Population-Environment Interrelationships in Urban Areas in Thailand

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Goals and Aims

Our proposed project applies the spatial digital technologies of remote sensing (RS) and geographic information systems (GIS) to the study of urban environments. We are particularly interested in using these technologies to improve our understanding of changing urban structure, providing some aspects of the context in which migrants live. We consider a range of urban environments extending from (a) small villages in Nang Rong district, northeast Thailand; (b) administrative towns in the Northeast, including but not limited to Nang Rong town, the principal node within the district; and (c) different areas in Bangkok, a primate city and a significant migrant destination. Previously, the Mellon Foundation supported the collection of data from migrants from rural Nang Rong villages. Now, support is requested for the collection of data about migrant destinations, especially urban destinations. With the encouragement of the Mellon Foundation, the Nang Rong projects have expanded their scope to fully include urban contexts.

There are four specific aims. First, we will explore the use of remote imagery to characterize urban environments in the Thai setting. Satellite digital data for this purpose will come from the Landsat Thematic Mapper, Enhanced Thematic Mapper, and Ikonos systems. These satellite systems have different spatial resolutions that range from 1 – 30 meters, and hence offer different views of the urban structure. We will also draw on aerial photography for purposes of validating historical views of the urban morphology from an assembled satellite time-series for our selected urban hierarchy so that urban change as part of urban sprawl can also be considered. The purpose is to develop and test appropriate methods for the use and interpretation of these data for urban studies. So far, all the use of remotely sensed data in social demography has been in rural settings. With the proposed research, we will examine the potential of remotely sensed data to better understand urban contexts and their history. Previously, we have focused on aspects of rural land cover/land use (e.g., deforestation, expansion of lowland rice, and extensification of upland crop production) and also to some extent on village settlement and the expansion of the road network. Moreover, the proposed project brings in satellite digital data from new systems (ETM and Ikonos). Indeed, it is the availability of these new data sources, with their much higher spatial and spectral resolutions, that makes a detailed description of urban environments based on satellite data possible, particularly, at the level of detail required to match our migrant population data.

Second, we will use the satellite data to describe the composition and spatial organization of urban environments and assess similarities and differences across villages, towns, and large cities. We will apply the data and tools developed under the first aim. The emphasis is on description and interpretation. Variables based on the remote imagery can be tied to people and localities in a longitudinal survey data set, the Nang Rong CEP-CPC surveys (see the project web site at http://www.cpc.unc.edu/projects/nangrong). The validity of these measures will be assessed in several ways, including comparisons with observational data collected for this

purpose (ground-truthing) and also comparisons with information collected in the survey as part of the most recent data collection in 2000 and 2001.

Third, we will use data collected about the spatial location of migrants from Nang Rong district in selected Intensive Study Areas (ISA) in Bangkok to examine migrant proximity and concentration. Bangkok is the most common migrant destination, but Bangkok is large and internally diverse. Work completed in the first two aims will contribute to the description of this diversity, especially settlement patterns relative to a changing urban structure. We do not expect migrants from Nang Rong (or indeed, anywhere) to settle randomly over the urban landscape. One relevant factor is the concentration of other migrants, an attractive force. But because of the richness of the Nang Rong surveys, we can do considerably more than consider spatial proximity per se. We can assess spatial proximity relative to measures of social proximity based on social network data collected in the most recent round of the survey.

Fourth, we will use the description developed as part of the second and third aims as a focus for developing new collaborative ties between researchers at the Carolina Population Center, as well as researchers at the Institute for Population and Social Research, Mahidol University, Thailand, and researchers at the Center for Urban and Regional Studies (CURS, University of North Carolina. This project is the first foray of CPC researchers into the study of urbanization per se, although we have examined the experiences of migrants from rural Nang Rong villages to urban areas (and back again). Discussing the proposed descriptive analyses with scholars whose primary focus is urban studies will greatly enrich the interpretation and potentially redirect next steps in the analysis as well as creating the possibility of analyses that cannot now even be envisioned. This project is the first foray of CURS researchers into the analysis of our Nang Rong data. Through formal and informal discussions, these researchers will learn about the Nang Rong case and associated projects and hopefully become excited about the potentialities therein.

The focus of this proposal is data acquisition, processing, coding, measurement, preliminary analysis, and interpretation. This foundational work will make possible future analysis of a wide range of questions: How is the nature of land use and land cover change in Nang Rong associated with the pattern of out-migration to cities within the selected urban hierarchy? Are migrants choosing to settle in newly urbanized areas in the cities, or in pre-existing places, possibly more familiar to earlier migrants from the same or spatially- and/or socially-connected villages? What are the spatial links between migrants in destinations and the home locations of migrants? What are the connections between transportation arteries, land fragmentation patterns in Nang Rong district, and the out-migration of young adults? All of these questions fit within a much broader question that is at the heart of this proposal: To what extent can the concepts, techniques, and data of spatial analysis be brought to bear to help us understand the social demography of urban areas, the interrelationships between rural and urban places, and the bridge between traditional demographic data sources and the newer remote sensing and GIS technologies.

Setting

Nang Rong, our original research site, is located in Northeast Thailand (Map 1). Until well into the second half of the Twentieth Century, Nang Rong was a frontier area, more similar in this respect to recently settled areas in Latin America than to a typical Southeast Asian setting. A few villages date back several hundred years to when the district was part of Cambodia, but

primary waves of recent settlement occurred at the turn of the century and then again especially after the second world war. The district is relatively poor. Most villagers are farmers, growing rice and upland crops such as cassava, sugar cane, kenaf, and corn. As is true for Thailand as a whole, Nang Rong is in the final phase of the demographic transition, with low mortality and replacement level fertility. Migration, both permanent moves to Bangkok and other urban areas and temporary movement, is common. Demographically speaking, Nang Rong resembles source areas for urban migrants found elsewhere in Asia and Latin America, including source areas in Mexico for international migrants to the U.S.

Data

Over the past decade we have assembled an impressive array of data on which the proposed research capitalizes and to which it adds (Figure 1). The data come from many sources: surveys, administrative records, maps, satellite images, aerial photographs, and field observations. The data are multilevel. On the social side, they cover individuals (including migrants), households, and villages. On the spatial side, they cover pixels, plots, village territories, and the district. The proposed project expands the scope of the spatial data to also include urban sites. The data cover an extensive time period. On the social side, the data extend from 1984 to 2000/01. On the spatial side, they extend from 1954 to the present. The data are linked, over time, between scales, and between social and spatial domains. The following paragraphs describe the highlights of the data of key interest in this proposal.

Survey Data

The Nang Rong CEP-CPC surveys consist of three waves of data collection—1984, 1994, 2000—each more elaborate than what preceded it. We begin with two surveys conducted in 1984: a community survey in 51 study villages; and a complete household census conducted in the study villages, with the census obtaining information on all members of all households. The 1994/95 data collection included: a community survey, done in all villages in Nang Rong, including but not limited to the original 51; a household survey, again a complete census of all households in each of the 51 villages; and a migrant follow-up, which collected data from out-migrants from 22 of the original 51 villages who had gone to one of four urban destinations (Bangkok and surrounds; the Eastern Seaboard, a focus of rapid growth and development; Khorat, a regional city; or Buriram, the provincial city). The 2000/01 data collection included: a community survey, again done in all villages in Nang Rong; a household survey, again a complete census in the 51 study villages; the collection of locational data for dwelling units and agricultural plots, linked to the household survey; a migrant follow-up following migrants from 22 villages to the four urban destinations and to rural villages within Nang Rong district. The surveys are linked, such that migrants can be attached to home households, which can be placed in their village contexts. Data for individuals, households, and villages are also linked over time. For additional information, see http://www.cpc.unc.edu/projects/nangrong/nangrong_home.html. It is the existence of this rich and varied data set that makes synergies possible when spatial data are added. Spatial and satellite data pertaining to the rural villages and the larger context of Nang Rong district have been integrated into our previous studies. This proposal extends this integration by expanding the scope of these data to also include selected urban areas as well.

Remote Sensing Data

An aircraft and satellite image time-series has been assembled that extends from the 1950s to the present. Panchromatic aerial photography at scales ranging from 1:6,000 to 1:50,000 have been acquired for 1954, 1968, 1969, 1974, 1976, 1982, 1983/84, 1985, and 1994. Satellite data have been obtained from Landsat systems for the period of 1975-1999, usually with multiple images per year to track intra-annual variation in landscape conditions. SPOT Panchromatic and Multispectral images have been acquired in 1994 and 1997. Finally, approximately 150 NOAA Advanced Very High Resolution Radiometer data have been acquired for the district from 1997-2000 to document regional "greenness" patterns as context to higher resolution views afforded by Landsat and SPOT digital data. Although we have satellite images for the villages and district towns in the Nang Rong area, we have emphasized agricultural land use in our interpretation of these data. "Urban" is a category of land use in our classification, but we have not yet addressed diversity within this class, nor have we sought to interpret primate cities and their urban structures, urban sprawls, and the manner of development within these settings. This proposal thus extends the analysis of data already in hand. It also augments the remote sensing data set to include destination areas in Bangkok for migrants from Nang Rong District.

GIS Data

An array of GIS thematic coverages have been developed, for instance, to assess (a) the resource endowments of a site, (b) geographic accessibility of villages and lands linked through the hydrographic and transportation networks, (c) terrain settings, (d) and the position of villages, villages that have split from other villages over time, and temples and schools, among other elements of the social and economic infrastructure of the district. We have also gathered land use and land cover control data, as well as geodetic reference data, for defining land use and land cover conditions through satellite image processing and for providing spatial reference to our social, biophysical, and geographical data with high degrees of precision for subsequent mapping, modeling, and visualization efforts. We have used GPS (Global Positioning Systems) technology to precisely locate dwelling units, school, temples, and other population-related features as well as critical biophysical features such as ponds and other elements of the hydrologic network. We have used GPS technology to collect in-situ information across the landscape as calibration and validation data to support remotely-sensed interpretations and outcomes from a host of population-environment analyses.

Analysis

The first aim of the project is to explore the use of remote imagery to characterize urban environments in the Thai setting. The first step is to augment our collection of satellite imagery for Nang Rong district to include selected areas in Bangkok. The second step is to develop, adapt, evaluate, and apply a suite of satellite image enhancement and classification techniques to map urban structure.

Remote sensing has been used by a number of researchers outside the demographic community to characterize urban settings by mapping land cover within urban environments (e.g., Ward et al. 2000). Some have tended to explore satellite and aircraft systems of different

spatial and spectral resolutions to map elements of urban structure (e.g., Jensen et al. 1999, Chen et al. 2001), apply spatial analysis techniques within a GIS to distinguish high-resolution urban heterogeneity (e.g., Barnsley and Barr 1996, Myint 2001, Zhang and Wang 2001), and map landscape greenness as a temporal indicator of increasing urbanization (Weng and Lo 2001). GIS was used by Mesev (1998) to integrate census data and urban landuse and landcover information derived from remotely sensed data for improved classification of urban structure, and Yeh and Li (2001) mapped the distance from town centers and roads as indicators of the spatial pattern of urban sprawl as an approach to identifying spatial variations and temporal changes of urban patterns. Spectral mixture modeling, a technique used to decompose the information contained in a single picture element or pixel into its component parts, has been used by Rashed et al. (2001) to assess the anatomy of cities, and Chen et al. (2000) have relied upon spatial pattern to assess urban structure. We will draw upon this work to extend to social demographic processes.

We are interested in areas typical of large and intermediate cities as well as small towns and villages defined in our hierarchy. Landsat Thematic Mapper and Enhanced Landsat Thematic Mapper digital data with spatial resolutions of 30 m and 15 m respectively will be used. Ikonos data at a spatial resolution of 1 x 1 m panchromatic and 4 x 4 m multispectral will also be employed within our multi-resolution scheme. Aerial photography will also be integrated into the analyses by using photogrammetric techniques to define the 3-D perspective of urban areas and to help validate satellite interpretations of historical periods. Urban sprawl will be considered through an image time-series. The spatial pattern of development (e.g., core vs. periphery) and its changing urban structure will be assessed over time and space, and in relation to the geographic position of key urban features (e.g., transportation network and open green spaces).

The second aim is to use the coded satellite data to describe the composition and spatial organization of urban environments and assess similarities and differences across villages, towns, and large cities. The emphasis is on description and interpretation. The nature and definition of urban structure and transition in such settings will be examined and remote sensing methodologies developed for measuring urban transitions across the hierarchy, including urban sprawl. What constitutes urban structure, sprawl, and change at one level in the urban hierarchy may not be the same at another stage in the hierarchy, nor for different periods in the urban morphology. For example, the conversion of forest to agriculture within associated territories of rural villages might be contrasted with the intensification of transportation arteries and the densification of urban structures in intermediate to large cities. Core patterns of development are often associated with the near absence of green and open space, high density of buildings, and a relatively high degree of urban structure. Peripheral development is often marked by the presence of green and open space, reduced density of buildings, and a smoother transition of urban structure.

Our basic intent is to differentiate urban areas that are characteristic of large, medium, and small urban places through spectral responses secured through satellites and by aircraft by directly measuring key indicators of urban form and function. Methods to be used include: (a) image change-detections (e.g., post-classification, binary mask, and change vector analysis) for defining urban transition and urban sprawl, and for assessing land use and land cover change through deforestation and agricultural extensification in rural areas and at the urban fringe; (b) classification approaches (e.g., supervise and unsupervised) for categorizing urban land use types in intermediate to large urban settings and land use/land cover conditions in rural settings; and

(c) digital enhancements (e.g., textual filters and wavelet transforms) for examining trends in the urban transition as well as details in the local variation of urban environments. As stated, aerial photography and photogrammetric techniques will also be used to consider urban environments within a 3-dimensional perspective, as well as a basis to validate historical image snapshots of urban morphology through satellite digital data. We will also explore the use of indirect indicators of urban structure. For instance, spectral characteristics of atmospheric aerosols over urban areas have been used to differentiate cities by population size, density, and urban function. These are the byproducts of urban activities. They modify the background matrix -- its atmosphere and landuse/landcover in and adjacent to these defined places.

The third aim is to collect data about the spatial location of migrants from Nang Rong district in selected Intensive Study Areas (ISA) in Bangkok to examine migrant proximity and concentration. Geocoding of migrants, followed in 1994/95 and 2000 from the 22 sample villages, will be implemented within a GIS environment. Spatial analyses of their relative (i.e., within an urban aggregation unit) and absolute (i.e., at the point location of a specific housing unit) positions, and spatial patterns will be assessed as a composite group, for newly arriving migrants, and for relative sectors in the urban setting (e.g., industrial, commercial, and residential). The data on migrant proximity will be linked to survey data on social ties among migrants and between migrants and their home villages for purposes of preliminary analysis.

Land use and land cover patterns in Nang Rong district will be assessed through a hybrid classification scheme in which general landscape classes are defined for each year of the analysis - 1994 and 2000. Deeper historical data will be used to give context to the nature of land use and land cover types and their spatial patterns for the 1994 and 2000 "snapshots." Pattern metrics will be used to assess the landscape organization or geometry of land use and land cover types occurring for land associated with the nuclear villages of Nang Rong district, and for assessing the urban structure within Nang Rong town, the sub-district cities, and for Bangkok. Spatial pattern has been related to landscape function in ecological settings. We will explore the utility of spatial pattern as it relates to urban settings.

Expected Outcomes

The outcomes are both substantive institution building. The idea is to build institutional bridges within the context of specific, ongoing research. With respect to the substantive outcomes, the morphology of urban environments has been characterized through image change detections using a number of remote sensing systems, but, generally, the coarse spatial resolution of satellite systems and the high density of urban structures has made the task of urban mapping difficult from space. The availability of new satellite systems, producing imagery at a much finer spatial resolution, has created new opportunities to study urban places. Here we examine different urban settings representing a size continuum ranging from Thailand's largest city to typical small rural villages. Once mapped, urban settings will be spatially linked to the geocoded location of migrants from the 22 sample villages to ascertain their spatial pattern relative to the core/periphery of urban settings, new versus prior migrants, and the topology of migrants to the changing nature of the urban structure. We anticipate that (a) image enhancement and classification approaches will permit the mapping of urban structure and change, (b) "signatures" of urban structure and change for different urban settings will be derived through space-based remote sensing that are dependent upon the scale of the urban environment and the spatial resolution of the sensor system, and (c) increased land fragmentation beyond some critical

threshold will signal an out-migration from rural villages to higher levels of cities along the urban hierarchy.

With respect to institution-building, an important aspect of the project is to explore bridging the population and urban studies communities at the University of North Carolina. We will do this formally and informally. Bi-monthly lunch meetings, with the cost of the lunch covered by the grant rather than the participants, will provide an informal setting in which to establish collaborative ties – with a "free lunch" providing an attendance incentive over and above the intellectual incentive. We will use these meetings to review progress in the acquisition of data, development of appropriate tools, and interpretation of the descriptive analyses that we have propose. We will also use them as idea-generating sessions, organized around as-yet unrealized potentials in the data set. The budget also includes seed funding for research that promises to bridge the two communities. The point is to allow the specifics of this research to emerge from discussion rather than imposing them before the collaboration is really established. Within the context of the above described research, smaller projects will be developed and proposed that link demographers, geographers, and urban planning specialists for the study of urban environments within a diverse and interdisciplinary perspective. The funds allocated to the seed grants and the manner of their review are in the budget and budget notes.