identify urban inequities at a disaggregated level, UN-HABITAT developed a household questionnaire within the MUIP, which was customized to reflect the specific reality of Addis Ababa. The questions covered a wide variety of topics such as access to water and sanitation, solid waste disposal, building material, security of tenure, social capital as well as health and education. Over 1500 household interviews were conducted in November 2003.

Addis Ababa the city is divided into 10 sub-cities, which are further divided into a total of 203 kebeles. Figure 8 shows the boundaries of the sub-cities, which include large parts of agricultural land. This becomes even more evident in Figure 10, which shows the 18 rural kebeles. In order to avoid an inclusion of the rural parts of Addis Ababa into this specifically urban survey, the rural kebeles were

excluded from the sample frame. Then, a sample of 54 kebeles from the 185 urban kebeles was selected (total of 203 kebeles minus 18 rural kebeles). In a second step, in each of these 54 kebeles between 25 and 30 households were selected for an interview.

Past experiences have shown that often information from censuses or households surveys is being misinterpreted. That is especially true for information derived from water and sanitation variables. Typically, census questionnaires inquire the source of water (piped water, standpipe, river, ...) and the type of sanitation used by household members (flush toilet, septic tank, open defecation, ...). Many people in slum areas correctly respond to this answer by indicating that they are getting water from a pipe. This, however, means that there is a piped water connection somewhere in the area, from where they bring the water to their house in buckets or water canisters, after queuing for hours and paying up to ten times the metered prices of individually connected households. The MUIP surveys therefore introduce the concept of "Improved water", which combines the variable on the water source, availability (a minimum of 20 litres per person per day), time spend daily on collecting water (less than 1 hour per household per day) and affordability (a maximum of 10% of monthly income spent on water). Only households fulfilling all these criteria are considered to have access to improved water. A comparison of Figure 9 and 10 shows the variation within the city but also the loss of information through aggregation from kebele to sub-city level. The map showing improved water at sub-city level indicates that in sub-city Cherkos 84% of the households have access to improved water, while the improved water at kebele level shows that from the 5 kebeles actually covered by the household survey in one kebele just 73% of the household have access to improved water.

Figure 8: LandSat image of Addis Ababa and Sub-city boundaries

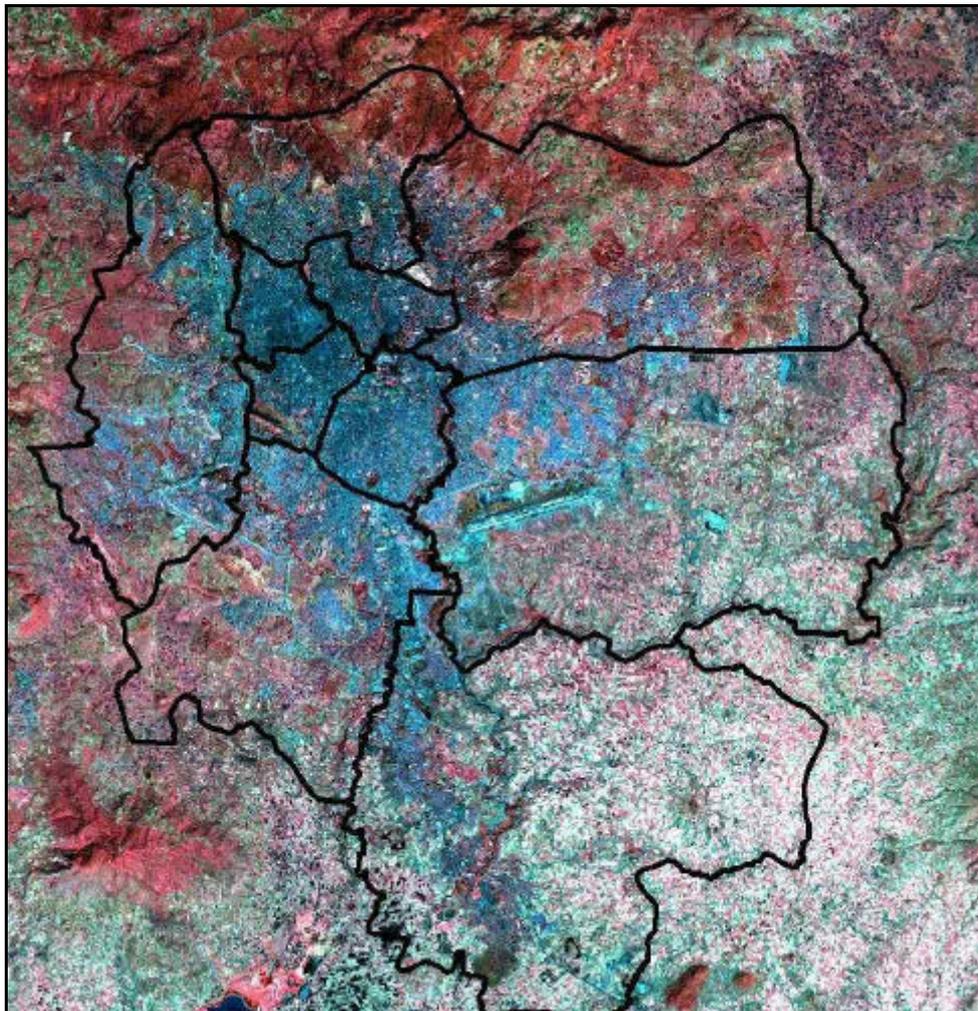


Figure 10 also shows those kebeles, which were not covered by the household survey. Covering a whole city at a spatially disaggregated level such as the kebele level would require a much larger sample and cause much higher costs. If auxiliary data (such as recent census data, social welfare records, municipal population registration, large surveys) are available these can be related to the data obtained through the household survey. By developing a model to identify the relationship between the survey and the auxiliary data more reliable estimates can be made and the results can be extrapolated to areas not covered by the household survey. Unfortunately, the fact that in Addis Ababa the most recent Census data is from 1994 makes such an extrapolation unreliable. An additional problem is that the administrative level of the sub-cities is new and many kebeles boundaries were changed during their introduction. This makes a comparison of datasets and relating variables difficult.

Figure 9: Access to improved water at sub-city level (Source: UN-HABITAT MUIP Survey Addis Ababa 2003)

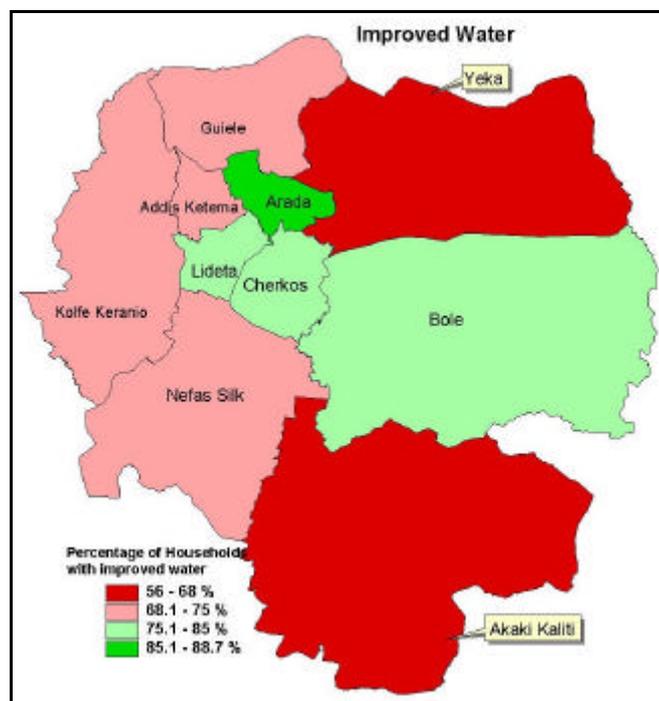
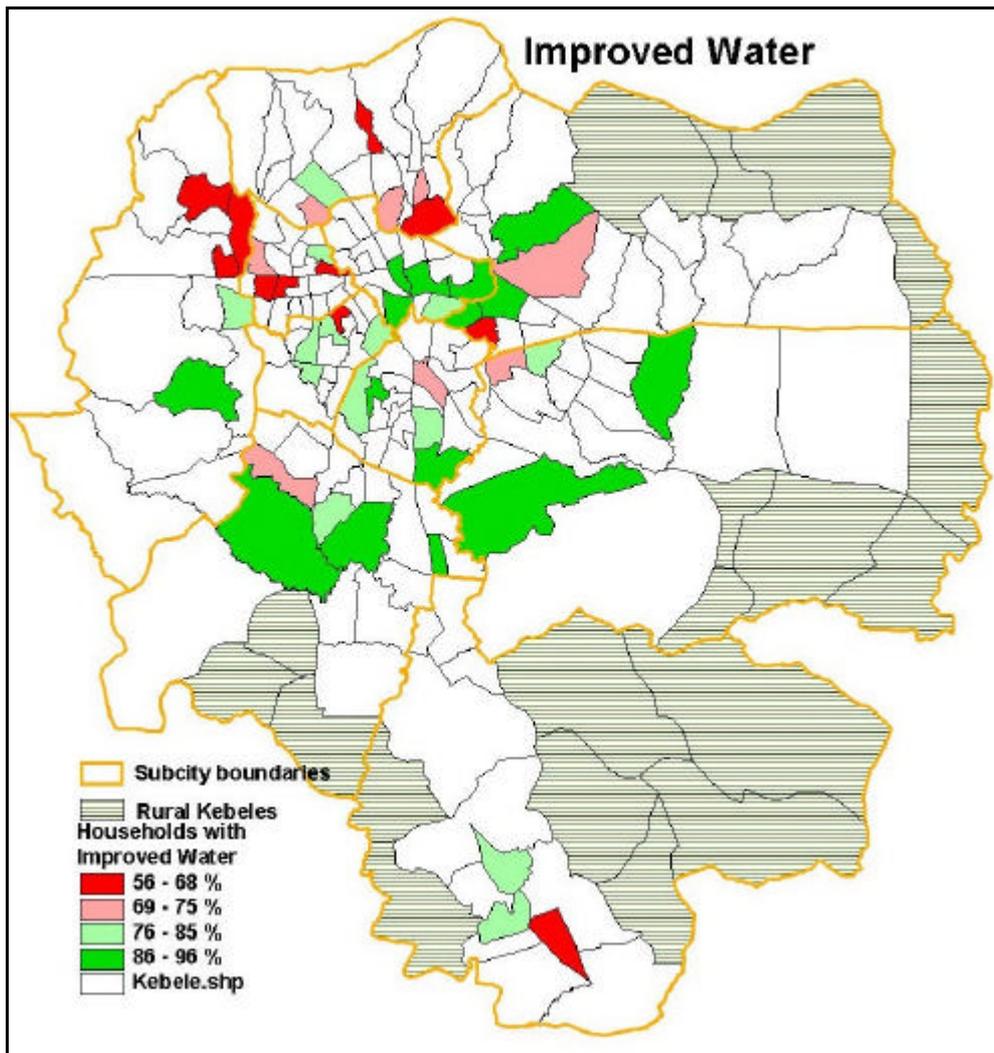


Figure 10 Access to improved water at kebele Level (Source: UN-HABITAT MUIP Survey Addis Ababa 2003)



Conclusions

Both case studies have demonstrated that mapping of the spatial variations in living conditions is a powerful tool to visualise urban inequalities, or, in a more programmatic language, urban inequities. GIS communicates this message in a convincing way, which is easy to understand for an audience of mostly non-technical decision-makers at the local level. Especially in combination with high-resolution satellite images as an objective medium (what the sensor sees is what you get), GIS maps as a communication tool are very convincing. Other useful opportunities for this combination lie in e.g. the verification of other data sources or using it as a data source itself (counting of buildings, population estimation). There are two important actions to be taken: the first one is that actions need to be undertaken to improve the living conditions of slum dwellers. These strategic actions plans need to be developed not only at the sector level (e.g. water) but preferable at the district or neighbourhood level (e.g. the sub-cities and kebeles of Addis Ababa) with a variety of stakeholders including the residents themselves. The second action is that GIS should not be seen as a project or product ("project GIS") but be part of an incremental development process, in which spatial databases are developed gradually across different institutions ("community GIS"). The improved quality (up-to-date, compatibility, accuracy) of such an inter-institutional spatial data infrastructure will allow the institutionalisation of the monitoring activities described in this paper without exorbitant costs. Since a number of years, the Global Urban Observatory Section at UN-HABITAT has assisted governments and local authorities to monitoring human settlements

at country and city level. Now, increasingly support is giving to local level partners (so-called local urban observatories) to monitor the impact of policy and development intervention on the living conditions at the intra-city level using GIS. The challenge ahead is to embed GIS within local communities and institutions, generate genuine interest of politicians, and support this development with effective actions. We do hope that the availability of GIS software through an ESRI grant to UN-HABITAT partners (1000 Cities GIS Programme) will serve as a stimulation to our partners, and help them to address the urgent problems at hand rather than creating databases, only. In that respect, the introduction of monitoring systems and community GIS is a first step towards developing targeted, evidence-based proposals to improve the living conditions of the one billion slum dwellers worldwide.

Acknowledgement

The authors like to thank the Kenyan Central Bureau of Statistics to make the Census data for Nairobi available and are grateful to Mr. Ning Deng, a PhD researcher, who has been working on the Urban Inequities Studies of Nairobi and Addis Ababa. Mr. Aki Stavrou was the principal consultant for the household survey in Addis Ababa, and Mr. Gora Mboup, UN-HABITAT, was in charge of data processing.

Endnotes

1 The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries or regarding its economic system or degree of development. The analysis, conclusion and recommendations of this paper do not necessarily reflect the views of the United Nations Human Settlements Programme (UN-HABITAT), the Governing Council or its Member States.

References

- APHRC (2002): Population and Health Dynamics in Nairobi's Informal Settlements. Report of the Nairobi Cross-Sectional Slums Survey (NCSS) 2000. Nairobi.
- UN-HABITAT (2003a); The Challenge of Slums, Global report on Human Settlements 2003. Nairobi.
<http://hq.unhabitat.org/register/shop.asp>
- UN-HABITAT (2003b); Slums of the World: the face of urban poverty in the new millennium. Nairobi.
<http://www.unhabitat.org/publication/slumreport.pdf>
- UN-HABITAT (2003c): Guide to Monitoring Target 11: Improving the lives of 100 million slum dwellers. Nairobi.
- UN-HABITAT (2004); Urban Poverty and slums, intra-city differential study of Nairobi, interna; report UN-HABITAT. Nairobi.

Authors

¹ Dr. Ir. Jan Turkstra is an urban planner and working at the International Institute for Geo-Information Science and Earth Observation (www.itc.nl) and seconded to UN-HABITAT to support the GIS activities of UN-HABITAT (jan.turkstra@unhabitat.org, turkstra@itc.nl)

¹ Dr. Martin Raitelhuber is an urban development specialist working with the Global Urban Observatory at UN-HABITAT. He is the task manager of the 1000 Cities GIS Programme (www.unhabitat.org/guo, martin.raithelhuber@unhabitat.org)