Exercise – Cartography and Map Comprehension

Introduction

GIS = Geographical Information Systems

GIS make it possible to capture, store, manipulate, analyze, and display spatially referenced data (geodata). GIS allow us to visualize data, for example in the form of maps, apps, reports and charts.

Such outputs help us to understand, question, and interpret data such as to reveal spatial relationships, patterns, and trends.

By the end of this exercise we hope that you may have revealed the potential of a few base-line functions of a GIS software, and to present geographic data in a neat and informative manner.

Typically, any ordinary GIS software will let you:

- View geographic data
- Edit geographic data
- Query spatial data
- Analyze spatial data
- Create professional maps
- … and much more

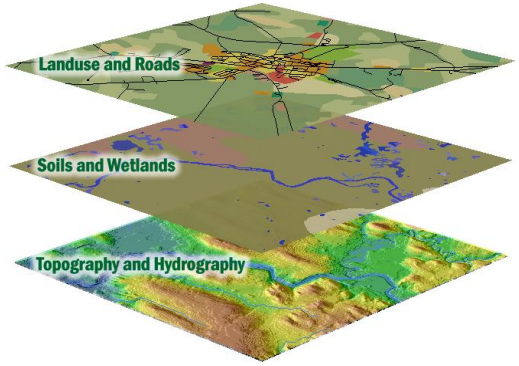
Objective

Aim:

This exercise will give you an introduction to the 'art' of producing a neat and informative digital map including all the essential components.

The first part of the exercise will make you acquainted to a few basic functionalities of the *ArcGIS Pro* GIS software. You will learn to:

- Start your project (called "map" in ArcGIS Pro).
- Add data to your project.
- Manage data layers in the Table of Contents (TOC).



Then, during the map-generating phase of the exercise, you will learn:

- About (projected) coordinate systems.
- About various common file types of geodata.
- To symbolize geodata by colors and text labels.
- To add a scale bar, a North arrow and a legend to the map.
- To save your map as an image file (which may be imported to a project report or a PowerPoint presentation).

Finally, you will save your map/project, and learn how to transfer the project to another location for purposes of sharing.

On the way, you will also get an introduction to the digital learning environment:

- Where to find the exercise documents and data.
- The drive structure on the computers (H:/T:, I: and C: drives).

It is necessary to learn these basic skills to be able to produce map layouts in the following exercises, and during the Project. (The Project, with a capital 'P', is at the end of the course, where you will make use of the skills from all the exercises.)

Exercise

Figure 1 and 2 are showing what the end results of the first part of this exercise may look like:

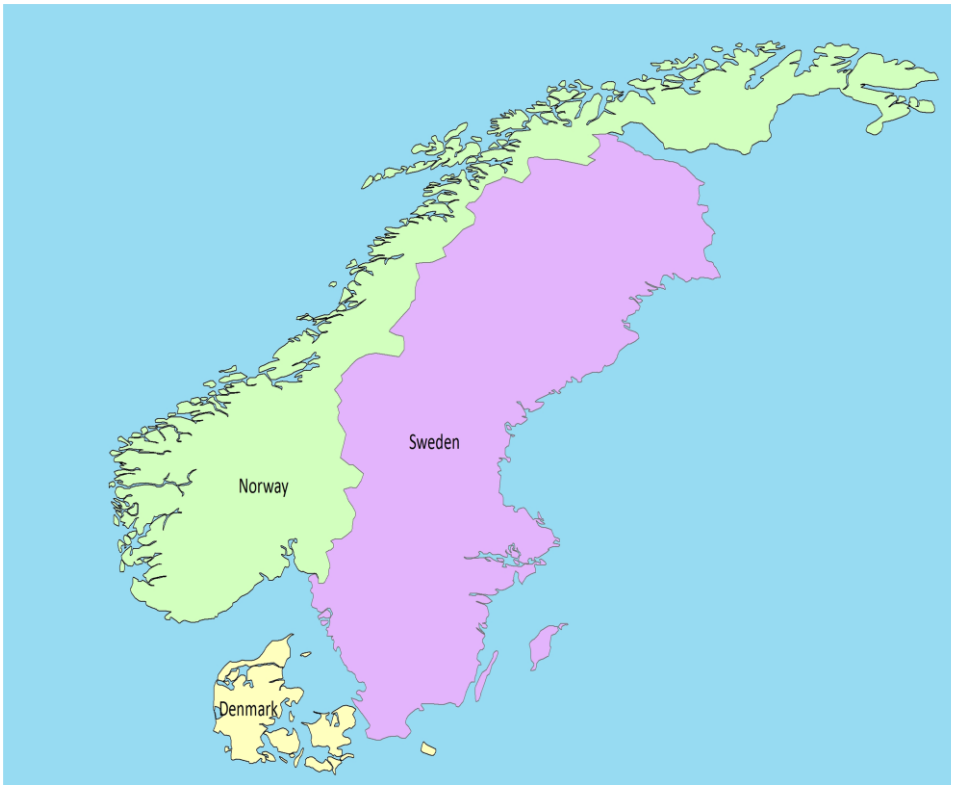


Fig. 1. An image (not map) of Scandinavia.

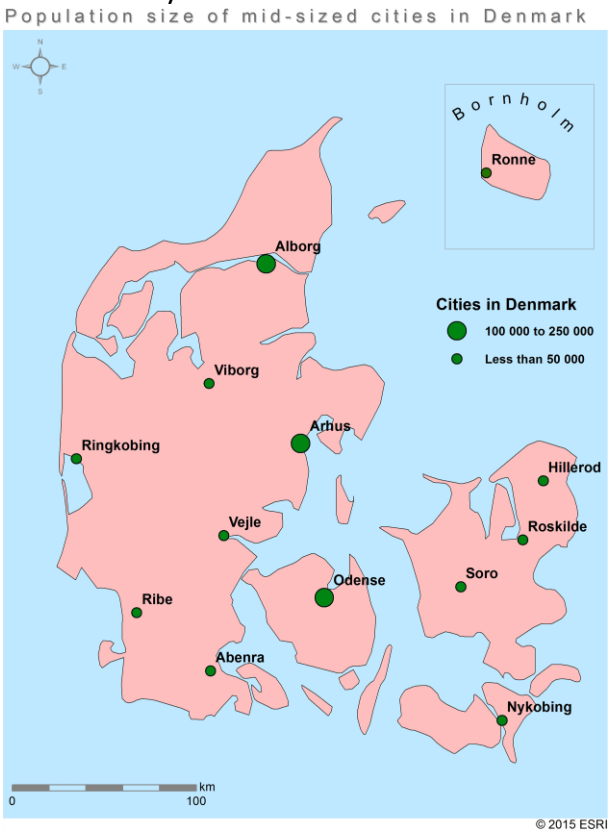


Fig. 2. A proper map (representing Denmark), *incl.* auxiliary map elements like a North arrow, a scale bar, a legend, a title and data references.

DIGIT = Did I Get It
are simple question to ensure that you have grasped the main message/skills of the exercise. One DIGIT test is found in each of the GIS exercise sections on the ***E-learning environment*** *(**Absalon**).*

All along the exercise you will encounter a marker like this: **DIGIT-1** ➔➔➔➔➔➔ , in the left margin.
This marker refers to a specific question of what we call a 'DIGIT test'.
The DIGIT tests are online tests found under the exercise/quiz section on the E-learning platform called Absalon.

All the DIGIT tests are compulsory. That is, you have to go them through, at least once.
(You may take a test as many times as you like.)
However, your results are not evaluated by us, and they will have no influence on your final grade on the course.
We just think that these small tests will add to your comprehension of the subject and the software used.

Exercise

ArcGIS Pro** is the successor of **ArcGIS Desktop.

ArcGIS Pro is the GIS software you will use during the exercises.

Some of you may have encountered a software suite called ArcGIS Desktop previously. ArcGIS Desktop contained applications like ArcMap, ArcCatalog and ArcScene etc.

All these separate applications are now put together in ArcGIS Pro. ArcGIS Pro is the successor of ArcGIS Desktop (and any further development of ArcGIS Desktop has terminated).

Start ArcGIS Pro

1. Start ArcGIS Pro:

   a) Start ➔ All Programs ➔ ArcGIS ➔ ArcGIS Pro
   (Alt. Double-click the ArcGIS Pro shortcut on the Desktop)

   ArcGIS Pro starts and a range of options are presented (Fig. 3).

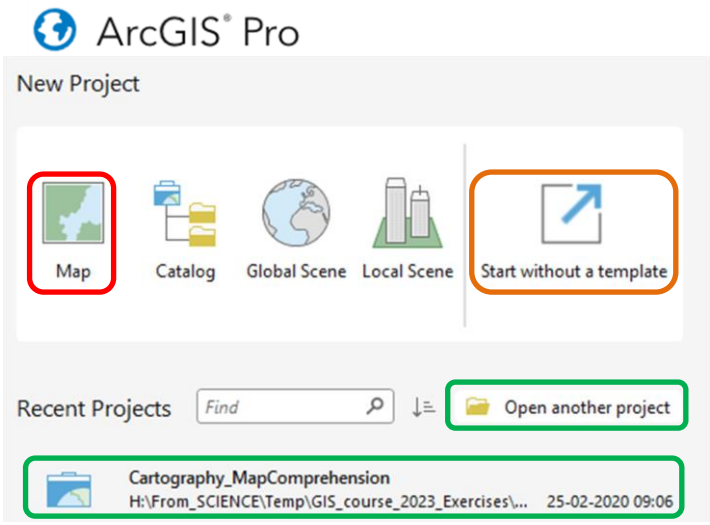


Fig. 3. The ArcGIS Pro start window.

   b) Click the Map option (see the **red** box in Fig. 3).

   The Create A New Project dialog opens (Fig. 4).

Fig. 4. The Create A New Project dialog.

   c) Name: Type a name for your project.

   d) Location: Browse to your personal H:/T: drive (see **blue** box), and select/create an appropriate location folder ➔ OK.

Valuable tips! ➔ ➔ ➔ ➔

DIGIT-1 ➔ ➔ ➔ ➔ ➔

Start Options

A Project – The Map option (see the **red** box in Fig. 3).
This is a good way to start a *long-term* Project. That is, this is the choice when you know that you will be working with some geographic data for some time, and you would like to save the material for later use.

Quick view – The Start Without A Template option (see the **orange** box in Fig. 3).
When the intentions are *short-term.* For example, you are only interested in viewing some geographic data.

Previous projects – At the bottom, there are various alternatives to open saved Projects (see the **green** boxes in Fig. 3).

Exercise

The ArcGIS Pro graphical user interface (GUI) opens (Fig. 5).

GUI = graphical user interface

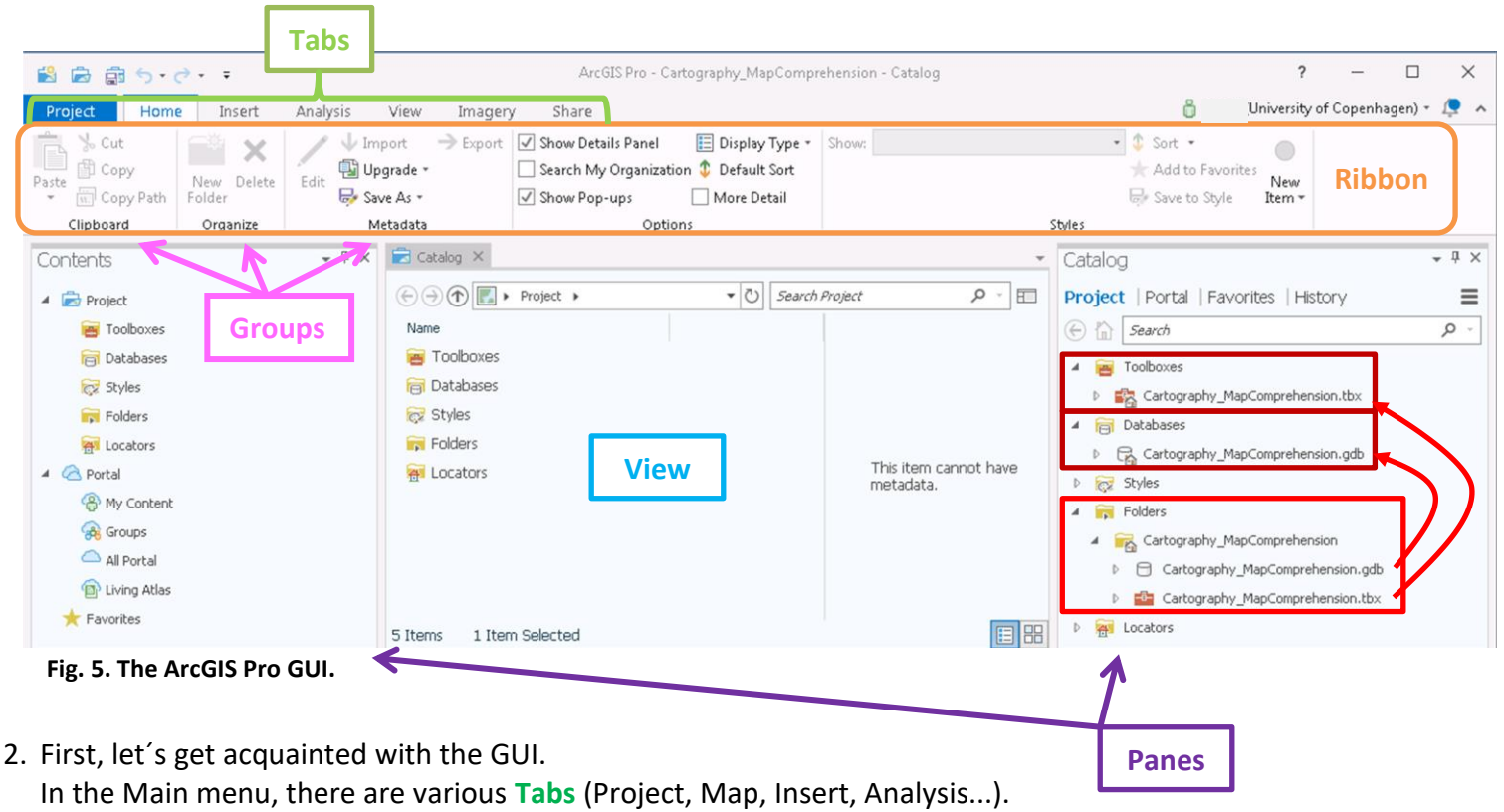


Fig. 5. The ArcGIS Pro GUI.

Tab

Ribbon

Group

2. First, let´s get acquainted with the GUI.
   In the Main menu, there are various **Tabs** (Project, Map, Insert, Analysis...).
   When you click a certain tab, its particular **Ribbon** is displayed.
   A ribbon is divided into some **Groups** (Here: Clipboard, Organize, Metadata...).

   The principle is just the same as with toolbars and their dropdown menus, which you have met in other softwares. However, ribbons generally consume less space, and offers more flexibility when it comes to your own customization.

View

3. In the middle, there is a **View**. (**NOTE**: This may differ somewhat from your own View at the moment.)
   This is the place where you, for example, will be able to view and create maps.

Pane

4. On both sides are the **Panes**.
   A Pane is a dockable window, where you may set the order of your data layers, manage data etc.

Exercise

Now, let´s have a look at what happened as you created your new Map project.

5. In the Catalog pane (Fig. 5, far right), there are some Items.
They are called: Maps – Toolboxes – Databases – Styles – Folders – Locators.

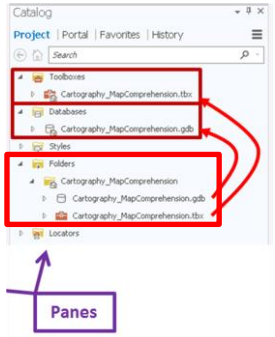
Toolbox (.tbx)

a) When you expand the **Toolboxes** item, you will find an *.atbx* file.

/Geo/database (.gdb)

b) As you expand the **Databases** item, you will find a *.gdb* file.

Both files have the name that you assigned for the project.
They are generated by default, and are both empty at start.



Snapshot from fig. 5 on the previous page.

Geodata =
Digital data with a location (e.g. XY coordinates, address)

At this point, the only thing you need to know, is that a *.gdb* (a geodatabase) is a container of geodata.
(In a moment, you will learn more about geodata layers; How to add them, process them, store them etc.)

c) In the **Folders** item, a direct connection is set up to your project folder. The same files as in a) and b) are displayed.

Before we are proceeding with more hands-on GIS tasks, let us first have a look at the files mentioned above, however, in another environment – the Windows File Explorer.

Windows File Explorer

6. Open Windows File Explorer by clicking the  button on the bottom panel of the Desktop screen.

7. Browse through the Windows catalog to the location/folder where you saved the ArcGIS Pro project (see step 1 d).

Once again, you will find the same files as in the Catalog pane of ArcGIS Pro (Fig. 6):

- The toolbox file (*.atbx*)
- The geodatabase file (*.gdb*)

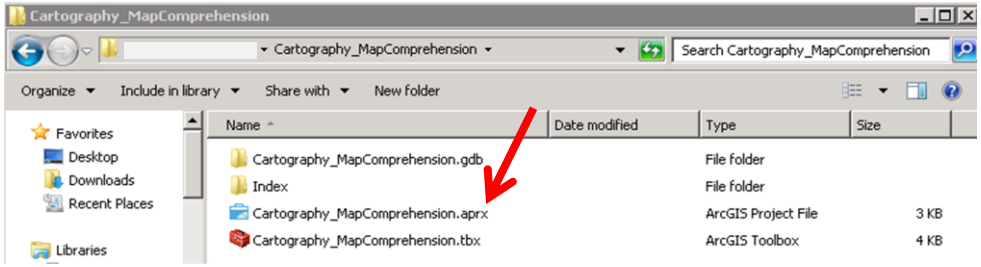


Fig. 6. The files of an ArcGIS Pro project, seen in Windows File Explorer.

Project file (.aprx)

Additionally, here, you will also be able to see the ArcGIS Pro project file (*.aprx*).
This is an important file.

The *.aprx* file will store many of the crucial details of the project, like which geodata layers are being used, and the look of the map layouts.

TB = terabyte
(1 TB = 1000 GB)

Even though a GIS project may include large amounts of geodata (even TBs), you will find that the *.aprx* file will not grow much as the project is developing. This is because the *.aprx* file mainly stores *relations* (where things are and look like), rather than the large physical geodata files (which often are stored in the geodatabase file, the *.gdb*).

Useful information

Before we commence with the exercise, here are a few helpful tips:

Exercise material

Exercise manual and data

You may find and download the exercise manual from two locations:

* The course site on the E-learning environment (the Absalon)

* The I: drive (on the server), specifically - ***I:\SCIENCE-IGN-CGD-UVMAT\GIS_course\Exercises\ArcGIS_Pro***

You will always be able to download any exercise *data* from the exercise folder on the I: drive.
You may sometimes find the *data* on the Absalon too, unless they are too big to be stored there.

Managing a project

Storing the ArcGIS Pro project

As you may remember, in step 1d) above, you were instructed to save your project (and its files) on the H:/T: drive.

This is a good idea for several reasons. The H:/T: drive is:

+ Your private space (No other student may access your files).

+ Located on the university server (you may access it from any school computer).

However, you might experience some limitations to the H:/T: drive, mainly:

- The amount of storage space is limited.
  (This is usually not a problem, however since geodata sometimes are big, you may eventually hit the storage limit.)

- Processing of geodata may be slower.
  (Since the H:/T: drive is located on a server (rather than on the computer hard drive), there might be occasions when the network traffic is heavy, which may impair data transfer speed.)

Useful information (cont.)

Problem solving

Lack of storage

Slow processing

Sharing data

DIGIT-2 ➔ ➔ ➔ ➔ ➔

Storing the ArcGIS Pro project (*cont.*)

IMPORTANT!
Please contact a GIS supporter,
in case you are in doubt of any of the practices described here.
If the file transfer is not done properly,
the transferred files may end up corrupt (and thus useless).

Problem solving

***i*) Storage space on the H:/T: drive is full**

Evidently, you would need to release some space.
Transfer some other, old material to another storage unit (*e.g.* a private USB stick or some other external hard drive).

***ii*) Data processing is abnormally slow**

Copy the project (and all its content) over to the computer hard drive (*i.e.* the C: drive), **temporarily**.
This action will save you time, since data flow over the network (to/from the I: or H:/T: drives) often is slower, than working from your local hard drive.
Later, when you have finished working with the project, you will have to transfer the project (and all its files) back to your own personal folder on the server (*i.e.* the I: or H:/T: drive).
Finally, do NOT forget to **delete** the files on the C: drive (else that computer will soon run out of memory).

***iii*) You would like to share the project with a fellow student**

Copy the project (and all its content) over to a folder on ***I:\SCIENCE-IGN-CGD-STUD\Blok_Y_20XX***

Table 1. Storage in the Student Computer Lab (aka the CGD)

Computer drive	Location	Access	Sharing
H: or T:	On the university server.	Access from any university computer.	Your private space (no other person may access). No sharing.
I:	On the university server.	I:\SCIENCE-IGN-CGD-UVMAT\ or I:\SCIENCE-IGN-CGD-STUD\ Access from any computer in the Student Computer Lab.	A shared space (anyone may access). Good for sharing data. Create your own folder on: I:\SCIENCE-IGN-CGD-STUD\ Blok_Y_20XX\
C:	The computer hard drive.	Specific to a computer. NOTE! If you save something here, you need to return to the very same computer.	No sharing.

Exercise

Now, back to dealing hands-on with ArcGIS Pro.

Throughout this course, you will experience various ways to search for and access geodata.
In this first exercise we will simply provide you with them from this folder:
I:\SCIENCE-IGN-CGD-UVMAT\GIS_course\Exercises\ArcGIS_Pro\Exercise_Cartography_MapComprehension\Geodata

All students may access this folder. That means, if every student would start using those data in their projects, directly from this shared location, everyone soon would experience drastically longer handling times.
As a consequence, it is often a good procedure to **copy** the geodata over to your own H:/T: drive, if not they are too big. (This is true, unless the geodata is located on the university GIS server, which you will be acquainted with later.)

Transfer geodata

The transfer of files is preferably conducted in the Catalog pane.

8. a) In the Catalog pane, located along the right edge, expand the Folders item (Fig. 7).

At this point, there is only one folder connection – the one to your own project folder.
This folder connection was set up automatically as the project was created.

Follow the link to watch video:
Connect to Folder

b) Create a new folder connection to where the exercise data are kept – The exercise folder on the I-drive.
(**I:\SCIENCE-IGN-CGD-UVMAT\GIS_course\Exercises\ArcGIS_Pro\Exercise_Cartography_MapComprehension**)

DIGIT-3 ➔ ➔ ➔ ➔ ➔

Now it is time to transfer (copy) the geodata in this folder to your personal project folder.

c) Expand the *Exercise_Cartography_MapComprehension* folder
➔ Then the *Geodata* folder.

The geodata you are going to use are located in the *World.gdb* geodatabase that appears.

Copy/Paste geodata

d) Right-click the *World.gdb* geodatabase ➔ **Copy**.

e) Now, right-click your own *Cartography_MapComprehension* folder ➔ Paste.

A copy of the *World.gdb* is now available in your personal project folder (Fig. 7).

f) Remove the connection to the ***Exercise_****Cartography_MapComprehension* folder:
In the Catalog pane: Right-click the folder ➔ Remove From Project.

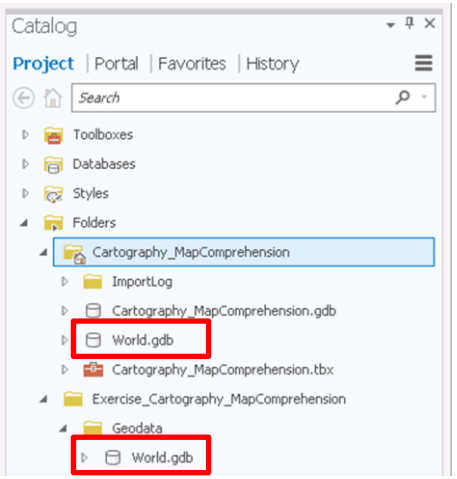


Fig. 7. The *World.gdb* geodatabase has been copied over to the personal exercise folder.

Exercise

So, with the geodata in place, you might wonder: How may I view them geographically (not just as files).
For that to take place you need to open a new View – a Map.

Add a new Map (view)

Basemap

Shift Basemap

9. Add a new Map
   (Skip if you already have a Map view).

By default, a 'Basemap' layer has been added to the Map view. This is a Topographic map, which you may shift to any of the other Basemap types available (Fig. 8).

A Basemap may serve several purposes:
- It may help you to orient yourself.
- It may be used as a background for the map you are going to produce, or for other tasks.

DIGIT-4 ➔ ➔ ➔ ➔ ➔

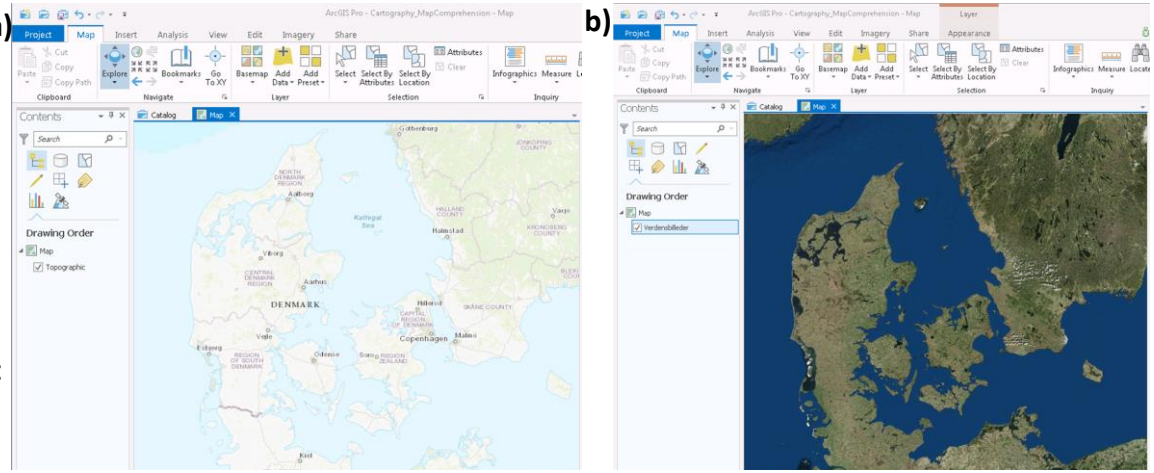


Fig. 8a. The Topographic basemap, added to a new Map view by default.
b. A change to the Orthophoto basemap.

Add geodata

You will now start adding your own geodata to your Map.

File geodatabase .gdb

Feature class

10. From your personal (home) project folder, inside the *World.gdb* file geodatabase:
    Add the *Countries_world* feature class to the Map view.

Map ribbon

11. Spend some time to learn how to navigate in the Map view using the Map ribbon (Fig 9).

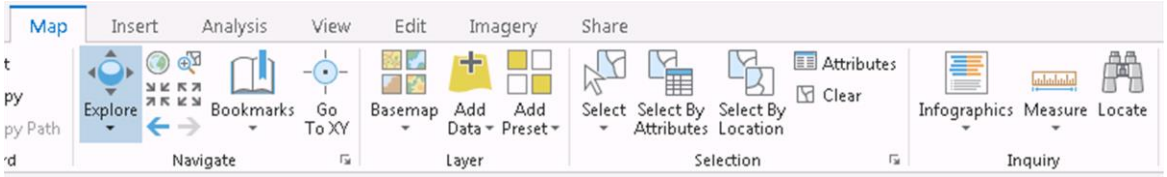


Fig. 9. The Map ribbon.

What is the Contents pane?

DIGIT-5 ➔ ➔ ➔ ➔ ➔

12. Then spend a few more minutes to get acquainted with the Contents pane.

Task A - Produce an image

Your boss knocks on the door. She asks if you could produce a simple image with the countries of Scandinavia.

She needs it for a PowerPoint presentation at a meeting later the same day. -Sure, no problem.

What is an Attribute Table?
DIGIT-6a-c ➔ ➔ ➔ ➔ ➔
Attribute Table
– Select manually

13. You start your task by selecting and zooming in on Denmark using an Attribute Table.

As your boss clearly stated that the image should contain only Scandinavia and no other (distracting) features, it is a good idea to create a new geodata containing only the countries of interest.

a) Supplement your selection with the two remaining countries of Scandinavia (Norway and Sweden), also using select inside the Attribute Table.

Export geodata

b) Create a new geodata file containing only the Scandinavian countries.

c) Remove the *Countries_world* map layer.

DIGIT-7 ➔ ➔ ➔ ➔ ➔

At this point, the fundamentals of your image are displayed – the three Scandinavian countries.

14. However, there is room to improve the layout.

a) Change the background in order to improve the contrast to the country features.

Modify background

b) There are various techniques to change the symbology of the objects in a geodata layer.

Change colour Same/Unique

c) To add text, you need to create a Map layout.

Create a Map layout

NOTE! The new version of the software has two new techniques. Please follow the instructions below:
➔Unlike in the video, after you have selected the Map Frame, you need to draw a rectangle on the Layout canvas.
➔Also new: Press Share ➔ Export Layout. The Export Layout dialog appears along the far right edge.

DIGIT-8 ➔ ➔ ➔ ➔ ➔

Map vs. Image

As you may have noticed in the video, the output of this Map layout was called an 'image'.
Was it not a 'map'?

Map primitives
(a title, scale bar, legend, North arrow, references etc)

We believe that a map is more than just a few geographical objects and some text notes.
A proper map should include more essential ingredients – we call them ***map primitives***.
Map primitives include graphics like a map title, scale bar, legend, North arrow, references etc.
You will learn more about those in a moment.

Good saving procedures

15. Save the Project.

Task B – Produce a map

Suddenly, your boss returns to your office. She remembered that she also would need an image of only Denmark.
It should display all the main cities outside Copenhagen.
You should be able to tell roughly the distances between the cities and a hint of their importance (in terms of pop. size).
From her description you realize that what she wants is not a simple image – but a proper *map* (incl scale bars etc).

Map vs. Image

You may add several Map views to your Project.

16. a) Start a completely new Map view session (Insert tab ➔ New Map).

b) As you were adviced to just a minute ago, save your changes to the project.

It´s always a good idea saving a Project early and then keep saving every now and then during the progress of the Project.

Rename a Map view or a Layout view

c) Rename the Map view, perhaps to something like '*Denmark – Major cities*'.

Use your skills

17. Once again, from the *World.gdb*, add the *Countries_world* feature class.

Obviously, you will only need geodata specific for Denmark for this map layout, not the rest of the world.
Consequently, it is a good idea to extract the features related to Denmark and to save them as a separate geodata file.

A moment ago you learnt how to select features manually using the Attribute Table.
Now, you are going to learn two more techniques.
Both techniques are very efficient when you would like to select many features swiftly.

SQL = Structured Query Language

The first technique is also making use of the data in the Attribute Table.
However, this time you will type a selection query using the database language SQL.

AttributeTable – Select By Attributes

18. Select the '*Denmark*' feature from the *Countries_world* geodata.
NOTE! Unlike in the video, you do not need to click 'Add Clause' the first time (Fig. 10).

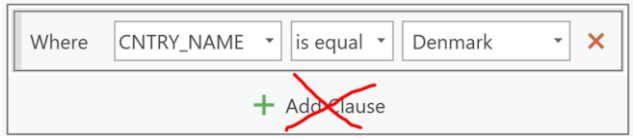


Fig 10. Since the video was recorded, ArcGIS Pro has changed, so you do NOT need to press 'Add Clause' the first time. Later, however, when you are creating additional SQL statements, you need to click 'Add Clause'.

Use your skills

19. Save (export) the selected feature of '*Denmark*' as a separate geodata file.

20. Add the new '*Denmark*' geodata to the Map.
Then you may remove the *Countries_world* map layer if you like.

Task B – Produce a map

For this new task, you will also need some additional geodata – The major cities of Denmark.
Those are stored in the *NonCapital_city_pop_250000* geodata, among the non-capital cities of the rest of the world.

So, next you will need to extract the non-capital cities in Denmark from the *NonCapital_city_pop_250000* geodata.
For this operation we will show you another select technique – Select By Location.
Here you are going to use the 'Denmark' feature (polygon) that you just generated, to help you finding your cities.

Select By Location

21. a) Add the *NonCapital_city_pop_250000* feature class from the *World.gdb*.

b) Select the cities in Denmark point features from the *NonCapital_city_pop_250000* geodata.

Shapefile (.shp)

You will now save the selected cities (those in Denmark) as a separate geodata.
This time, however, you will save them as another file type – a shapefile (.shp).

Export data as shapefile

22. a) Save the cities in Denmark as a separate geodata file (a shapefile).

Feature class vs. Shapefile

b) Add the new geodata to the Map.

DIGIT-9a-b ➔ ➔ ➔ ➔ ➔

Many Danish students would probably agree that the present 'look' of Denmark in the Map view is a bit odd/tilted (Fig. 11).
At least it is not the way they are used to see their country:
One thing is that the coastline is a bit 'rough', and the reason for this is that this Denmark feature is a small part of a world map.

This is a deliberate choice by the geodata creator – there is just no need for a detailed picture of the Danish coastline in a world map.

The other thing is that Denmark is looking quite 'compressed', not as elongated as many Danes are used to.
The reason is the use of a certain coordinate system.
Here, the 'WGS84' coordinate system is used.

Coordinate system

WGS84 = World Geodetic System 1984

The 'WGS84' works well looking at global geodata as a sphere.

Fig 11. Denmark in the WGS84 coordinate system.

Task B – Produce a map

However, when you try to convert a spherical globe to a flat surface (a paper map), it is not that easy.

Try yourself to make an orange peel into a nice rectangular paper map – it´s impossible (Fig. 12).
Instead, you would need to try and 'stretch' some parts of the peel/globe, in order to make it as a flat coherent rectangular map.
And, when you are stretching some parts you are in fact distorting them.

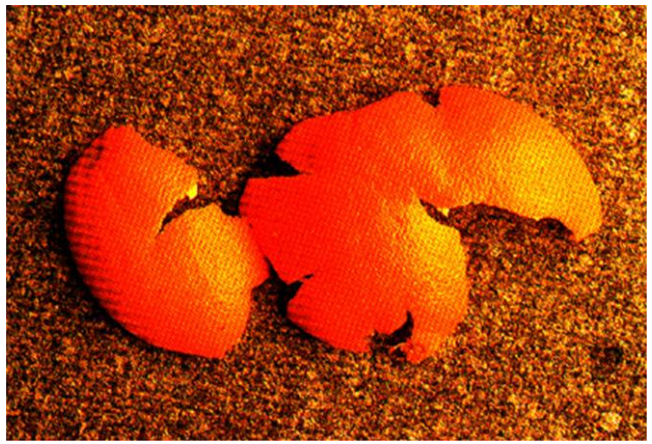


Fig 12. An orange peel made flat.

Distortion:

Distance - Direction - Area - Shape

Distortions may come as an incorrect *distance* and/or *direction* between geographical objects.
Additionally, there may be a distortion of the *area size* and/or the *shape* of geographical objects.

Projection

A projected coordinate systems (or *Projection*) may control some of the distortions – but <u>never all at the same time</u>.
A Projection is way to present <u>a smaller area</u> of the curved Earth surface as a flat one using a mathematical formula (Fig. 13).

Depending on what you would like to preserve – a correct distance, direction, area size or shape – you may favour one among the hundreds of different projections, which have been developed for various areas of the World.
Which one to choose, really depends on the purpose of your map.

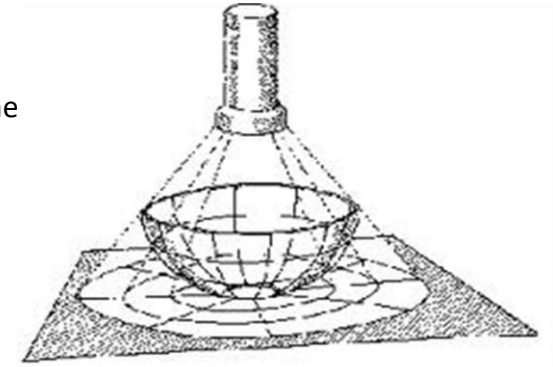


Fig 13. The principle of a projection – a light source projecting the curved shape onto a flat background. Where the paper is touching the curved surface, the representation will be correct. Often, the further away from the point of contact the greater the distortion.

Use your skills

23. Measure the distance between two of the Danish cities in the Data View. Take a note of the measured distance.

On the next page you are going to see what happens when Denmark is set in another coordinate system.

Task B – Produce a map

You are going to change to a *projected* coordinate system and look what happens in the Map view.

Change Projection – Map view

24. Change the coordinate system of the Map view to this projection:
'*ETRS_1989_UTM_Zone_32N*'

This projection is one of the most commonly used in Denmark,
and now the shape of Denmark is probably more familiar to the Danes (Fig. 14).
You will mostly use this projection for the Danish geodata all through the course.

Change Projection – Geodata

25. It is a good procedure to transform *all* the map layers in the Map view to the same projection.
(**NOTE!** Unlike in the video, the tool is now called 'Export Features')

Use your skills

26. Measure the distance between the same two cities once again. Any difference?

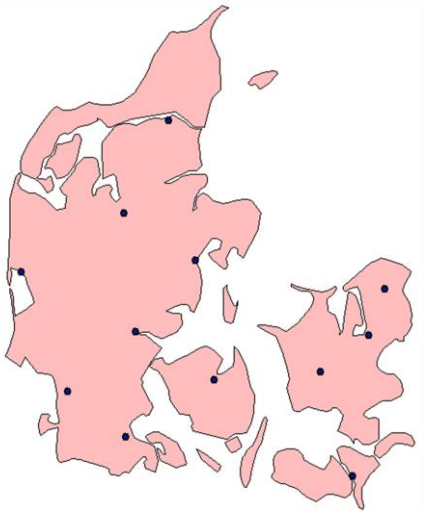


Fig 14. Denmark in the 'ETRS 1989 UTM Zone 32N' projected coordinate system – one of the most commonly used in Denmark.

The geographic objects for a map are now in place – all the essential geodata,
set in an appropriate projection. You may start planning for the map layout.

Map primitives

Map-making requires a few more things, though (like a scale bar, a legend, a North arrow etc)
– what we are calling the map primitives.

As you have learnt from Task A, simple images with labels are generated in a Layout view,
This is also the place where proper maps are produced, and here you have control over ingredients such as extra map frames and map primitives.

Use your skills

27. Insert a new Map layout with a Map frame.

With the island of Bornholm far to the east, your map would ideally have a 'landscape' orientation.
The format of the map, however, needs to be in a 'portrait' orientation. Is there a solution to this challenge?

Add Map frame

28. Solution: Set up a Map layout (portrait) of Denmark with several Map frames
– one Map frame of the 'mainland' and another one of Bornholm (Fig. 15, next page).

Task B – Produce a map

There are plenty of things you can do to facilitate the comprehension of a map.
We will introduce a few of them in this order:

- Labels and Symbology
- Map Primitives (*e.g.* scale bar, North arrow, legend, references)
- Transparency, Halo and (text) Graphics.

The cities outside Copenhagen are essential in your map layout.
At the moment they are difficult to find, though.
Name labels would be an improvement.

Add Labels

29. Add text labels of the city names.

Another thing, the map would benefit from some sort of symbology,
which would give weights to the cities (in terms of pop. size).

Symbolize features

30. Symbolize the city point features by importance (Fig 16, on next page).

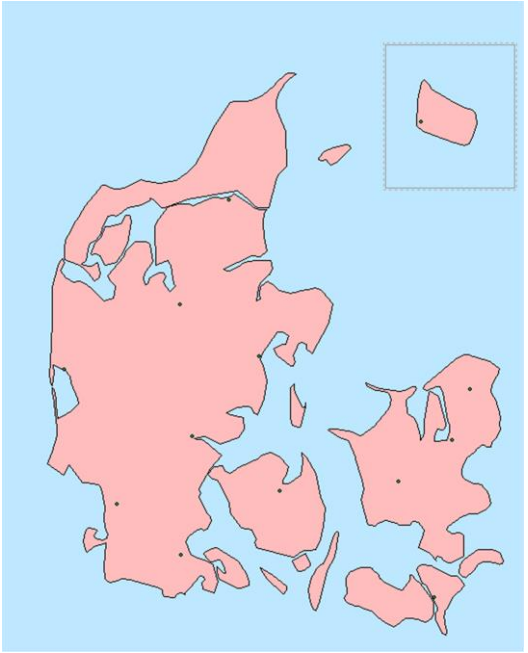


Fig 15. Denmark presented as two Map frames – one with the mainland, and one with Bornholm.

Creating a meaningful and aesthetic symbology may be time-consuming.
So, when you would like to use the layer and its symbology once again,
in another project, it would save some time if the symbology could be re-used.
Other occasions might be if you would like to share the map layer and its symbology, for example with a project partner.

Create a layer file (.lyrx)

31. This is done by creating a layer file (*.lyrx*).

Task B – Produce a map

Map vs. Image

The Map Primitives (*e.g.* scale bar, legend, North arrow) are what makes a map different from a simple image.
They all help a viewer to a better spatial comprehension.

Insert North arrow

Insert Scale bar

30. Add a North arrow, a scale bar and a legend to your Layout View.

Insert Legend

The legend is a helpful description of the symbology in the map.
However, a viewer should not have to search for and interpret the legend in order to get the main message of a map – a map title is a better alternative.

Insert Title

31. Add an informative map title.

References & Copyrights

A map should be considered the same as any type of publication.
That is, all material that you have not produced by yourself from scratch, ought to have references to your source of information or data.
Moreover, if you would like to protect your own output map layout from unauthorized use, you should protect it by means of copyrights.

Insert Reference & Copyright

32. Add a reference to the geodata owner (and copyright of the map-maker).

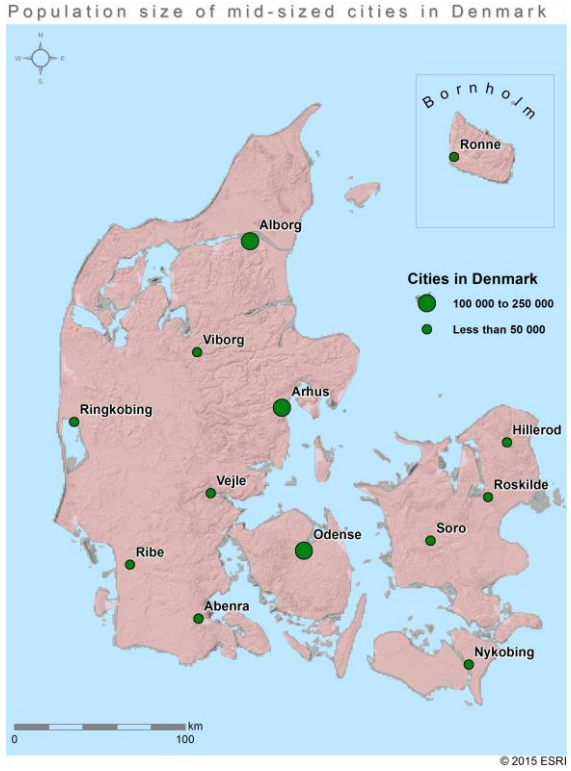


Fig 16. An example of the map output in this exercise. Disclaimer: The elevation shading seen in this map is not a part of this exercise,

The necessary ingredients of a map are in place.
There are always things you can do to improve the aesthetics, the comprehension or the readability of a map.

Insert graphics/text/image

Add Halo

Make map layer transparent

We cannot cover all these possibilities, but here beside are a few video tips (optional) that may come in handy later.
Else, we encourage you to further explore the editing possibilities by yourself.
Remember though, that ArcGIS Pro is NOT a layout software and there are limitations to what you may accomplish.
If you feel you have reached the limits of ArcGIS Pro, it might be a good idea to export your map to another software, like Adobe Photoshop, Illustrator or InDesign (or their corresponding free software GIMP, InkScape or Scribus).

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Use your skills

33. Save the Map layout as an image file.

34. Finally, make sure to save your Project according to the best practices in step 15, above.

Please continue if you have some time left.

Thanks for your attention!

Task C – Telling your story

The final section of this exercise – Task C – is optional. We have called it: 'Telling your story'.
We encourage you to go through this task if you have some time left. If time is limited, please just read it through.

This task serves to give you some further insights into the use of symbology, for example:

– How you may use the geodata to highlight a certain spatial phenomenon.

– How the symbology may be misleading.

– What you can do to overcome any deficiencies in the geodata (here, in the Attribute Table).

The Task C will also help you recalling a few concepts and actions you learnt during the earlier tasks.
Accordingly, instead of telling you explicitly what to do, you will occasionally be asked to return to previous instructions.

Use your skills

35. Add a new Map view to the project.

Basemap
Feature class
File geodatabase (.gdb)
Shapefile (.shp)
IGN Geodata Library

The Map view opens, and a map layer has been added by default by the software.
This is what is called a Basemap, and is geodata representing the world.
As such, it is set in a geographic coordinate system appropriate on a worldwide scale.
Basemaps have been presented as map layers earlier in the exercise.
You have also encountered a feature class (stored inside a file geodatabase (*.gdb*), and a shapefile (*.shp*).

For this specific task you will be using another source of geodata – the *IGN Geodata Library* (Fig. 17).
This is a rather huge collection of geodata stored on the school´s GIS server.
The library contains thousands of primarily Danish nationwide geodata, which may be used as map layers.

Fig 17. The IGN Geodata Library. It is organized into fourteen themes. There is an English and Danish version.

There is a close similarity between a feature class, stored inside a file geodatabase (*.gdb*), and geodata from the *IGN Geodata Library*, stored in a geodatabase on a GIS server.

Windows File Explorer
vs.
GIS software

In Windows File Explorer, you may view the names of the various geodata in the *IGN Geodata Library* using this path:

I:\SCIENCE-IGN-CGD-UVMAT\GIS\Geodata\English (alt. *I:\SCIENCE-IGN-CGD-UVMAT\GIS\Geodata\Danish*)

However, you may only open and view the content of those geodata using a GIS software (*e.g.* ArcGIS, QGIS).

Task C – Telling your story

36. a) Start by inserting a new Map to your Project.

b) Rename it 'Telling your story' (or anything else you might prefer).

Use your skills

As you may remember, a Basemap layer is added automatically (as long as you have an Internet connection).
Many of the Basemaps are worldwide, and they are set in a coordinate system adapted for a large-area view. Which?

Next you will add some additional geodata from the *IGN Geodata Library*.
Since you have not used this source before, you will first need to establish a connection to it.

37. a) Make a Folder Connection to this folder: ***I:\SCIENCE-IGN-CGD-UVMAT\GIS\Geodata*** (See step 8, above)

b) In the Catalog pane: Expand the Geodata/English/13. Copenhagen folders.

c) Scroll down to the *SocioEconomicData_statistics_10k_KK_2018.lyr* geodata ➔ Add it to the new Map view.

The added map layer is covering an area representing the Municipality of Copenhagen (Fig. 18).
As you also may recall, the Map view is zooming in to the extent of the first added map layer after the Basemap.
Additionally, the Map view adopts (transforms to) the coordinate system of the first added map layer. Which?

Metadata = information about data

Studying the geodata name in more detail, will give us some useful metadata:

- 2018 = Year of production/release.
- KK = Municipality of Copenhagen (KK = Københavns Kommune). Owner/Distributor of the geodata.
- 10k = Scale 1:10 000 An indication of the level of detail of the features in the geodata.

And finally, a descriptive name ('*SocioEconomicData_statistics*'), telling us the nature of the data.

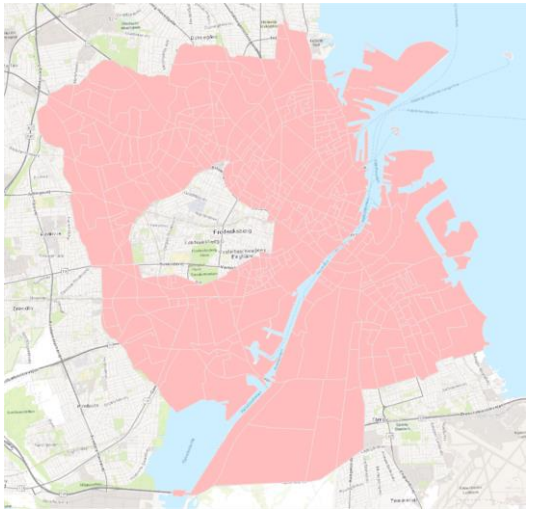

Fig 18. The Municipality of Copenhagen (in pink). The donut hole represents the enclave of the Municipality of Frederiksberg.

Use your skills

38. Open the Attribute Table of the *SocioEconomicData_statistics_10k_KK_2018*.

Use your skills

39. a) Make a Select By Attribute of the year 2013 (Field 'aar' = 2013) See step 18.

b) Save (export) the selected features as *SocioEconomicData_2013*.

Task C – Telling your story

Attribute Table

Field & Row

As you realize, the title of the geodata is not lying. There are quite many fields in the Attribute Table, and each of them is keeping data on some socio-economic variable (as for now the field names are a bit cryptic, though).
In this piece of geodata, the Municipality of Copenhagen is divided into polygons of varying sizes.
Each polygon is represented by a row in the Attribute Table.

Here, the Municipality of Copenhagen is divided into 'rode', which is a spatial unit used for statistical purposes (originally a 'rode' was a tax collecting area).

Symbology

You will display a few of the data variables from the Attribute table in the Map view.
By doing so, you will at the same time learn a little more about the symbology capabilities in ArcGIS Pro.

40. a) Enable symbology of the *SocioEconomicData_*2013 map layer (See step 14b, above).

Graduated colours

b) In the Symbology pane, select Graduated Colours, then:

- Field: **antal_lav_** (= No. of individuals with a low income)

Equal intervals

- Method: **Equal Interval**

Classes

- Classes: **6**

The small units ('rode') in Copenhagen are now coloured based on the value of the field in the Attribute Table with data on the number of people with low income.

This Map view is based on our decision to use 6 classes with equal intervals
(*i.e.* Max. value = 1688 ➔ 1688/6 ≈ 281 pers.).

Overall, there seems to be a pattern with fewer people with low income in the city center (Fig. 19a, blue circle).

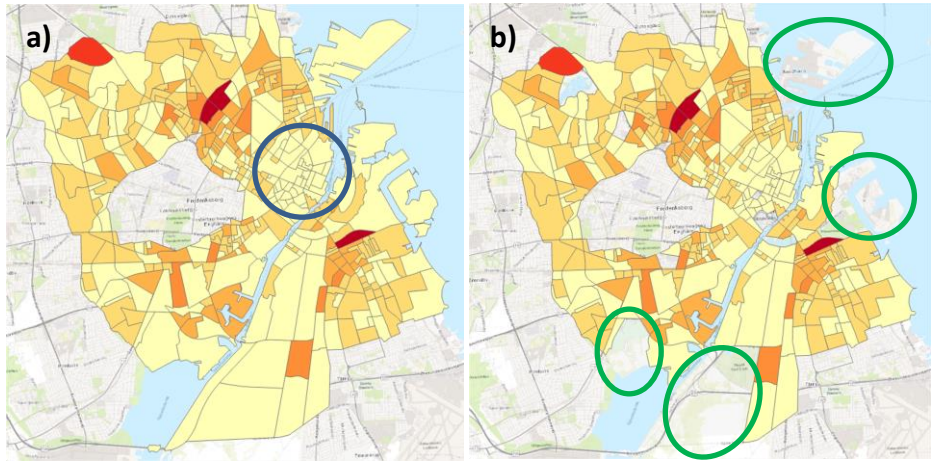

Fig 19. a) The no. of individuals with a low income in the Municipality of Copenhagen. b) As above, but after removal of sparsely populated areas (green ovals).

Deceptive maps?

What you need to realize, is that the impression of a map may change dramatically. The number of classes and in particular where you decide to place the border between classes may help highlighting (or concealing) certain areas. Even the choice of colours may have an influence.

- Maps are never objective! (Please, try out some other class and interval settings to experience the difference.)

Task C – Telling your story

One confounding factor in this Map view is that an area may have a relatively low population compared to its size.
The reason may be that the area is mainly made up of offices, industry or green areas.
A markedly low population may be mistaken for an affluent area, and so it may be a good reason to remove it.

Add Definition Query

A convenient technique to 'remove' such areas, is by means of a Definition Query, whereby they are hidden away.
(The features still do exist in the database, though, and they are not removed from the Attribute Table).

SQL = Structured Query Language

41. Add a Definition Query (SQL) to hide away those areas with a population lower than or equal to 50 individuals.
    (That is, to keep the areas with a population greater than 50 individuals)

In figure 19b (previous page) the polygon features dominated by workplaces, industries and green areas are hidden.

Proportional measure

Number of individuals with a low income in an area is a rather blunt instrument. It may not tell the whole truth.
For example, an area/'rode' might have more low income inhabitants simply because it is heavier populated.
A proportional measure would most likely give a better picture of the differences among the areas.
A common way to accomplish this is by dividing with the total population size.

Absolute vs. Relative

Thereby we will get a *relative* measure of the 'poverty' in an area, which may be used for comparison between areas.

Fortunately, in the Attribute Table, there is a field with data on number of inhabitants in each area.
The field is called 'antal_bebo' (No. of inhabitants).

Normalization

There are several ways you may accomplish such a calculation in ArcGIS Pro.
The easiest way, though, is by way of 'normalization'
– a simple procedure performed in the Symbology pane.

42. In the Symbology pane:
    Select 'antal_bebo' from the Normalization dropdown list.

    The Map view is updated.
    Now it is showing the proportion of inhabitants with a low income in an area/'rode' (Fig. 20).

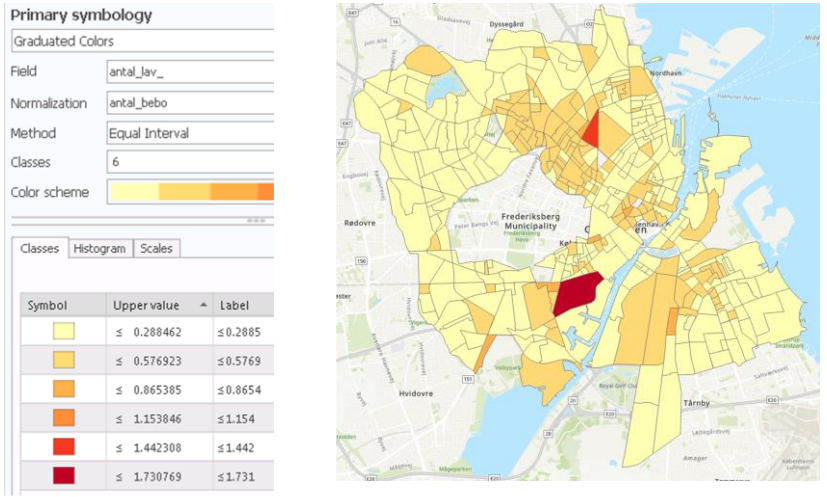

Fig 20. The symbology settings in the Symbology pane (left).
The No. of inhabitants with a low income in a 'rode' of Copenhagen, normalized by its pop. size (right).

Actually, there is an anomaly in this Attribute Table.
In one area there are more people with a low income, than there are inhabitants(!?)
This highlights the importance to study your data thoroughly, to correct or discard any errors.

Task C – Telling your story

The Map view above would be quite useful, for example in a social science study or for municipality planners.
Still, in terms of accessibility of data, it is quite an exception today.

High spatial resolution:

- Geodata = accessible

In Denmark, and in very few other countries, the government has decided to share many nationwide geodata publicly so that anyone may use them, and for free. This generousity covers mainly highly detailed geodata of the physical environment, like elevation data, administrative borders, infrastructure, land use etc.

- Statistics ≠ accessible

When it comes to geodata representing socio-economic variables, however, the current situation is quite bleak.
You may find statistics relating to a geographic area, but they are regularly aggregated to very large areas, like on a country, a region or on a municipality level (unless you are prepared to pay for a higher spatial resolution).
Obviously, at such a coarse a level, a data variable of an area will represent tens of thousands of people, if not millions(!).
It would be meaningless to use them in a study requiring greater spatial detail, like this one, where we are studying the socio-economic variations *within* a municipality.

Personal integrity

Of course, there is an aspect of personal integrity to this. You may not share data publicly of an identifiable person.
Still, a lot of statistical data would be possible to release, after aggregation to for example a 100m-by-100m area.
And, they would be of tremendous value for the society.
For the government, this is by and large an economic issue – detailed data is a source of income for the state.
Currently, the winds are blowing in a direction towards free and easier access. So in Denmark, ten years from now, contemporary socio-economic data variables of high spatial resolution will most certainly be more accessible.

Finally, we are going to share some reflections of what you, as a GIS analyst, may do when data are scarce.
In the example above, we had a geodata with quite many socio-economic variables in our possession.
This is typically the exception.

So, what if we would like to get a glimpse of the relative level of 'poverty' among the 'rode' in Copenhagen, but without having access to the statistical variables? Is there another way to catch such a glimpse?
Well, there are ways around. They may not give a 100% true picture, but may even so contribute to our analysis.

Proxy variable

The trick is to use a variable, based on data we do have access to, which is presumably correlating closely with the data variable we cannot access. This is called a *proxy variable*.

Task C – Telling your story

In our example we were studying the level of 'poverty', by using the proportion of low income people as a measure.
Is there a way we may construct a proxy 'poverty' variable, simply from freely available geodata (in Denmark)?

In this case it might be sufficient with the following data (Fig. 21):

Administrative border

A. Administrative borders: The 'rode' **(Fig. 21, yellow lines)**

Building footprint

B. Population data list: No. of inhabitants per rode

C. Building footprints: The area measurements **(Fig. 21, pink polygons)**

From these datasets, we may calculate a ratio:

$$\frac{\text{Total area of building footprints within a 'rode'}}{\text{The population size of a 'rode'}}$$

Fig 21. Two relatively poor 'rode' areas to the east, with a large population distributed among a few block of flats, and an affluent west 'rode' (relatively few people living in villas).

The logic would be: The smaller the 'living space' per person, the poorer the area.
We may compare a map layer showing the living space per person (Fig. 22a) and another with the proportion of people with a low income (Fig 22b). There seems to be some correlation between the coloured areas in the two map layers(!)

Correlation

Comments on general availability of the data A-C, above:

A. Quite often you are able to find geodata of the administrative borders in a country, including the national, regional/state, and municipal borders. You may also find the boundaries between urban and rural areas, but perhaps not always the districts within a city.

B. Population size data are always available on national scale, and often on a regional scale, or city level.
A finer the resolution, though, is sometimes harder to find.

C. The building footprints are surprisingly often available, at least for the largest cities. And, the polygon areas of the buildings are easily calculated using any GIS software.

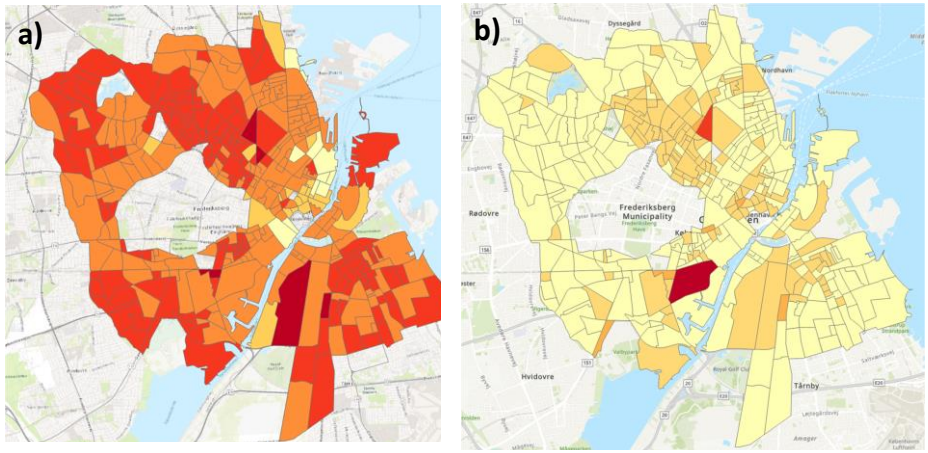

Fig 22. a) The total size of building area divided by no. of inhabitants (m^2/pers) in the 'rode' areas in Copenhagen.
b) The proportion of inhabitants with a low income in the corresponding areas.

Thanks for your attention (once again)!