Cartographic History and Education

P.S. Roy and **Minakshi Kumar**
Indian Institute of Remote Sensing, National Remote Sensing Agency, 4- Kalidas Road, Dehradun
psr@iirs.gov.in

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Abstract

Cartography is the science of map making. Till very recently cartography was viewed as an art form. The early cartographers gave aesthetic treatment to their products with all kind of graphic embellishments, fancy borders and decorative compass rose. The evolution of cartography has gone through three main ages- primitive age, medieval age and modern age. The present day cartography has its roots in the modern period, which began from 18th century onwards. Modern "cartography" is used to mean all aspects of mapping, starting from collection of the field data and includes intermediate processes for compilation in digital or analogue form for final presentation of results either as soft or hard copies. Aerial photographs and satellite images of high spatial resolution (1m) and with stereo capability are available to update the cartographic database. Geographic Information System coupled with Global Positioning System technologies have added new dimensions to the computer based cartography or digital cartography. Education and training in cartography should be given prime importance. Educational cartography should be the very essence part of the geography curricula starting right from the schools through colleges, universities and training in research institutions.

Overview

1. Introduction

Cartography is as old as human civilization and has been playing an important role in the activities of the mankind from the beginning of the civilization. One of the acceptable definitions of cartography has been that it is an art and science of map making. It is concerned with all stages of evaluation, compilation, design and drafting required to produce a new or revised map documents from all forms of basic data. Till very recently cartography was viewed as an art form. The early cartographers gave aesthetic treatment to their products with all kind of graphic embellishments, fancy borders and decorative compass roses. A map drawn on paper has been the traditional product of cartography since many centuries. Maps served as a kind of analogue geographical information system giving spatial locations as points and areas of interest in relation to each other. Earlier the maps were prepared mainly for military purposes. Slowly, the requirement of maps was felt for development, academic and research purposes.

2. Cartographic History

The history of cartography dates back to the dawn of civilization. In the prehistoric period trails and signs carved on the rocks were used for hunting purposes. The science of cartography evolved in three stages:

1. The primitive age (from dawn of civilization to 4th century B.C),
2. The medieval age (from 4th century to 15th century A.D)
3. Modern age (15th century onwards)

Primitive Age – According to Erwin Raisz this age continues upto 4th century. In this age five major periods were observed. In the ancient period, simple diagrams were made without the concept of scale drawn on rocks, leaves and skins of animals. The sea routes in the form of straight and curved lines were drawn with the help of fibers of coconut leaves and the islands with the help of shells. The Terracotta maps drawn by Babylonians, about 4500 years old are believed to be the first maps of the world.

In this age, a major contribution of the Greeks was the development of concept of latitude and longitude. It was in this period that the world map was reformed on the basis of astronomical principles. In this period there were many Indian cartographers. The Indians possessed the knowledge not only of the world but space as well. Aryabhatta, Varahmihir, Bhaskaracharya, Brahmgupta were eminent cartographers in ancient time. They determined the cardinal coordinates of many places. The Indian astronomers were conscious of the fact that local time of a place depends on the position of the sun and the moon. The known world was divided into several Dwipas in Puranas.

The Medieval Age: The initial period of the medieval age is known as dark age as in this period the knowledge achieved so far by the Greeks and Indians was forgotten. The maps were prepared for pilgrimages leading to Jerusalem. After 13th century British cartographers prepared two maps –one of the world and other of Britain. In these maps emphasis was given to scale and direction. The maps depicted the important towns with true locations.

The Modern Period: This period began from 15th century. Initially, that is, between 15th century and 18th century, maps were drawn on a plane projection by a German priest Donis Nicholas, which were originally drawn on a conical projection. This period is known for the revolutionary change in map printing. Copper plate was used to draw maps.

A Dutch cartographer named Mercator, who is also Father of Dutch cartography, belonged to this period. Mercator Projection- an Azimuthal conformal projection, named after him, is recognized in its original form even today. Amsterdam was a renowned center of cartography in 17th century.

The period during the 19th century opened new avenues for cartography with the introduction of sophisticated instruments, easy methods of printing and publishing, establishment of national and international survey institutes and the international cooperation among the cartographic communities of the world.

Now the term "cartography" is used to mean all aspects of mapping, starting from collection of the field data and includes intermediate processes for compilation in digital or analogue form for final presentation of results either as soft or hard copies. Cartographic challenges of the present times are intimately related with the vast spectrum of multidisciplinary sustainable development process. Cartography in its true sense is intimately connected with the depiction of geo-spatial distribution of different natural and man made phenomena. It is essentially a multidisciplinary subject. Advent of computers, computer graphics and digital cartography has also enhanced the role of cartography as the tool for identifying and solving various problems by accurate planning and monitoring the execution of plans at various levels.

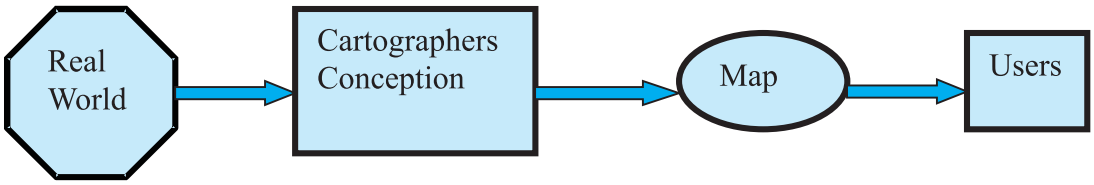

Figure 1: Cartographic Communication System [5]

3. Changing Trends in Cartography

The art and science of cartography are developing so fast that it is getting difficult for teaching and practicing cartographers to keep up with the developments. Everybody wants accurate and up-to-date information in the shortest time. This is the case with cartographic data also. Today we have the technology and know how to create the accurate and up-to-date cartographic data and to disseminate it to the user community. Aerial photographs and satellite images of high spatial resolution (1m) and with stereo capability are available to update the cartographic database. Geographic Information system coupled with global positioning system technologies have added new dimensions to the computer based cartography or digital cartography. Today digital data is replacing the paper information, planning, and implementation of programmes. New technologies in the present age have been rapidly developed and popularized techniques like remote sensing, global positioning system have supplied new productive force for the acquisition, processing, analysis, management, cartographic visualization and dissemination of geo–spatial data.

4. Digital Cartography

The digital cartography offers the cartographic community the tools to design aesthetically acceptable, clear, and concise maps. The digital mapping/GIS system is an interactive topologic environment that provides new and improved functions for mappers and GIS analysts - a new paradigm for both producers and users of geospatial data. The digital cartographic topological working environment automatically maintains clean topological data structures as you add and edit features and attributes.

The digital cartographic techniques replaces line work scribing, photomechanical open-window negatives, masks, screens, type stick-up, resulting in reduction in materials and labor required by manual cartographic production and provides utilities for performing familiar photomechanical manipulations on raster files - mirror, spread, rotate, flip, multiple imposition, and boolean raster file operations.

5. Digital Photogrammetry

Since a past few years digital photogrammetry has revolutionized cartography, as the computer hardware

and software has become more and more powerful. Digital photogrammetry is ideal for handling stereo satellite image in its digital form. This enables quick and periodic updation of maps. It also facilitates generation of digital elevation models of very high accuracy, which can be used for many applications like automatic rail/road alignment, line of sight analysis and view shed analysis.

6. Digital Topographic Database

The digital technology allows users to convert the topographic data to a digital topographic database, which is primarily the digitized version of digital topographic database. This allows the users to create products according to their exact requirement. For this national standard exchange format for digital vector data covers fundamental and structured aspects of Indian topographic maps.

7. National Spatial Data Infrastructure

The National Spatial Data Infrastructure (NSDI) is envisioned to be a part of the evolving National Information Infrastructure which will provide the means to make "current and accurate geospatial data available to contribute locally, nationally, and globally to economic growth, environmental quality and stability, and social progress." In using geographic data to aid in decisions about pieces of geography such as watersheds, towns, states or the nation which are of common interest to all citizens, we must come together to help improve the access, sharing, dissemination and use of geospatial data (Fig. 2). Our country is in need of NSDI today much more than at any other time in history. NSDI will enable the establishment of a national repository of the national map data holdings, which will facilitate sharing, and access to the digital geospatial information. As a national

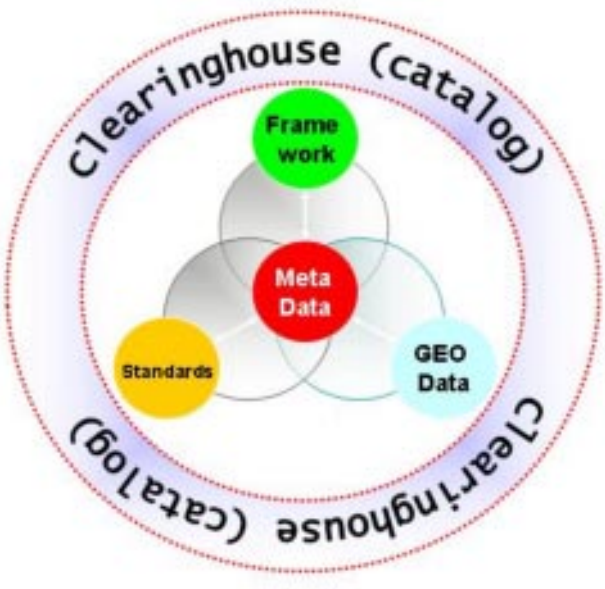

Figure 2: National Spatial Data Infrastructure

infrastructure, NSDI will have the potential to serve as a "one-stop" source of spatial information and the "mining" of these GIS layers from the NSDI would be the major source for all GIS activities in support of sustainable development and economic growth.

8. Remote Sensing

As a part of the ongoing series of Indian remote sensing satellites IRS programme to support the implementation of satellite based remote sensing for earth resource survey and mapping, mainly for cartographic application, Indian Space Research Organization (ISRO), department of space (DOS), government of India, is planning to launch IRS-P5 (Cartosat-1) an operational high resolution stereo mission. IRS-P5 is fitted with two panchromatic cameras one looking fore at +26 degrees with respect to nadir and other looking aft at –10 degrees with respect to nadir, along the track direction, thereby giving stereo pair of imagery providing 1 to 2.5 m resolutions with 12-30 km swath. The unique capabilities of IRS-P5 will be topographical map updation, DEM generation and cost effective mapping, and hence will serve as a major milestone in the history of cartography.

The role of remote sensing in thematic mapping has already been well established. Remote sensing technique has proved to be of great value for vast applications since each band of data collected from sensor contains important and some unique information. It can be used for monitoring crop types, for detecting disease, for production forecasts, for mapping forests. In weather analysis and forecasting, ice and snow monitoring, assessment of damage caused by flood, by earthquakes. Given here is land use / land cover map, mapped from IRS-1C LISS–III imagery. (Figure 3)

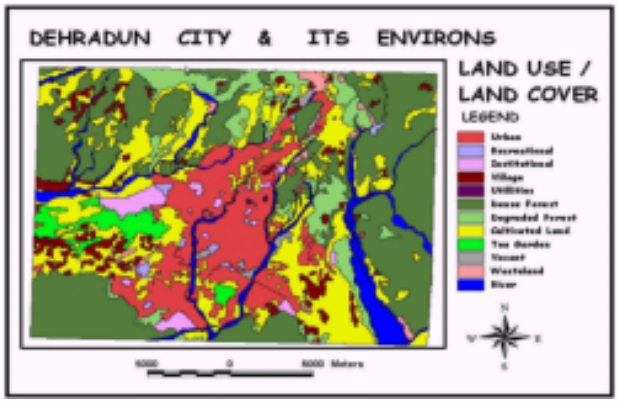

Figure 3: Land use / Land cover map of Dehradun mapped from IRS-1C LISS – III imagery.

9. GIS

A geographic information system (GIS) is a computer-based tool for mapping and analyzing geographic phenomenon that exist, and events that occur, on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique

visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. Map making and geographic analysis are not new, but a GIS performs these tasks faster and with more sophistication than do the traditional manual methods. The GIS in particular has its origin in the geography discipline and most location specific thrusts of cartographic relevance are from them.

10. GPS

The NAVSTAR (Navigation Satellites with Time and Ranging) Global Positioning System emerged as a strong technological advancement in the field of geodesy, geography, survey, spatial analysis and hence cartography. This technology overcomes the limitation of the terrestrial surveying methods like the requirement of intervisibilty of survey status, dependability of weather, difficulties in night observations etc. Advantages over conventional techniques, economical operation and time make GPS most promising survey and mapping technique.

Given here is an example of map updation using integration of GIS and GPS technologies. The roads were extracted using GIS software from the guide map of Dehradun city and IRS-1C PAN (Figure 4) . GPS coordinates were used as ground control points to rectify the imagery.

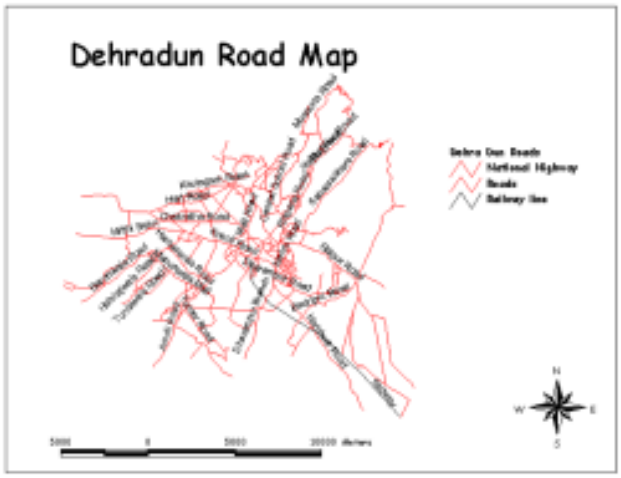

Figure 4: Road Map of Dehradun mapped using GIS and GPS

Role of the web: Increasingly spatial data are available on the web, be they of national or international origin. Publishing maps on web is easy as the software to do this, are available. Some web courses in aspects of cartography already exist as part of geography. Modules about projection are rather very popular. But there is no overall cartography programme available on web as yet.

11. Cartographic Education In India

In our country, at primary and middle school level, the students are introduced to the concept of map reading. The concept of globe, latitude, longitude, representations of various physical and cultural features by simple notations are taught at this stage. The secondary and higher secondary education in India focuses on familiarizing the students to maps and diagrams used in interpretation of geographic facts and figures, elementary surveying techniques, conventional symbols, cartographic techniques and certain mapping techniques. At the school levels, stress is more towards the identification and location of the earth features on the maps. In the high school the concepts of map scales and map projections have also been introduced along with the various elementary cartographic techniques.

At the undergraduate level, concepts of scales and measuring devices, map projections, surveying and leveling, field survey instrument and map interpretation and considerable expansion of the concepts already introduced at school level find a place in the course curriculum. The undergraduates' cartographic course in Indian universities go stages further to acquaint the students with the art of map making. Here the students trained in the selection and choice of scale, representation of relief features and landform types on maps and various analytical methods, topographical map interpretation, making of weather maps, representation of statistical methods and their application to cartographic representation. A basic component at this stage involves the education on various map projections and their utility. Surveying, an integral part to gather land information forms an important part to cartographic education at the degree level.

The postgraduate level cartography is more extensive which includes depiction of relief, representation of climatic data. The techniques of aerial photograph interpretation and remote sensing are also given due importance. The P.G course in the Indian universities provides additional cartographic methods to the students. These include detailed methods of representation of relief and climatic data, photogrammetry, air photo interpretation and remote sensing techniques, cartographic representation and interpretation of population, agricultural industrial and transport data are also being offered at this stage. With the introduction of the GIS, computer aided cartography has been introduced as a part of the syllabus in the Indian universities.

12. Research and Educational Issues

Education and training in cartography should be given prime importance. Educational cartography should be the very essence part of the Geography curricula starting right from the schools through colleges, universities and training in research institutions. Even though education in cartography is generally being imparted through

geography curricula, the student is introduced the art of map reading at an early stage, still popularizing cartography among the students has been a difficult task.

Cartographers have a great role to play in the national planning. Every kind of planning need a map and a map must be made by cartographers. Geographers and cartographers should always keep themselves engaged in the preparation of thematic maps with the predominant idea in mind that these maps would be useful to the social scientist / administrator / planners / demographic, agricultural experts and other research workers. Cartography should be made more appealing to the students. One way to do this is to introduce GIS at an early stage so that the students learn to play with various types of maps.

Digital cartography though used by various research organizations and private companies, has yet to make its proper dent in the teaching and training curricula in the education system in our country. Urgent action is therefore, required on cartographic education geared towards digital cartography to be spread rapidly so that individuals involved in decision making and planning use the data produced by them which will enhance the quality of decision making, planning and implementation.

Digital cartography is providing following distinct products :

1. The digital database is replacing the printed map as the storage medium for geographic information.
2. Cartographic visualization on many different media now satisfy the second function served previously by printed map.
3. Visualization of attribute information that is not visible to eye or the non imaging database is the current field of research.

Today the compute hardware and software available to cartographic scientists is capable of replacing all analog methods used previously in cartography.

13. Quality Issue

Student in the future should be aware of the quality issues/positional accuracy, attribute accuracy, lineage, logical consistency and completeness and uptodateness are to be accounted for.

Every spatial database can be characterized in terms of temporal, topographic and taxonomic resolution *(Figure 5)*. Topographic resolution refers to the size of the smallest item or object that are rendered separately. Taxonomic resolution refers to attribute differentiation that is the number of categories concerned. Temporal resolution refers to the length of the cycle between surveys. On the basis of their knowledge the cartographers should be able to guide the potential spatial data user to the database that fits the intended use.

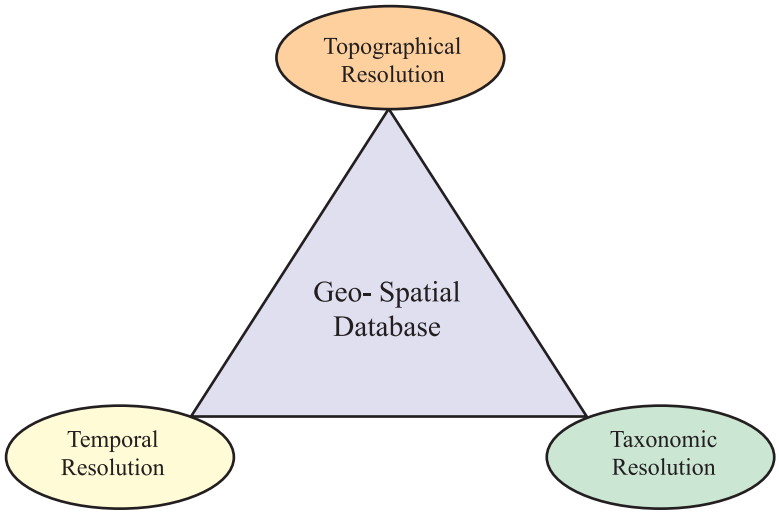

Figure 5 : Resolutions associated with Geo-spatial database.

A problem at this stage in the transition to digital cartography is a lack of skilled professionals. The cadre of cartographers trained in digital technology is still too small to take full advantage of new opportunities. To address this education gap the cartographic curriculum need revision. This creates a need for training in the public schools and continuing education for the adults. A need to focus on the non specialist is new for cartographic education and will require much more attention than it has received in the past.

A cartographer must be familiar with all mapping activities including those associated with other mapping sciences like geodesy, surveying, photogrammetry, remote sensing and geographic information system. A skilled cartographer must know a great deal about human

thought and communication and the disciplines with the environmental features being mapped.

The research focus in cartography should be continuous evolvement from participatory mapping to topographical mapping. To involve the community and create a basic awareness of mapping, community mapping – mapping of the community by its residents locals would serve an ideal purpose. For the local level planning, the concept of neighbourhood mapping or local level mapping should be introduced, where the maps are prepared by the local level community starting the village school children to non-governmental agencies and finally the mapping agency. Integration of various geo-spatial technologies, including remote sensing, GIS, GPS, digital photogrammetry, cartography have opened up a host of new and exciting possibilities.

With the objective of generating village maps for planning and decision making, in what could be a new beginning for rural planning, a band of young researchers have come up with India's first geographical information system (GIS) software that enables creation, storage, editing and accessing of map related databases for effective decision-making for the villagers. Developed by Centre for Spatial Database Management and Solutions (CSDMS) here, under a Media Lab Asia project, the software, Gram Chitra, can be utilised to update maps of about *65,000* villages in the country. The software is the first product coming out of Media Lab Asia. After gathering the land-based data, the researchers took GPS reading with the help of villagers to coordinate village objects. Using all information, the team came out with a Linux based open-source GIS software of the village that ensures a cost effective way of using digital maps for developmental activities by rural communities. The software will be available free for rural community as well as planners to upgrade village maps for developmental purpose.

14. Conclusion

Maps have always been produced in response to social demands. The modern cartographer will have to accept that increasingly users are preferring to make their own maps interactively rather than have them made by specialist or trained cartographers. The survival of cartography as a discipline and profession will depend very much on how cartographers respond to the challenges of the information age. The requirements at different levels of cartographic education at school, college or universities level have to be considered seriously. One of the major challenges for education in cartography is to decide how to define the scope and contents of emerging cartographic discipline.

In our future data rich society it will be possible for everyone with access to information highway to get at the relevant data. The cartographer will have to be able to indicate which data sets are relevant for a specific spatial decision support system as well as graphic designer and should be able to visualize the relevant spatial data.

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