25 January 2006

Ruth DeFries, Chair
Otis B. Brown, Jr., Vice-Chair
NRC Decadal Survey
Panel on Land-use Change, Ecosystem Dynamics and Biodiversity

Dear Dr. DeFries and Dr. Brown:

As members of a group of social and Earth scientists who recently convened at a workshop, "Estimates and Projections of City and Urban Populations" (January 9-10, 2006, New York City), we wish to stress the critical role that the next generation of satellites should play in researching the nature and dynamics of the world's urban areas. The United Nations Population Division forecasts that over the next 30 to 40 years, the Earth's population will grow by some two billion persons, the vast majority of whom (over 90 percent) will be added to the cities and towns of poor, developing countries. What is underway is a fundamental reshaping of patterns of human settlement across much of the globe. This urban transformation can be expected to alter the terms upon which the human and natural environments interact, whether in the ecosystems with which urban areas are linked, in the extent and nature of air pollution, in the consumption of fuels and other non-renewable sources of energy, or in human vulnerability to hazards.

As social scientists prepare their methods and data sources for an urban future, they must grapple with gross deficiencies in basic information about the dimensions of urban populations in poor countries. At present, there is no systematic program underway in the social sciences whereby spatial information on urbanization is gathered. In many poor countries—especially in Africa, low-income Asia, and parts of the Americas—conventional methods of data collection do not delineate the spatial extents of large cities, leaving planners without the spatially disaggregated data they need to anticipate urban growth. Social scientists—economists, demographers, sociologists, geographers, political scientists, and public health analysts—cannot pursue core research questions without data on the spatial features of urban settlements. As a recent National Research Council study (2003) report argues, central scientific and policy questions will go unanswered until urban research can be firmly embedded within a spatial context.

Remote sensing approaches are by far the most systematic means for collecting a significant share of this spatial information. While surveys, censuses, and other conventional methods will remain essential in understanding urban socioeconomic trends, the value of these methods would be much enhanced if they could be combined with remotely sensed urban data. There is growing recognition of the scientific potential. As demonstrated by the enclosed attendance list of the urban workshop, satellite-derived information about urban areas provides a platform for fruitful interdisciplinary collaboration among social and Earth scientists working on urban research issues.

The social science needs fall into three broad areas:

1. Detection and characterization of the geographic "footprints" of urban settlements of all sizes.
2. Objective identification of intra-urban classes, such as core-urban, suburban, and ex-urban; and detection of the areas of cities that may be disproportionately poor (with less formal dwellings and infrastructures).

3. Detection of changes in intra-urban and urban footprints over time, with sufficiently regular updates to inform planning.

Access to these basic data would facilitate the study of the drivers of urban demographic dynamics and composition, help scientists to understand the social, economic and demographic relationships between cities of different sizes, and enable measurement of the gradations of the urban-rural continuum. Improvements in the urban geographic knowledge base would also further research in related fields such as public health and political science. Examples include the distribution of health services or people's exposure to environmental and man-made stresses (natural hazards, air pollution, and the like), and identification of urban populations living in areas in which local governmental authority is ill-defined. These are issues with significant implications for human welfare and ones in which research could help identify improved strategies for sustainable development.

As we mentioned at the outset, urban and suburban areas play an important yet often overlooked role in Earth's physical and ecological systems. Improving the representation of urban/suburban land cover at regional scales could yield tangible benefits in our understanding of mesoscale climatic, hydrologic, and ecologic processes. Urban and suburban land cover is physically distinct from other land cover classes and generally not represented accurately in physical process models that rely on thematic classifications for input. The land cover classifications that drive most global and regional scale models generally represent urban and suburban land cover in terms of one or at best two homogeneous classes. However, it has been shown that urban and suburban areas are far more heterogeneous than most other land cover types and do not necessarily share the same physical properties worldwide (Small, 2005). It is necessary to quantify the physical characteristics of this heterogeneity and to determine the spatial scales at which it is most pronounced in order to ensure that human-modified landscapes are accurately represented in physical and ecological process models.

There is potential for near-term gains in our understanding of mesoscale dynamics in at least three areas related to urban/suburban land use. For example, it is unknown the extent to which moderate scale (100 m – 10 km) variation in urban/suburban vegetation cover influences mesoscale atmospheric convection. Studies such as Baidya-Roy and Avissar (2000), Li and Avissar (1994), Jin and Shepard (2005) and Grossman-Clarke et al. (2003) suggest that more detailed representation of urban land cover has a significant influence on mesoscale climate model performance. Further research will indicate the minimum resolution at which urban/suburban vegetation needs to be represented in these models.

Secondly, more information is needed on how the density and spatial distribution of pervious and impervious surfaces in the suburban mosaic influence hydrologic fluxes in partially developed watersheds. The importance of surface permeability to hydrologic processes is understood (e.g., Smith et al., 1992) but, to our knowledge, the effect of infill density and fragmented development on basin scale runoff has not been quantified, although some work suggests that higher densities may be beneficial (Richards et al., 2005). This is already recognized as a significant issue for policy makers (Wolosoff and Endreny, 2002). Yet, it is presently unknown whether there is a critical scale of infill density beyond which the hydrologic consequences of urban/suburban land use are more pronounced.

Thirdly, scale and spatial distribution are known to be of central importance to the spread of invasive species (e.g. Collingham et al., 2000), but to our knowledge, they have not been systematically quantified and mapped. The recent spread of Asian Longhorned Beetle through the urban areas of the U.S. is a well-documented example (e.g. Haack et al.,1997; Poland et al., 1998) and the potential impact has been estimated as in excess of 30 percent tree mortality, with potential costs ranging as high as $2.3 billion per city (Nowak et al., 2001). New missions should provide the opportunity to assess the potential for developing and using continuous-field maps of urban/suburban vegetation and land cover properties (rather than thematic classifications) to model the spread of invasive species and other ecological processes.

Current sensors and missions do not adequately meet these needs. To be sure, high-resolution optical data (e.g., IKONOS, Quickbird) are revealing of intra-urban features of interest to the social science and land use communities. But the classification of urban features from these sources is an arduous and unduly subjective exercise, difficult to extend to a global scale or to update with sufficient regularity to permit dynamic analysis. Similar problems of scale and subjectivity afflict the moderate-resolution optical data (e.g., Landsat) and intra-urban classification is of course less precise with these data than with higher-resolution sources. In examining the DMSP OLS "Night-time Lights" data, we see the potential value of this form of global observation. However, coarse spatial resolution and a lack of radiometric calibration limit the applications which the DMSP lights can address. Moreover, although light sources provide good proxies for urban settlements in high-income countries, the urban settlements of poor countries are not fully electrified and significant portions of these settlements may lie below the detection threshold of the sensor. In addition, investigators have encountered ambiguities in the interpretation of changes found in the DMSP time series because the system records light in only a single spectral band.

VIIRS, the Visible Infrared Imaging Radiometer Suite, is the follow-on to both MODIS and the DMSP-OLS, and may fly as early as 2009. In terms of low light imaging, it will address several of the important shortcomings of the OLS: it will have on board calibration; the detection limits will be comparable to OLS, but with wide dynamic range and no saturation in urban centers; and the spatial resolution (742 m) will be better than the OLS. However, two important drawbacks with VIIRS are that: 1) low light imaging data will still be too coarse for observation of the structure inside urban areas (i.e., it cannot distinguish between (bright commercial centers, streets, dimly lit residential areas, and areas with no lighting); and 2) the lack of spectral bands for identifying lighting types and changes in lighting type. Both of these will result in ambiguities in change detection and measurement of growth rates.

Current radar technology has promise but is not, in itself, adequate to address the social sciences objectives. SRTM SAR data does not have fully global coverage and is limited to a year 2000 baseline. Further, although SAR data have high resolution (10-100 m), providing valuable data for verification and validation in selected study areas, the coverage is limited in space and in time. Scatterometer data, such as the currently operating QuikSCAT/SeaWinds instruments, cover 90 percent of the world in a single day, providing frequent global data with strong signatures of man-made structures. Newly developed techniques such as the Dense Sampling Method (DSM) allows mapping of urban extents with some capability for identifying urban typologies (e.g., core urban area) at 30 arc seconds by combining multi-look data. The frequent global coverage enables annual partitioning of the data for studies of urban dynamics. However, current scatterometer resolution is too coarse to detect smaller settlements with sparse building distribution, and the single frequency and single polarization limit its capability to detect detailed intra-urban classes.

Some basic specifications on the measurements of physical parameters, as described above, to meet the needs of the social science and urban land use/land cover communities, include:

- Accuracy (tolerance) for the parameters
- Geolocation accuracy
- Consistency with surface surveys/observations/measurements
- Global coverage
- Annual repeat
- Maximum latency for a global product generation at or near one year
- Data archive and open distribution
- Mission lifetime (multi-year) and data continuity.

We briefly assessed all the mission concepts submitted to the Decadal Survey for their relevance to urban research. The attached table lists those with the most likely relevance. We have highlighted features of those missions concepts with respect to their likely capability for urban detection. In some instances, though there was a general sense that some urban detection would be feasible, it was not possible to classify in specific terms which aspects of urban detection would be likely.

Of the mission concepts, only one—the NightSat proposal—has a clear focus on urban areas. This mission concept has also taken seriously the main shortcomings in the current use of DMSP for urban and other socioeconomic applications, and has proposed significant enhancements of value to the urban social science community. We wholeheartedly endorse this mission concept. It also is significant in that processing the NightSat data into an annual global product would be streamlined by the simple separation of pixels that contain lights from those that do not; few other proposed missions would rapidly provide a useable product to the urban social science community. This turnaround time is ideal for the uses highlighted in this letter.

We also wish to endorse several other mission concepts that would collect global data useful for mapping human settlements. These include scatterometers and high-resolution SAR data, as well as the hyperspectral and multispectral missions. For example, planned future scatterometers, such as the WOWS instrument (see Liu and Yueh), are expected to have significantly better resolution, frequency, and polarization diversity, which will significantly enhance the capability of scatterometers to provide useful data for urban studies at a global scale. However, due to processing volume, the proposed SAR data mission concepts (e.g., the InSAR) which have medium resolution (10- 100 m) are limited in temporal and spatial coverage. These instruments would provide valuable data for verification and validation at selected focused study areas, but would probably not be useful in achieving a global inventory of urban areas and change. Similarly, the Landsat-like "low-cost multispectral" would also be helpful for regional-scale validation but is not ideal for global detection. The hyperspectral "FLORA" and combined radar/lidar "Biomass Monitoring Mission" (see NAS_BioMM) concepts would produce a much improved understanding of urban vegetation, and possibly features of the built environment. These missions would encourage synergies between the land use/land cover and the urban social science community, in and of itself an important objective. However, synergistic research alone is inadequate if the direct needs of the social science urban community were not also met through other missions.

It is important for urban and suburban land cover mapping and monitoring to be a factor for consideration in sensor development and mission design for any future programs focusing on land cover mapping. Accurate representation of the characteristics of urban and suburban land cover and solid understanding of the dynamics of the urban environment can greatly influence policy decisions by quantifying the biophysical consequences and specification of policy choices.

The urban social science community is poised to use spaceborne assets in its research. We hope the decadal survey panels strongly endorse the proposed missions that enable systematic and sustainable linkages between the urban social science and Earth science communities.

Cordially yours,

Deborah Balk
Columbia University

Uwe Deichmann
The World Bank

Thomas Buettner
United Nations Population Division

Mark Montgomery
SUNY-Stony Brook and Population Council

Enclosures/
Urban workshop agenda
Participants list

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| Name of Proposed Mission | System Properties | | | | | | Urban Detection Prospects | | | | Other comments | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | System Description (Spectral Resolution) | Spatial Resolution | Spatial Coverage | Temporal Coverage | Intended Observation | Proposed mission duration (operation) | Urban foot-prints | Intra-urban classes | Urban change over time | Land-use change | Positive | Negative |
| **Radar / Radiometers** | | | | | | | | | | | | |
| WOWS | Multi-frequency radar scatterometer and radiometer, polarmetric (active and passive) | 1km - 5km | Global | Global every 3 days | Sea winds | Unspecified | Yes | Yes | Yes | Yes | Radar backscatter is sensitive to man-made structures. Multifrequency signal can be used to isolate urban areas. | No current plan presented for global urban product. |
| Mosaic | Ku-band radar, polarimetric | 1-5 km (coastal); 10-100 km (open ocean) | Global | 3 days | Ocean surface current | 3 years | Yes | Some capability | Yes | Yes | Polarimetric capability provides further information for urban mapping. Coastal ocean data together with concurrent urban data are important for coastal hazard | No current plan presented for a global urban product. |
| Gismo | P-band interferometric and polarimetric radar | 250m | Global | 14 days | Polar ice sheets and glaciers | 1 year | ? | ? | ? | ? | Radar backscatter at P-band highly sensitive to manmade structures. Interferometry can be used for 3D urban mapping. | Radio-frequency interference from urban areas at P-band may be a significant limitation. At VHF it will probably preclude the measurement. |
| MOSS | UHF/VHF and SAR (L-band is being considered) | 1 km | Global | 7-10 days | Soil moisture | ? | ? | ? | ? | ? | Radar backscatter at VHF highly sensitive to manmade structures; L-band backscatter sensitive to urban structures. | Radio-frequency interference from urban areas may be a significant limitation. At VHF it will probably preclude the measurement. |
| InSAR | L-band interferometric SAR | <100m | Can target anywhere, but data collection will be limited. No global coverage. | Global seasonal coverage | Geophysical features | 5 years | Yes | Yes | In selected regions | No | L-band backscatter sensitive to urban structures. L-band repeat pass interferometry can determine building heights. | Data rate is a major constraint to global coverage. May be overcome with more ground stations, but highly infeasible to produce a global urban product. |
| OLOM | SAR (dual frequency: C- or X- band and L-band) and visible/infrared sensors | 5 to 250 meters | Limited coverage | 8 days | Ocean and land processes | 15 years | In selected regions | Some capability | In selected regions | In selected regions | High-resolution for verifications at selected areas | Global inference unlikely. |
| WatER and Hydrosphere Mapper | Near nadir Ka-band interferometer + altimeter | 10-100 meters | Global | 16 day cycle | Elevation of inland water | ? | see comments | | | | Ka-band may be sensitive to urban structures. | Potential unknown due to lack of data for urban structures near Ka-band |
| **Optical / Multispectral / Hyperspectral** | | | | | | | | | | | | |
| NightSat | Measurement of radiances from nocturnal lighting present at the earth's surface. | 25-50 meters | Global | 30 days | Urban settlements | ? | Yes | Yes | Yes | Yes | Detection limit and dynamic range set to span detection of dim lighting present in sparse rural setting to the cores of urban centers. Focus on observing a human activity. Would benefit from multispectral. | |
| Low-cost multispectral | Similar to Landsat | 7.5-30 meters | Global | 4-16 days | Land cover/ land use | Long term | Yes | No | Yes | Yes | Would permit cross-validation with NightSat as well as local studies. | Global inference unlikely. |
| FLORA | Hyperspectral sensor (400-2500 nm) | 45 meters | Global | 31 days | Ecosystems | 3 years | ? | ? | ? | Yes | Intended for mapping vegetation but the hyperspectral data could be valuable for imaging urban areas. | |
| CICERO | Cellular Interferometer | 5 cm (theoretical) | Global | Continuous | RF emissions and reflections | Long term | see comments | | | | May be capable of mapping the distribution of radio frequency emissions from a variety of electrical devices & appliances, e.g., cell phones and microwave ovens. | Urban detection abilities unknown. Likely bias towards measures of economic activity rather than settlements, and against poor economies. |
| MAUVE and SWIPE | UV detection with visible, near infrared, and short-wave infrared; MAUVE (350 1050 nm); SWIPE (1050-1600 nm) | 1 km | Global | Daily | Aerosol particles, climate | 5 years | ? | ? | ? | ? | UV imaging might highlight urban areas, since a lot of building materials have distinctive UV siginature. | 1 km resolution is low |
| STRIVE | MISR-like imager with stereophotogrammetry | 100m to 1 km | Global | 7-day cycle | Ecosystems | 3 years | ? | ? | ? | Yes | May be capable of observing height structure in urban areas. | |
| **Combined Optical / Radar** | | | | | | | | | | | | |
| NAS_BioMM | Radar and Lidar | Radar: 100-250 meters; Lidar: 25 m, 1 m vertical | Global | 30-45 days | Forest 3-D structure, above ground woody biomass | 3-8 years | ? | ? | ? | Yes | Depending on the acquisition plan, this could provide valuable constraints on height varability and return characteristics. | Although this system offers the ability to detect heights, a prominent urban feature, the current plan was constructed without urban detection in mind, and thus its applicability uncertain. |

**Rethinking the Estimation and Projection of Urban and City Populations**

**Faculty Room, Low Library, Columbia University**
**New York City**
**9-10 January 2006**
**Agenda**

| Time | Monday, January 9 | Presenter |
|---|---|---|
| **8:30 AM** | **Breakfast (Presenters to deposit presentations on laptop.)** | |
| **9:00 AM** | **Setting the Stage** | **Chair: Deborah Balk** |
| | Introduction and Objectives | **Hania Zlotnik** |
| | Spatial social science | **Uwe Deichmann** |
| | The value of city and urban projections for development | **Gordon McGranahan** |
| | Prospects for publishing workshop findings | **Mark Montgomery** |
| **10:05 AM** | **Break** | |
| **10:20 AM** | **Where Do We Stand?** | **Chair: Paul Cheung** |
| | Lessons from the IUSSP panel on urbanization | **Tony Champion** |
| | The UN Population Division Cities Database | **Thomas Buettner** |
| | Detecting the spatial extents of urban areas; linking extents to population | **Deborah Balk** |
| | Demographic surveys and spatial linkages in models of city growth | **Mark Montgomery** |
| | Discussion | **George Martine** |
| **12:15 PM** | **Lunch** | **Intro: Roberta Balstad** |
| | **Urbanization and populations at risk: Spatial data for malaria burden estimation** | **Andy Tatem** |
| **1:15 PM** | **What Can We Learn from Remotely-Sensed Data?** | **Chair: Deborah Balk** |
| | Optical imagery at moderate and high resolutions | **Chris Small** |
| | Optical imagery: Night-time lights | **Chris Elvidge** |
| | The potential of radar | **Son Ngheim & Ernesto Rodriguez** |
| | Discussion | **Steve Sheppard** |
| **2:50 PM** | **Break** | |
| **3:15 PM** | **Measuring the Components of City Growth** | **Chair: Mark Montgomery** |
| | Small area estimates of urban fertility and mortality schedules | **Renato Assuncao** |
| | Indirect estimates of migration; the scope for multi-regional projections | **James Raymer** |
| | Regional challenges in modelling growth | **Kam Wing Chan** |
| | Nature and extent of slum populations | **S. Chandrasekhar** |
| | Discussion | **Hania Zlotnik** |
| **6:30 PM** | **Dinner: Turkuaz** | **2637 Broadway (at 100th Street)** |

Workshop sponsored by the International Union for the Scientific Study of Population, the United Nations Population Division, and the NSF-ADVANCE Project at the Earth Institute at Columbia University

**Tuesday, January 10**

| | | |
|---|---|---|
| **8:30 AM** | **Breakfast (Presenters to deposit presentations on laptop.)** | |
| **9:00 AM** | **Discussion** | |
| | **Reviewing the RS component** | Deborah Balk |
| | **Reviewing the components of city growth** | Mark Montgomery |
| **10:30 AM** | **Break** | |
| **10:45 AM** | **New Forecasting Methods** | **Chair: Thomas Buettner** |
| | Classical and Bayesian approaches to forecasting city populations | **Mark Montgomery** |
| | Joint projections of urbanization and migration | **Brian O'Neill** |
| | Recent advances in urban forecasting | **Philippe Bocquier** |
| | Projecting the urban poor | **Eduardo Moreno** |
| | Discussion (incorporated into lunch) | **Joel Cohen** |
| **12:30 PM** | **Lunch** | |
| | **Informal Thoughts on Urban Population Projections** | **Speaker: Joel Cohen** |
| | **Additional group discussion** | **Thomas Buettner** |
| **1:45 PM** | **Urban Projections, Poverty, and the MDGs** | **Chair: Deborah Balk** |
| | UNFPA | **Rogelio Fernandez-Castilla** |
| | International Census efforts | **Tufuku Zuberi** |
| | Survey data providers | **Livia Montana** |
| | Satellite data provision and acquisition | **Andy Nelson** |
| | Discussion | |
| **3:30 PM** | **Wrap-up** | **Chair: Mark Montgomery** |
| **4:00 PM** | **Adjourn or Opportunity for smaller side-meetings** | |
| **5:00 PM** | **Final adjournment** | |

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*Rethinking the Estimation and Projection of Urban and City Populations*

**January 9-10, 2006**
**Columbia University**

## PARTICIPANT BIOGRAPHIES

**Sonya Ahamed** is a Staff Associate at Columbia University's Center for International Earth Science Information Network (CIESIN). Ms. Ahamed works on the Global Rural Urban Mapping Project (GRUMP), using GIS to convert tabular data on urban and rural populations into spatial data. She has an M.Sc. in Planning from the University of Toronto, and she is currently completing her thesis for an M.A. in the Philosophical Foundations of Physics at Columbia University.

**Bridget Anderson** is a Research Associate at the Center for International Earth Science Information Network (CIESIN) at Columbia University. She has a Masters Degree from Columbia University's School of International and Public Affairs. Ms. Anderson has worked extensively on CIESIN's Gridded Population of the World and Global Rural-Urban Mapping Project. Additional projects with CIESIN include the Environmental Sustainability Index 2005, Global Poverty Mapping Project, and MDG analysis of the December 2004 tsunamis.

**Renato Assuncao**, is Professor Adjunto at the Statistics Department of the Universidade Federal de Minas Gerais (UFMG) in Belo Horizonrte, Brazil. His work focuses on the development of statistical methods and software to analyse geographical data. He is the Director of the Laboratorio de Estatistica Espacial (LESTE) and Vice-Director of the Centro de Criminalidade e Seguranca Publica (CRISP) of the UFMG. Dr. Assuncao received his Ph.D. in Statistics from University of Washington and an M.S. in Mathematics from the Instituto de Matematica Pura e Aplicada (IMPA).

**Deborah Balk** is Associate Research Scientist at Columbia University's Center for International Earth Science Information Network (CIESIN). Dr. Balk has led several major initiatives to spatially render demographic data, including the Gridded Population of the World (GPW) database and the Global Rural Urban Mapping Project (GRUMP), and a recent Global Poverty Mapping Project. These large-scale, multi-institutional projects integrate demographic census or survey data and geographic information, including in some instances, that which is derived from earth observing satellites. She received her Ph.D. in Demography from the University of California at Berkeley.

**Roberta Balstad** is the Director of Columbia University's Center for International Earth Science Information Network (CIESIN). She has published extensively on science policy, information technology and scientific research, remote sensing applications and policy, and the role of the social sciences in understanding global environmental change. She is the author of numerous articles and books, including City and Hinterland: A Case Study of Urban Growth and Regional Development (1979) and editor, with Harriet Zuckerman, of Science Indicators: Implications for Research and Policy (1980). Dr. Balstad received her Ph.D. from the University of Minnesota in 1974.

**Philippe Bocquier** is a Demographer at the DIAL Research Unit at the French Research Institute for Development (IRD), and he is the Coordinator of the Centre for Applied Research, a department of AFRISTAT. Prior to assuming his position at the IRD, he was the Director of the French Institute for Research in Africa (IFRA), based in Nairobi. Dr. Bocquier holds a PhD in Demography and an MSc in Statistics.

**Melanie Brickman** is a Research Associate at the Center for International Earth Science Information Network (CIESIN) at Columbia University. Her research interests include population health, tuberculosis, urban health, poverty, demography, and GIS and she has worked extensively on projects such as Gridded Population of the World, Small Area Estimates of Poverty, The Living City, and U.S-Mexico Demographic Data viewer. She holds an MSc in Medical Demography from the London School of Hygiene & Tropical Medicine, and she is a Ph.D. candidate in Medical Geography at the University College London.

**Thomas Buettner** if the Chief of the Estimates and Projection Section at the United Nations Population Division. He leads the Division's efforts to estimate and project urban populations at the national and global level, and he also leads efforts concerned with individual cities. Dr. Buettner has published on sex differences in old-age mortality, population ageing, and the projection of mortality patterns. He holds a Ph.D. in Demography from the College of Economics in Berlin, and a DSc in Demography from Academy of Sciences in Berlin.

**Tony Champion** has over 30 years of research experience at Newcastle University, focusing primarily on population change and migration and their implications for regional and local population profiles and planning policies. He is currently engaged in a re-evaluation of urban and city-region trends in Britain since 1991. Part of this work aims at a new specification of the UK urban system, which also is feeding into a monograph of the changing nature of urban Britain.

**Paul Cheung** is the Director of the Statistics Division, Department of Economic and Social Affairs of the United Nations Secretariat. Prior to joining the United Nations in 2004, he was the Chief Statistician of the Government of Singapore, a post he held since 1991. In this role, he served as the National Statistical Coordinator as well as the Chief Executive of the Singapore Department of Statistics.

**Kam Wing Chan** is a Professor in Geography and Chinese Studies at the University of Washington in Seattle. He is the author of *Cities with Invisible Walls: Reinterpreting Urbanization in Post-1949 China* (OUP, 1994) and over 50 articles on urbanization, migration, urban labor markets, the household registration system, and urban finance. Dr. Chan received his M.Sc. in Urban Planning from the University of Hong Kong and a PhD in Geography from the University of Toronto.

**S. Chandrasekhar** is currently a visiting fellow at Indira Gandhi Institute of Development Research (IGIDR), Mumbai, India. His research falls broadly in the realm of development economics. His current work focuses on cost of primary education, decentralization and willingness to contribute to public projects, urban poverty, poverty hotspots, and the role of ICT's in development and progress towards MDG's. Dr. Chandrasekhar received his Ph.D in Economics from The Pennsylvania State University.

**Robert Chen** is the Deputy Director of the Center for International Earth Science Information Network (CIESIN) at Columbia. He manages the Socioeconomic Data and Applications Center (SEDAC), a data center in NASA's Earth Observing System Data and Information System. Dr. Chen is also Secretary-General of the Committee on Data for Science and Technology of the International Council for Science (ICSU). He received his Ph.D. in Geography from the University of North Carolina at Chapel Hill and holds Masters and Bachelors degrees from MIT.

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