

Bringing dark data to light: a case study of historic vegetation data for modern ecological analysis

*Maggi Nina Kelly¹

1.University of California, Berkeley. University of California Division of Agriculture and Natural Resources. University of California Geospatial Innovation Facility

Research efforts that synthesize historical and contemporary ecological data with GIS and spatial modeling approaches improve our understanding of the complex response of species, communities, and landscapes to changing biophysical conditions through time and in space. Historical ecological data are particularly important in this respect. Detailed records of past agricultural, ecological, and climate conditions exist in several forms, including paper archives, historic imagery, biological specimens, and digital data. Unfortunately, these materials are often hidden, many are disorganized or degraded, and some exist as “dark archives” that are currently invisible to researchers. There are remaining technical barriers that limit the synthesis of historic and contemporary data. Recent technological improvements derived from work in digitization, spatial database design, and web visualization can make multiple diverse datasets more readily available for integration and synthesis. This talk presents one case study of a historical archive of vegetation data (the Wieslander Vegetation Type Mapping project in California) and highlights the importance of rescuing, digitizing and sharing historical datasets through cloud-based application programming interfaces (APIs). The digitization and sharing of the data via the web has broadened the scope and scale of the types of analysis performed: the data have now been used to understand legacies of land use change, to examine changes to chaparral and forest communities around the state and to predict community structure and shifts under a changing climate.

Keywords: GIS, historical data, API, Climate change

Geospatial assessment of ecosystem services in Southeast Asian cities

*Ronald C. Estoque¹, Yuji Murayama¹

1.Faculty of Life and Environmental Sciences, University of Tsukuba, Japan

Ecosystem services refer to the benefits that ecosystems (e.g. cropland, forest, etc.) generate for and provide to people. Such benefits can be tangible (goods, e.g. food from cropland) or intangible (services, e.g. air quality regulation by forest), large or small and direct or indirect. Although cities largely rely from the ecosystems outside of their respective boundaries, they also benefit from their own urban ecosystems. The assessment of the spatial distribution of ecosystem services within cities can help in the understanding of the human-environment interactions. Furthermore, a spatial analysis of landscape pattern and how ecosystem services are distributed along urban-rural gradients might also help in the context of sustainable landscape and urban planning. In this study, we explore the landscape patterns of some major Southeast Asian cities and examine how their various ecosystem services are distributed along their respective urban-rural gradients.

Keywords: ecosystem services, spatial analysis , urban-rural gradient , Southeast Asian cities

Spatial accuracy assessment of soft classification land cover map
Spatial accuracy assessment of soft classification land cover map

*堤田 成政¹

*Narumasa Tsutsumida¹

1.京都大学大学院地球環境学堂

1.Graduate School of Global Environmental Studies, Kyoto Univeristy

Reliable land use/cover information contributes to assess terrestrial environments. Land use/cover map is fundamental data for broad ranges of studies such as future earth, digital earth, and interdisciplinary researches including geography and environmental studies. Showing accuracy of a land use/cover map is essential to tell how the map is reliable. Accuracy assessment is often implemented by using R-squared, root mean squared error (RMSE), mean absolute error (MAE) for soft classification approach, while user's, producer's, and overall accuracies for hard classification approach. However, as such traditional measures are global indicators which tell the overall evaluation of map, they do not show any local information: where the classified land covers are accurate. For hard classification, previous studies successfully developed the accuracy surface of user, producer, and overall by applying a geographically weighted (GW) logistic regression, while as yet there is no application of them for soft classifications. Thus, the aim of this study is to demonstrate the way of estimating spatially explicit accuracy surfaces of soft classification land cover map. R-squared, RMSE, and MAE are estimated spatially on the classification map by applying the GW approach. Proportional impervious surface rate map in Jakarta metropolitan areas is used as a case study and accuracy surfaces of this are estimated from GW-Rsquared, GW-RMSE, and GW-MAE using independent proportional validation data. The proposed techniques are applicable for other case studies easily, and help understandings of accuracy of a soft classification map locally.

キーワード: Soft classification land cover map、Geographically weighted model、Accuracy assessment
Keywords: Soft classification land cover map, Geographically weighted model, Accuracy assessment

Geoinformation Sharing System for East and Southeast Asia

*Joel Calupas Bandibas¹, Shinji Takarada¹

1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

Geographic Information System (GIS) is the most efficient tool for storing, managing, processing and sharing geographically referenced information. However, the cost of procuring and maintaining proprietary GIS software is very prohibitive, especially for some countries in east and southeast Asia. Furthermore, conventional GIS is not very efficient for sharing geoscience information from multiple countries. This paper presents a GIS-based spatial information sharing system for the region, using the internet as the platform and Free and Open Source Software (FOSS) and Open Geospatial Consortium (OGC) standards as the backbone for geoscience information management, processing and sharing. In this system, the GIS software and database are setup in a central server. Spatial information processing and sharing are implemented through the formulation of web services Web Map Service (WMS) and Web Processing Service (WPS) in the server. Clients process, render and share geoscience data by sending request to these web services. OpenLayers JavaScript library is mainly used for the rendition of spatial contents online. The developed system also includes an important component to control data access privileges for each user. Data owners could decide the users' data access privileges which are view (read), write (edit) and download, and all possible combinations of the three. Users' group could also be created to classify users with the same data access privileges. The URL of the geoinformation sharing system is http://ccop-gsi.org/MyPortalCreator/new_main/index.html .

Keywords: WebGIS, GIS, FOSS, OGC Geoinformation Sharing

A Framework for Generating Opt-in Data Donation Map Apps Based on ManpoKit

A Framework for Generating Opt-in Data Donation Map Apps Based on ManpoKit

*陸 恣¹、杉山 綾子²、有川 正俊¹

*Min Lu¹, Ayako Sugiyama², Masatoshi Arikawa¹

1.東京大学空間情報科学研究センター、2.東京大学新領域創成科学研究科

1.Center for Spatial Information Science, The University of Tokyo, 2.Graduate School of Frontier Sciences, The University of Tokyo

User-generated data has become a very important resource in spatial information services and researches for many aspects, such as enriching the contents, enhancing the service qualities, improving the human interfaces and so on. The methods of collecting user-generated data can be various in current commercial services. Most of the data are collected automatically without users' conscious based on the users' agreements. For example, history data of users' visits, text input for searching, users' positions, log data of users' operations, and so on, are often gathered in the backend. This kind of methods can collect large amounts of data, but the data may have limited types and pertinence. Users can also create and contribute data actively, for example the volunteered geographic information (VGI) is applied in online map services. However, this way often sets high requirements for users' knowledge and skills. On the other hand, traditional ways of data collection, such as online or offline questionnaires, are still widely used.

In this research, we want to explore a new approach of user data collection, which can include the following features:

- (1) Higher pertinence of the required data, which means the types of data to collect and the generating methods are designed specifically according to the purposes.
- (2) Opt-in based data donation, which means the users can choose and upload the data to contribute of their own will, and can also cancel the donation at any time.
- (3) Lower operation burden for the users, which means users are guided to input or record the required data with ease.

The particular objects of user data to collect in this research are foreign-tourist-oriented maps, which are large-scale illustrated maps for certain sightseeing areas, and are usually printed on free leaflets provided free of charge in tourist information centers, stations and so on. The collected data will be used to improve the map designs and tourist information services. For this purpose, the users' behaviors and feedbacks are the main targets, such as:

- (a) The users' moving trajectories as records of the places they have visited,
- (b) Important operations when the users browse the maps,
- (c) Comments on certain points or parts of the maps,
- (d) Impressions of the visited places that the users are interested in.

As such data are usually difficult to obtain from the users of paper-based maps, we propose a framework for the quick development of mobile map apps that can browse such tourist maps in smartphones. With the location sensors and interactivity of the devices, the apps provide functions for viewing the maps and attached multimedia content interactively with the user's position and moving trajectory. The users can also add their own content as personal memorials or comments to the maps and places, which may include text, photos and audios, at any place of the maps with their current location.

This framework is based on a development library named ManpoKit, which is a result of our previous research on Human-Centered Mobile Mapping. ManpoKit can import analog maps and related multimedia content to mobile environments by attaching georeferences to them. With the mapping functions of

ManpoKit, developers can implement map apps easily, and create customized layers upon the map interface to realize more user interactions, such as appending users' own contents.

Prototype apps are developed for undergoing experimental projects, in order to test the feasibility of the proposed framework. One of them is a joint project with a city tourism association for improving their official tourist maps. The map app for this project is already on service. Another one tries to get users' feedback of some hand-drawn walking tour maps created by students. The intermediate results of the developments and experiments will be presented in the conference.

キーワード: data donation、tourist map、ManpoKit、mobile mapping

Keywords: data donation, tourist map, ManpoKit, mobile mapping

The democratization of planetary-scale geospatial analysis through cloud computing and massive parallelization

*David Thau¹

1. Google, Inc.

The advent of cloud computing platforms puts the capacity for performing planetary-scale geospatial analyses into the hands of anyone with access to a web browser. Cloud-based geospatial analysis platforms potentially combine several services: access to data, programming interfaces for analyzing the data, and mechanisms for sharing the analyses and publishing results. This talk will describe examples of cloud-enabled geospatial analysis solutions, and provide examples of the types of analyses these systems support. Planetary-scale examples include the global monitoring of forest loss and gain, global surface water availability, and analyses of the global fishing fleet. On a more local scale, multiple sources of data can be combined and deep stacks of temporal imagery analyzed to estimate crop yield, malaria outbreak risk, and measure evapotranspiration. Each of the examples described will demonstrate how open access to large amounts of remotely sensed data can be analyzed without the need to download source data or manage large installations of servers.

Keywords: cloud-computing

The use of GIS and spatial statistics to study the spatial distribution of strokes in Rhone-Alpes (France) to target health care location priorities

*Julie Freyssenge¹, Florent Renard^{1,5}, Anne-Marie Schott^{2,3,6}, Anne Termoz^{2,3}, Julie Haesebaert^{3,2}, Karim Tazarourte^{2,4}

1.University Jean Moulin Lyon 3 (France), 2.Laboratoire HESPER (Health Services and Performance Research - France), 3.Pôle IMER - Hospices Civils de Lyon (France), 4.Emergency department - Lyon CHU (France), 5.UMR 5600 Environment City Society CNRS, 6.University Claude Bernard Lyon 1 (France)

Stroke is a disease with a major impact on societies, particularly in developed countries. Thus, it is essential to understand this public health issue, especially in its spatial distribution and its possible relations with the surrounding areas. Consequently, a GIS (Geographic Information System) is really useful to make a spatial and statistical analysis of this phenomenon. The results are based on the AVC69 2007 study in Rhone-Alpes, on a cohort of about 1,000 patients. Rhone-Alpes is a region in south-eastern France which covers nearly 44,000 km². The city of Lyon, main town of Rhône-Alpes, is the second city in France after Paris.

In the presented study, GIS is a tool for the analysis of spatial distribution. Indeed, it has allowed studying the spatial distribution of stroke, particularly to identify the presence of clusters. Thus, after data processing, 900 patients were selected for analysis. The distribution of stroke has been studied from the stroke density per 1,000 inhabitants across the town (fig. 1). To characterize this distribution, calculating Moran's index was performed. This index indicates that the distribution of stroke is clustered (Moran's $I = 0.16$; z -score = 27.5 and p -value < 0.001). In addition, the LISA (Local Indicator of Spatial Association - Anselin, 1995) method is applied to explore the spatial patterns of stroke in different clusters (Marijon et al., 2013 ; Sasson et al., 2012). LISA method allows in particular identifying the High High-type clusters (HH), bringing together towns with high stroke rates surrounded by towns with similar characteristics. It also identifies the High Low-type clusters (HL) that are towns having lots of strokes surrounded by cities with few of them, thus being isolated. In addition, the Hot Spot Analysis Getis-Ord G_i^* statistic is applied to identify spatial clusters of statistically significant areas with high strokes rate (Ord and Getis, 1995). The Getis-Ord G_i^* statistic indicates whether high or low values of strokes are likely to cluster, and confirms the results obtained with the LISA method (fig. 1). The clusters (HH) are mainly distributed along the eastern part of the Rhône-Alpes (fig. 1). These results are used by the health and social services to target health care location priorities and focus on these precise cities. The HH and HL clusters are mainly rural. This factor might start explaining this distribution. However, additional socioeconomic and environmental factors (Mechtouff et al., 2012) are also considered to understand this dissemination, using a PCA with varimax rotation whose results will be mapped by using a GIS.

Anselin L., 1995. Local indicators of spatial association -LISA. Geographical analysis, vol. 27, no 2, p. 93-115.

Marijon, E., Bougouin, W., Celermajer, D.S., Perier, M.-C., Benameur, N., Lamhaut, L., Karam, N., Dumas, F., Tafflet, M., Prugger, C., Mustafic, H., Rifler, J.-P., Desnos, M., Heuzey, J.-Y.L., Spaulding, C.M., Avillach, P., Cariou, A., Empana, J.-P., Jouven, X., 2013. Major regional disparities in outcomes after sudden cardiac arrest during sports. European Heart Journal 34, 3632-3640.

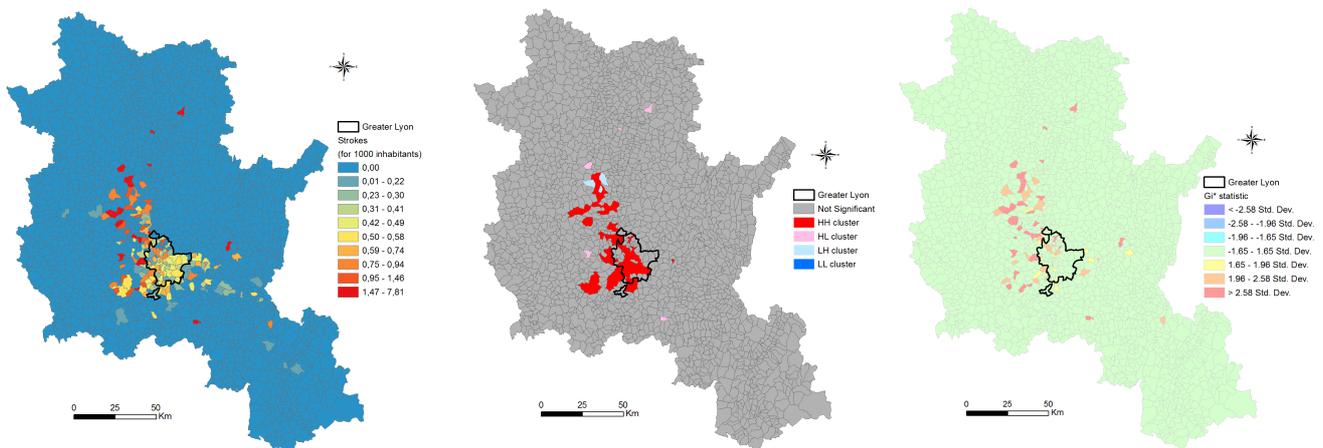
Mechtouff, L., Canoui-Poitrine, F., Schott, A.-M., Nighoghossian, N., Trouillas, P., Termoz, A., Porthault-Chatard, S., David, J.-S., Chasles, V., Derex, L., 2012. Lack of association between air

pollutant exposure and short-term risk of ischaemic stroke in Lyon, France. *Int J Stroke* 7, 669-674.

Ord J.K., Getis A., 1995. Local spatial autocorrelation statistics: distributional issues and an application. *Geographical Analysis* 27, 286-306

Sasson, C., Cudnik, M.T., Nassel, A., Semple, H., Magid, D.J., Sayre, M., Keseg, D., Haukoos, J.S., Warden, C.R., (The Columbus Study Group), 2012. Identifying High-risk Geographic Areas for Cardiac Arrest Using Three Methods for Cluster Analysis. *Academic Emergency Medicine* 19, 139-146.

Keywords: stroke, GIS, cluster, Moran's index, local indicator of spatial association (LISA), Getis-Ord G_i^* statistic



Spatiotemporal Analysis of Tsunami Vertical Evacuation: A Case Study of the Shizuoka Metropolitan Area

*Gerasimos Voulgaris¹

1.University of Tsukuba, Spatial Information Science

The city of Shizuoka directly faces the Nankai Trough, which is expected to give a major tsunamigenic earthquake every 100 to 200 years. A tsunami generated by such an earthquake could have major implications to the lives of the city's residents, even from the very first moments of the tsunami when they will need to escape. As such, there is a need to study the potential for a vertical evacuation in the city in order to provide multiple options for safe refuge in such an event.

This study has the main objective of finding vertical evacuation sites among the currently existing buildings in the city, by examining how these buildings become inundated under variable tsunami scenarios, and how the city's population moves throughout them in different times of the day leaving increased or decreased volume available for evacuation. A wide range of Geographic Information System (GIS) datasets, as well as demographical and people flow movement data were used in order to (a) calculate the inundation ratio of buildings in Shizuoka City, (b) calculate the volume loss of buildings due to tsunamis based on the inundation ratio, (c) estimate the building population of the buildings in Shizuoka over 24 hours of the day and (d) introduce criteria per tsunami scenario in order to estimate how many people can be accepted in each building for evacuation based on the variable population.

The approach of this research has indicated that for four different tsunami scenarios (5m, 10m, 20m, and 34m run-up) there are 3204 potential vertical evacuation sites for the 34m scenario, 10,426 potential vertical evacuation sites for the 20m scenario, 2,046 potential vertical evacuation sites for 10m scenario, and 1643 potential vertical evacuation sites for the 5m scenario.

The analysis of the people movement over 24 hours has shown that there are discreet population distribution patterns depending on the time of the day. In the daytime, people are concentrated in the CBD for work and the other areas of the city are less populated, while in the nighttime the majority of the population is at home and distributed at the whole extent of the city. Finally, there are morning, noon and evening transit hours where great parts of the population are in transit, and outside buildings, at different locations in the city based on their transportation method. Concerning the capacity to accept people for vertical evacuation, the temporal population estimation and volume loss calculation indicate that on all four scenarios, the maximum total capacity to accept evacuees is achieved at 10am in the morning, with the 5m scenario sites allowing for 608,948 people to be accepted in the vertical evacuation sites, the 10 meter scenario allowing for 1,746,543 people to be accepted, the 20m scenario allowing for 5,764,030 people to be accepted, and the 34m scenario allowing for 1,865,315 people to be accepted. These numbers indicate that a majority of the city's population can be evacuated in potential evacuation sites that meet this study's criteria, within the tsunami flood zone of each scenario, greatly reducing the need for movement outside the tsunami flood. The approach further reveals, that this can be achieved by utilizing only existing buildings in the city without the need for additional construction.

The approach used in this research combines methods from different fields of Geography and GIS into a new approach that can be used in different locations that meet the data requirements, producing results that can be used by interested parties such as disaster planners, emergency managers and other Geographers in order to produce enhanced and optimized vertical evacuation plans.

Keywords: Vertical evacuation, Shizuoka, Tsunami, Building population estimation, GIS

陸前高田市における震災前後で比較したコンビニエンスストアの立地の変化による住民への影響
Influence on Residents Emerged from Location Changes of Convenience Stores, through
Comparison of Pre and Post Earthquake Disaster in Rikuzentakata City

*佐藤 和平¹、古谷 勝則¹

*Kazuhei Sato¹, Katsunori Furuya¹

1. 千葉大学大学院園芸学研究科

1. Graduate school of Horticulture Chiba University

本論文は、2011年3月11日に発生した東北地方太平洋沖地震に伴う津波被害を受けた岩手県陸前高田市における、コンビニエンスストアの立地の変化による影響を分析するものである。住民意識およびアクセシビリティの観点から、2つの調査手法によって震災前と現在の状態を比較した。アクセシビリティとは交通の便の良さの度合いを意味し、本論文ではGISの到達圏解析によって求めた、その地点から最寄りのコンビニエンスストアまでの道路距離の度合いを指す。

住民意識調査では、陸前高田市内の周辺環境の異なる7区域の住民を対象としてアンケートを実施した。2015年9~10月に各戸へアンケートを配布したのち、郵送で回収した。配布数1,012に対し、有効回答数は382だった。調査内容として、自宅から最寄りのコンビニエンスストアまでどの程度遠く感じるかなどを設定した。アクセシビリティの解析は市内全域を対象とし、ArcGISのNetwork Analystを用いて、震災前と現在について各店舗から一定の道路距離による到達圏を求めた。

住民意識調査では、震災前の最寄りコンビニエンスストアについて、「遠いと感じる」が42.6%、「やや遠いと感じる」が22.3%、「あまり遠いと感じない」が19.9%、「遠いと感じない」が15.1%となった。一方現在の状態については、「遠いと感じる」から順に、16.9%、14.5%、26.9%、41.7%という結果となった。震災後、回答者が最寄り店舗を近いと感じるよう変化していることが分かる。また、アンケートの対象区域ごとに結果を比較すると、震災後ほとんどの区域で「遠いと感じる」の回答率が減り「遠いと感じない」の回答率が増える傾向にあったが、被災によって失われた中心市街地に接していた津波の到達点付近の区域では、逆の傾向がみられた。

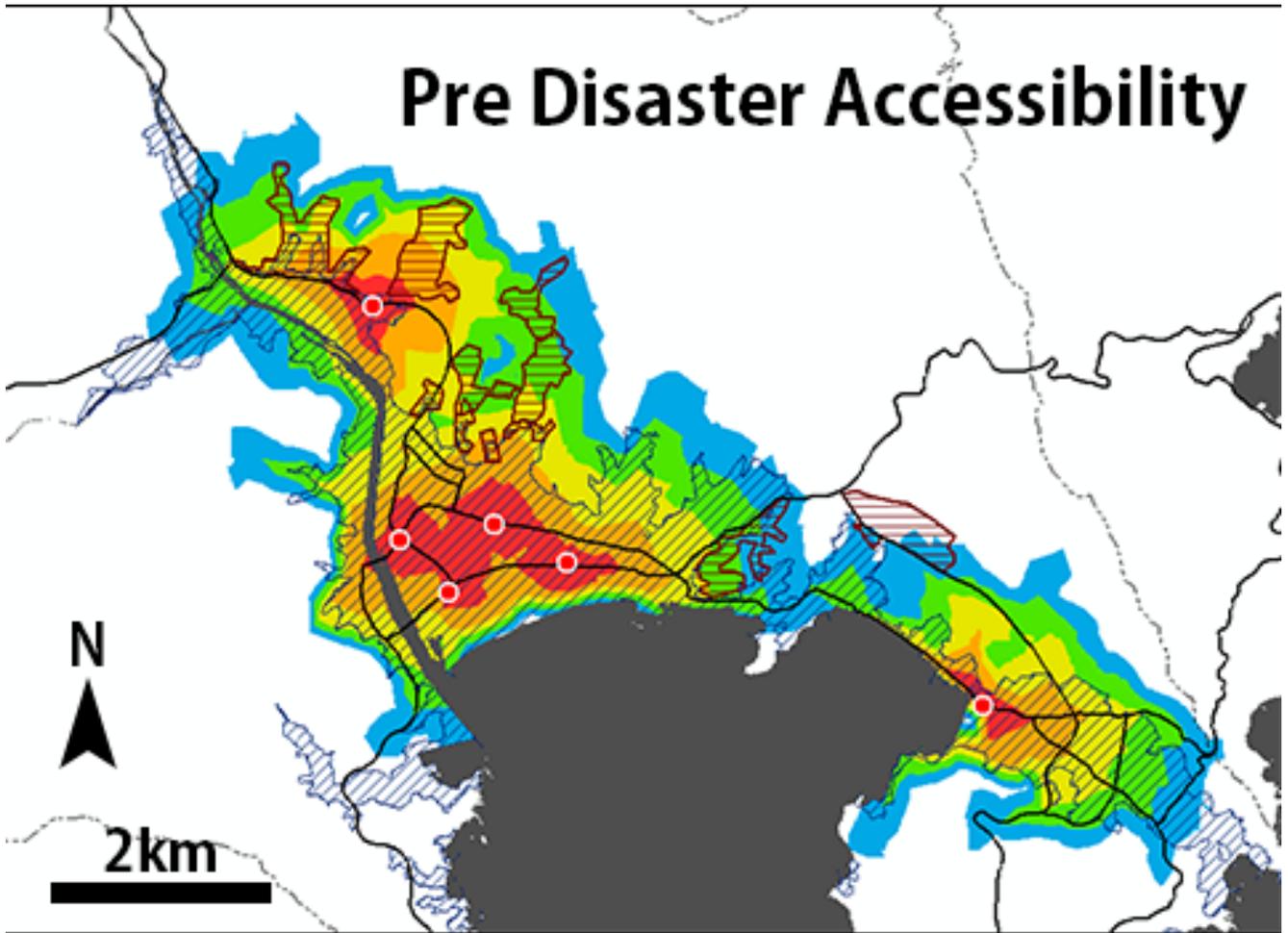
空間分析では、コンビニエンスストアに対するアクセシビリティは、震災前には主に中心市街地のあった平野部で高かったのに対し、現在はその外縁部のより広範な範囲においてアクセシビリティが高いことが分かった。これは震災前に平野部に集中していた店舗が失われ、建築制限が行われていない場所に分散的に新たな店舗が建てられたことが原因である。

最後にアンケートを行った区域の空間分析の結果を、住民意識の結果と比較した。対象区域の大半では、震災後のアクセシビリティが上昇している。また津波の到達点付近の区域のアクセシビリティの変化は場所によって異なり、明らかなアクセシビリティの上昇は見られない。以上から、住民意識の「遠いと感じる」の回答率が減る傾向の区域と、空間分析でアクセシビリティの上昇がみられる場所は一致していることが分かる。異なる2つの調査手法が明らかにした施設の立地の変化による住民への影響は、概ね一致するといえる。本研究は日本デジタル道路地図協会より、全国デジタル道路地図研究用データの寄与を受けて行った。

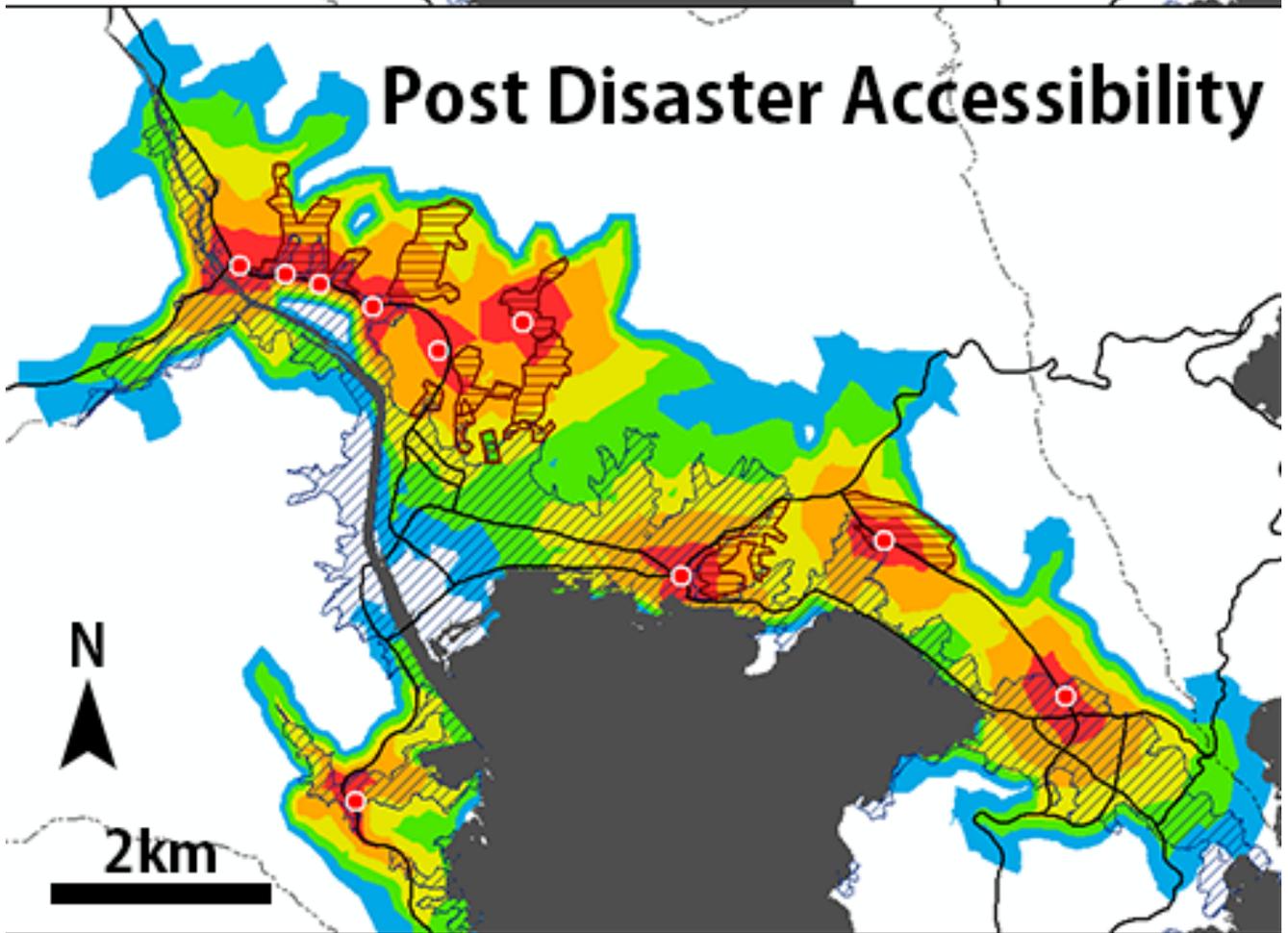
キーワード：東日本大震災、陸前高田、アクセシビリティ、GIS、ネットワーク分析

Keywords: Tohoku Regional Pacific Coast Earthquake, Rikuzentakata, Accessibility, GIS, Network Analyst

Pre Disaster Accessibility



Post Disaster Accessibility



Legends

City limits

GIS based decision support system for Sri Lankan agriculture sector

*Ranagalage Mahinda Manjula¹, Sanjeewa Lasantha Dissanayake¹

1.Rajarata University of Sri Lanka

The agriculture plays a dominant role in the economy of Sri Lanka while it contributes nearly 17.9 % to the Gross National Products (GNP) or Gross Domestic Product (GDP). Moreover, agriculture sector of Sri Lanka has generated more than one-third of the labour force and provides a livelihood for more than 800,000 farm families. Several government and non-government organizations involves with various sectors of agricultural related activities including management, research, and policy planning in the country. However, there is a gap in between these organization to integrated agricultural related data in order to provide a frame for better decision making practices. In this context, the development of a computer based tool is very important. The main objective of the study is to develop a user friendly GIS based decision support tool for the benefit of agricultural sector of Sri Lanka. Specifically, this will help both GIS users and non-GIS users who involves in agricultural related decision making process. Basically, this tool facilitates the user to find several agriculture related information, like suitable crop, suitable place, suitable time for farming and harvesting in Sri Lanka.

Keywords: NADSS, Decision making, spatial information

GIS based decision support system for Sri Lankan agriculture sector

Manjula Ranagalage¹, DMSLB Dissanayake¹

1. Rajarata University of Sri Lanka

The agriculture plays a dominant role in the economy of Sri Lanka while it contributes nearly 17.9 % to the Gross National Products (GNP) or Gross Domestic Product (GDP). Moreover, agriculture sector of Sri Lanka has generated more than one-third of the labour force and provides a livelihood for more than 800,000 farm families. Several government and non-government organizations involves with various sectors of agricultural related activities including management, research, and policy planning in the country. However, there is a gap in between these organization to integrated agricultural related data in order to provide a frame for better decision making practices. In this context, the development of a computer based tool is very important. The main objective of the study is to develop a user friendly GIS based decision support tool for the benefit of agricultural sector of Sri Lanka. Specifically, this will help both GIS users and non-GIS users who involves in agricultural related decision making process. Basically, this tool facilitates the user to find several agriculture related information, like suitable crop, suitable place, suitable time for farming and harvesting in Sri Lanka.

Key words- NADSS, Decision making, spatial information

Spatiotemporal pattern of urban process in Colombo metropolitan area, Sri Lanka

*Shyamantha Subasinghe¹

1. Graduate School of Life and Environmental Sciences, University of Tsukuba

Identifying and evaluating urban land use changes (ULCs) and its driving forces supports to the decision-making in urban planning and resource management. The study analyzes the ULCs in Colombo metropolitan area (CMA), and detects the geospatial dimension of its urbanization pattern as the main objective. The study site is the largest and only metropolitan area of the Sri Lanka, which contains mosaic of complex urban land use types. The methodology of study includes three major components. The first is the remote sensing based land use/cover mapping and defining urban land uses (ULUs) based on neighborhood characteristics. The second is examining the ULCs using the land intensity analysis. The third is characterizing the spatial dimension of urban development through infill, extension, and leapfrog development pattern indicators. Main two scenarios are defined to achieve the main objective of the study: the rapid urban expansion period (1992-2001) and drastic urban expansion period (2001-2014). These two scenarios are defined depending on the country's political backgrounds and urban planning policies. Specifically, it is used Landsat TM/ETM+ data and employs hybrid mapping techniques (pixel/object-based) in producing the LUC maps. Further, the variety of GIS-based operations is used in order to detect the geospatial dimension of urbanization patterns. Finally, the ULC pattern, and the major driving factors in particular are discussed.

Keywords: Colombo metropolitan area, Hybrid mapping, Neighborhood, Urban land use change

Monitoring the urban growth pattern and intensity of Lusaka City, Zambia

*Matamyo Simwanda¹

1.Division of Spatial Information Science; Graduate School of Life and Environmental Sciences;
University of Tsukuba

Many cities in Sub Saharan Africa have experienced rapid urban growth. Uncontrolled and unplanned population growth caused by rural urban migration has been the main driving force of urban growth in these cities. Consequently, the form of urban growth of SSA cities is usually characterized by emergence of informal settlements which are located close to urban growth centers such the Central Business District and other industrial and commercial areas. This has transformed many SSA cities into complex urban environments with different Urban Land Forms (ULF) (Residential, Industrial, Commercial etc.). Therefore, spatial temporal monitoring of the urban growth pattern is inevitable for the local planning authorities and decision makers to address urban growth problems and for better future urban planning, management and development.

This study examined the urban growth pattern and growth intensity of deferent ULFs in Lusaka, the capital City of Zambia. First the city landscape was classified into two urban classes (Built up and Non Built Up) from Landsat TM and ETM+ images using Remote sensing and GIS techniques for three time periods, 1990, 2000 and 2010. Then six ULFs from the built up class were characterized for all the three time periods: (1) Unplanned High Density Residential (UHDR) (2) Unplanned Low Density Area (ULDR) (3) Planned High Density Residential (PHDR) (4) Planned Low Density Residential (PLDR) (5) Commercial and Industrial Areas (CIA) and (6) Public Institutions and Areas (PIA).

The study also adopted the Burgess Concentric Zone Model to characterize the urban growth pattern. Four Zones were identified: (1) CBD Core, (2) CBD Fringe, (3) Transition Zone and (4) Peri-Urban Zone. The magnitude and intensity of each ULF was then analyzed within the entire administrate boundary of the city and the four zones from 1990 to 2010. Pearson's Correlation method was also used to analyze the correlation between different ULFs

The results show that the urban land changed from 49.2 km² in 1990 to 84.4 km² in 2000 and 158.8 km² in 2010. This translated into an Urban Growth Intensity (UGI) of 8.4% for 1990-2000 and 17.9 % for 2000 -2010 with annual intensities of 0.84 and 1.79 respectively. It was observed that urban growth has been dominated by the UHDR followed by PHDR and CIA. All the UGIs for all the ULFs were very high with annual change intensities ranging from 3.4 to 4.6% for 1990-2000 and 3.6 to 7.7 % for 2000-2010. In terms of Zones, the UHDR contributed significantly urban land increase except for the CBD which was dominated by commercial and industrial areas. The correlation analysis results showed that there is high correlation between UHDR and PHDR as well a CIA.

The paper revealed problems in city planning as shown by high dominance of UHDR areas. Therefore, the information from this paper can be used by local city planners for better future planning.

Keywords: Urban Growth Pattern, Urban Land Forms, Intensity, Lusaka City