1 Systems, Science, and Study

The chapter introduces the conceptual framework for the book, by addressing several major questions:

- What exactly is geographic information, and why is it important? What is special about it?
- What is information generally, and how does it relate to data, evidence, knowledge, wisdom, and understanding?
- What kinds of decisions make use of geographic information?
- What is a geographic information system (GIS)?
- What is geographic information science, and how does it relate to the use of GIS for scientific purposes?
- How do companies make money from GIS?

LEARNING OBJECTIVES

- **Know definitions of the terms used throughout the book, including GIS itself;**
- **Be familiar with a brief history of GIS;**
- **Recognize the sometimes invisible roles of GIS in everyday life, and the roles of GIS in business;**
- **Understand the significance of geographic information science, and how it relates to geographic information systems;**
- **Understand the many impacts GIS is having on society, and the need to study those impacts.**

KEY WORDS AND CONCEPTS

Knowing about ‘where’; geographic problems; scale/detail; science and practical problem solving; spatial is special; the sequence data/information/evidence/knowledge/wisdom; knowing how; GIS roles; GIS history; Internet and GIS; GIS as several businesses; ‘systems’, ‘science’ and ‘studies’

OUTLINE

CHAPTER SUMMARY

1.1 Introduction: Why does GIS matter?

- GIS are a special class of information systems that keep track not only of events, activities, and things, but also of *where* these events, activities, and things happen or exist.
- Knowing where something happens is of critical importance
- Geographic location is an important attribute of activities, policies, strategies, and plans.
- *Geographic problems*. involve an aspect of location, either in the information used to solve them, or in the solutions themselves
- Three bases for classifying geographic problems

- the scale or level of geographic detail
- the intent or purpose
    - practical problem-solving or *normative* applications, such as finding new locations
    - curiosity driven or *positive* uses that advance science, such as predicting behavior based on location
- the timescale
    - *operational* decisions required for smooth functioning of an operations
    - *tactical* decisions which are medium-term
    - *strategic* decision for long-term direction
    - *transactional* timescales at which databases are updated

- Applications Box 1.1 Hurricane Katrina, August 29, 2005, discusses how location was crucial in the emergency responses to Hurricane Katrina.
- Applications Box 1.2 Where did your ancestors come from? Illustrates curiosity driven research.

1.1.1 Spatial is Special

- The basic terms need clarification
    - *Geographic* refers to the Earth's surface and near-surface
    - *Spatial* refers to any space, often used in place of geographic
    - *Geospatial* implies a subset of spatial applied to the Earth's surface and near-surface
- Spatial is special because
    - almost all human activities and decisions involve a geographic component
    - working with geographic information involves unique, complex and difficult choices
- technical reasons are summarized in Technical Box 1.3

1.2 Data, Information, Evidence, Knowledge, Wisdom

- No universally agreed definition of these terms, however,

- *Data* are raw facts, neutral and context-free, internal meaning is irrelevant
- *Information* is data refined for some purpose or that have been given some degree of interpretation, often costly to produce but easy to add value to through processing.
- *Knowledge* is information to which value has been added by interpretation based on a particular context, experience, and purpose; it is often acquired over substantial periods and involvement in many projects.
    - *Codified* – can be written and transferred easily to others
    - *Tacit* – is slow to acquire and difficult to transfer accurately

- *Evidence* – is halfway between information and knowledge, a multiplicity of information from different sources whose selection and analysis is focused on specific problems

- *Wisdom* – used in the context of decisions made or advice given

- Table 1.2 compares and illustrates these terms

1.3 Systems and Science

- GIS are computer-based systems for storing and processing geographic information.
- GI Science (GISc) is the scientific context and underpinnings of geographic information systems

1.3.1 The science of problem solving

- Knowledge about how the world works (*process*) is more valuable than knowledge about how it looks (*form*), because such knowledge can be used to predict

    - *Idiographic* geography focuses on the description of form and emphasizes the unique characteristics of places

    - *Nomothetic* geography seeks to discover general processes

- GIS is useful as a tool for problem solving because it combines the general with the specific

- Software captures and implements general knowledge

- The database represents specific information

- General knowledge for problem solving comes in many forms
    - Classifications
    - Rule sets, some based on statistical generalisations
    - Laws
- Solving problems needs *objectives* which can be expressed in *tangible* (measured on some well-defined scales) and/or *intangible* ways. There may be multiple objectives.

1.3.2 The technology of problem solving

- Table 1.3 lists several definitions of GIS and the groups who find them useful

1.4 A brief history of GIS

- This section mentions several milestones including
    - The Canada Geographic Information System or CGIS, designed in the mid-1960s as a computerized map measuring system
    - The US Bureau of the Census and the DIME program for the 1970 census
    - Harvard University's Laboratory for Computer Graphics and Spatial Analysis which developed ODYSSEY GIS in the late 1970s
    - UK Experimental Cartography Unit pioneered high quality computer mapping from 1968 up to the mid-1970s
    - Computer mapping at the national mapping agencies
    - Remote sensing developments including military satellites, Landsat and GPS
- "The modern history of GIS dates from the early 1980s, when the price of sufficiently powerful computers fell below a critical threshold."
- Table 1.4 summarizes the major events

1.5 Views of GIS

- There are many different perspectives on GIS
    - It is clearly too much for any one software package to handle
- GIS has grown from its initial commercial beginnings as a simple off-the-shelf package to a complex of software, hardware, people, institutions, networks, and activities that can appear very confusing to the novice.

1.5.1 Anatomy of a GIS

1.5.1.1 The network

- This section offers a brief history of the Internet and its impacts
- The links between GIS and the Internet are described, as a vehicle for delivering information, applications and services (including location-based services)

1.5.1.2 The other five components of GIS

- Figure 1.16 illustrates the six component parts of a GIS
- Hardware, software, procedures, data, people and network

1.6 The business of GIS

- Includes:
    - The software industry
    - The data industry
    - The GIService industry
    - The GeoWeb Service industry
    - The publishing Industry
    - GIS education
- Technical Box 1.4 lists magazines and websites offering GIS news and related services
- Technical Box 1.5 lists scholarly GIS journals
- Technical Box 1.6 lists sites offering Web-based education and training in GIS

1.7 GISystems, GIScience and GIStudies

- The term *geographic information science* was coined in a paper by Michael Goodchild published in 1992.
- Related terms include geomatics, geoinformatics, spatial information science, geoinformation engineering.

- All suggest a scientific approach to the fundamental issues raised by the use of GIS and related technologies
- Technical Box 1.7 shows the UCGIS GIScience research agenda and ties it to the chapters in the book
- *GIStudies* can be defined as the systematic study of society's use of geographic information, including its institutions, standards, and procedures

1.8 GIS and the Study of Geography

- This section explores this relationship and its sometimes tense characteristics.
- While spatial analysis has a long history, new data handling techniques and rich data sources are moving it strongly to new frontiers
- However, there is enduring unease in some academic quarters about GIS applications and their social implications, including
    - GIS favors certain phenomena and perspectives
        - Often used for purposes that may be ethically questionable or invade individual privacy
        - Concern about a field led by the technology and the marketplace rather than human need (as articulated by academics)
        - GIS as a tool in the hands of the already powerful
    - An absence of critical research in GIS
    - 'Guilt by implied association' – the uninformed bind GIS to logical positivism, with its restrictive assumptions.

ESSAY TOPICS

Generally speaking, these get more searching as one progresses down the list:

1. List and outline any four geographical problems to which GIS might be applied.
2. What are the three characteristics that enable distinctions to be made between different geographical problems?
3. The authors state that 'spatial is special'. List seven reasons why this is true.
4. Figure 1.6 shows the 'geography' of the family names of the authors in 1881 and in 1998. What processes over the Twentieth Century do you think account for the similarities and differences between the maps?
5. If you (or any of your classmates) have a fairly common Anglo Saxon family name, visit gbnames.publicprofiler.org and worldnames.publicpfofiler.org and investigate (a) the

Great Britain geographies of the family name in 1881 and 1998 and (b) the international dispersal of the name – to North America and Australasia in particular. Perhaps after consulting family members, suggest some of the processes that may have fuelled this dispersal.

6. What are the distinguishing characteristics of the scientific method? Discuss the relevance of each to GIS.
7. Why is a GIS much more than 'a container of maps in digital form'?
8. Is knowing 'where' as important as knowing 'when'?
9. Why should 'knowing about how the world works' be more valuable than 'knowing how it looks'? Illustrate your answer with real world examples.
10. Can a 'single collection of tools' like a GIS ever 'bridge the gap between curiosity-driven science and practical problem solving'?

MULTIPLE CHOICE QUESTIONS (MCQ)

The material, and the relatively high level of the intended learning objectives set for this chapter, do not readily lend themselves to the use of MCQs.

ACTIVITIES

1. Look ahead to Chapter 2, A Gallery of Applications, and select any one of the case studies. Using the information provided, suggest how well it illustrates each step in the sequence: data/information/evidence/knowledge/wisdom.

2. Examine the geographic data available for the area within 50 miles (80 km) of either where you live or where you study. Use it to produce a short (2,500 word) illustrated profile of either the socioeconomic or the physical environment. (See for example http://www.data.gov/; http://www.data.gov.uk; www.arcgis.com; http://www.inspire-geoportal.eu/; or www.magic.gov.uk).

3. Allocate each student the task of researching the career history of a well known protagonist, or detractor, of GIS (e.g. the contributors to the Foresman book referenced below, or one of the authors of the book or of this Instructor Manual). Each student should prepare a ten minute presentation illustrating the importance of software systems, (social, natural or environmental) science and GIStudies to the individual's career history. A summary session might be used to develop the class's thinking as to whether

the academy provides adequate bridgeheads between GISystems, GIScience and GIStudies.

4. A debate on the critical theoretical perspective on GIS. Create two teams, and organize a full debate using as a guide the instructions given in Chapter 5 of Gold et al (1990, see http://www2.glos.ac.uk/gdn/gold/ch5.htm). The first team should propose the motion that 'Geographic information systems sell second rate geography' using as evidence relevant essays in Pickles J. 1993 *Ground Truth: The Social Implications of Geographic Information Systems*. New York: Guilford Press. The second team should use the Research Agenda provided by the University Consortium for Geographic Information Science to oppose this motion, see UCGIS 1996 'Research priorities for geographic information science'. *Cartography and Geographic Information Systems* 23(3): 115–127.

5. The fundamental importance of scale can be best illustrated by examination of a series of paper or on-screen maps from a single national mapping agency at scales from, say, 1:2,500 to 1:1,000,000. Using the Google™ search engine to do image searches is an easy way to find suitable maps, but the map extracts sequence provided by the Ordnance Survey of Great Britain at www.ordnancesurvey.co.uk are also easy to access.

6. A very good way to introduce the power of Internet mapping is through a project that uses it. A very good source of on-demand thematic mapping can be found http://www.maptube.org/ and http://geocommons.com/. Using these sources, ask students to prepare a presentation of what types of data are contained on the sites, and what this can say about the country in which they live.

7. Figure 1.13, shows the world geography of Internet usage in April 2008 and illustrates a phenomenon that has been called the 'digital divide' – the gap between information rich, Internet connected developed countries and the rest, where even access to electricity is rare. Data from the World Bank website, at www.worldbank.org/data enables a class investigation of this divide more formally, by a correlation analysis of economic indicators for a sample of countries with their reported number of Internet users. Having completed this at the country level, a useful discussion can be held on other regional and local dimensions of the 'divide' such as age, income, gender, and rural/urban differences.

8. Section 1.5.1.2 provides Websites for a number of major GIS vendors. Divide the class into four or more groups, with the objective that each group will represent the interests of

a particular vendor. Each group visits the Websites and produce a summary catalogue of the products on offer. In each case, each groups rates the offering as High/Medium/Low on a series of criteria such as level of user sophistication, intended data volume, commercial applicability, cost, amount of computer power needed, and so on. In a seminar presentation, a spokesperson for each vendor provides a market assessment of the vendor's position in the GIS marketplace.

9. The five M's of GIS are mapping, measuring, management, monitoring and modeling. Ask each student to chose an academic journal from the list given in Technical Box 1.5, or a trade magazine from those in Technical Box 1.4 and using this as source find, say, ten articles that use GIS. In each case classify the principal aim of the article into one or other of these M's. This exercise is valuable in drawing student attention to the literature, and it can be followed by assembling a frequency table using all the class results that should/might provide an interesting commentary on which of the M's is valued by which user community.

10. Either individually or in class, examine the research themes of the UCGIS research agenda listed in Technical Box 1.7. In each case locate the theme on the triangle diagram presented as Figure 1.18. Use a different color symbol for the 'long-term research challenges' and the 'short term research priorities', and comment on any differences that you observe.

FURTHER READING

Chrisman N.R. 2003 *Exploring Geographical Information Systems* (2nd edn). Hoboken, NJ: Wiley.

At first sight this is a standard text on GIS, but in fact it contains a great deal of wisdom about its social and scientific consequences from one of the pioneers.

Curry M.R. 1998 *Digital Places: Living with Geographic Information Technologies*. London: Routledge.

Together with the set of essays edited by Pickles (1993), Curry's book articulates the 'critical theory' critique of GIS.

Foresman T.W. (ed) 1998 *The History of Geographic Information Systems: Perspectives from the Pioneers*. Upper Saddle River, NJ: Prentice Hall.

An edited series of essays that together show how GIS developed, largely from a North American perspective.

Goodchild M.F. 1992 ‘Geographical information science’. *International Journal of Geographical Information Systems* 6: 31–45.

THE seminal paper defining the field:

Longley P.A. and Batty M. (eds.) 2003 *Advanced Spatial Analysis: The CASA Book of GIS*. Redlands, CA: ESRI Press.

A series of useful case studies showing the richness of advanced research in spatial analysis.

Pickles J. 1993 *Ground Truth: The Social Implications of Geographic Information Systems*. New York: Guilford Press.

When it was published, the essays in this book, which are almost all critical of GIS as it was then practiced, led to a furry of counter claims and challenges in what has been called geography’s version of the ‘science wars’. From the perspective of a decade a truce seems to have been called.

University Consortium for Geographic Information Science 1996 ‘Research priorities for geographic information science’. *Cartography and Geographic Information Systems* 23(3): 115–127.

Exactly what it says on the tin can. This is also available at www.ucgis.org

RELATED READING

Longley P.A., Goodchild M.F., Maguire D.J. and Rhind D.W. (eds) 2005 *Geographical Information Systems: Principles, Techniques, Management and Applications* (abridged edition). Hoboken, NJ: Wiley.

- 3. Geography and GIS, R J Johnston
- 4. Arguments, debates and dialogues: the GIS-social theory debate and the concern for alternatives, J Pickles J
- 40. The future of GIS and spatial analysis, M F Goodchild, P A Longley
- 54. Enabling progress in GIS education, P Forer, D Unwin

Maguire D.J., Goodchild M.F. and Rhind D.W. (eds) 1991 *Geographical Information Systems: Principles and Applications*. Harlow, UK: Longman (text available online at www.wiley.co.uk/gis/volumes.html).

- An overview and definition of GIS, D J Maguire, pp. 9-20
- The history of GIS, J T Coppock and D W Rhind, pp. 21-43
- The technological setting of GIS, M F Goodchild, pp. 45-54
- The commercial setting of GIS, J Dangermond, pp. 55-65
- The academic setting of GIS, D J Unwin, pp. 81-90
- The organizational home for GIS in the scientific professional community, J L Morrison, pp. 91-100

Clarke, K.C. (2010) Getting Started with Geographic Information Systems. Fifth Edition. Boston, USA: Prentice Hall.

O'Sullivan, D., Unwin, D. (2010) Geographical Information Analysis. Second Edition. Hoboken, USA, John Wiley and Sons.

ONLINE RESOURCES

For an independent review of the analytical capabilities of GIS software see: www.geospatialanalysis.com

For an excellent summary of the history of GIS see the GIS Timeline at

www.casa.ucl.ac.uk/gistimeline

NCGIA Core Curriculum in GIScience, 2000 (www.ncgia.ucsb.edu/giscc)

What is GIS?- Michael Goodchild (http://www.ncgia.ucsb.edu/giscc/units/u002/)

Land Information Systems and Cadastral Applications Steve Ventura (http://www.ncgia.ucsb.edu/giscc/units/u164/)