

Chapter 6 Thematic maps

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(see also section 4.3.2, where the production of a thematic map is described from first concept to final map)

6.1 Spatial concepts

In thematic mapping, we visualise data on the basis of spatial concepts, like density, ratio, percentages, index numbers or trends, and of procedures like averaging. To make things comparable, we relate them to standard units like square kilometres, or we convert them to standard situations. In order to compare average temperatures measured at different latitudes, we first assess the height above sea level of the stations where the temperatures were measured, and then we reduce them to sea level (for every 100 metres of height difference with the sea level there is 1°C decrease in average temperature).



Figure 6.1 Spatial concepts (drawing A. Lurvink).

6.2 Data analysis



Figure 6.2 Data analysis (drawing A. Lurvink).

Before we can map data, we have to analyse their characteristics. We have to check whether the data represent different qualities (nominal data) or can be ordered (like in cold-tepid-warm-hot, or in hamlet-village-town-city-metropolis), so that they would be called ordinal data. If the data represent different quantities, these quantities can refer to an arbitrary datum, like in temperature (the datum here is the point where water freezes), and then they would be called interval data, or, finally, they have an absolute datum that would allow for ratios to be computed; thence they are called ratio data. The relationships between the data can be visualised with graphical variables (differences in colour, shape, value or size), that would be experienced by map readers as perception of similarities, hierarchies or quantities (see figure 6.3).

Differences in size, be they applied in point, line or area symbols, are experienced as rendering differences in

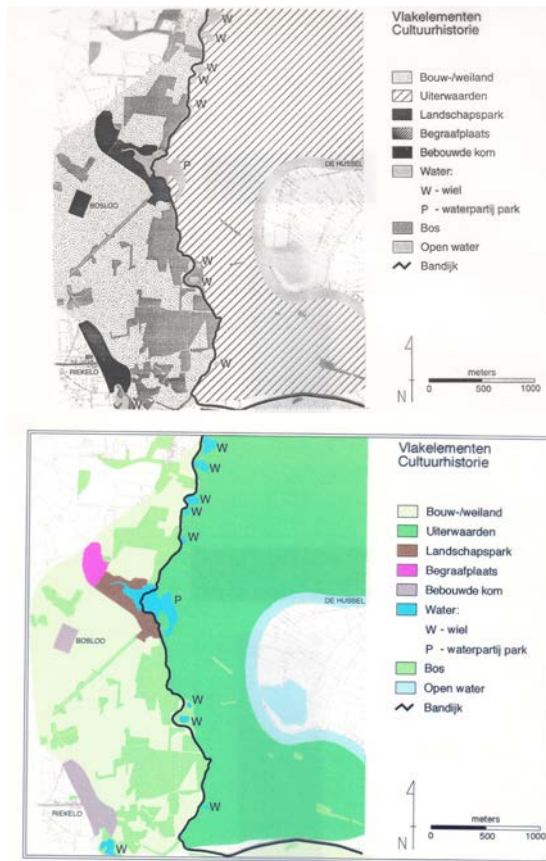
differences in:	symbols		
	point	line	area
size			
value			
grain			
colour			
orientation			
shape			

Figure 6.3 Graphic variables (from Kraak & Ormeling, Cartography, visualization of spatial data, 2010).

quantity (see also section 4.3.4). Differences in tint or value (like the lighter and darker shade of a colour) are experienced in the sense of a hierarchy, with the darker tints representing higher relative amounts and the lighter tints representing lower relative amounts. If we leave out the examples of symbol grain and symbol orientation (see figure 6.3), that are hardly applied in thematic mapping, we find that differences in colour hue (see also section 4.3.5) are experienced as nominal or qualitative differences. The same is valid for differences in shape. When we use shape differences for rendering qualitative data all objects or areas falling in the same class are not recognizable as such. That would be the case when rendered by different colours (see figures 6.4 and 6.5).

6.3 Map types

We discern different map types based on the graphical variables they are using and consequently on the geographical relationships they let map users perceive (see figure 6.6). These are:



Figures 6.4 and 6.5 In the upper map all elements belonging to the same class cannot be identified at a glance, while they can when rendered with different colours (maps by B. Köbben).

-*chorochromatic maps*, showing qualitative differences with the use of colour differences;

-*choropleth maps*, showing differences in relative quantities with differences in value or tint;

-*proportional symbol maps*, showing differences in absolute quantities through size differences;

-*isoline maps*, rendering differences in absolute or relative values on a surface perceived as a continuum;

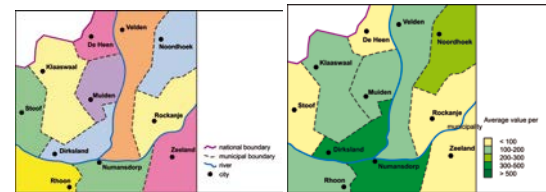
-*diagram maps* use diagrams, either for points or areas. Pie graphs are an example;

-*flow maps*, showing the route, direction (and size) of transportation movements and

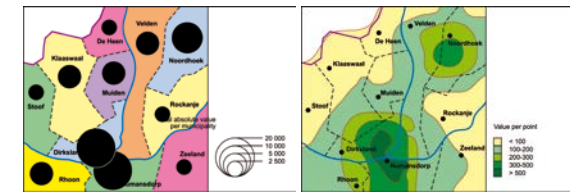
-*dot maps*, representing the distribution of discrete phenomena with point symbols that each denote the same quantity.

6.3.1 Chorochromatic maps

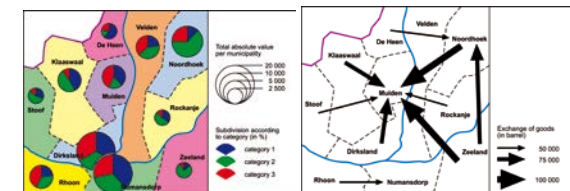
Chorochromatic maps are much used for physical phenomena, like soils, geology and vegetation. We are able to distinguish at a glance the distribution of up to 8 differently coloured classes; if more classes have to be represented, codes should be added as well in order to



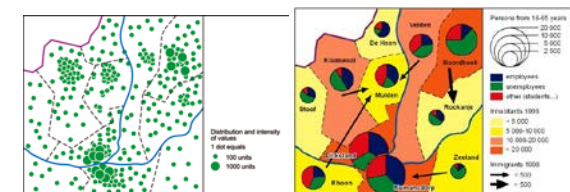
(6.6a) Chorochromatic (left) and (6.6b) choropleth maps.



(6.6c) Proportional symbol (left) and (6.6d) isoline map.



(6.6e) Diagram map (left) and (6.6f) flow map (right).



(6.6g) Dot map (left) and (6.6h) combination map.

Figure 6.6 Frequently occurring thematic map types.

2 SOIL MAP (detail)

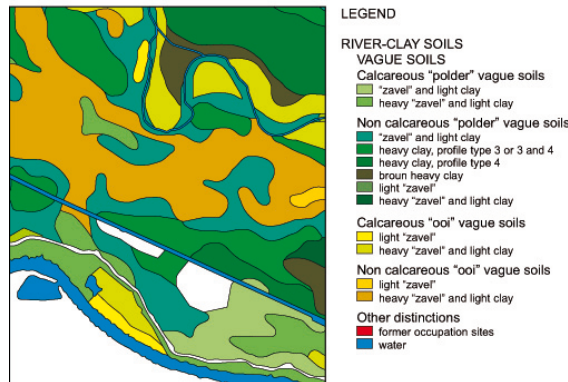


Figure 6.7 Soil map: too many shades of green are hard to discern on the map (Netherlands Soil Survey).

be able to recognize the relevant phenomena.

When used for socio-economic phenomena, the image they represent frequently has to be corrected. The use of coloured areas gives the map readers the impression that these areas are homogeneous with regard to the phenomenon mapped while in fact there may be enormous differences. Take for instance Figure 6.8: the actual number of Muslims is much smaller than the size of the green-coloured areas on the map would suggest. Therefore diagrams with the correct numbers are added. The actual number of Hindus is much larger than suggested by the relatively small size of brown-coloured area on the map.

6.3.2 Choropleth maps

Chorochromatic maps are mostly used for socio-economic phenomena. They denote relative quantitative data, such as ratios or densities. In figure 6.9 the

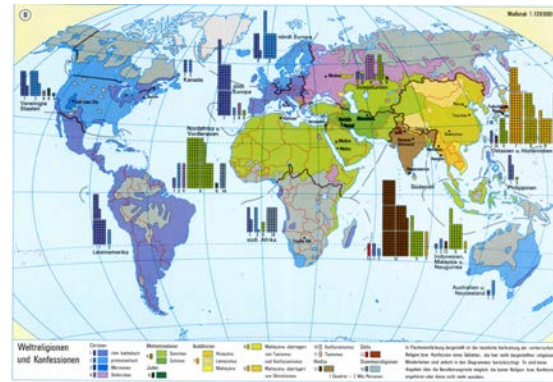


Figure 6.8. Distribution of religions. Much of the green-coloured areas (denoting Muslims) consist of sparsely inhabited deserts. See also figure 6.22. (Westermann, Diercke Atlas).

unemployment ratio is rendered, showing the percentage of the labour force out of work. When confronted with this map, the immediate reaction would be that unemployment at the time was highest in the north and the south of the Netherlands, but here again appearances may deceive. The impression that unemployment is highest in those areas is based again on the assumption that the country has a homogeneous population density, which it has not. The population is centred in the lightly-coloured western area, and the north and south generally have a much lower population density. High unemployment percentages therefore would mean much smaller absolute numbers of unemployed as compared to the higher absolute number in the west of the country. That will be obvious when we compare this map to the proportional symbol map of the same phenomenon in figure 6.10.

This distortive effect of choropleth maps does not occur



Figure 6.9 Unemployment percentage of the labour force in the Netherlands, 1980 (Ormeling and Van Elzakker, 1981).

when we deal with density maps. Here, as in maps of population density, the values concerned have already been normalized by dividing them by the surface areas concerned.

6.3.3 Proportional symbol maps. This map type is used for rendering absolute quantitative data. Figurative symbols are not well-suited to be scaled proportionally, so the best option here is to go for simple geometrical symbols like circles and squares. Bars would do as well if it were not the case that they easily pop out of the area they represent. When well-constructed the surface area of the squares or the circles is geometrically proportional to that of the values represented.



Figure 6.10 Absolute numbers of the unemployed in 1980 in the Netherlands (Ormeling and Van Elzakker, 1981).

Figure 6.10 shows that the portrayal of relative quantitative data in choropleth maps as in figure 6.9 can indeed be misunderstood by the unwary. The actual largest number of the unemployed can be seen here as located in the western part of the country.

6.3.4 Isoline maps

The construction of isoline maps is an elaborate process, explained here on the basis of temperature maps: at weather stations the average temperature is computed over a period of 30 years. The resulting values would be classified, and the values of the class boundaries would then have to be constructed in between the locations of the weather stations (by interpolation). The next step would be the construction of the isolines, by linking the constructed class boundary points, and the final step would be to make the pattern of isolines clearer by

inserting increasingly darker tints in between them (see figure 6.11).

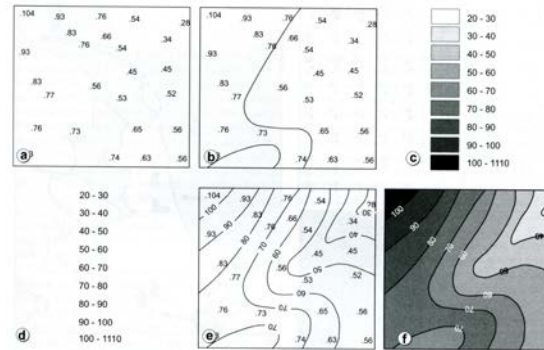


Figure 6.11 production scheme for an isoline map (from Kraak & Ormeling, *Cartography, visualization of spatial data*, 2010).

6.3.5 Diagram maps

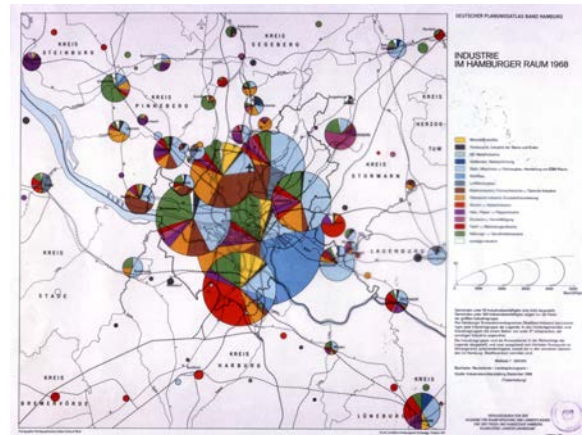


Figure 6.12 Employment in different types of manufacturing in Hamburg, shown with pie graphs (*Deutscher Planungsatlas, Hamburg*, 1970).

Diagram maps are maps that contain diagrams. The latter are primarily meant for being looked at individually or to be compared in pairs, and not so much for being combined in maps, where because of coastlines, boundaries and geographical names such comparisons are difficult to execute. These diagrams can vary from simple pie graphs to elaborate population pyramids. In principle thematic maps are meant to provide global information about the (quantitative) distribution of spatial phenomena at a glance; if one needs more detailed information, one should consult the original data or statistics on which the map was based. That is why diagram maps often are rather disappointing, from a communication point of view.

6.3.6 Flow maps

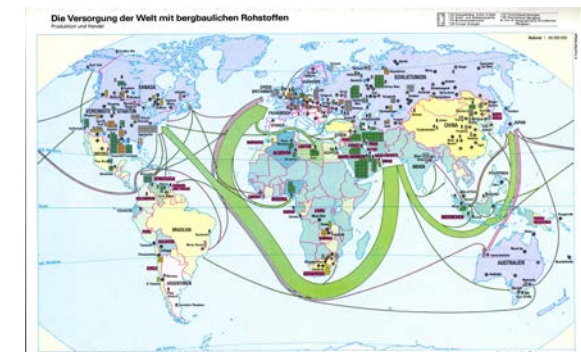


Figure 6.13 Transportation of mineral resources (green arrows show route, direction and volume of oil exports). (©Westermann Verlag, *Diercke Atlas*).

Flow maps show the routes and amounts of transports, mostly by arrow symbols. Arrows are most versatile symbols, as they can show the route, the direction and the quantities of the transported volumes. The arrows

can be differentiated by colours in order to show the transport of different commodities. In figure 6.13 it is

Minard's *Carte Figurative* of Napoleon's 1812 Russian campaign

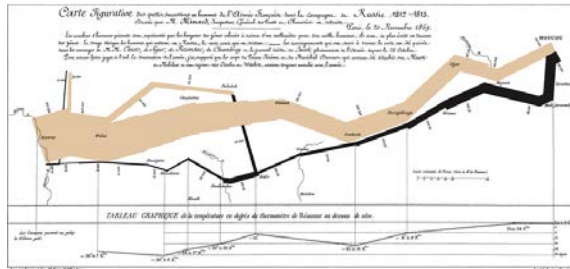


Figure 6.14 Minard's map of Napoleon's Russian Campaign

One of the best and most captivating flow maps ever produced is the map of Napoleon's Russian campaign in 1812 by the Frenchman Joseph Minard in 1869 (see figure 6.14). The pink flow line shows Napoleon's march on Moscow, the black flow line his retreat, when Moscow was set on fire and could not provide any food for his troops in winter. The width of the flow lines is proportional to the number of Napoleon's troops: he started with 550,000 soldiers when crossing the boundary river with Russia, the Neman, but had already lost most of his soldiers when he arrived in Moscow (with 100,000 soldiers). The real drama struck on the journey back to Poland, when the temperature went below -30°C , and when crossing the Berezina River, the bridges collapsed. The stark reduction of Napoleon's forces during the campaign is manifest in the map, but the message of this grim picture is further strengthened by the combination of a temperature graph below the map, which shows the temperatures on the way back.

20,000 troops returned to cross the Neman westwards.

shown that when this map was produced most oil exported from the Middle East was transported round the Cape of Good Hope to Europe.

6.3.7 Dot maps

Dot maps show distribution patterns by using dots that each represent the same amount or number. They are not meant for counting the number of dots to assess quantities; instead we would use proportional symbols for showing quantities. The patterns shown by dot maps result from a dot location practice during which one tries to locate the position of the dots as accurately as possible, for the dots to represent the actual geographical distribution of the mapped phenomenon.

In figure 6.15 one black dot shows 1,000 acres' increase in corn cropland per county, and one red dot represents 1,000 acres' decrease in corn acreage per county. The pattern of the map is most eloquent as it shows a decrease in the South-Atlantic states and in the southern Great Plains and an increase in the Corn Belt heartland.

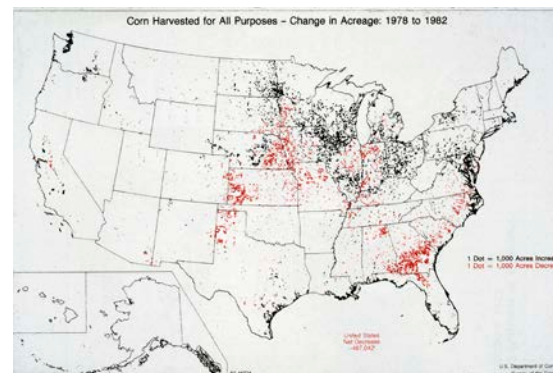


Figure 6.15 Change in acreage of corn, 1978-1982. (©U.S. Bureau of the Census).

6.3.8 Combinations of map types

Of course, map types can be combined: In figure 6.6 we see a combination of diagram, choropleth and flow maps, figure 6.8 is a combination of a chorochromatic map and a diagram map, and figure 6.13 combines a flow map with a proportional symbol map, showing the mineral production. The issue here is that the map should remain legible and that the various information categories should not block the overview of each other.

6.4 Map categories

Opposite to map types (that is maps produced according to specific construction methods), we discern map categories; that is, maps devoted to specific topics, like geology, soil (figure 6.7), demography, vegetation, transportation or elections. We will deal here with a selection of map categories, shortly indicating the specific problems in their construction.

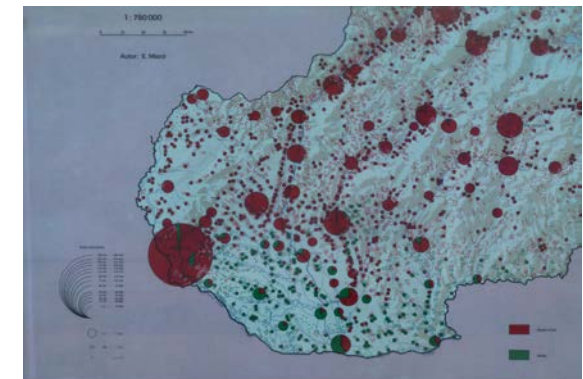


Figure 6.16 Distribution of the population in Slovakia. Red represents Slovak-speaking citizens; green, Hungarian speaking. National Atlas of Slovakia, 1980.

Demographic maps show aspects of the population, like its density or distribution and that of minorities (see figure 6.16), and its growth or decrease (chapter 7, figure 7.12), percentages of the young or elderly and their increase or decrease, emigration or immigration, nativity or mortality.

Economic maps try to integrate both agricultural activities, expressed in land use, and manufacturing and service occupations. The problematic aspect is that the manufacturing symbols tend to expand over agricultural areas, masking their land-use types. Figure 6.17 portrays an economic base map of India and Bangladesh, from a German school atlas. The light green land-use symbols refer to irrigated zones, mainly rice and orange zones to non-irrigated crops like wheat. Forests are dark green, the square symbols refer to manufacturing industries and the red town symbols render service industries.



Figure 6.17 Detail of an economic map of India and Bangladesh. ©Ernst Klett Verlag GmbH.

Ethnographic maps show the distribution of linguistic groups. Here, the issues are what colours to assign to which group, whether to assign different shades of colour and even when to assign colours at all. When should an area be shown as inhabited by people

speaking a specific language? When the largest group speaks that language, or when over 50 or 80 % of the population does? Which language groups should be represented by positively perceived colours like red,



Figure 6.18 Ethnographic map of the Balkans in 1877.

and which by more neutral colours? Should mountain areas that are only inhabited in summer by nomadic herdsmen be coloured in or not? In figure 6.18, apart from languages, the various population groups in the Balkans are also differentiated on the basis of religion. Albanians are for instance coloured green, with dark green for Muslims, middle green for Roman Catholics and light green for Greek Orthodox ones.

Environmental maps portray the level of degradation of the environment or the threats the environment is subject to. In figure 6.19, the threats from nuclear power plants in Europe is indicated. The darker the reddish tints, the higher the risk. The dark blue power plants apparently are considered more dangerous than the turquoise ones, which are mainly situated in Western Europe.

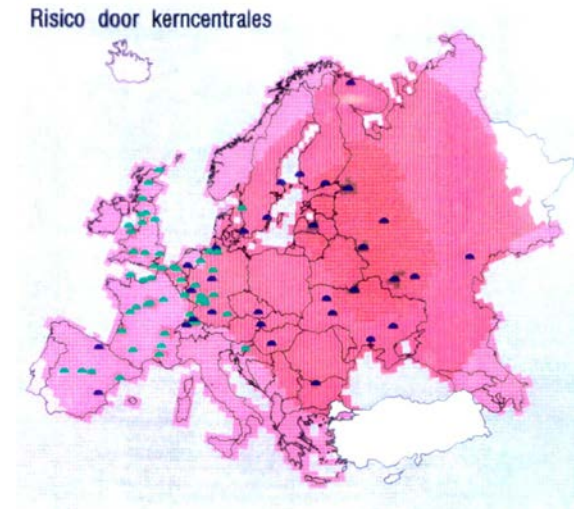


Figure 6.19 Risk from nuclear power plants.

In figure 6.20, the darker the areal tints, the stronger the impact of traffic (both marine and terrestrial) on the environment. The same goes for the circles that denote the traffic junctions: the darker they are, the more they pollute. For this kind of map the effects of all kinds of traffic on the environment is assessed, and these effects are added up per areal unit, like cells of 10 x 10 or 50 x 50 km. Then the aggregate values are classified and tints are chosen for each pollution class, and adapted to the audience: instead of giving numeral values, which will only inform the initiated, these are described like very strong, strong, medium, weak or very weak impact on the environment.

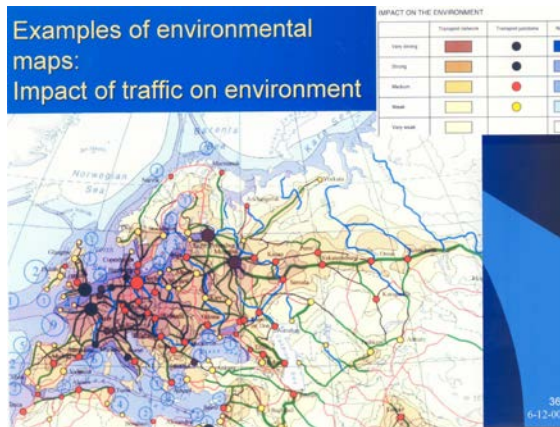


Figure 6.20 shows the impact of traffic on the environment. From: *Resources and Environment World Atlas*. Russian Academy of Sciences. ©Ed.Hölzel.1998.

History maps aim to present situations in the past, be they political, economical or cultural. Their main problem is to find the data to be able to present a complete picture. To present a complete picture of a situation in the Middle Ages, for instance, one should be able to assess the population density in the mapped area, the forest coverage and the road network, and often such information would not be available for the whole mapped area. Often there would be only information on a part of the map and not for the remainder.

Another challenge of history maps is to show developments in time. In figure 6.21, the last days of the Paris commune are shown. It was conquered in seven days by troops loyal to the French government, and the area last occupied is rendered in the darkest colour, so the troops of the commune had their last stand in eastern Paris at Ménil-Montand near the Père Lachaise cemetery.

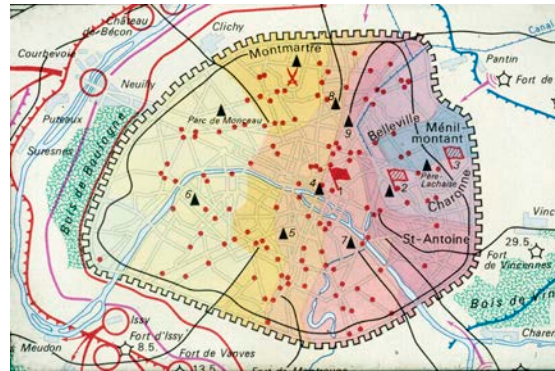


Figure 6.21 Last days of the Paris Commune in 1871. Haack *Atlas zur Geschichte*, 1970.

Religion maps: the same issues are valid here as for ethnographic maps: which colours to assign to which creeds, and how to deal with minority groups. In figure 6.22, the problem of minorities is solved by inserting dot

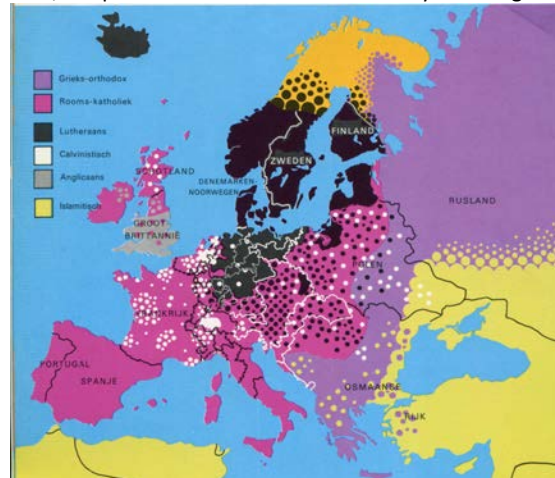


Figure 6.22 Distribution of religions in Europe around 1550 (*Geschiedenisatlas* mavo havo vwo, Meulenhoff 1979).

patterns on the majority colours, so that the idea of a sprinkling of other denominations is brought across.

Agricultural maps can show the sizes of the actual agricultural production or the physical (see chapter 7, figure 7.5) or social conditions (access to water or to the land or to capital), or the farming systems devised by the farmers to cope with both physical and social conditions. So the results could be land-use maps, maps showing the size of the production for specific crops or integrated maps in which the different crops and even farm animals have been converted into the same denominator.

So these maps can range from simple maps showing the production of a single crop or animal product, to highly complex maps into which many aspects of the agricultural production have been integrated. Figure 6.24 shows the legend of a Land-use map for Cyprus, produced in the framework of the World Land Utilization Survey, and Figure 6.24 is a map from the GDR showing both the productivity and the nature (either animal or vegetarian) of the production.

In order to combine products from animal husbandry and from crop farming, they need to be expressed in the same units, for instance in money—like the price they would fetch in the local market. Other measurement units would be the time it takes to produce them, or the exchange rate between grain and meat in local markets.

A similar problem would be encountered when we want to make a map of all farm animals: they would have to be converted all in 'equivalent animal units,' in which 1 cow would be equal to 0.8 horses, to 2.5 swine, to 5 sheep, based on their grazing capacity.

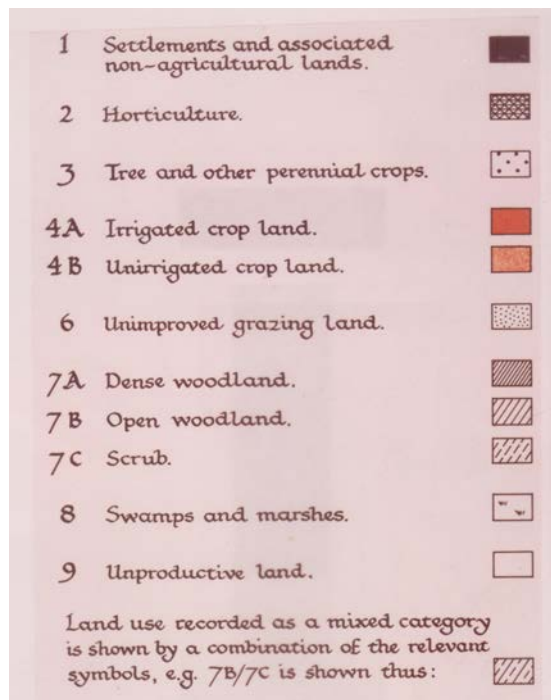


Figure 6.23 Legend of a map of a land-use map of Cyprus.

In figure 6.24 the darker the colours, the higher the value of the overall agricultural production. The more reddish the colour, the more the production is oriented towards animal products; the bluer the more it is oriented towards crop products.

Physical planning maps aim at showing the planning measures that have been taken for the future. Frequently, the exact location of future town extensions, highways or airport has not been defined yet, and that

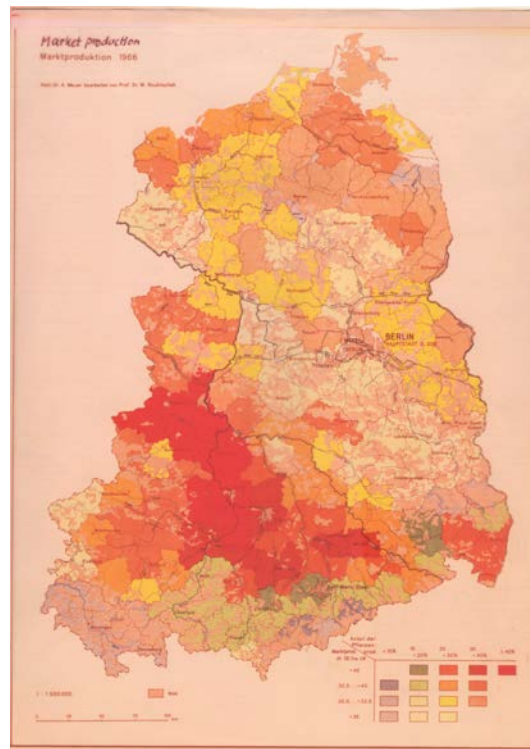


Figure 6.24 Size and nature of the overall agrarian production in the GDR for the year 1966.

results in these planning maps having a more or less schematic character, so that new roads, plants or town extensions cannot be located exactly, thus diminishing the possible antagonism against these proposed developments. Figure 6.25 is an example.

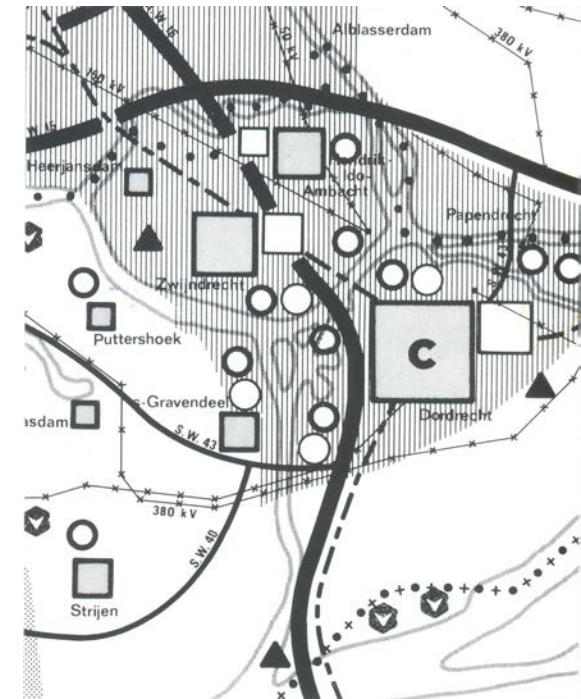


Figure 6.25 Physical planning map.

Urban maps show the present or future urban land use; in the latter case they would be related to planning maps. They can either portray individual towns and cities or render urbanization phenomena. In figure 6.26 the degree of urbanization of the GDR is shown. What is mapped here is the density of residential buildings that is the number of residential units per km². The light green squares have less than 3 residential units per km², while the purple squares have 60–150 and the red squares over 150 per km².

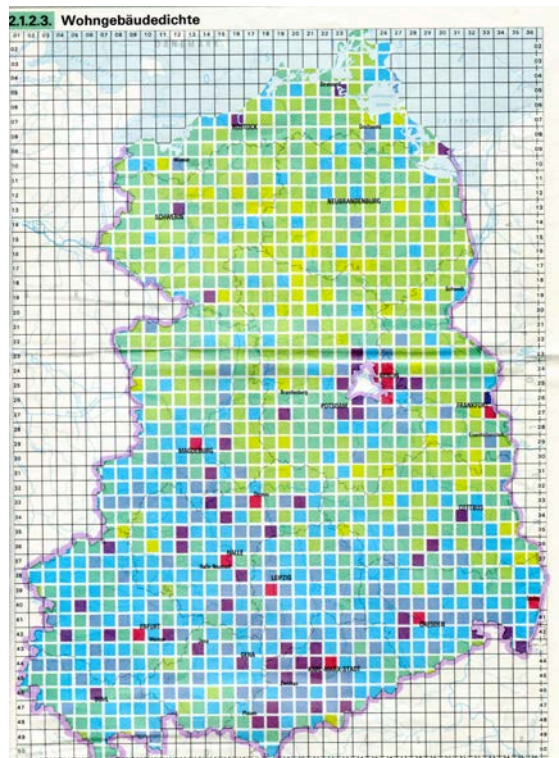


Figure 6.26 Map of residential density for the GDR. The squares measure 10 x 10 km.

Hydrographic maps show the flow or capacity of rivers. They are produced by measuring this flow in all streams over a certain period, in order to be able to compute average flows. These would then be classified, and standard widths would be assigned to each class. In figure 6.27 the intermediate stages in the production of the map are shown, with the manuscript map or author's original (see chapter 4, section 4.3.2) of the river network, the locations where the river flows were measured and codes that indicate the average

magnitudes of the flow. This document would allow the cartographer to draw the river network with the widths proportionate to the flow. The basis of the map is a precipitation or rainfall map, which is relevant as the river flow, at least in this part of the world, is determined by the amount of rainfall in the river basins. The tints to render the average amounts of rainfall range from yellow (low precipitation) to blue (high).

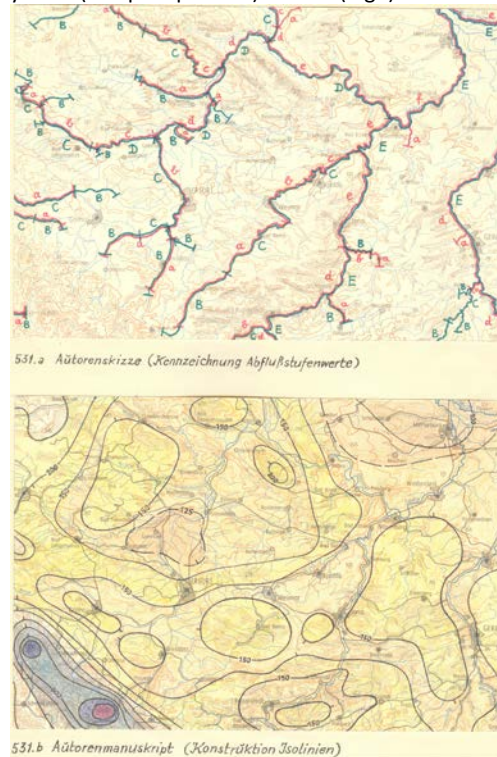


Figure 6.27 Author's originals of river flows (above) and rainfall as a basis for the map in figure 6.29.

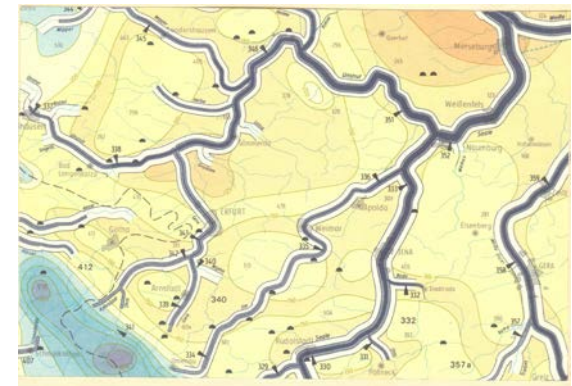


Figure 6.28 Hydrographic map (produced for ICA textbook).

6.5 Aggregation of enumeration areas

Data for socio-economic maps are available at different levels: usually they are available for postal code areas, for municipalities and combinations of municipalities, for districts, departments or provinces, etc. At every one of these levels the image of the mapped phenomenon will be different. This is caused by the fact that when data are aggregated, the new ratios or densities computed will be less extreme than on lower enumeration area levels: the higher the aggregation level, the more the resulting values will approach the national average.

The large map in figure 6.29 shows the referendum results in Norway regarding joining the European Union in 1994. A majority of 52% voted against joining, a minority of 48% voted for joining (if applicable). On the map reddish colours mean a community with a local majority voting against, blue a community with a local majority for joining. The blue areas are hard to find, but they represent the major urban areas in Norway.

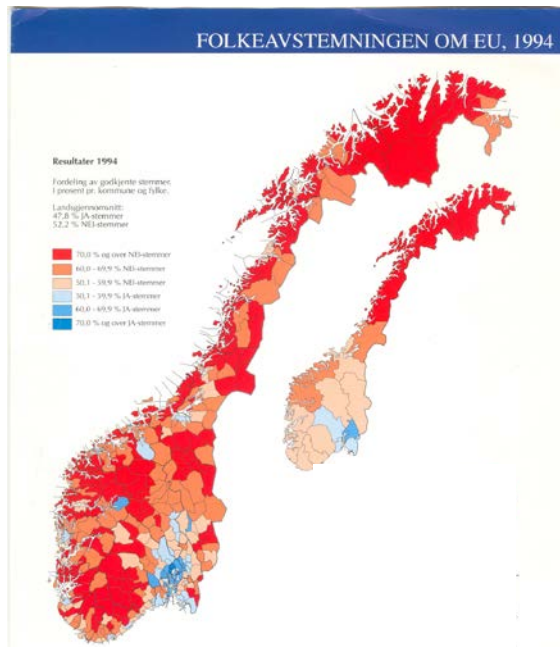


Figure 6.29: Result of data aggregation. National atlas of Norway.

The smaller map portrays the same information, but now aggregated for provinces. Much fewer areas are characterised by the bright red colour denoting over 70% against; aggregating the data makes them less extreme.

6.6 Analytical and Synthesis maps

Most thematic maps portray just one aspect of a phenomenon: just soil type or religion or unemployment, population distribution or nuclear risk. We would call them *analytical maps*. Other maps show a few related aspects, like in figure 6.13, production of minerals and its transportation, or in figure 6.16 land use, manufacturing industries and service industries. When maps would

portray all possible aspects of a topic, we would call it a synthesis map.

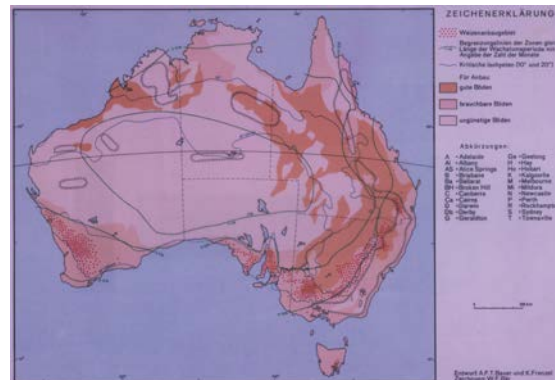


Figure 6.30 Synthesis maps: all relevant aspects combined (International Cartographic Yearbook 1967).

Figure 6.30 is an example of a synthesis map. Its topic is wheat growing in Australia. Green isolines show the length of the growing season (when it is humid enough for crops to grow), and blue isolines show critical isohyets, that is lines of equal rainfall. Good soils suitable for wheat growing are rendered in dark brown, lesser soils have lighter colours. As accident terrain might pose problems to mechanical agriculture, hachures indicate such terrain. Finally the current acreage under wheat is shown with red dots, so that people can gauge from the map whether the present acreage could still be extended because there would be other areas still where all positive conditions prevail. The only relevant information not provided on this map is the transport infrastructure: apart from growing and harvesting wheat, it also should be transported to export ports.

Snow's London Cholera victims map of 1854

Medical doctor John Snow investigated the 1854 cholera outbreak in London. He suspected that cholera outbreaks were related to the contamination of drinking water. He therefore mapped the victims of the cholera epidemic at their home addresses (see figure 6.32). When studying this map (on which he also had indicated the location of the water pumps, because of his suspicion – at that time this part of London did not have a piped water supply), he found out that the victims were located around the pump in Broad Street. He then convinced the local authorities to remove the handle of this pump and as a consequence no further cholera cases developed. Apparently the contaminated water of the Broad Street pump had been the cause of the cholera outbreak.



This is a nice case history of the beneficial role of map analysis. In his later life Snow also researched the statistics of cholera epidemics

6.7 References

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