UNIT-V

DATA VISUALIZATION

7.1 GIS AND MAPS

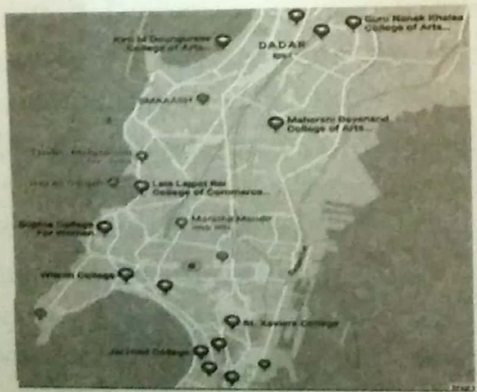
A map is "a representation or abstraction of geographic reality. A tool for presenting geographic information in a way that is visual, digital or tactile."

The definition holds three key words. The "geographic reality" represents the object of study, our world. "Representation" and "abstraction" refer to models of these geographic phenomena. The second sentence reflects the appearance of the map. A map is a reduced and simplified representation of the Earth's surface on a plane.

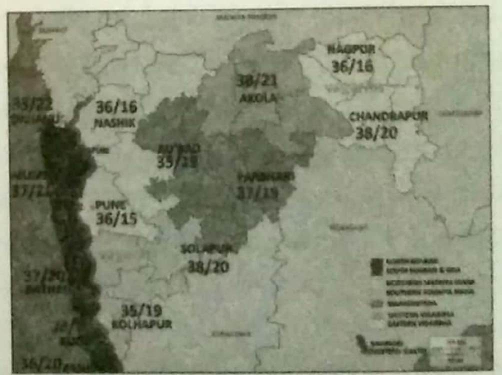
Maps and GIS are closely related to each other. Maps can be used as input for a GIS. Also play a key role in relation to all the functional components of a GIS.

A map can often be the most suitable tool to solve the question contains "where", and provide the answer. "Where do I find GPO?" and "Where do B. Sc. IT colleges are located?". The answers could be in non-map form like "in the FORT Region" or "in all over Mumbai." These answers could be satisfying; however, they do not give the full picture.

A map would put these answers in a spatial context. It could show where in the Fort Region, GPO is to be found and where it is located. A Mumbai map would refine the answer "in all over the Mumbai," since it reveals that some B. Sc IT Colleges are from South Bombay, and a few are located near Dadar, as can be seen in Figure below (A).



A



MAHARASHTRA ..MAX / MIN TEMP IN C .. 28 FEB 2019

B

A map becomes useful, as soon as the location of geographic objects ("where?") is involved. Maps can do more than just providing information on location. They can also inform about the thematic attributes of the geographic objects located in the map. An example would be "What is the Maximum / Minimum temperature in Maharashtra Region?" The answer could, again, just be verbal and state "cool." However, such an answer does not reveal patterns. In Figure (B) above, a variation of temperature in different regions of Maharashtra can be clearly distinguished. Maps can answer the "What?" question only in relation to location the map as a reference frame.

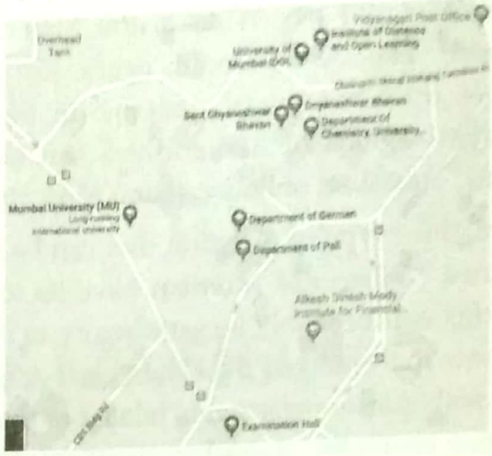
A third type of question that can be answered from maps is related to "When?" For instance, "When did Mumbai have its longest coastline?" The answer might be "1875," and this will probably be satisfactory to most people. However, it might be interesting to see how this changed over the years. A set of maps could provide the answer. Maps can deal with questions/answers related to the basic components of spatial or geographic data: location geometry, characteristics thematic attributes and time, and/or their combination.

Maps are the most efficient and effective means to transfer spatial information. The map user can locate geographic objects, while the shape and color of signs and symbols representing the objects inform about their characteristics. They reveal spatial relations and patterns, and offer the user insight in and overview of the distribution of particular phenomena. An additional characteristic of on-screen maps is that these are often interactive and have a link to a database, and as such allow for more complex queries.

Looking at the maps above demonstrates an important quality of maps: the ability to offer an abstraction of reality. A map simplifies by leaving out certain details, but at the same time it puts the remaining information in a clear perspective. The map on the other hand, only gives the outlines of buildings and the streets in the surroundings. It is easier to interpret because of selection/omission and classification of features. The symbolization chosen highlights our building. Additional information has been added, such as the name of the major Building: Examination Hall. Other non-visible data, like cadastral boundaries or even the sewerage system, can be added in the same way. However, it also demonstrates that selection means interpretation, and there are subjective aspects to that. In certain circumstances, a combination of photographs and map elements can be useful.

There is a relationship between the effectiveness of a map for a given purpose and the map's scale. The Public Works department of a city council cannot use a 1 : 250, 000 map for replacing broken sewer-pipes. The map scale is the ratio between a distance on the map and the corresponding distance in reality. Maps that show much detail of a small area are called large-scale maps. Scale indications on maps can be given verbally like 'one-inch-to-the-mile', or as a representative fraction like 1 : 200, 000, 000 (1 cm on the map equals 200, 000, 000 cm (or 2, 000 km) in reality), or by a graphic representation like a scale bar as given in the map in Figure (B). The advantage of using scale bars in digital environments is that its length changes also when the map is zoomed in, or enlarged before printing. Sometimes it is necessary to convert maps from one scale to another, but this may lead to problems of cartographic generalization.

(A)



(B)

Maps are divided into topographic maps and thematic maps. A topographic map visualizes, limited by its scale, the Earth's surface as accurately as possible. This may include infrastructure (e.g. railroads and roads), land use (e.g. vegetation and built-up area), relief, hydrology, geographic names and a reference grid. Figure (A) below show a topographic map of Mumbai.

(A)

(B)

Figure : Topographic Map Thematic Map

Thematic maps represent the distribution of particular themes. One can distinguish between socio economic themes and physical themes. The map in Figure (B), showing poverty density in Mumbai, is an example of the economic theme. Thematic maps also contain information found in a topographic map, so as to provide a geographic reference to the theme represented. The amount of topographic information required depends on the map theme. In general, a physical map will need more topographic data than most socio-economic maps, which normally only need administrative boundaries.

The design of topographic maps is mostly based on conventions, of which some date back several centuries. Examples are the use of blue to represent water, green for forests, red for major roads, and black to denote urban or built-up areas. The design of thematic maps, however, should be based on a set of cartographic rules, also called cartographic grammar. Suppose that one wants to quantify land use changes between 1990 and the current year. Two data sets (from 1990 and 2018) can be combined with an overlay operation.

The result of such a spatial analysis can be a spatial data layer from which a map can be produced to show the differences. The parameters used during the operation are based on models developed by the application at hand. It is easy to imagine that maps can play a role during this process of working with a GIS by showing intermediate and final results of the GIS operations. Clearly, maps are no longer only the final product they used to be.

Maps can further be distinguished according to the dimensions of spatial data that are graphically represented. GIS users also try to solve problems that deal with three-dimensional reality or with change processes. This results in a demand for other than just two-dimensional maps to represent geographic reality. Three-dimensional and even four-dimensional (including time) maps are then required. New visualization techniques for these demands have been developed. Figure below shows the dimensionality of geographic objects and their graphic representation.

7.2 THE VISUALIZATION PROCESS

The characteristic of maps and their function in relation to the spatial data handling process was explained in the previous section. In this context the cartographic visualization process is considered to be the translation or conversion of spatial data from a database into graphics. These are predominantly map like products. During the visualization process, cartographic methods and techniques are applied. These can be considered to form a kind of grammar that allows for the optimal design and production for the use of maps, depending on the application

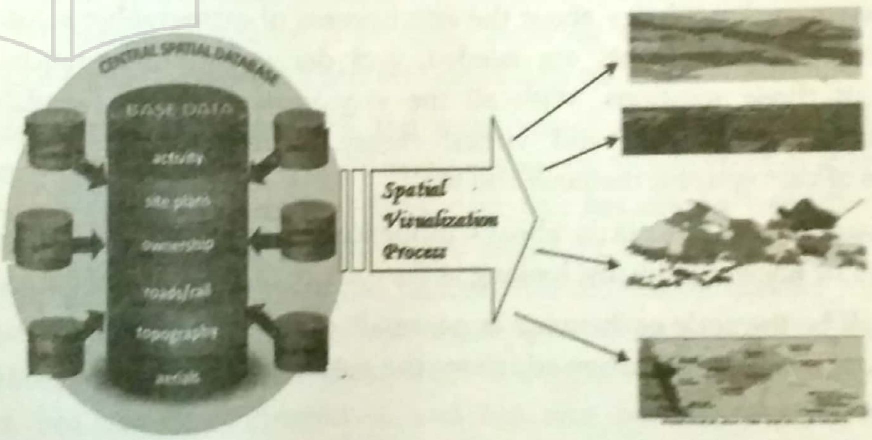


Figure : Spatial Visualization

The producer of these visual products may be a professional cartographer, but may also be a discipline expert, for instance, mapping vegetation stands using remote sensing images, or health statistics in the slums of a city. To enable the translation from spatial data into graphics, we assume that the data are available and that the spatial database is well structured.

The visualization process can vary greatly depending on where in the spatial data handling process it takes place and the purpose for which it is needed. Visualizations can be, created during any phase of the spatial data handling process. They can be simple or complex, while the production time can be short or long.

Some examples are the creation of a full, traditional topographic map sheet, a newspaper map, a sketch map, a map from an electronic atlas, an animation showing the growth of a city, a three-dimensional view of a building or a mountain, or even a real-time map display of traffic conditions. Other examples include 'quick and dirty' views of part of the database, the map used during the updating process or during a spatial analysis. However, visualization can also be used for checking the consistency of the acquisition process or even the database structure. These visualization examples from different phases in the process of spatial data handling demonstrate the need for an integrated approach to geoinformatics. The environment in which the visualization process is executed can vary considerably. It can be done on a stand-alone personal computer, a network computer linked to an intranet, or on the World Wide Web (WWW/Internet).

The visualization process is guided by the question "How do I say what to whom?" "How" refers to cartographic methods and techniques. "I" represents the cartographer or map maker, "say" deals with communicating in graphics the semantics of the spatial data. "What" refers to the spatial data and its characteristics. "Whom" refers to the map audience and the purpose of the map—a map for scientists requires a different approach than a map on the same topic aimed at children.

In the past, the cartographer was often solely responsible for the whole map compilation process. During this process, incomplete and uncertain data often still resulted in an authoritative map. The maps created by a cartographer had to be accepted by the user. Cartography, for a long time, was very much driven by supply rather than by demand. In some respects, this is still the case. However, nowadays one accepts that just making maps is not the only purpose of cartography.

The visualization process should also be tested on its effectiveness. To the proposition "How do I say what to whom" we have to add "and is it effective?" Based on feedback from map users, or knowledge about the effectiveness of cartographic solutions, we can decide whether improvements are needed, and derive recommendations for future application of those solutions. With all the visualization options available, such as animated maps, multimedia and virtual reality, it remains necessary to test the effectiveness of cartographic methods and tools.

The visualization process is always influenced by several factors. Some of these questions can be answered by just looking at the content of the spatial database:

- What will be the scale of the map: large, small, other? This introduces the problem of generalization. Generalization addresses the meaningful reduction of the map content during scale reduction.
- Are we dealing with topographic or thematic data? These two categories traditionally resulted in different design approaches as was explained in the previous section.
- More important for the design is the question of whether the data to be represented are of a quantitative or qualitative nature.

Understanding the impact of these factors may increase, since the compilation of maps by spatial data handling is often the result of combining different data sets of different quality and from different data sources, collected at different scales and stored in different map projections.

Cartographers have all kind of tools available to visualize the data. These tools consist of functions, rules and habits. Algorithms used to classify the data or to smooth a polyline are examples of functions. Rules tell us, for example, to use proportional symbols to display absolute quantities or to position an artificial light source in the northwest to create a shaded relief map. Habits or conventions—or traditions—tell us to color the sea in blue, lowlands in green and mountains in brown. The efficiency of these tools will partly depend on the above-mentioned factors, and partly on what we are used to.

7.3 VISUALIZATION STRATEGIES : PRESENT OR EXPLORE?

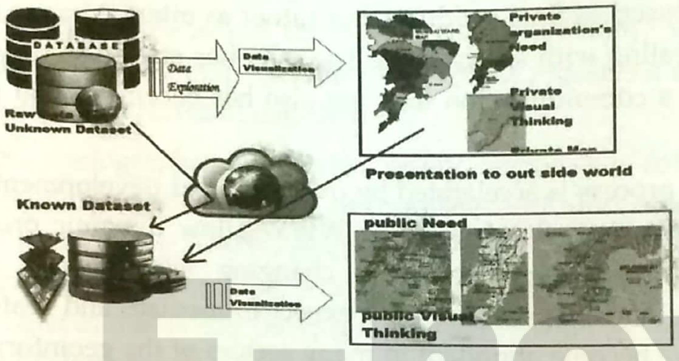
The cartographer's main task was the creation of good cartographic products. The main function of maps is to communicate geographic information, i.e. to inform the map user about location and nature of geographic phenomena and spatial patterns. This has been the map's function throughout history. Well-trained cartographers are designing and producing maps, supported by a whole set of cartographic tools and theory. The widespread use of GIS has increased the number of maps tremendously. Many of these maps are not produced as final products, but rather as intermediaries to support the user in her/his work dealing with spatial data. The map has started to play a completely new role: it is not only a communication tool, but also has become an aid in the user's visual thinking process.

This thinking process is accelerated by the continued developments in hardware and software. Media like DVD-ROMs and the WWW allow dynamic presentation and also user interaction. These went along with changing scientific and societal needs for georeferenced data and maps. Users now expect immediate and real-time access to the data; data that have become abundant in many sectors of the geoinformation world. This abundance of data, seen as a 'paradise' by some sectors, is a major problem in other sectors. We lack the tools for user-friendly queries and retrieval when studying the massive amount of spatial data produced by sensors, which is now available via the WWW. A new branch of science is currently evolving to deal with this problem of abundance. In the geo-disciplines, it is called visual data mining.

These developments have given the term visualization an enhanced meaning. According to the dictionary, it means 'to make visible' or 'to represent in graphical form'. It can be argued that, in the case of spatial data, this has always been the business of cartographers. Progress in other disciplines has linked the word to more specific ways in which modern computer technology can facilitate the process of 'making visible' in real time. Specific software toolboxes have been developed, and their functionality is based on two key words: interaction and dynamics. A separate discipline, called scientific visualization, has developed around it, and has also had an important impact on cartography. It offers the user the possibility of instantaneously changing the appearance of a map. Interaction with the map will stimulate the user's thinking and will add a new function to the map. As well as communication, it will prompt thinking and decision-making.

Developments in scientific visualization stimulated DiBiase to define a model for map-based scientific visualization, also known as geovisualization. It covers both the presentation and exploration functions of the map. Presentation is described as 'public visual communication' since it concerns maps aimed at a wide audience. Exploration is defined as 'private visual thinking' because it is often an individual playing with the spatial data to determine its significance. It is obvious that presentation fits into the traditional realm of cartography, where the cartographer works on known spatial data and creates communicative maps. Such maps are often created for multiple use. Exploration, often involves a discipline expert who creates maps while dealing with unknown data. These maps are generally for a single purpose, expedient in the expert's attempt to solve a problem. While dealing with the data, the expert should be able to rely on cartographic expertise, provided by the software or some other means. Essentially, here the problem of translation of spatial data into cartographic symbols also needs to be solved.

The above trends all have to do with what has been called the 'democratization of cartography' by Morrison. He explains it as "using electronic technology, no longer does the map user depend on what the cartographer decides to put on a map. Today the end user is the cartographer. Users are now able to produce analyses and visualizations at will to any accuracy standard that satisfies them."



Exploration means to search for spatial, temporal or spatio-temporal patterns, relationships between patterns, or trends. In case of a search for patterns, a domain expert may be interested in aspects like the distribution of a phenomenon, the occurrence of anomalies, the sequence of appearances and disappearances. A search for relationships between patterns could include: changes in vegetation indices and climatic parameters, location of deprived urban areas and their distance to educational facilities. A search for trends could, for example, focus on the development in distribution and frequency of landslides. Maps not only enable these types of searches, findings may also trigger new questions, and lead to new visual exploration or analytical acts. What is unknown for one is not necessarily unknown to others. For instance, browsing in Microsoft's Encarta World Atlas CD-ROM is an exploration for most of us because of its wealth of information. With products like these, such exploration takes place within boundaries set by the producers. Cartographic knowledge is incorporated in the program, resulting in pre-designed maps. Some users may feel this to be a constraint, but the same users will probably no longer feel constrained as soon as they follow the web links attached to this electronic atlas. This shows that the data, the users, and the use environment influence one's view of what exploration entails.

To create a map, one selects relevant geographic data and converts these into meaningful symbols for the map. Paper maps in the past had a dual function. They acted as a database of the objects selected from reality, and communicated information about these geographic objects. The introduction of computer technology and databases in particular, has created a split between these two functions of the map. The database function is no longer required for the map, although each map can still function like it. The communicative function of maps has not changed.

The sentence "How do I say what to whom, and is it effective?" guides the cartographic visualization process, and summarizes the cartographic communication principle. Especially when dealing with maps in the realm of presentation cartography, it is important to adhere to the cartographic design rules. This is to guarantee that the resulting maps are easily understood by their users. How does this communication process work? It starts with information to be mapped (the 'What' from the sentence). Before anything can be done, the cartographer should get a feel for the nature of the information, since this determines the graphical options. Cartographic information analysis provides this. Based on this knowledge, the cartographer can choose the correct symbols to represent the information in the map. A user has a whole toolbox of visual variables available to match symbols with the nature of the data.

In 1967, the French cartographer Bertin developed the basic concepts of the theory of map design, with his publication Sémiologie Graphique. He provided guidelines for making good maps. If ten professional cartographers were given the same mapping task, and each would apply Bertin's rules, this would still result in ten different maps. For instance, if the guidelines dictate the use of color, it is not stated which color should be used. Still, all ten maps could be of good quality.

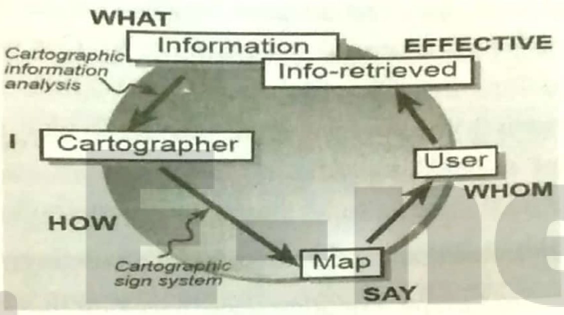


Figure : HOW do I SAY, WHAT to WHOM and how is it EFFECTIVE

The map (the medium that does the 'say' in the sentence) is read by the map users (the 'whom' from the sentence). They extract some information from the map, represented by the box entitled 'Info-retrieved'. From the figure it becomes clear that the boxes with 'Information' and 'Inforetrieved' do not overlap. This means the information derived by the map user is not the same as the information that the cartographic communication process started with. There may be several causes. Possibly, the original information was not all used or additional information has been added during the process. Omission of information could be deliberately caused by the cartographer, with the aim of emphasizing the remaining information. Another possibility is that the map user did not fully understand the map. Information gained during the communication process could be due to the cartographer, who added extra information to strengthen the already available information. It is also possible that the map user has some prior knowledge on the topic or area, which allows them to combine this prior knowledge with the knowledge retrieved from the map.

7.4 THE CARTOGRAPHIC TOOLBOX

- **What kind of data do I have?**

To derive the proper symbology for a map one has to execute a cartographic data analysis. The core of this analysis process is to access the characteristics of the data to find out how they can be visualized, so that the map user properly interprets them. The first step in the analysis process is to find a common - denominator for all the data. This common denominator will then be used as the title of the map. For instance, if all data are related to land use, collected in 2015, the title could be Landuse of . . . 2015. Secondly, the individual component(s), such as landuse, and probably relief, should be analyzed and their nature described. Later, these components should be visible in the map legend.

Different types of data in relation to how it might map or display them.

Data will be of a **qualitative** or **quantitative** nature.

Qualitative data is also called nominal or categorical data. This data exists as discrete, named values without a natural order amongst the values. Examples are the different languages (e.g. English, Hindi, Marathi, Tamil), the different soil types (e.g. sand, clay, peat) or the different land use categories (e.g. arable land, pasture). In the map, qualitative data are classified according to disciplinary insights such as a soil classification system represented as basic geographic units: homogeneous areas associated with a single soil type, recognized by the soil classification.

Quantitative data can be measured, either along an interval or ratio scale. For data measured on an interval scale, the exact distance between values is known, but there is no absolute zero on the scale. Temperature is an example: 40° C is not twice as warm as 20° C, and 0° C is not an absolute zero. Quantitative data with a ratio scale does have a known absolute zero. An example is income: someone earning ₹ 1000 earns twice as much as someone with an income of ₹ 500. In order to generate maps, quantitative data are often classified into categories according to some mathematical method.

In between qualitative and quantitative data, one can distinguish ordinal data.

These data are measured along a relative scale, based on hierarchies. For instance, one knows that one value is 'more' than another value, such as 'warm' versus 'cool'. Another example is a hierarchy of road types : 'highway', 'main road', 'secondary road' and 'track'. The different types of data are summarized in Table below.

Scale	Description	Example
Nominal	Data consists of names or categories only. No ordering scheme is possible.	A bag of candy contained the following colors : Yellow 15 Red 10 Orange 9 Green 7
Ordinal (Ranking)	Date is arranged in some order but differences between values cannot be determined or are meaningless.	Product defects, where A type defects are more critical than D type defects are tabulated as follows: A 16 B 32 C 42

		D 30
Interval	Data is arranged in order and differences can be found. However, there is no inherent starting point and rations are meaningless.	The temperatures of three ingots were 200ºF, 400ºF and 600ºF. Note, that three times 200ºF is not the same as 600ºF as a temperature measurement.
Ratio	An extension of the interval level that includes an inherent zero starting point. Both differences and ratios are meaningful.	Product A costs \$300 and product B costs \$600 is twice as much as \$300.

- **How Can I Map My Data?**

Basic elements of a map, irrespective of the medium on which it is displayed, are point symbols, line symbols, area symbols, and text. The appearance of point, line, and area symbols can vary depending on their nature. Most maps in this book show symbols in different size, shape and color. Points can vary in form or color to represent the location of shops or they can vary in size to represent aggregated values (like number of inhabitants) for an administrative area. Lines can vary in color to distinguish between administrative boundaries and rivers, or vary in shape to show the difference between railroads and roads. Areas follow the same principles: difference in color distinguishes between different vegetation stands. Although the variations in symbol appearance are only limited by the imagination they can be grouped together in a few categories. Bertin distinguished six categories, which he called the visual variables and which may be applied to point, line and area symbols.

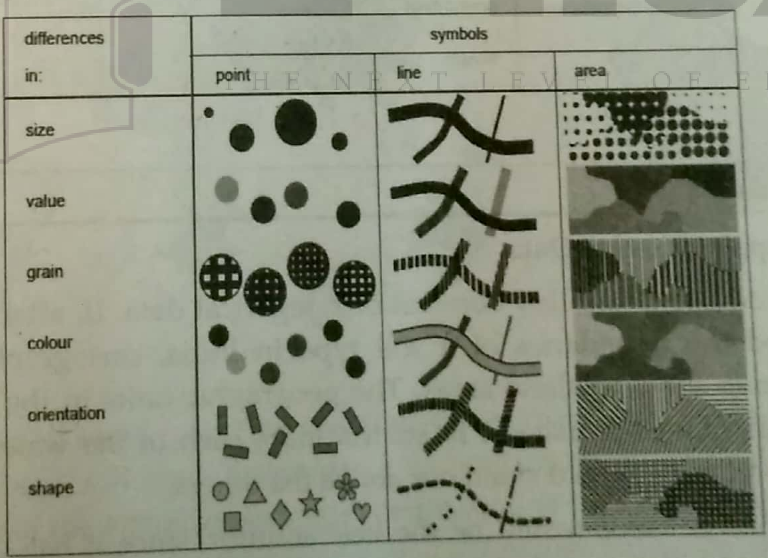


Plate 1 Basic Graphic Variables

Plate 2 Differences in value or lightness

Plate 3 Differences in color

Plate 4 Color scale bar lengthened by adding saturation

These visual variables can be used to make one symbol different from another. In doing this, map makers in principle have free choice, provided they do not violate the rules of cartographic grammar. They do not have that choice when deciding where to locate the symbol in the map. The symbol should be located where features belong. Visual variables influence the map user's perception in different ways. What is perceived depends on the human capacity to see or perceive:

❖ What is of equal importance (e.g. all red symbols represent danger),

❖ Order (e.g. the population density varies from low to high—represented by light and dark color tints, respectively),

❖ Quantities (e.g. symbols changing in size with small symbols for small amounts), or An instant overview of the mapped theme.

There is an obvious relationship between the nature of the data to be mapped and the 'perception properties' of visual variables. 'Dimensions of the plane' is added to the list of visual variables; it is the basis, used for the proper location of symbols on the plane (map). The perception properties of the remaining visual variables have been added. The next section discusses some typical mapping problems and demonstrates the above.

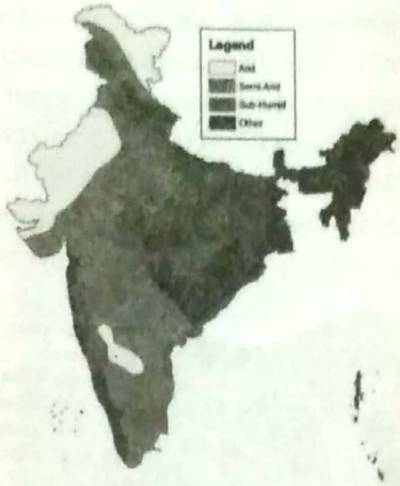
perception properties	visual variables	measurement scales: nominal	ordinal	interval	ratio
	dimensions of the plane	x	x	x	x
order & quantities	size		x	x	x
order	(grey) value		x	x	
	grain/texture		x	x	
equal importance	colour hue	x			
	orientation	x			
	shape	x			

7.5 HOW TO MAP . . . ?

● **How to Map Qualitative Data**

Qualitative data is also called nominal or categorical data. If, after a long fieldwork, finally delineated the boundaries of a soil type in India, cartographer likely will be interested in a map showing these areas. The geographic units in the map will have to represent the individual watersheds. In such a map, each of the watersheds should get equal attention, and none should stand out above the others.

The application of color would be the best solution since it has characteristics that allow one to quickly differentiate between different geographic units. However, since none of the soil type is more important than the others, the colors used have to be of equal visual weight or brightness. The readability is influenced by the number of displayed geographic units. In this example, there are about 4. When this number is much higher, the map, at the scale displayed here, will become too cluttered. The map can also be made by filling the soil type areas by different forms (like small circles, squares, triangles, etc.) in one color (e.g. black for a monochrome map) as an application of the visual variable shape. The amount of geographic units that can be displayed is then even more critical.



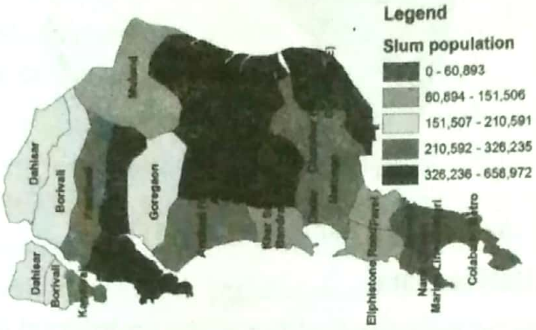
Qualitative data display map of India showing soil type.

- **How to Map Quantitative Data**

Quantitative data can be measured, either along an interval or ratio scale. When, after executing a census, one would for instance like to create a map with the number of people living in each municipality, one deals with absolute quantitative data. The geographic units will logically be the municipalities. The final map should allow the user to determine the amount per municipality and also offer an overview of the geographic distribution of the phenomenon. To reach this objective, the symbols used should have quantitative perception properties. Symbols varying in size fulfill this demand. Figure below shows the map for informal settlement population growth in Major cities of the world.

Different tints of same color (the visual variable 'value'), if used to represent absolute population numbers will show improper data, will cause impression of the individual amounts but not of the actual geographic distribution of the population, as the size of the geographic units will influence the perceptional properties too much. Imagine a small and a large unit having the same number of inhabitants. The large unit would visually attract more attention, giving the impression there are more people than in the small unit. Another issue is that the population is not necessarily homogeneously distributed within the geographic units. Color has also been misused in a most maps. The applied color scheme may makes it is impossible to infer whether red represents more populated areas than blue.

It is impossible to instantaneously answer a question like "Which is the most populated place of informal settlements?". On the basis of absolute population numbers per municipality and their geographic size, we can also generate a map that shows population density per municipality. We then deal with relative quantitative data. The numbers now have a clear relation with the area they represent. The geographic unit will again be municipality. The aim of the map is to give an overview of the distribution of the population density. In the map below, value has been used to display the density from low (light tints) to high (dark tints). The map reader will automatically and in a glance associate the dark colors with high density and the light values with low density.



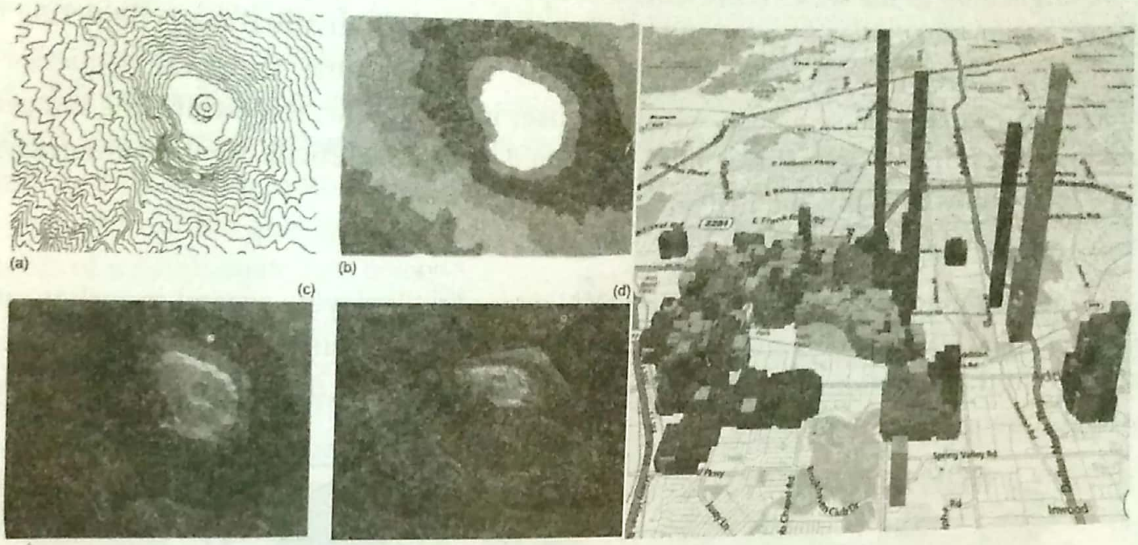
- **How To Map The Terrain Elevation**

Terrain elevation can be mapped using different methods. Often, one will have collected an elevation data set for individual points like peaks, or other characteristic points in the terrain. Obviously, one can map the individual points and add the height information as text. However, a contour map, in which the lines connect points of equal elevation, is generally used. To visually improve the information content of such a map the space between the contour lines can be filled with color and value information following a convention, e.g. green for low elevation and brown for high elevation areas. This technique is known as hypsometric or layer tinting. Even more advanced is the addition of shaded relief. This will improve the impression of the three-dimensional relief.

The shaded relief map uses the full three-dimensional information to create shading effects. This map, represented on a two-dimensional surface, can also be floated in three-dimensional space to give it a real three-dimensional appearance of a 'virtual world', as shown in Figure (d). Looking at such a representation one can immediately imagine that it will not always be effective. Certain (low) objects in the map will easily disappear behind other (higher) objects.

Interactive functions are required to manipulate the map in three-dimensional space in order to look behind some objects. These manipulations include panning, zooming, rotating and scaling. Scaling is needed, particularly along the z-axis, since some maps require small-scale elevation resolution, while others require large-scale resolution, i.e. vertical exaggeration. One can even imagine that other geographic, three-dimensional objects (for instance, the built-up area of a city and individual houses) have been placed on top of the terrain model, like it is done in Google Earth. Of course, one can also visualize objects below the surface in a similar way, but this is more difficult because the data to describe underground objects are sparsely available.

Socio-economic data can also be viewed in three dimensions. This may result in dramatic images, which will be long remembered by the map user. Figure (E) shows the absolute population figures in three dimensions. Instead of proportionally sized circles to depict the number of people living in a region the proportional height of a region now indicates total population. The image clearly shows the large column on the right is the highest populated slum regions in Mumbai.



E

- **How To Map Time Series**

Advances in spatial data handling have not only made the third dimension part of GIS routines. Nowadays, the handling of time-dependent data is also part of these routines. This has been caused by the increasing availability of data captured at different periods in time. Next to this data abundance, the GIS community wants to analyse changes caused by real world processes. To that end, single time slice data are no longer sufficient, and the visualization of these processes cannot be supported with only static paper maps.

Mapping time means mapping change. This may be change in a feature's geometry, in its attributes or both. Examples of changing geometry are the evolving coastline of the Mumbai, the location of India's national boundaries, or the position of weather fronts. The changes of a land parcel's owner, landuse, or changes in road traffic intensity are examples of changing attributes. Urban growth is a combination of both. The urban boundaries expand and simultaneously the land use shifts from rural to urban. If maps are to represent events like these, they should be suggestive of such change.

This implies the use of symbols that are perceived as representing change. Examples of such symbols are arrows that have an origin and a destination. They are used to show movement and their size can be an indication of the magnitude of change. Size changes can also be applied to other point and line symbols to show increase and decrease over time. Specific point symbols such as 'crossed swords' (battle) or 'lightning' (riots) can be found to represent dynamics in historic maps. Another alternative is the use of the visual variable value (expressed as tints). The map (A) below shows the availability of green, dark tints represent abundance, while drought porn areas are represented by red tints.

It is possible to distinguish between three temporal cartographic techniques :

1. **Single static map**

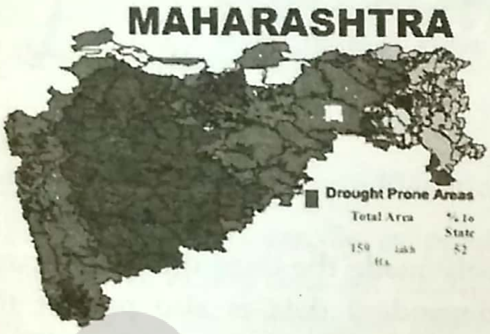
Specific graphic variables and symbols are used to indicate change or represent an event. Figure (a) applies the visual variable value to represent the availability of the water in Maharashtra;

2. **Series of static maps**

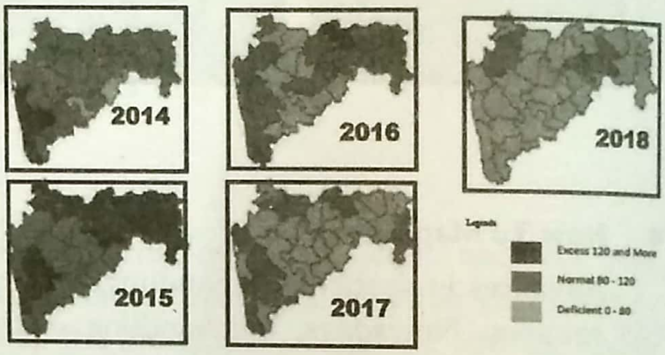
A single map in the series represents a 'snapshot' in time. Together, the maps depict a process of change. Change is perceived by the succession of individual maps depicting the situation in successive snapshots. It could be said that the temporal sequence is represented by a spatial sequence, which the user has to follow, to perceive the temporal variation. The number of images should be limited since it is difficult for the human eye to follow long series of maps (Figure (b));

3. **Animated map**

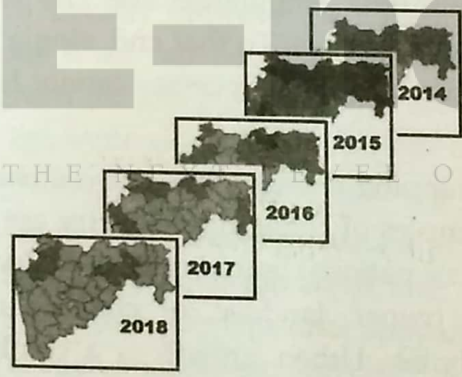
Change is perceived to happen in a single image by displaying several snapshots after each other just like a video cut with successive frames. The difference with the series of maps is that the variation can be deduced from real 'change' in the image itself, not from a spatial sequence (Figure (c)).



(A)



(B)



(C)

For the user of a cartographic animation, it is important to have tools available that allow for interaction while viewing the animation. Seeing the animation play will often leave users with many questions about what they have seen. Just replaying the animation is not sufficient to answer questions like "What was the position of the coastline in the north during the 15th century?" Most of the general software packages for viewing animations already offer facilities such as 'pause' (to look at a particular frame) and 'fast-forward' and 'fast-backward', or step-by-step display. More options have to be added, such as a possibility to directly go to a certain frame based on a task like: 'Go to 1947'.

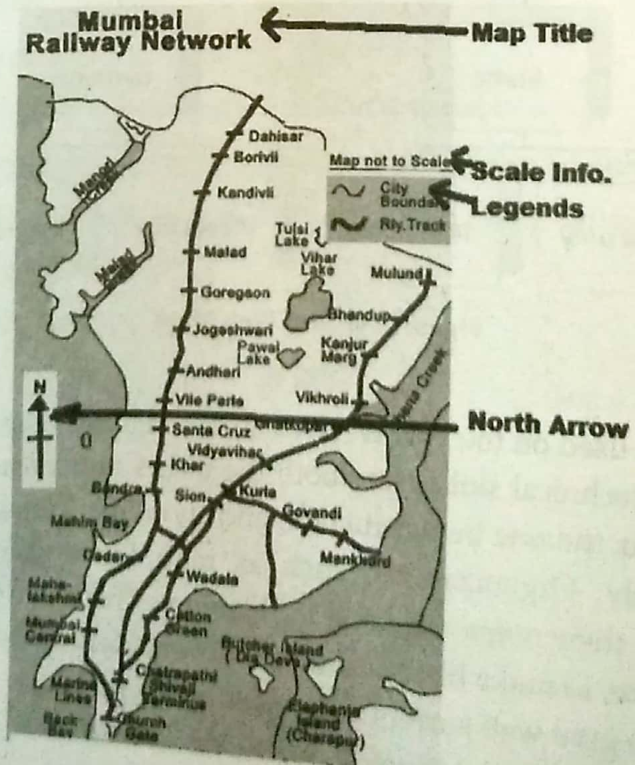
7.6 MAP COSMETICS

Most maps in this chapter are correct from a cartographic grammar perspective. However, many of them lack the additional information needed to be fully understood that is usually placed in the margin of printed maps. Each map should have, next to the map image, a title, informing the user about the topic visualized. A legend is necessary to understand how the topic is depicted. Additional marginal information to be found on a map is a scale indicator, a north arrow for orientation, the map datum and map projection used, and some lineage information, (such as data sources, dates of data collection, methods used, etc.). Further information can be added that indicates when the map was issued, and by whom (author / publisher). All this information allows the user to obtain an impression of the quality of the map, and is comparable with metadata describing the contents of a database or data layer.

Figure below illustrates these map elements. On paper maps, these elements (if all relevant) have to appear next to the map face itself. Maps presented on screen often go without marginal information, partly because of space constraints. However, on-screen maps are often interactive, and clicking on a map element may reveal additional information from the database. Legends and titles are often available on demand as well.

Text is used to transfer information in addition to the symbols used. This can be done by the application of the visual variables to the text as well. Italics—cf. the visual variable of orientation—have been used for building names to distinguish them from road names. Another common example is the use of colour to differentiate (at nominal level) between hydrographic names (in blue) and other names (in black). The text should also be placed in a proper position with respect to the object to which it refers.

Maps constructed via the basic cartographic guidelines are not necessarily visually appealing maps. Although well-constructed, they might still look sterile. The design aspect of creating appealing maps also has to be included in the visualization process. 'Appealing' does not only mean having nice colors. One of the keywords here is contrast. Contrast will increase the communicative role of the map since it creates a hierarchy in the map contents, assuming that not all information has equal importance. This design trick is known as visual hierarchy or the figure-ground concept. The first object to be noted will be the Railway Network map of Mumbai (the darkest patches in the map) followed by other info, with the border on a lower level and the lakes at the lowest level.



7.7 MAP DISSEMINATION

The map design will not only be influenced by the nature of the data to be mapped or the intended audience (the 'what' and 'whom' from "How do I say What to Whom, and is it Effective"), the output medium also plays a role. Traditionally, maps were produced on paper, and many still are. Currently, most maps are presented on screen, for a quick view, for an internal presentation or for presentation on the WWW. Compared to maps on paper, on-screen maps have to be smaller, and therefore their contents should be carefully selected. This might seem a disadvantage, but presenting maps on-screen offers very interesting alternatives. A mouse click could also open the link to a database, and reveal much more information than a paper map could ever offer. Links to other than tabular or map data could also be made available. Maps and multimedia (photography, sound, video or animation) can be integrated. Some of today's electronic atlases, such as the Encarta World Atlas are good examples of how multimedia elements can be integrated with the map. Pointing to a country on a world map starts the national anthem of the country or shows its flag. It can be used to explore a country's language; moving the mouse would start a short sentence in the region's dialects.

The World Wide Web is a popular medium used to present and disseminate spatial data. Here, maps can play their traditional role, for instance to show the location of objects, or provide insight into spatial patterns, but because of the nature of the internet, the map can also function as an interface to additional information. Geographic locations on the map can be linked to photographs, text, sound or other maps, perhaps even functions such as on-line booking services. Maps can also be used as 'previews' of spatial data products to be acquired through a spatial data clearinghouse that is part of a Spatial Data Infrastructure. For that purpose we can make use of geo-webservices which can provide interactive map views as intermediate between data and web browser.

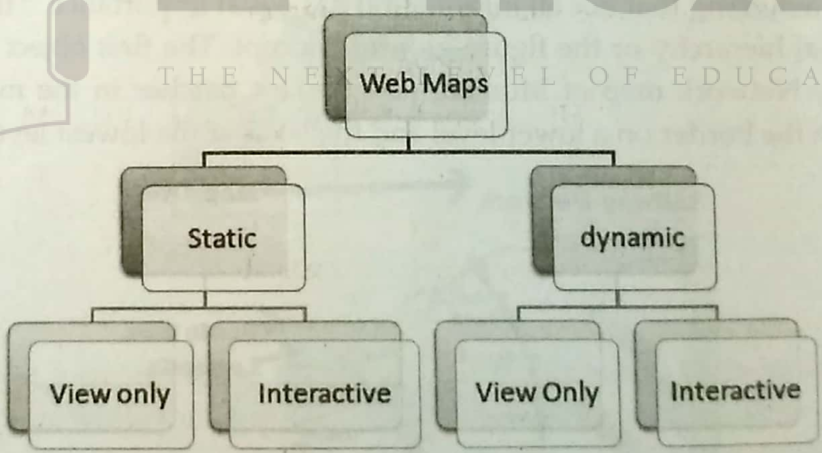


Figure : Types of Web Maps

How can maps be used on the WWW? We can distinguish several methods that differ in terms of necessary technical skills from both the user's and provider's perspective. An important distinction is the one between static and dynamic maps. Many static maps on the web are view-only. Organizations, such as map libraries or tourist information providers, often make their maps available in this way. This form of presentation can be very useful, for instance, to make historical maps more widely accessible. Static, view-only maps can also serve to give web surfers a preview of the products that are available from organizations, such as National Mapping Agencies. When static maps offer more than view-only functionality, they may present an interactive view to the user by offering zooming, panning, or hyperlinking to other information. The much-used 'clickable map' is an example of the latter and is useful to serve as an interface to spatial data. Clicking on geographic objects may lead the user to quantitative data, photographs, sound or video or other information sources on the Web. The user may also interactively determine the contents of the map, by choosing data layers, and even the visualization parameters, by choosing symbology and colours. Dynamic maps are about change; change in one or more of the spatial data components. On the WWW, several options to play animations are available. The animated-GIF can be seen as a view-only version of a dynamic map. A sequence of bitmaps, each representing a frame of an animation, are positioned one after another, and the WWW-browser will continuously repeat the animation. This can be used, for example, to show the change of weather over the last day. Slightly more interactive versions of this type of map are those to be played by media players, for instance those in QuickTime format, or as a Flash movie.

Plug-ins to the web browser define the interaction options, which are often limited to simple pause, backward and forward play. Such animations do not use any specific WWW environment parameters and have equal functionality in the desktop environment. The WWW also allows for the fully interactive presentation of 3D models. The Virtual Reality Markup Language (VRML), for instance, can be used for this purpose. It stores a true 3D model of the objects, not just a series of 3D views.

QUESTIONS

1. Explain using suitable example and map the relationship between GIS and MAP.
2. What are topographic and thematic maps? Explain.
3. Explain visualization process using suitable diagram.
4. Write a short note on visualization strategies.
5. What do you mean by "HOW do I SAY, WHAT to WHOM and how is it EFFECTIVE", in GIS? Explain.
6. Explain the different types of data.
7. Write a note on Bertin's six categories of visual variable.
8. Explain using suitable diagram how to map qualitative and quantitative data?
9. Explain using suitable diagram how to map terrain elevation and time series?
10. Write a note on map cosmetics.
11. Explain map dissemination.