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Changing the Face of Geography

Roger F. Tomlinson

This article is a summary of the presentation given by the author during the cellebration of the 21st Anniversary of the Laboratory of Geographic Information and Teledetection (LIGIT) of the Universidad Autónoma de Barcelona *(Spain) in October of 2008. The development of Geographic Information Systems (GIS) has provided a decisive impetus to solve a large number of the problems facing humanity, based on extraordinary improvements in the availability and in the capacity to analyse data and relevant spatial variables. The author examines numerous examples of current GIS programs and highlights future challenges.*

Keywords: Geographical Analysis, Geography, GIS, Globalization, Spatial Heterogeneity, Spatial Model, Spatial Variables.

Author

Roger F. Tomlinson is an English geographer and the primary originator of modern computerized Geographic Information Systems (GIS), and has been touted as the "father of GIS". He received a Masters degree in geography from McGill University (Montreal, Canada) and obtained his Doctorate at the University College London (UK). Dr. Tomlinson has worked in geographic consulting and research for a variety of private sector, government and non-profit organizations, largely through his Ottawa-based company, Tomlinson Associates Ltd. He was Chairman of the International Geographical Union GIS Commission for 12 years. He pioneered the concepts of worldwide geographical data availability as Chairman of the IGU Global Database Planning Project in 1988. He is a past president of the Canadian Association of Geographers. Among the several international awards he has received, more recently he was made a fellow of University College London and received honorary Doctorates of Science from the University of Nottingham (UK), Acadia University (Nova Scotia, Canada), and from McGill University, the Gold Medal of the Royal Canadian Geographical Society and the Order of Canada by the Governor General for "changing the face of geography as a discipline"[1] . <talgeo@magma.ca>.

Geographers have as their task the description and explanation of the living space of humans and of the resulting spatial structure of society. The development of formal views of these concerns forms the basis for the modern science of Geography. The extent and complexity of the world we live in makes this task hard. The volumes of data that result from even cursory global investigation are a serious impediment to our understanding. Fifty years ago, it was not possible to handle any large set of the hardcopy maps and data that were being gathered, much less analyze them in any efficient way. The resulting inability, indeed the failure, to ask questions, let alone consider in depth the role of various interacting influences shaping the individual and societal factors left us with a deep and generally unrecognized ignorance of space and time behaviour.

The advent of computers as information processing tools and the development of Geographic Information Systems (GIS) has measurably assisted geographers in their work. These new tools are being added to the discipline. Just as the advent of the telescope by Galileo increased the knowledge of the heavens and the concepts of space, and as the advent of the tool of the microscope revolutionized biology with its ability to add resolution and depth to enquiry, so the advent of the tools of GIS has impacted the discipline of geography. The quality of questions asked is rising and the scope and use of spatial analysis is becoming more sophisticated. We are digging deeper into the spatial variables in considering factors that otherwise would not be explored. The trade-off between effort and enquiry is shifting in favour of enquiry. Workers are able to exchange their reasoning (decision models) very easily. This is contributing to the awareness of geography and the growing number of people becoming involved in the field. There is increasing exchange of ideas and methods. As a result, the study of geography is changing significantly and beneficially, and in particular expanding outside of the academic confines. Geography as a discipline is no longer encompassed by academic geography. It is not principally reductionist, curiosity-driven, with a goal to produce general laws (although that is a long established scientific method with great virtue). There is an urgent demand for the use of geographic science in governments, relative to society, and to address the pressing issues facing the world. The theme of this congress emphasizes this direction. Geographers have major contributions to make to these issues.

There is, for example, broad agreement in the scientific community that the Earth's climate is changing and that it is part human induced. Very little is known, however, about the societal impacts of climate change, and there are very important geographical questions that need to be answered about the changes in bio-geo-chemical cycles, ecosystems,

[1] Author biography summarized from <http://en.wikipedia.org/wiki/Roger_Tomlinson>.

water resources, resource utilization, continued atmospheric pollution, and the overall economic, political and social implications. Geographers can contribute to the body of knowledge about climate change by synthesizing, analyzing and modeling possible impacts.

Similarly, with respect to human health and well-being, understanding of a population's health, the distribution of disease in an area, and the environment's effect on health and disease is central to human existence and a quintessentially geographical problem. There are also significant issues about the accessibility to health care and spatial distribution of health care providers.

Globalization is about interaction and integration among people, companies and governments of different nations, a process driven by international trade and investment, and aided by information technology. It has effects on the environment, culture, political systems, economic development and prosperity, and human physical well-being in societies around the world. Again, the analysis of these conditions has a strong spatial component.

Societal security is an essential goal of all governments, and one which has become increasingly difficult to fulfill in recent years. In an area of asymmetric warfare, socio-political solutions have become ever more complex and their impacts affect different communities and socio-economic groups in different ways.

Sustainability entails meeting the needs of the present without compromising the ability of future generations to meet their own needs, and still remains a problem, especially in the light of accelerated environmental change and the current food crisis. Geographers have a great deal to contribute to understanding and solving this complex, multi-dimensional, essentially spatial problem.

Underpinning Social Diversity means understanding and generalizing the processes of spatial heterogeneity: that of defining characteristics of patterns and processes on the surface of the earth. Understanding these processes, which account for social diversity, difference and inequality, is key to good governance.

The following are illustrations of some of the ways in which GIS are being used to examine spatial situations.

Climate

Consider the magnitude of occurrence per unit area of all East Pacific and North Atlantic Basin tropical cyclones. The Palmer Drought Severity Index is the basis for agricultural relief for farmers in major distress in the USA. Of particular interest is the analysis of drought on nuclear power plants. They require large volumes of water for cooling purposes and sustained drought means that they have to be closed down, removing their supply of electricity in the states concerned.

Human Impact

The first human impact map is of global population density, together with the CO_2 emissions in the atmosphere which can be tracked using real time Jet Propulsion Laboratory satellite sensor information.

Population Density

Provided as an element in the calculations of human impact and human footprint.

Human Footprint

The human footprint aims to measure the extent of human interference on the Earth's surface, using updated data on human population density, land transformation, human access, electrical power infrastructure and settlements. The latest version was produced in 2008. The work was produced by the Humanitarian Information Unit of the Office of the Geographer and Global Issues (Director Dr. Lee Schwartz) of the Bureau of Intelligence and Research in the United States Department of State.

Human Health

Human health examines the interaction of spatial variables, including the U.S. Department of Agriculture's work of animal influence on human health, the outbreaks of avian flu in China by location, the tracing of the Severe Acute Respiratory Syndrome (SARS) outbreak in China and in Hong Kong to identify its origins, the National Cancer Institute's analysis of environmental effects on cancer incidents, and the relationship of smoking and birth weight in part of Ontario, Canada.

Avian Flu

Avian flu and bird migration routes illustrate the correlation between known outbreaks of avian flu and bird migration corridors to assist in the process of identifying the source and the diffusion of the disease. The same GIS application allows users to identify quarantine stations, flu shot clinics and local public health departments.

Ambulance Location

The process of pre-positioning ambulances for better service is examined. Contours of actual demand (call density) and the existing position of ambulances to meet that demand are calculated from which to optimize response travel times affecting the efficiency of ambulance organization and survival rate in the area.

Flu Vaccine Distribution

Access to influenza vaccine distributions compares population distribution with access buffer zones of one mile radius and two mile radius around points of distribution of vaccines. Similar analysis is being used in preparation for avian flu epidemics.

Acquired Immunodeficiency Syndrome (AIDS)

The progress on the President's emergency plan for AIDS relief (EPPA) in sub-Saharan Africa is illustrated as a basis for policy change. Also included are results in Vietnam and Guyana. Further analysis and understanding of the AIDS epidemic in Africa, particularly Kenya, Uganda, Tanzania and Zambia and Malawi are examined by gender showing the percent Human Immunodeficiency Virus (HIV) posi-

tive in four categories (2-5%, 5-10%, 10-15% and more than 15% of the population). Similarly, the HIV prevalence among youth by first order administrative divisions in the countries concerned, again as a percent of the general population and by gender. These studies underpin the effective delivery of AIDS relief in sub-Saharan Africa and the monitoring and analysis of program effectiveness.

Life and Death in Africa

This is an analysis with broad scope. It includes infant mortality, access to drinking water, overall AIDS infections, gross national income and the resulting life expectancy by country. Bringing these variables together over a continent allows workers better to understand the measures necessary to improve the national condition.

Food Riots 2007-2008

The human condition of the world, particularly the food riots of 2007 and 2008, are tracked and illustrated. This is a first illustration of the worldwide dimension.

Afghanistan Opium Cultivation

Now supplying 80% of the world's heroin, this is a global issue. This map compares the population density in Afghanistan with the areas of poppy cultivation. The Taliban are operating extensively in the southern area of the country and have recently started operations in the Northeast.

Habitat Destruction

This example from Brazil graphically illustrates the extent of harvesting which is systematically removing rain forest.

Where to Plant a Billion Trees

The Greenbelt Movement, spearheaded by Nobel Prize-winner Wangari Maathai is a quasi-political/environmental, and very successful, movement with the object of planting a billion trees in Africa. Peter Ndunda is the GIS Coordinator for the project, actively working in east and west Africa to overlay soil types, climate, animal habitat, population density and tribal lands to determine the most effective sites for planting. Without the GIS, trees would be planted in unfavourable sites. Their survival would be dubious and the popular political support would wither away.

Plant Hardiness Zone Migration

The Nature Conservancy at the University of Washington has calculated the plant hardiness zones in 1960, 2008 and 2099. The northwards movementof the boreal forest and the ameliorating of temperature in the Arctic islands are particularly noticeable. Implications for habitat can be measured and better appreciated.

Arctic Sea Ice

The Artic sea ice conditions are put into perspective. NASA data show that Arctic perennial sea ice, which normally survives the summer melt season and remains year-round, shrunk abruptly by 14 percent between 2004 and 2005. The loss of perennial ice in the East Arctic Ocean was even higher, nearing 50 percent during that time as some of the ice moved from the East Arctic to the West. The overall decrease in winter Arctic perennial sea ice totals 720,000 square kilometers (280,000 square miles), an area the size of Texas. Perennial ice can be 3 or more meters (10 or more feet) thick. It was replaced by new, seasonal ice only about 0.3 to 2 meters (one to seven feet) thick that is more vulnerable to summer melt. The decrease in the perennial ice raises the possibility that Arctic sea ice will retreat to another record low extent this year. This follows a series of very low ice-cover years observed over the past four summers from active and passive microwave satellite data.

Travel History

Travel history is illustrated. Tracking the flights of one company over the course of a year allows an understanding of the environmental impact enroute, the use of increasingly high-cost fuel and the distribution of future corporate locations/regional offices.

Hydro-Watershed

The hydro-watershed of the Neuse River in North Carolina is a sophisticated exercise in flood probability and control based on rainfall and evaporation over the course of a year.

Humanitarian Aid

The first humanitarian aid example is one used by USAID to determine the location of individuals affected by cyclone activity in Bangladesh. This analysis was used as a basis for extensive aid being provided in the right locations.

The second example of humanitarian aid produced by the Office of Foreign Disaster Assistance in the USAID concerns the Greek wildfires of 2007. The principal map is the result of daily identification of five boundaries. In particular, the analysis concentrated on the degree of soil-burn severity in the Kladios Basin which allowed the focus of aid to be directed to those communities most affected by long-term damage and in the most desperate need of assistance.

Humanitarian aid provided by the U.S. Department of State in the Horn of Africa is concerned with the potential interaction of drought, locusts, flooding and earthquakes, providing measures of the probability by hazard type to provide policy guidance for assistance in this area.

Humanitarian aid for water supplies in Afghanistan is the frequently minimized side of the U.S. Department of Defense using mobile GIS in identifying the needs and building the facilities for water supply in Afghanistan.

The Press Response

The Press takes note of geography in action. There has been a series of newspaper headlines concerning GIS utili-

zation in city operations, police department activities, real estate transactions, riverine studies and so on.

Commercial Applications

Commercial store locations give the illustration of increasing use of geography in the business community, analyzing how specific retail outlets are located with respect to the drive distance in mile from their nearest competitors and the subsequent analysis of areas with access to more than one store to ensure that new store locations do not compete in the trade area of existing stores.

All the previous examples illustrate how GIS combines the ability to manage stores of geographical data, perform spatial analysis and modeling to visualize the output and disseminate the results and methods.

It is not surprising that GIS and geographical analysis are being widely used. But the diffusion of geographical analysis methodology throughout the real world is quite remarkable. Based on GIS licensing records, there are few countries or government departments in the world that area not using GIS. At least 5 million people in over 300,000 institutions in over 155 countries are doing geography using geographical methods in their work daily.

The largest campuses investigating geographical analysis are not in academia but are in the private sector. The ESRI company alone, in Redlands, California, has 4,000 worldwide employees, 100 Ph. Ds, 1,500 Masters, and adds 500 new graduates each year.

Using the assumption that every $1 million of investment of data and GIS systems requires at least one trained person to for the investment to be used effectively, then there is shortfall of at least 3,000 trained people per year in North America alone, compared to the output from all universities and technical colleges in North America. Students are realizing that geography offers career opportunities and interesting jobs throughout the working world.

Interest in the discipline is everywhere growing. Academic geography may be splintering into quasi-named departments and sub-specialties, but students who are trained in geographical analysis and can use the modern tools of GIS are in high demand. The growth of this interest is exemplified in the growth of the Association of American Geographers which has increased significantly in size (by 50%) in the past decade alone and whose yearly conferences are attended by more people than ever before (Figure 1).

1998 - 6,910
1999 - 6,527
2000 - 6,497
2001 - 6,731
2002 - 7,004
2003 - 8,475
2004 - 9,041
2005 - 9,478
2006 - 10,086
2007 - 10,346

Figure 1: Number of Affiliates to the Association of American Geographers During the Last 10 Years.

Similarly indicative is the reintroduction of Geography at Harvard after an absence of 60 years in the new Center for Geographical Analysis. At its inauguration the President of Harvard said "*Geographic Information Systems will let us change the nature of questions that are asked in a wide diversity of science and humanity*".

Indeed a wide variety of problems have already been illustrated and are being addressed, but a wide variety of broad-based issues demand the attention of geographers.

There is a geography of security and terrorism that is multifaceted and comparatively little researched and understood, in spite of the fact that it could contribute enormously to this pressing problem. There is great scope in this area for the development of critical theories to examine alternative geographies.

The extensive development of quantitative geography in the 1960s and 1970s addressing the problems of analyzing and modeling space need to be integrated with the GIS capabilities of today and brought together to develop wider and more generally applicable models of geographic space and time focusing on interactions and dynamics.

We still have no adequate models for major cities, much less for the world itself. I am convinced that we will have, or at very least our grandchildren will have, but there are many research questions that remain to be investigated on the way to creating Al Gore's "digital Earth". There are questions that touch on many aspects of geography, including representation, efficiency of information management, appropriate scientific visualization of issues, applications, and policy implications. I have no doubt that GIS will be at the core of this progress and that the future will be rich and productive.