

IUCN Eastern Africa Programme

Mnazi Bay Ruvuma Estuary Marine Park

# GEOGRAPHIC SKILLS

**Volume 2: Exercises**

**A training manual for  
Mnazi Bay Ruvuma Estuary Marine Park**

**E. van Walsum and R. Verwimp**



**July 2004**





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Mnazi Bay Ruvuma Estuary Marine Park**

**E. van Walsum  
and  
R. Verwimp**

**For the UNDP/GEF Development of  
Mnazi Bay Ruvuma Estuary Marine Park (MBREMP) Project**

**July 2004**

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# INTRODUCTION

This volume is the second part of the course on 'Geographic skills' developed for the 'Development of Mnazi Bay – Ruvuma Estuary Marine Park Project'. It contains exercises that help in understanding concepts introduced in the theory and provides the chance to get familiar with the basic tools in ArcGIS 8.3.

As is the case for the theoretic part, this volume is a self-study course. Students can go through the exercises themselves following the step-by-step approach. The GISic – NARI GIS team will provide assistance during the exercises.

The appendix contains the answers to the quizzes that are found after each chapter in the theoretical part.

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## EXERCISE 1: HOW TO TRANSFER THE REAL WORLD INTO GIS

The first and most important skill when learning GIS is to be able to translate the real world into the language and concepts of that particular GIS. In this exercise you will learn how to translate objects you see in the real world into classes or 'layers' in GIS. Here a small part of the real world (part of Mnazi Bay - Ruvuma Estuary Marine Park) is presented in an aerial photograph taken in 1989.



*Figure 1: Aerial photograph of a part of Mnazi Bay (Mnazi village area) (Source: Tanzania Mangrove Forests, NORAD, Sept. 1989)*

- 
1. Try to recognize elements you see ('objects') on the photograph and group them into object classes. For example, you can recognize some settlements, like Mnazi subvillage, Nalingu village and Mngoji village and group them in an object class or 'layer' called 'settlements'. Try to find at least three more layers.

<b>Layer</b>	<b>Objects</b>
e.g. settlements	Mnazi subvillage, Nalingu village, Mngoji village

2. In GIS, the objects in each layer are represented by a certain type of feature. Remember from the theory there are three feature types: points, lines and areas or polygons. By which feature type would you represent the objects in each layer you have identified in the table above?

Note: As you remember from the theory, the selected feature type depends on the scale. Settlements for example, can be represented by points or by polygons. Here you will represent them by polygons, because you can see them as a well defined area on the picture.

<b>Layer</b>	<b>Feature type</b>
e.g. settlements	polygons

3. In a GIS, not only the spatial information of objects (in GIS called 'features') is stored. In most GIS projects, the characteristics of the features are at least as important. In GIS, the characteristics of features are called 'attributes'. For every layer you have determined in the first step, give a number of attributes that you could determine for the features of that layer.

<b>Layer</b>	<b>Attributes</b>
e.g. settlements	name, population number, GPS readings, area

- 
4. For each of the attributes defined in the table above, you can define a number of categories. For the attribute 'population number' of the 'settlements' layer, for example, categories could be 'low', 'moderate' and 'high'. Try to define categories for some other attributes of the 'settlements' and other layers as well.

Layer	Attribute	Categories
settlements	<i>population number</i>	<i>low, moderate, high</i>

5. Suppose you would collect all the information from the mangroves defined above from the aerial photographs of 1989 and of 2004 and suppose you have stored all that information in a GIS. Which spatial analysis could you perform with that GIS?

Note: To recall the five types of questions you can ask in a GIS, have a look again at part 1.1.2 in the theoretical part of the course.

Questions
e.g. How far has the mangrove area migrated away from the villages?

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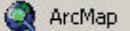
# EXERCISE 2: VISUALISING AND ANALYSING GEOGRAPHIC DATA IN ARCMAP

In this exercise, you will be introduced to the newest GIS software of the Environmental Systems Research Institute (ESRI), which is ArcGIS 8.3. Remember ArcGIS consists of 3 main tools: ArcMap, ArcCatalog and ArcToolbox. The exercises will introduce you to two of them: ArcMap and ArcCatalog.

In this exercise you will learn the basic skills to view and query geographical data in ArcMap. Furthermore you will experience how spatial and attribute data is linked in a GIS.

<b>Step 1</b>	<b>Launching ArcMap</b>
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To start up ArcMap, go to

- *Start -> All Programs -> ArcGIS -> ArcMap*
- *Click on the ArcMap icon* 

<b>Step 2</b>	<b>Visualizing data</b>
---------------	-------------------------

The ArcMap viewer is loading and you will see the interface of ArcMap, displaying the dialog window shown in Figure 2. You can choose whether you want to start a new empty document or open an existing one. You can see that an ArcMap file is stored as an ‘mxd’ file. For this exercise, a document has already been prepared in advance. To open this document, choose:

- *‘An existing map’*
- *Double-click ‘Browse for maps...’*

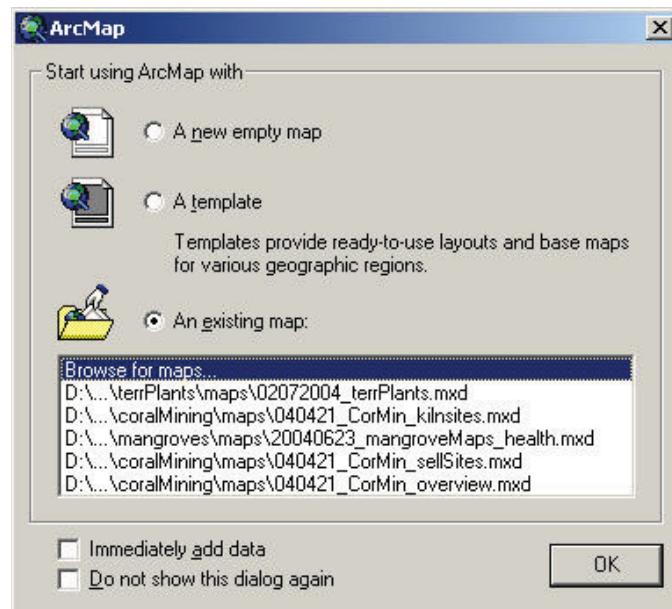


Figure 2: Browse for an existing map document



- Navigate to the C:\ drive and to the folders 'student' and 'exercises'
- Select the file 'exercise 1' and open it by clicking 'open', or by double-clicking on the file. The map document shown in Figure 3 will open.

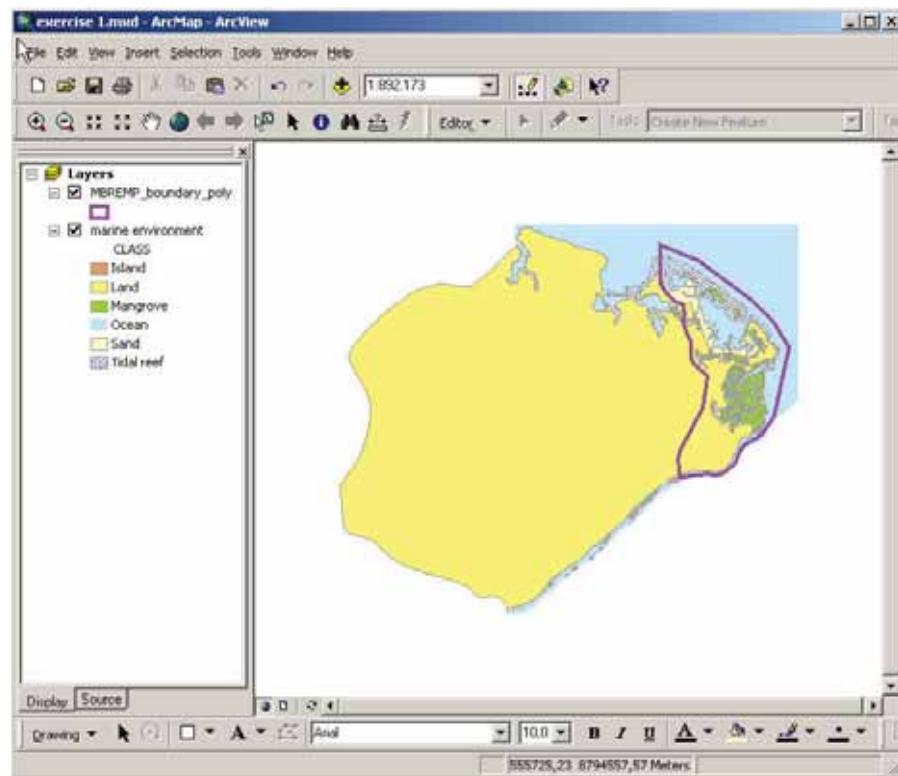


Figure 3: Map document opened in ArcMap

On the left side of the screen you can see the '*Table of Contents*', showing the different data '*layers*'. In the right hand frame you see the visualisation of the data. The basic components of the ArcMap interface are illustrated in Figure 4.

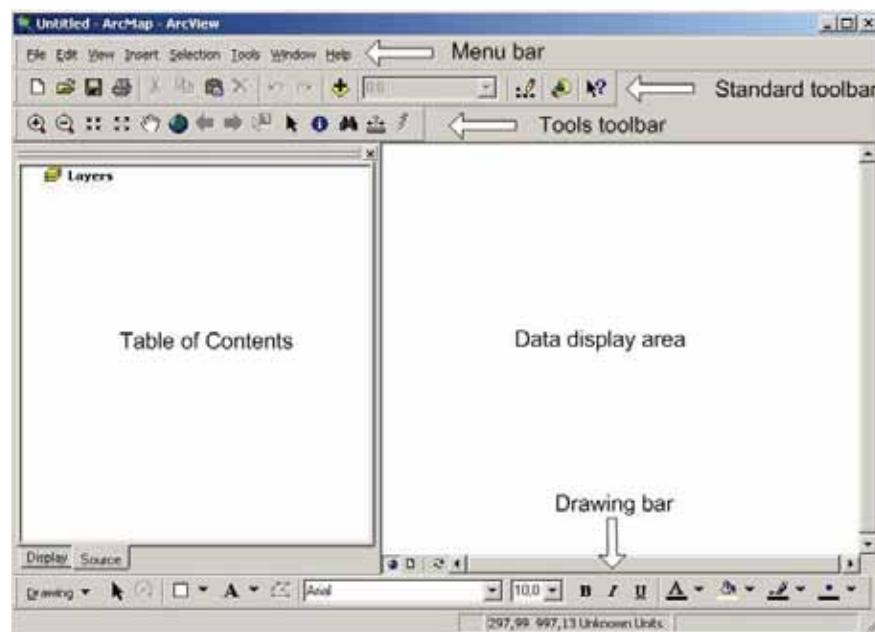


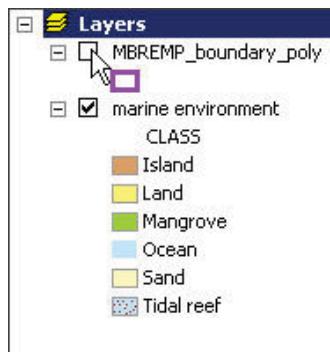
Figure 4: Basic elements of ArcMap

Remember the objects in every layer are represented by a certain type of feature. In this example, you can see that the marine environment (land, coral, sand, etc.) is represented as polygons. The park boundary is represented as a line feature.

### Step 3

### Visualize layers in a Map document and add existing layers

In this step you will learn how to switch the display of a layer on and off and how to add new layers.



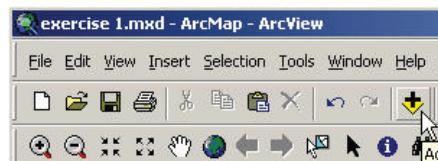
- In the Table of Contents, check off the check box of the layer 'MBREMP\_boundary\_poly' by clicking in the box in front of the layer*

After checking off the check box the boundary will no longer be displayed on the map.

- To display it again click again on the checkbox*

You can do the same for the layer 'marine environment'.

To add new layers to the map document, do the following:



- In the Standard toolbar click the 'Add data' button ( )*
- In the 'Add data' window (Figure 5) click on the drop down box next to 'Look in' and navigate to 'C:'. Next, select the folder 'student', and further select the folder 'data'.*
- If you are in the correct folder, select 'roads.shp' and click 'Add' or double click the 'roads' shapefile (Figure 5)*

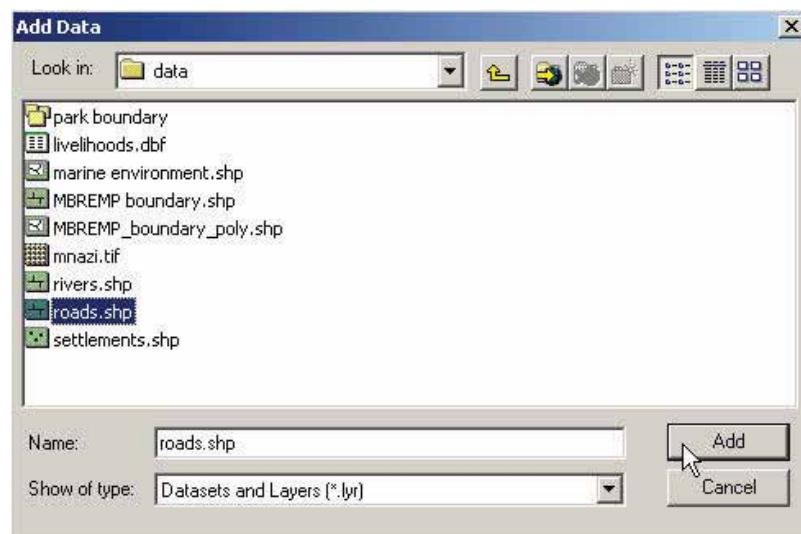


Figure 5: Add the 'roads' shapefile in the 'Add Data' window

The ‘roads’ data layer is now loaded into your Map document as well. Go through the same steps again to add the ‘settlements’ layer in the same way. Both new layers are also added to the Table of Contents at the left. Your map document now looks as in Figure 6.

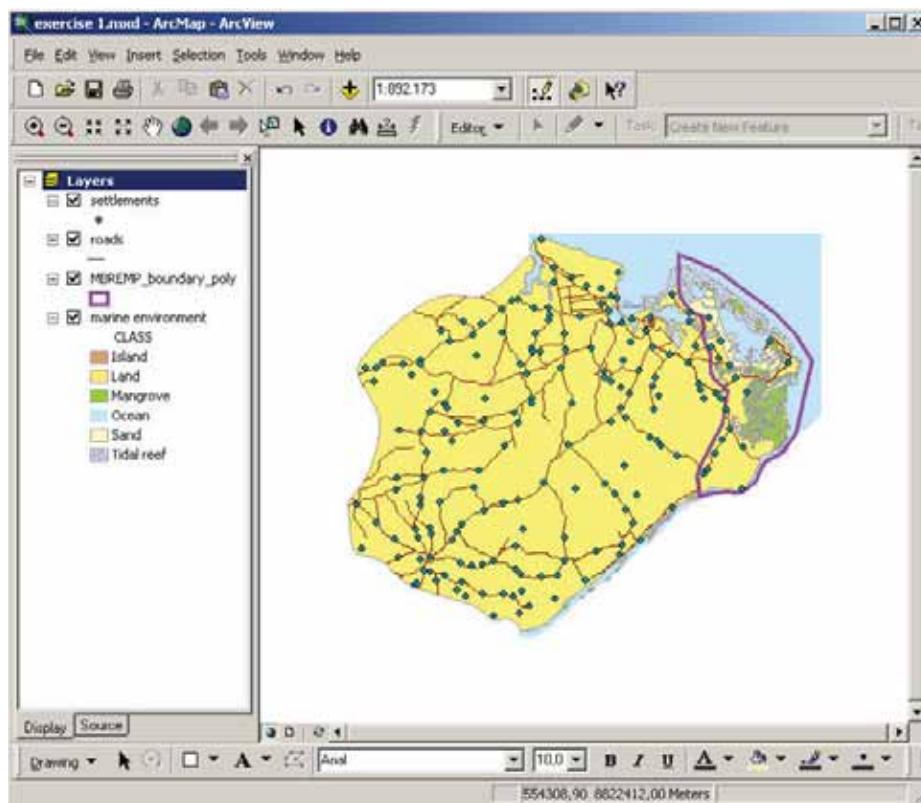


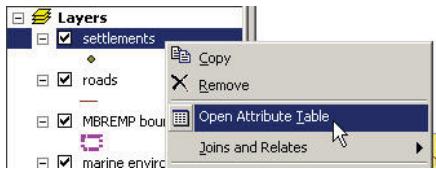
Figure 6: The ‘settlements’ and ‘roads’ layers are added to the Table of Contents and the data display area

The order of the layers in the Table of Contents determines how they will appear in the view. The layer at the bottom of the list ('marine environment') will be drawn at first and the next layer ('MBREMP\_boundary\_poly') will be drawn over the previous one. Next, the 'roads' and 'settlements' layers are drawn. Have you noticed that ArcMap immediately organizes the different layers so that they are optimally visible? Points are automatically added at the top, next the layers of the line type and below the polygon layers. In that way polygons are drawn first, then the lines and of top of those the points, so that all layers are optimally visible. The order of the layers within the same feature type can be changed by clicking the layer's name, holding the mouse button down and dragging the name to the place in the Table of Contents where you want to have the layer.

#### Step 4

#### Linking attribute and spatial data

Every layer has an attribute table in which the attributes of the features are stored. In this first step we will first open the attribute table of the 'settlements' layer.



- In the Table of Contents click with the right mouse button on the layer 'settlements'. From the menu that appears, select 'Open attribute table' and click on it.

You will see the following table appear on your screen (Figure 7).

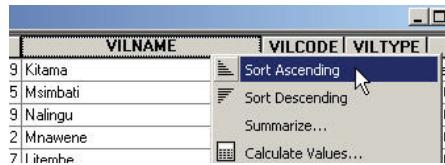
FID	Shape*	AREA	PERIMETER	VIL_ID	VILNAME	VILCODE	VILTYPE
0	Point	0	0	889	Kitama	15381	vil
1	Point	0	0	1365	Msimbati	12122	vil
2	Point	0	0	499	Nalingu	12114	vil
3	Point	0	0	502	Mnawene	12115	vil
4	Point	0	0	507	Litembe	12124	vil
5	Point	0	0	510	Mtendachi	12123	vil
6	Point	0	0	511	Msakala	12112	vil
7	Point	0	0	521	Kabisera	12525	vil
8	Point	0	0	527	Imekuwa	12523	vil
9	Point	0	0	1366	Mgao	12522	vil
10	Point	0	0	529	Namogoli	12521	vil
11	Point	0	0	576	Mbuo	12614	vil

Figure 7: The attribute table of the 'settlements' layer

The table has a number of columns. Each column contains one attribute. Following attributes are available:

- Standard attributes (automatically generated by the program)
  - FID: Feature ID, this is the unique ID given to each feature. The GIS software will use this field to link the spatial and attribute data.
  - Shape: indicates the feature type of every object (point, line or polygon).
  - Area: gives the area for each object. The area here is zero because we are dealing with points.
  - Perimeter: also zero because the feature type is points.
- Additional attributes (inserted by the user)
  - Vil\_ID: A unique ID given to each village by the user.
  - Vilname: village names.
  - Vilcode: village codes.
  - Viltype: the type of the village (town, village or subvillage).
  - and more...

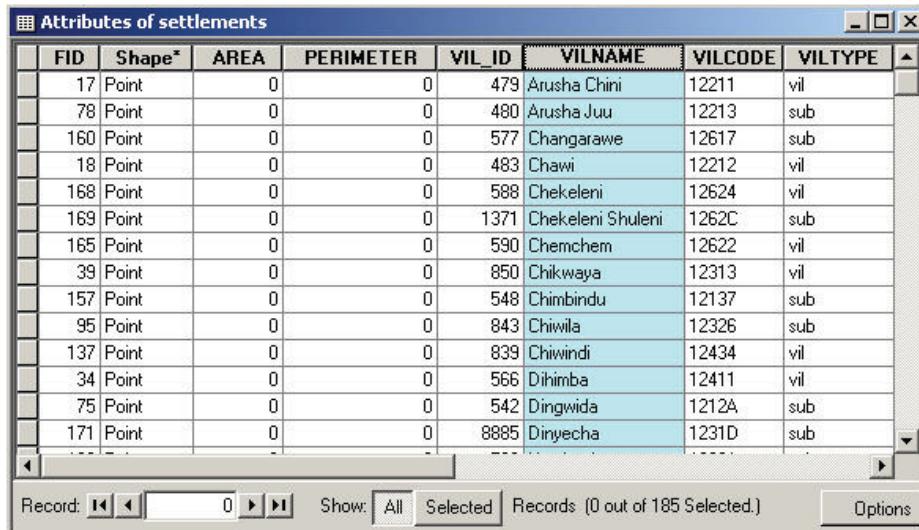
You can sort the records in the table based on any field. We will now sort the records based on their name.



VILNAME	VILCODE	VILTYPE
Kitama		
Msimbati		
Nalingu		
Mnawene		
Litembe		

- In the attribute table, right click the 'VILNAME' heading
- In the list that appears, click 'Sort Ascending'

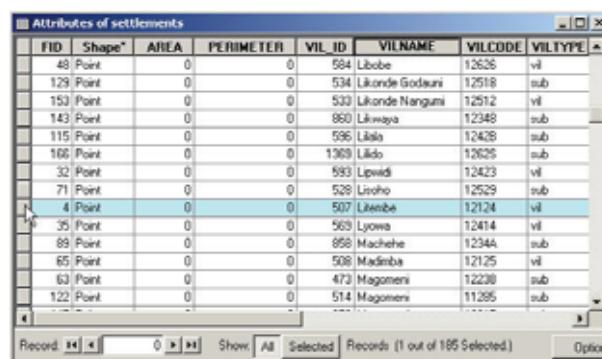
Now the settlements will be sorted based on their name as in Figure 8.



FID	Shape*	AREA	PERIMETER	VIL_ID	VILNAME	VILCODE	VILTYPE
17	Point	0	0	479	Arusha Chini	12211	vil
78	Point	0	0	480	Arusha Juu	12213	sub
160	Point	0	0	577	Changarawe	12617	sub
18	Point	0	0	483	Chawi	12212	vil
168	Point	0	0	588	Chekeleni	12624	vil
169	Point	0	0	1371	Chekeleni Shulenzi	1262C	sub
165	Point	0	0	590	Chemchem	12622	vil
39	Point	0	0	850	Chikwaya	12313	vil
157	Point	0	0	548	Chimbindu	12137	sub
95	Point	0	0	843	Chiwila	12326	sub
137	Point	0	0	839	Chiwindi	12434	vil
34	Point	0	0	566	Dihimba	12411	vil
75	Point	0	0	542	Dingwida	1212A	sub
171	Point	0	0	8885	Dinyecha	1231D	sub

Figure 8: Settlements sorted according to their name

There is a dynamic link between the view document and the attribute table. To see this link, do as follows:



FID	Shape*	AREA	PERIMETER	VIL_ID	VILNAME	VILCODE	VILTYPE
48	Point	0	0	584	Lilobe	12626	vil
129	Point	0	0	534	Likonde Godauri	12518	sub
153	Point	0	0	533	Likonde Nangumi	12512	vil
143	Point	0	0	860	Likwaya	12348	sub
115	Point	0	0	596	Lilala	12428	sub
106	Point	0	0	1369	Lilido	12625	sub
32	Point	0	0	593	Lipendi	12423	vil
71	Point	0	0	528	Liroho	12529	sub
4	Point	0	0	507	Litembe	12124	vil
35	Point	0	0	563	Lyowa	12414	vil
89	Point	0	0	658	Machehe	1234A	sub
65	Point	0	0	508	Madimba	12125	vil
63	Point	0	0	473	Magomoni	12238	sub
122	Point	0	0	514	Magomoni	11285	sub

- In the attribute table, click on the 'Record tab' (the small square in front of every row) of Litembe village

When the record tab is clicked, the entire row will be highlighted in a certain colour. Move the table a bit to the left so that you can see the map better (by clicking on the blue bar at the top and holding the mouse button while you move the table). If you take look at the map you will see that the same point you selected in the table is now also highlighted on the map (Figure 9).

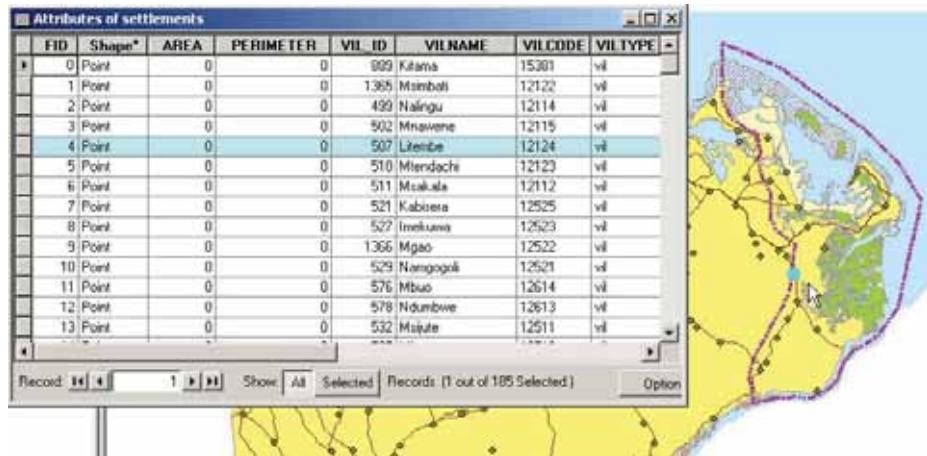


Figure 9: The selected record in the attribute table is also highlighted on the map

To clear your selection,

- Select 'Selection' from the Menu bar
- Choose 'Clear selected features'

Now, we will do the same type of analysis, but in the other direction. First close the attribute table by clicking on the cross in the right top corner of the table.



If you now move your mouse over the map you will see the 'i' symbol with it.

- Move your mouse toward a village you would like to know the name of
- Click exactly on the point symbol representing it

The 'Identify Results' window will appear in which you can find all the attribute information for the village stored in the attribute table (Figure 10).

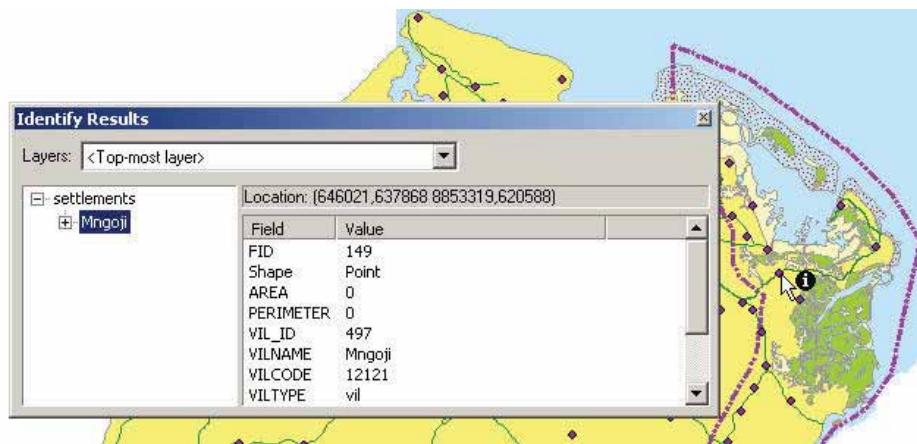
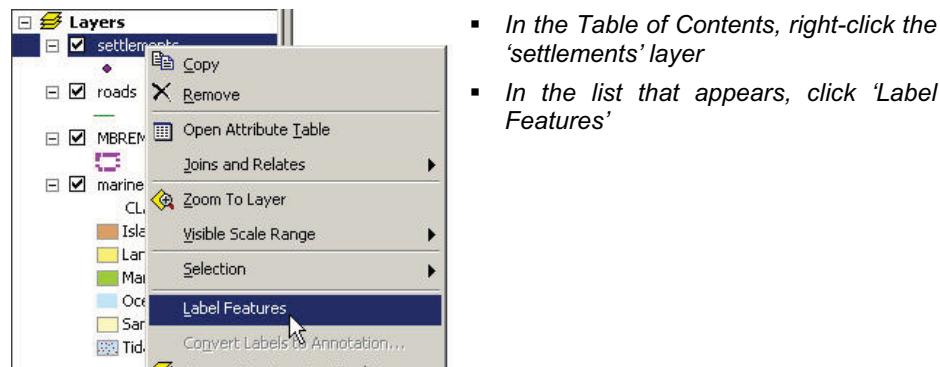


Figure 10: The 'Identify Results' window shows the attribute data for the selected feature

- Close the 'Identify Results' window
- In the Tools toolbar, click on the arrow ( ) to get rid of the identification cursor

You can also label the features displayed on the map document. This is for example very useful to display the names of the settlements on the map.



The villages' names will now be displayed with the features on the map document (Figure 11).

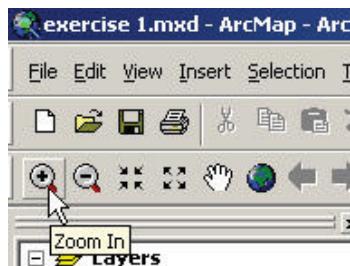


Figure 11: The ‘settlements’ features are now displayed with their name

## Step 5

### Zooming in and out

Up till now you have always seen the same area on your screen. However, you might want to have a closer look to a specific area, for example the mangrove area of Mnazi Bay – Ruvuma Estuary Marine Park. In this step you will learn to zoom in and out to an area.



- Select the ‘Zoom in’ tool from the Tools toolbar

- Drag a rectangular around the area you want to have a closer look at. To draw a rectangular, click somewhere on the map and hold the mouse button down. Drag now to the opposite corner of the rectangle you want to zoom in to (see Figure 12).

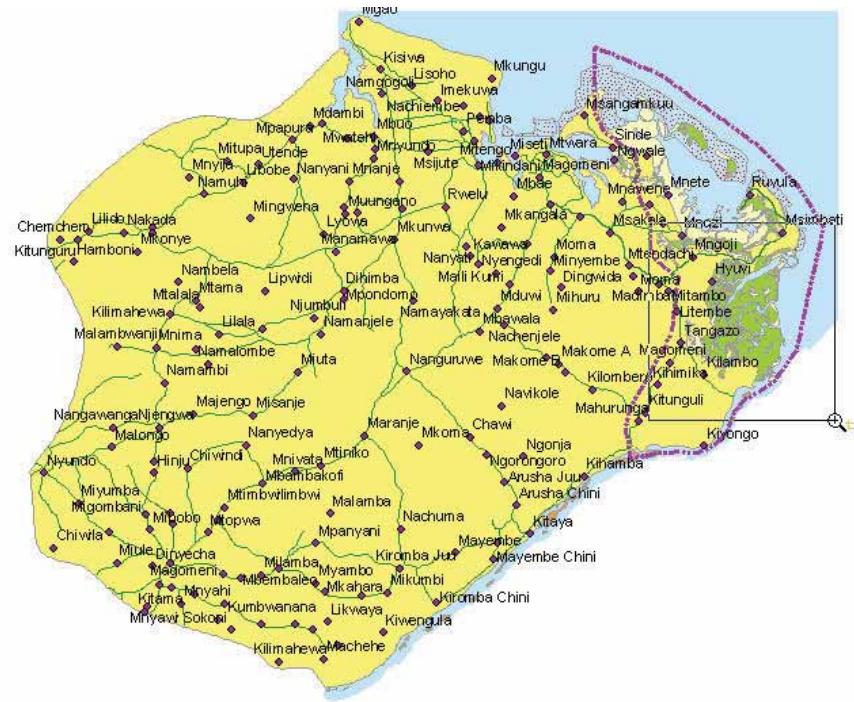


Figure 12: Draw a rectangle around the area you want to zoom in to

- Release the button and the area demarcated in the box will be now be displayed in greater detail (Figure 13)



Figure 13: You have now zoomed into the area you selected

You can also zoom in by clicking the ‘Zoom in’ tool and just clicking on the area of the map you want to enlarge. Similarly, you can zoom out by clicking the ‘Zoom out’ tool first and then clicking on the map.

Other useful tools for zooming are:

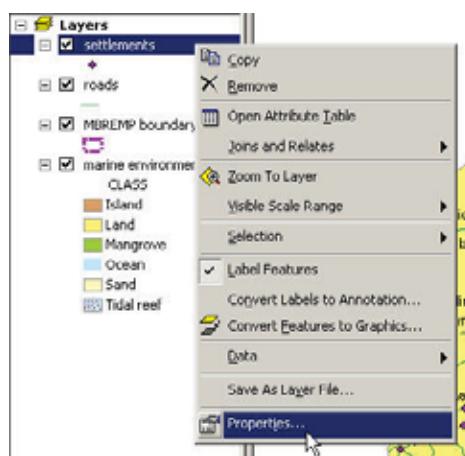
	This tool allows you to go to your previous zoom extent (if any available).
	This tool allows you to go to the next zoom extent (if any available).
	This tool allows you to zoom to the maximum extent of the layers loaded in the table of contents.
	This is the ‘pan’ zoom tool. It allows shifting the area viewed in all directions. The different areas visualized keep the same scale.



- Use the ‘Go back to previous extent’ tool to get back to your previous screen

## Step 6 Some other visualisation options

Often you want to display a subset of the features in a layer that meet some criteria. By displaying all types of settlements, our map has become quite crowded. In this step we will limit the settlements displayed on the map to the towns and villages.



- Right-click the ‘settlements’ layer in the Table of Contents
- In the appearing list, click ‘Properties’

The ‘Layer Properties’ window appears (Figure 14). Of the tabs displayed at the top,

- Click the ‘Definition Query’ tab
- Next, click the ‘Query Builder’ button at the bottom

In the ‘Query Builder’ window, you can create an expression to identify the features you want to display. Form the expression “VILTYPE” = ‘town’ OR “VILTYPE” = ‘vil’ by:

- Double-clicking “VILTYPE” in the ‘Fields’ list
- Clicking ‘=’ from the available operation buttons
- Double-clicking ‘town’ from the ‘Unique Values’ list. (If not all values are shown in the Unique Values list, click ‘Complete List’.)
- Clicking ‘Or’
- Again double-clicking “VILTYPE” in the ‘Fields’ list
- Clicking ‘=’
- Double-clicking ‘vil’ from the ‘Unique Values’ list
- Click ‘OK’
- Click again ‘OK’

The expression will be displayed in the box below (Figure 14).

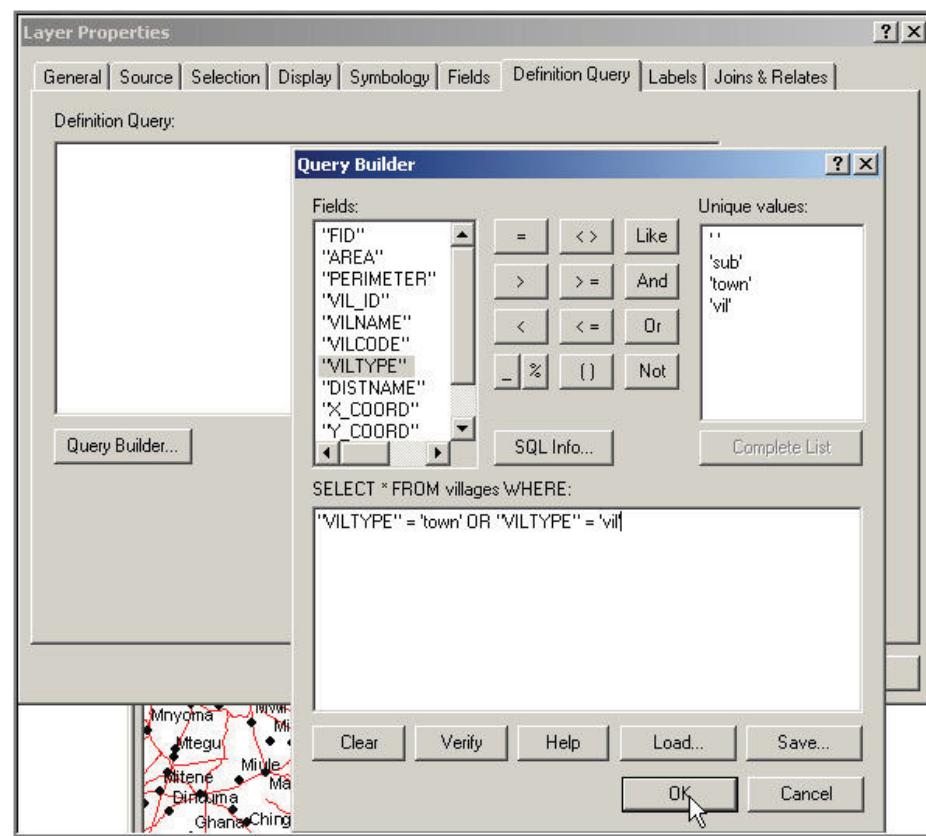


Figure 14: The 'Query Builder' is used to define a criteria for the settlements layer

The settlement features displayed on the map will now be limited to towns and villages.

## Step 7

### Some geographical operations

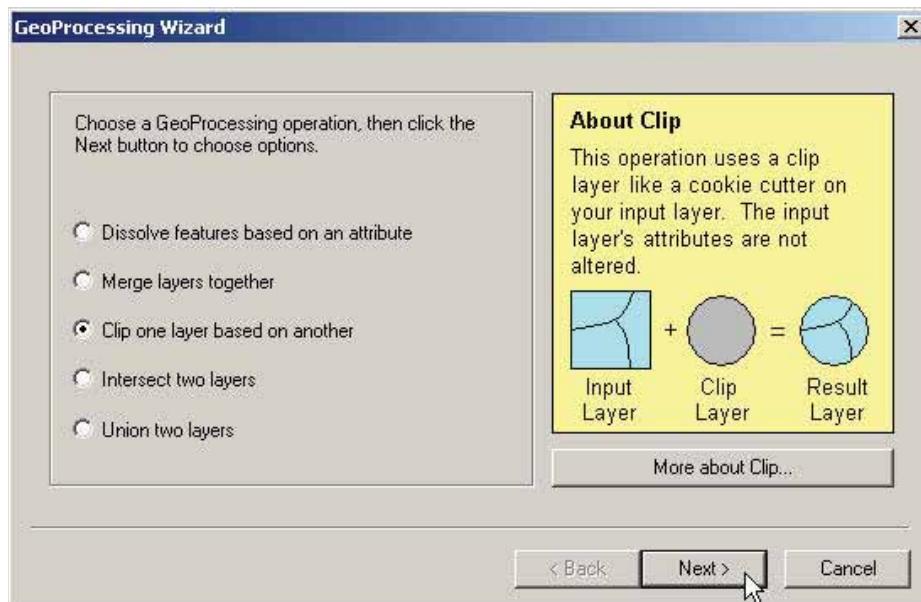
Next, we want to separate the settlements within the park boundary from the 'settlements' layer. We will do that with a '*Clip*' operation: we will cut out a piece of the settlements layer using the 'MBREMP\_boundary\_poly' layer as a cutter form.



- In the 'Menu' bar, click 'Tools'
- In the dropdown menu, select 'GeoProcessing Wizard'

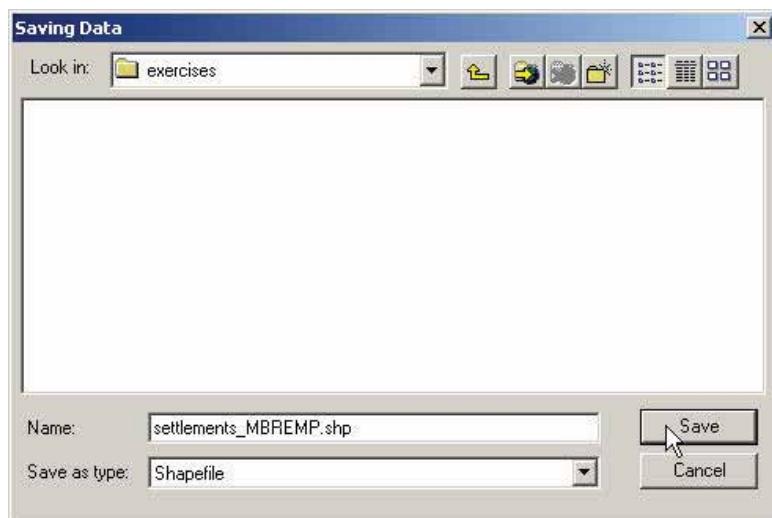
This will open the 'GeoProcessing Wizard' window. In this window,

- Select 'Clip one layer based on another'
- Click 'Next'

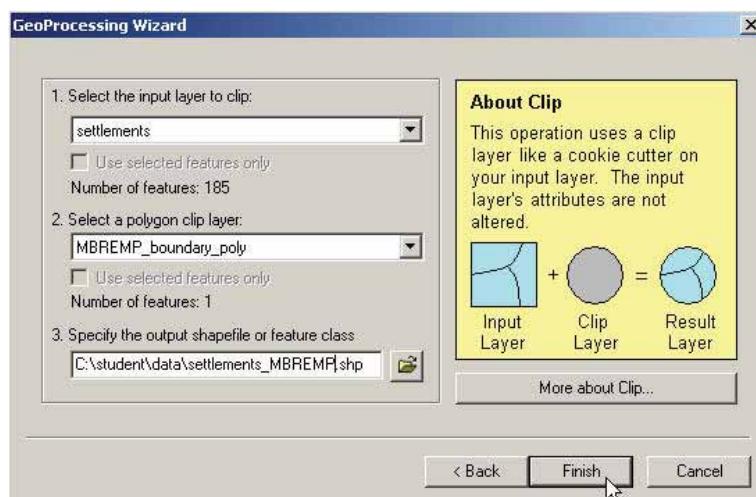


The layer we will cut, the ‘settlements’ layer, is called the ‘*input layer*’. The layer which is used as the cutter form, the ‘MBREMP\_boundary\_poly’ layer, is called the ‘*clip layer*’. So, in the following window,

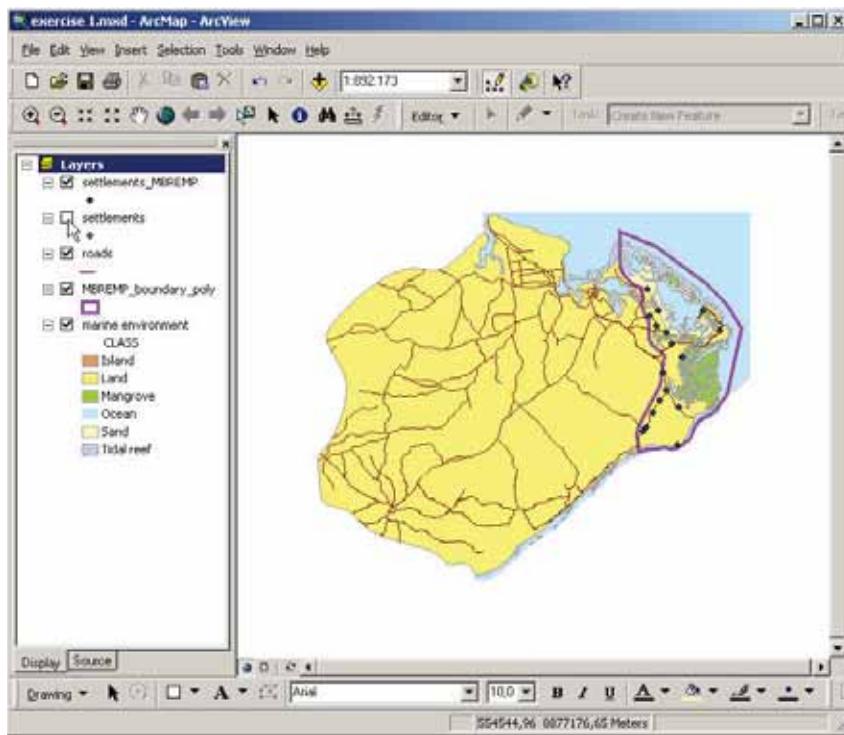
- Select ‘settlements’ as the ‘*input layer to clip*’
- Select ‘MBREMP\_boundary\_poly’ as the ‘*polygon clip layer*’
- To ‘specify the output shapefile or feature class’, click the folder button (  )
- Browse to the ‘data’ folder
- Fill in the Name: settlements\_MBREMP.shp
- Click ‘Save’



- Click ‘Finish’

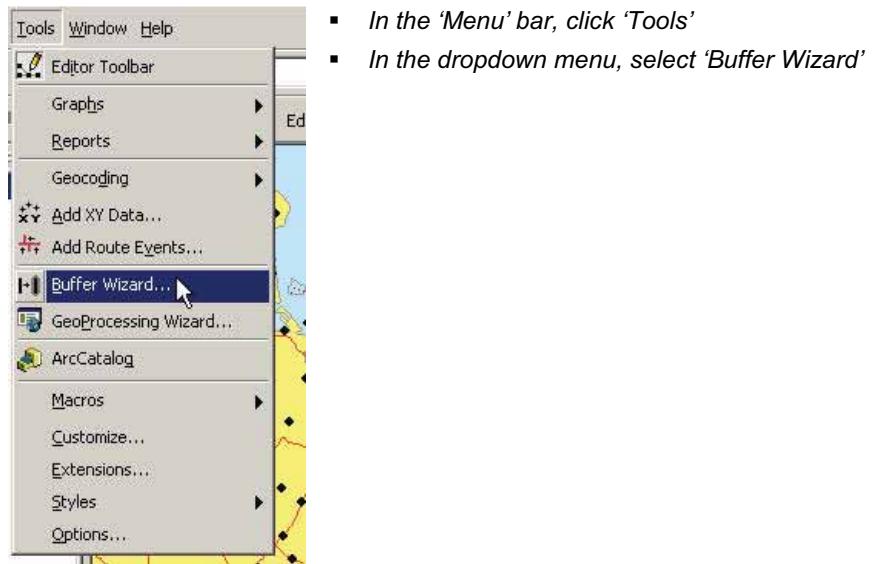


After the calculation, a new layer, called ‘settlements\_MBREMP’ is added to the map document. If you now turn off the ‘settlements’ layer, which holds all the settlements, you will see that only the settlements within the marine park boundary are retained in the new layer.

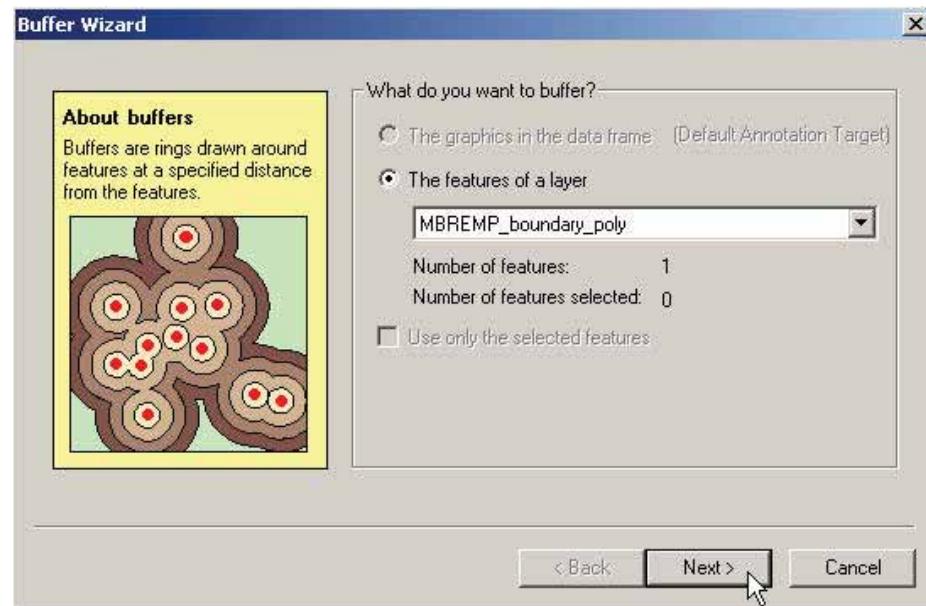


Another frequently used geographical operation is the '*Buffer*' operation. A 'buffer' operation calculates a 'buffer' or ring at a specified distance from the selected features. For a marine park, one could be interested to define a zone of 5 km outside the official park boundary, as a 'buffer area' to mitigate adverse influences from certain human activities on the park's ecosystem.

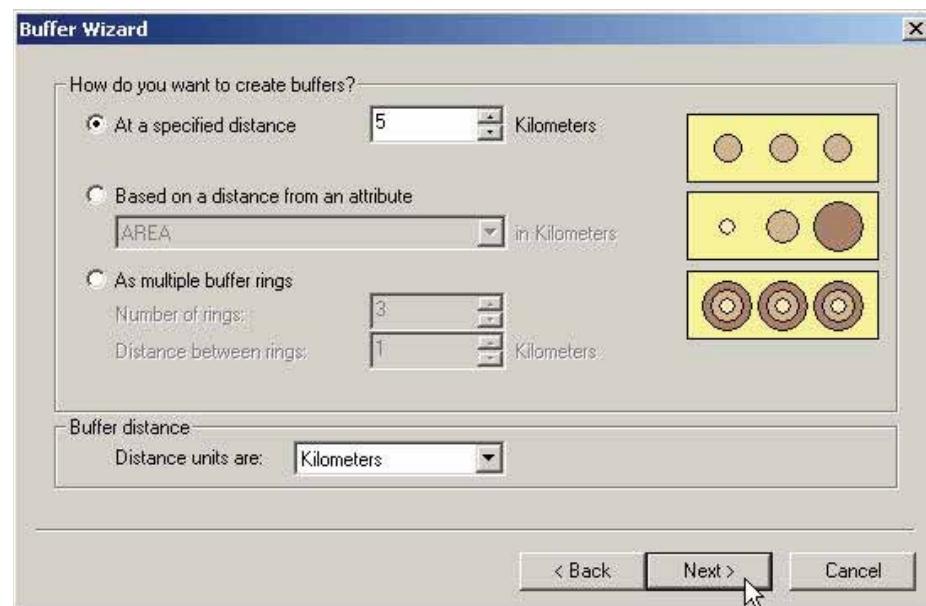
- Turn off the 'settlements\_MBREMP' layer
- Put the 'settlements' layer on, so that all the settlements are displayed again



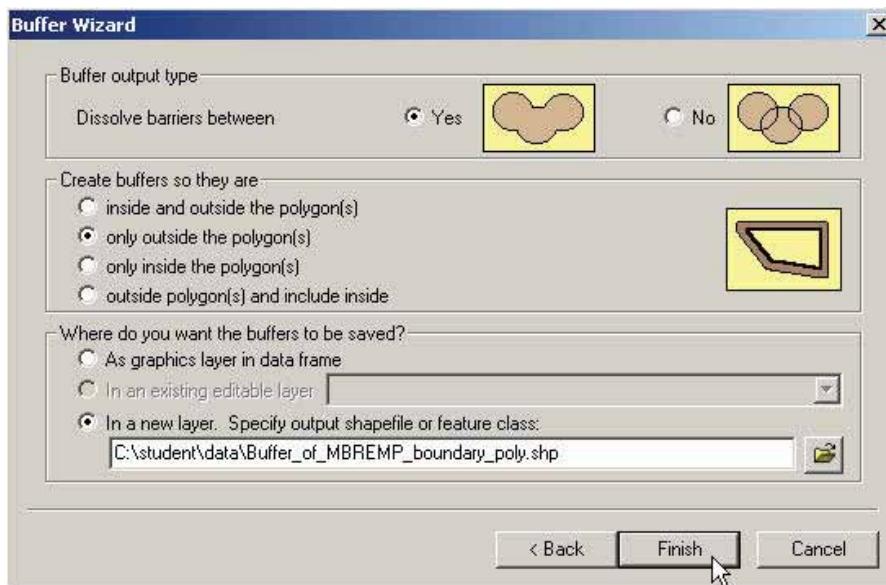
- In the ‘Buffer Wizard’, select ‘The feature of a layer’ and select ‘MBREMP\_boundary\_poly’
- Click ‘Next’



- Select ‘At a specified distance’ and put the distance at ‘5’ kilometers
- Click ‘Next’



- Set 'Dissolve barriers between' to 'Yes'
- Create the buffers so they are 'only outside the polygon(s)'
- Click 'Finish'



- Drag the new 'Buffer\_of\_MBREMP\_boundary\_poly' layer and drop it just under the 'settlements' layer (by clicking and holding the left mouse button while dragging)

Now you can see which settlements are located in the 5 km buffer around the park. The result will look as in Figure 15.

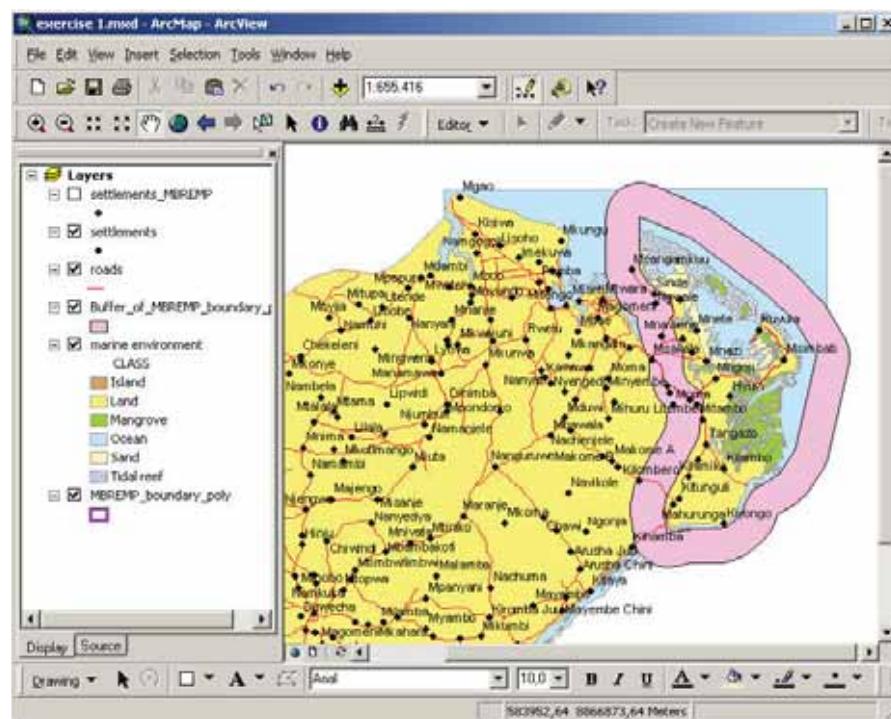
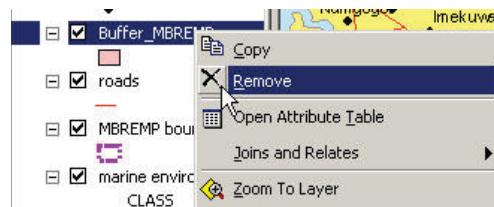


Figure 15: A buffer of 5 km is drawn outside the park boundary



- In the Table of contents, click on 'Buffer\_of\_MBREMP\_boundary\_poly' with the right mouse buttons and select 'Remove' to remove it from the map document

## Step 8 Add new attribute data

GIS becomes really interesting if we start adding descriptive data, in GIS called 'attribute' data, to the geographic features. In this step, we will display some socio-economic data collected for the villages associated with the Mnazi Bay – Ruvuma Estuary Marine Park.

Of the 11 villages where the socio-economic study has been conducted (for one village there is no data), two are outside the official park boundary. To include these villages, we have assigned an attribute 'inpark' to all villages. The 12 park villages have value '1', all other villages 'zero'. We will use the 'Query Builder' to display only these 12 villages.

- In the 'settlements' layer, select 'Properties' by clicking the right mouse button
- Use the 'Query Builder' to set the 'Definition Query' as "inpark" = 1 AND "VILTYPE" = 'vil' (see Figure 16)

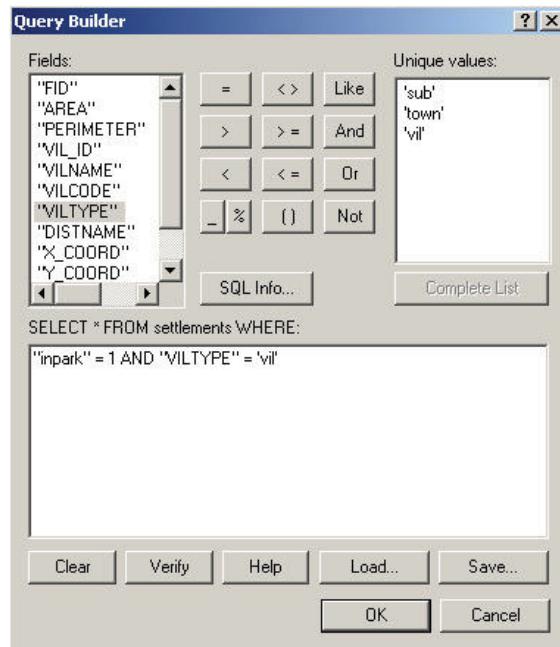


Figure 16: Defining the criteria in the Query Builder

- Click 'OK'
- Click again 'OK'

Your Map document should like as in Figure 17.

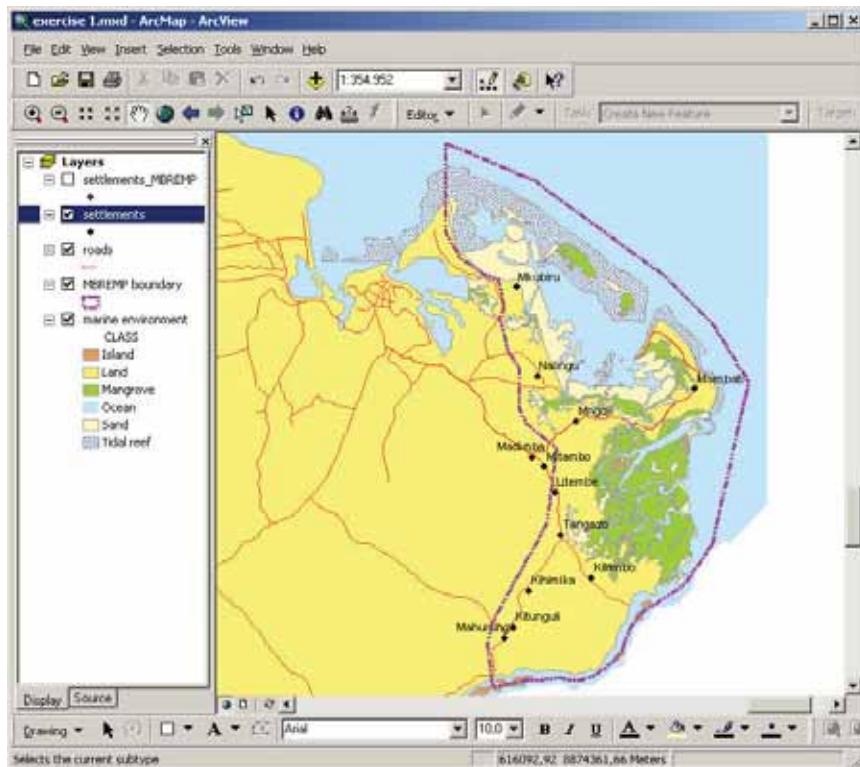
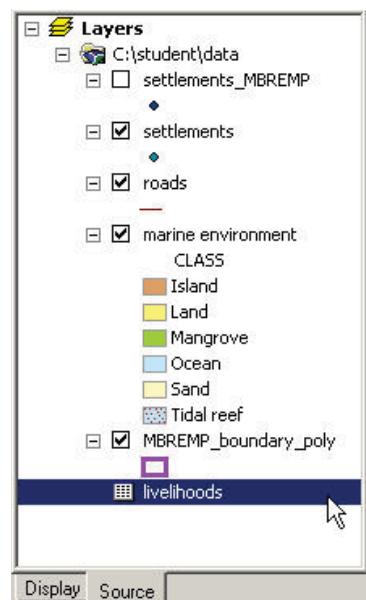


Figure 17: The map document is displaying the 12 park villages

Now we will load information on the livelihoods in the villages. Do the following steps:

- Click the 'Add data' tool in the Standard toolbar
- Navigate to 'C:', folder 'student', folder 'data'
- Select the file *livelihoods.dbf*. This is the 'dBase' table that contains the livelihood data of the 11 villages.
- Click 'Add'



The dBase file 'livelihoods' is now added to the Table of Contents.

Note: the data in the Table of Contents can be displayed in two ways:

- If the 'Source' tab (see below Table of contents) is selected, the layers are shown with their 'source': the folders in which they are organised. In this map you can't change the order of the layer. Additional attribute table (like the 'livelihood' table) are also displayed in this way.
- The 'Display' tab shows the layer in the order in which they are drawn on the map. You can drag layers to change the order of drawing. Additional attribute table (like the 'livelihood' table) are not visible in this view.

In the next step we will link this new livelihood data with the spatial data in the ‘settlements’ layer. The information shown in the two tables below is linked based on ‘VILNAME’ as the common field. For example, the spatial information of ‘Msimbati’ village in the ‘settlements’ attribute table, is linked to the livelihood information of the ‘Msimbati’ village in the livelihood table. This process of linking is called the ‘geo-relation model’. (For a fresh-up on the ‘geo-relational model’, have a look at the theory again.)

Attributes of settlements											
FID	Shape*	AREA	PERI	VIL_ID	VILNAME	VILCODE	VILTYPE	DISTNAME	X_COORD	Y_COORD	inpark
587	Point	0	0	1365	Mambani	12122	vil	Mtwara	656278.4375	8855820	1
588	Point	0	0	499	Nalingu	12114	vil	Mtwara	642815	8856890	1
590	Point	0	0	507	Likembe	12124	vil	Mtwara	644317.8125	8846940	1
642	Point	0	0	475	Mahununge	12231	vil	Mtwara	640033.375	8834470	1
643	Point	0	0	474	Kitungul	12233	vil	Mtwara	640701.075	8835300	1
645	Point	0	0	488	Tengazeo	12234	vil	Mtwara	644857.5625	8843290	1
648	Point	0	0	471	Kilambo	12236	vil	Mtwara	647469	8839660	1
650	Point	0	0	459	Khamka	12235	sub	Mtwara	642148.6875	8839520	1
651	Point	0	0	500	Madimba	12125	vil	Mtwara	642305.25	8849960	1
703	Point	0	0	503	Mkubuu	12118	sub	Mtwara	641029	8864550	1
705	Point	0	0	497	Mngoi	12121	vil	Mtwara	646191	8853050	1

Figure 18: Attribute table of ‘settlements’ layers

The ‘livelihood’ attribute table (Figure 19) contains data on the livelihoods practiced by villagers living in the Mnazi Bay – Ruvuma Estuary Marine Park. The livelihoods (indicated in the columns to the right of ‘VILNAME’) are (from left to right):

- Livelihood depending on marine resources
- Livelihood depending on river
- Other resources
- Farming
- Other business
- Artisan
- Casual labour
- Employed labour
- Other

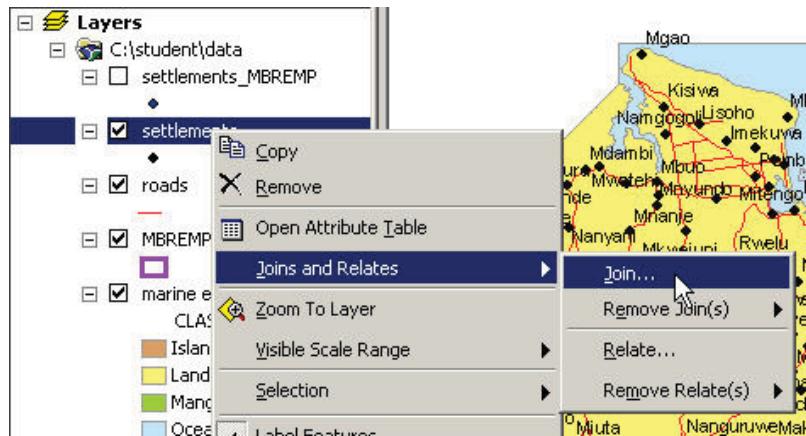
For every village, the percentage of households depending on each of these livelihoods is given.

Attributes of livelihoods											
DID	VILNAME	MARINE_RES	RIVER	OTHER_RES	FARMING	OTHER_BUS	ARTISAN	CASUAL	EMPLOYED	OTHER	
0	Khamka	0	9.2	45.6	97	43.7	12.1	22.4	3.3	0.7	
1	Klombo	19	0	43	38.9	19.5	3.6	9.4	4.6	1.2	
2	Khungul	0	15.7	8	96.8	9.3	1.9	2.9	5.6	0	
3	Lhembe	31	0	23.2	55.4	17	4	25.4	4.6	0.3	
4	Madimba	26	0	30.9	32.5	14.6	7.3	3.5	6	0.9	
5	Mahununge	0	19.8	23	99.1	12.6	5	16.2	0.9	0	
6	Mizambo	24	0	25.9	98.8	25.6	8.9	3.8	0.6	1.4	
7	Mkubuu	62	0	12.1	60.0	20.1	3	7.5	3	1.5	
8	Mngoi	62	0	23	89.9	15.4	6	8.5	3.7	0.5	
9	Msimbati	79	0	15.3	61.1	16.5	14.3	2.9	2.9	0	
10	Tengazeo	29	0	6.2	86.3	12.4	12.6	0.9	1.5	0.2	

Figure 19: Table with livelihood data for 11 villages

In ArcMap the geo-relational model can be implemented in different ways. Here both sets of data are linked in a ‘Join’ operation. Do this as follows:

- Click with the right mouse button on the ‘settlements’ layer
- Select ‘Joins and Relates’
- Click ‘Join...’



- Fill in the 'Join Data' table as shown below (Figure 20)
- Click 'OK'

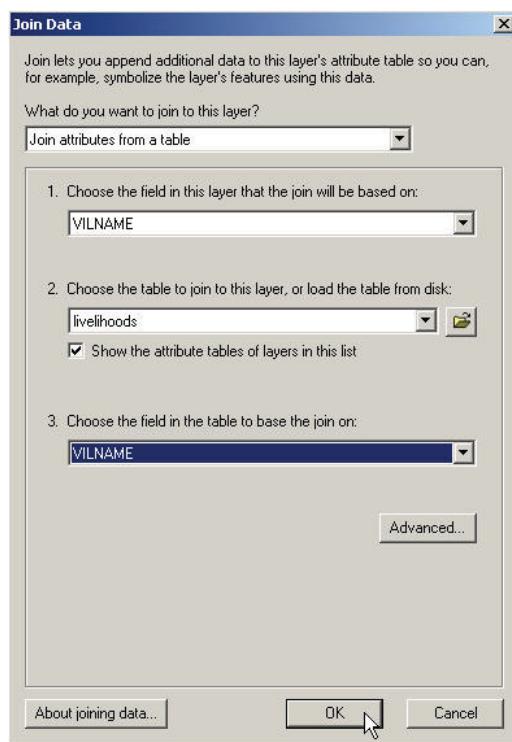


Figure 20: The field on which the linking is based has to be the same in both tables, here 'VILNAME'

If you now open the 'settlements' attribute table again (see step 4), you will see that the livelihood information is added as additional columns.

You can now show the newly added attribute data on the map as well. We will put the information on the map as graphs.

- In the Table of Contents, click 'settlements' with the right mouse button
- Select 'Properties'
- In the 'Layer Properties' window, select the 'Symbology' tab
- At the left side of the window, under 'Show:', select 'Charts'

- Select ‘Bar/Column’
- Next, under ‘Field Selection’, select the 9 last attributes, as in Figure 21. To select more than one attribute, press and hold the ‘Ctrl’-key while selecting the attributes.

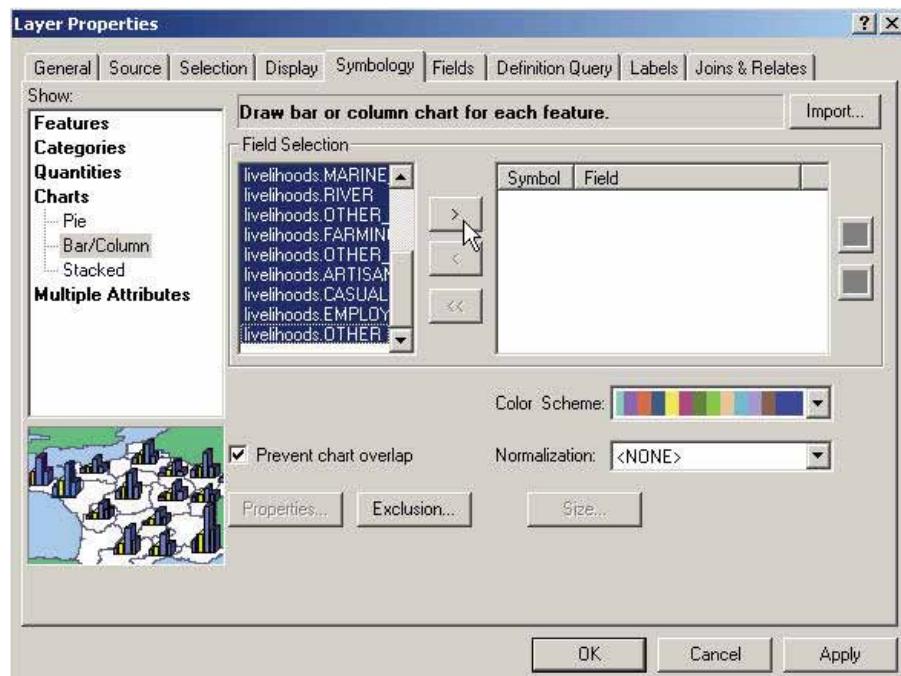


Figure 21: The charts will be drawn for the selected attributes

- Then click the arrow ('>'). This will put the selected attributes in the space at the right, as in Figure 22
- Click ‘OK’

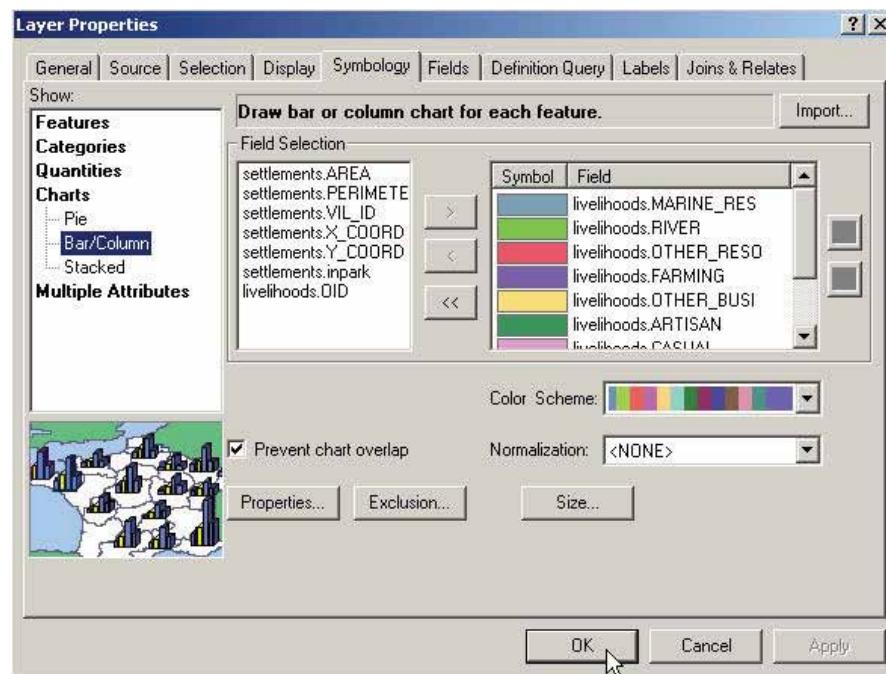


Figure 22: Displaying attributes as charts on the map

The charts will be displayed on the map (Figure 23). Each chart shows the livelihood information of the associated village. Later on you will learn how to modify the symbology of attributes indicated on the map.

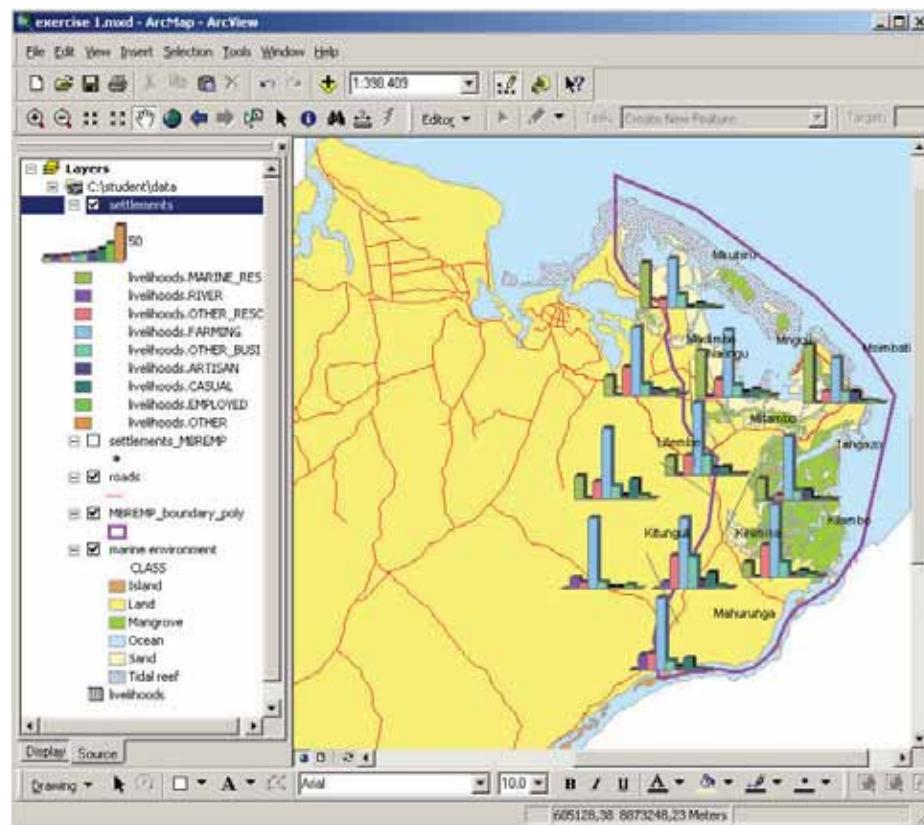


Figure 23: Each chart gives the livelihood data for the associated village

- Close ArcMap
- Save your changes

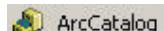
# EXERCISE 3: MANAGING FILES AND CREATING NEW DATA LAYERS IN ARCCATALOG

In the previous exercise you have learned how to use existing data layers to show information in a different way. You have for example produced a buffer around an existing polygon. In this exercise you will learn how to create a new data layer with new information from scratch. 'ArcCatalog' is the interface we use to manage spatial and attribute data files in GIS.

## Step 1

### Launching ArcCatalog

To start ArcCatalog do:

- Start -> All Programs -> ArcGIS
- Select the ArcCatalog button and click 

The ArcCatalog interface shown in Figure 24 will be displayed on your screen.

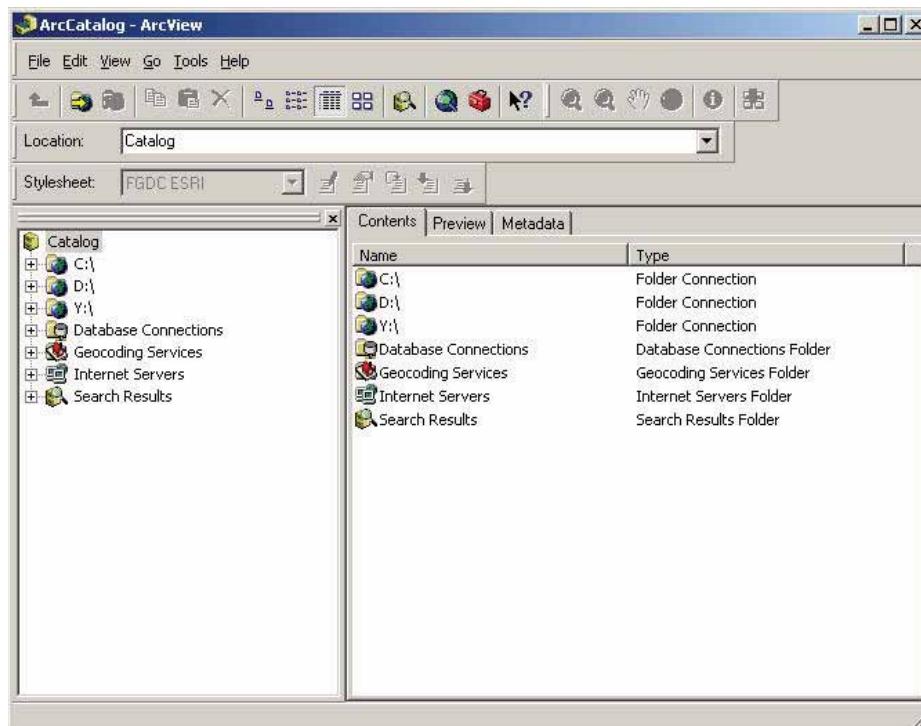


Figure 24: ArcCatalog interface

The ArcCatalog interface has two components. On the left you can see the *Catalog Browsing* component. Here you can navigate to a certain directory and select a file. On the right hand side you can choose between three options: *Contents*, *Preview* and *Metadata*. If you select *Contents*, you can visualise the contents of the folder selected in the left window. *Preview* will offer a preview of a particular dataset, chosen on the left. The *Metadata* option displays any available metadata of the data selected in the left frame. These options will become more familiar during this exercise.

## Step 2 Exploring data

As a first exercise, we will explore the data layers we have just worked with in the previous exercise.

- *On the left go to ‘C:, folder ‘student’, folder ‘data’*
- *Click on the cross next to where you see the drive letter C*
- *Click on the cross next to where you see the folder ‘student’*
- *Click on the folder ‘data’*

The right side will now show the data content of the ‘data’ folder, as in Figure 25.

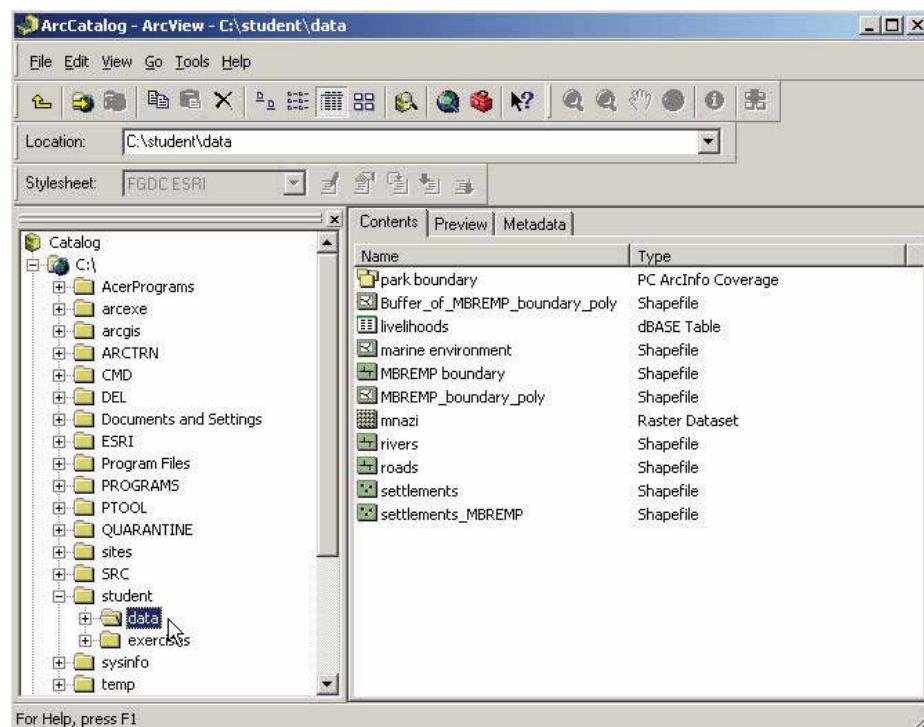


Figure 25: Contents of data directory

Do you recognize the layers we used the previous exercise? For example:

- marine environment: the polygon layer holding the marine environment layer
- rivers: a line layer holding the river layer (we have not used this in the previous exercise)
- roads: a line layer holding the roads layer
- settlements: a point layer holding the settlements layer

You see there are two types of data files:

- PC ArcInfo Coverages: a coverage is a folder, holding information on features in different classes. The 'park boundary' folder is an example of a PC ArcInfo Coverage. Double-click on the folder to see the different classes.
- Shapefiles: are the standard format in which spatial and attribute information of features are stored. All other layers used in the previous exercises are shapefiles.

ArcCatalog uses symbols to indicate the type of each layer. The different symbols are:

Symbol	Description
	Layer with polygon features
	Layer with line features
	Layer with point features
	Layer in raster model or image

Table 1: Symbols used in ArcCatalog

Next we will try out the 'Preview' window.

- In the left hand window, click on the 'marine environment' layer
- Then click on the Preview tab in the right hand window

A preview of the 'marine environment' data will appear in the right window.

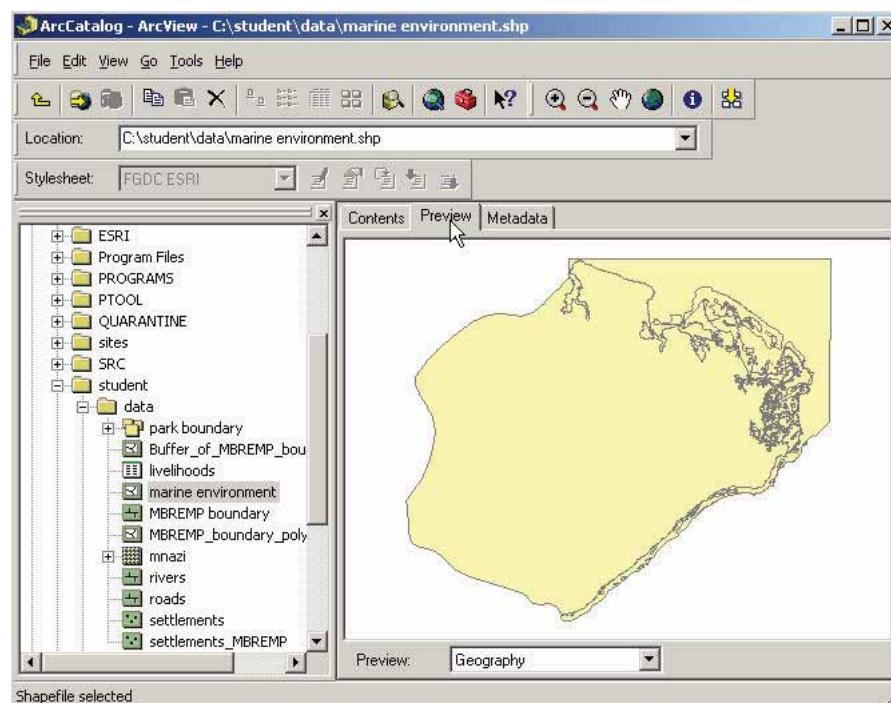


Figure 26: Previewing layers in ArcCatalog

In the same way, preview the other layers in the 'data' folder. Previewing data can help a lot if you are searching for a dataset or if you want to have a quick look to the data in a particular layer.

Below the preview window you can find the *Preview type selection box*. You can choose between 'Geography' and 'Table'.

- Click on the drop down box and select table

In this way you can preview the attribute data of the features within the 'marine environment' layer. This illustrates again the link between the spatial and attribute data in GIS.

### Step 3

### Exploring data properties

Select 'Contents' again in the right window. In the following step you will learn how to check the properties of a layer.

- In the left window, click with the right mouse button on the layer 'settlements'
- From the menu that appears select 'Properties'

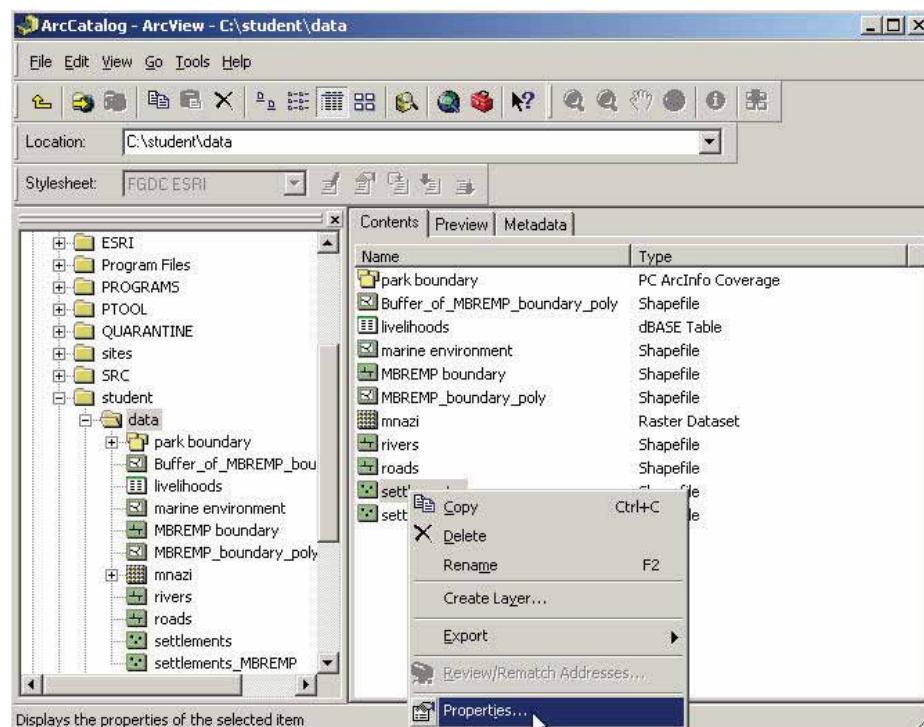


Figure 27: Selecting the properties of a layer

The 'Shapefile Properties' window will open.

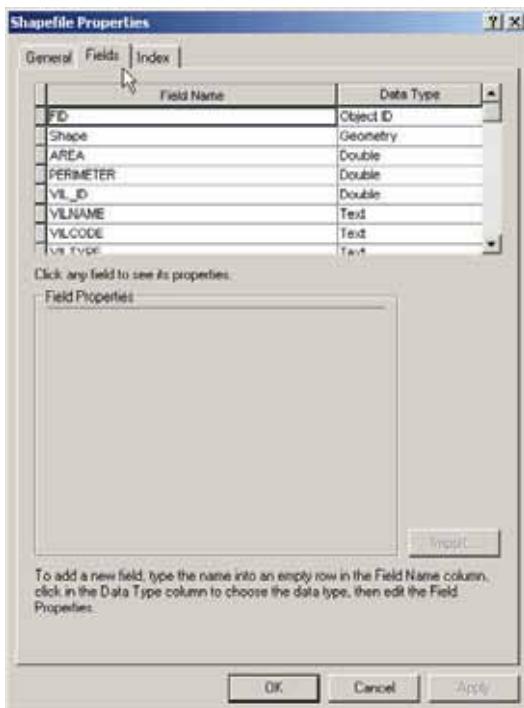


Figure 28: Properties window for shapefiles

- Select the 'Fields' tab if that is not selected yet

In the column 'Field Name' all the spatial and attribute data stored for that particular data layer is listed. In the second column 'Data Type', the type of the data is given. You can lookup the properties defined for a certain data field by clicking on the Field Name.

- Click on the 'VILNAME' attribute in the 'Field name' list

The properties of the 'VILNAME' attribute will become visible in the window below. For this attribute only one property is defined: the length of the village name is set to 25. Learning from the *Data Type* window that the data type is 'text', this means that we can store for each feature in our data layer a village name up to 25 characters (this includes spaces and symbols used in the name). Later on we will learn more about this properties window!



Figure 29: The properties for the 'vilname' attribute are listed under 'Field Properties'

- Close the Shapefile properties window by clicking 'OK'

#### Step 4

#### Creating a new data layer

In this step you will learn how to create a new GIS data file (layer) in ArcCatalog.

- First click with your mouse somewhere on a blank space in the right window (this is to clear any selection)
- Select the 'Data' folder without opening it
- In the menu bar click 'File'
- Go to 'New' and select 'Shapefile', then click to open the 'Create New Shapefile' window

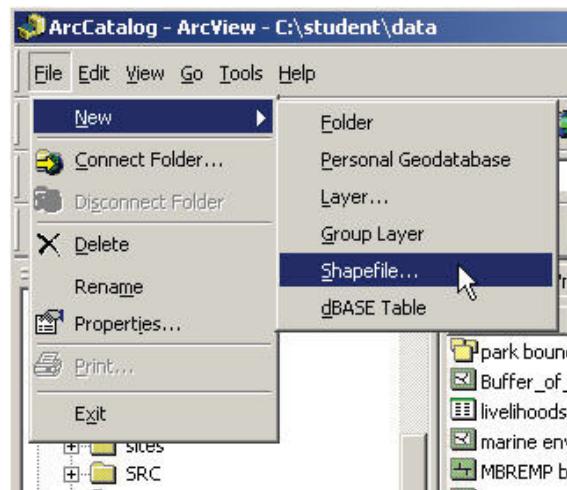
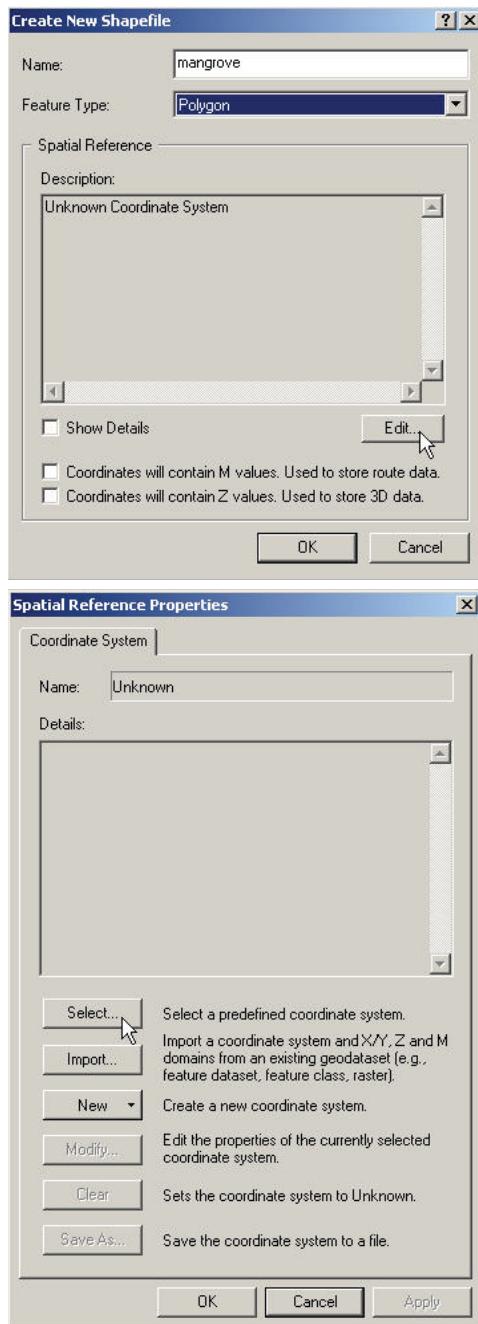


Figure 30: Create new shapefile from the file menu



The ‘Create New Shapefile’ window will appear on your screen.

To define your new shapefile you have to take the following steps:

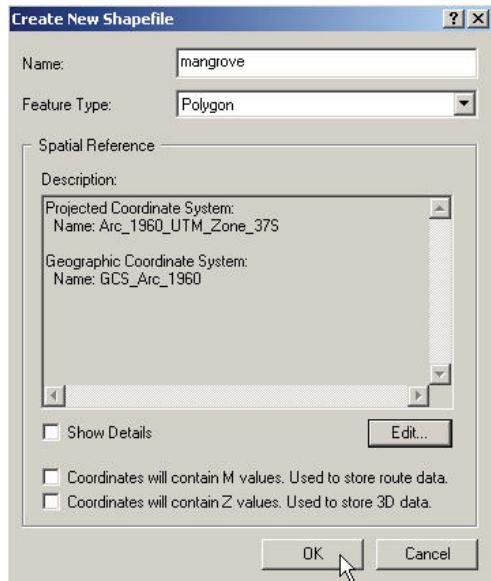
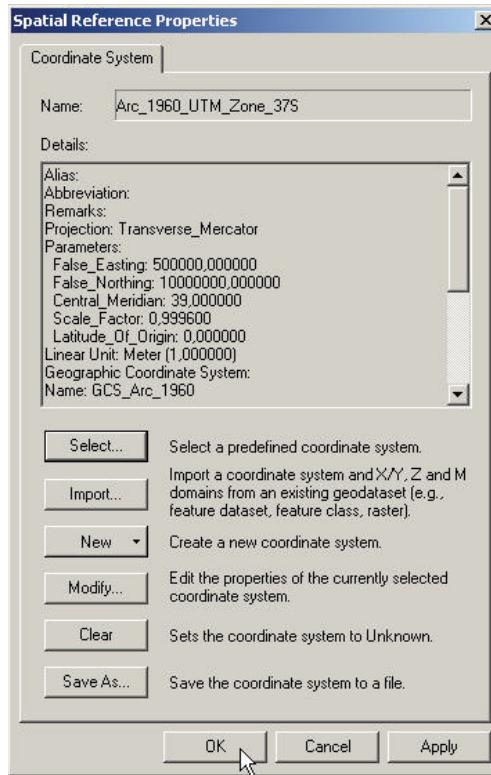
- In the ‘Name’ box, write ‘mangrove’ as the name for the new shapefile.
- As the ‘Feature Type’, select ‘Polygon’.

In the next step you have to set a projection system. (Have a look at chapter 2 of the theory ‘Introduction to GPS’ for a fresh-up on projection systems.) Here we will set the local UTM zone for East-Africa as the projection system. Do this as follows:

- In the ‘Spatial reference’ frame, click ‘Edit’
- Click the ‘Select’ button



- Double click 'Projected Coordinate Systems'
- Double click 'Utm'
- Double click 'Other GCS'  
(= Other Geographical Coordinate System)
- From the list select 'Arc 1960 UTM Zone 37S.prj' and click 'add'



We will return to the 'Spatial Reference Properties' window. The details of the selected projection system are now described in the 'Details' window.

- In the 'Spatial Reference Properties' window click 'OK'

- In the 'Description' box verify that your spatial reference description is the same as you have selected. If it is the same, continue with the next step. Otherwise you will have to define it again.

- Click 'OK'

You have now created a new shapefile, called 'mangrove'. It should be listed in the 'Contents' window.

- Select the new shapefile 'mangrove' in the Catalog browsing component
- Preview your new shapefile by clicking the 'Preview' tab
- What do you see?

Indeed, you don't see anything because there are no features inserted into the news layer yet. This you will do in the next exercise. However if you go to the 'Shapefile Properties' (see step 3) of your new file you will see that some attributes are already defined. These are attributes automatically generated by ArcCatalog for every new layer.

Attribute	Description
FID	Feature ID, this is the ID the software will use to link spatial and attribute information. You can not modify the values of this attribute.
Shape	The Shape field will indicate the feature type (geometry). This is point, line or polygon.
Id	This is an ID you can give to every feature. It can be modified.

Now we will define a new attribute (see Figure 31).

- Click in the list of field names under Id and type in the new name of your attribute 'Class'
- Left from it, choose the data type 'Text'
- In the field properties set the precision to '20'
- Click 'OK'

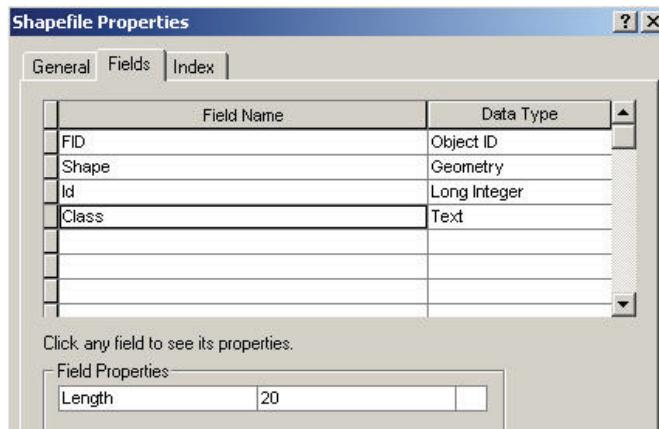


Figure 31: Defining a new attribute in ArcCatalog

Now you have successfully viewed and created new GIS files. In the next chapters we will go more in detail on how to use them.

- Close the 'Shapefile Properties' window by clicking the cross in the right top corner
- Close ArcCatalog (your changes are automatically saved in ArcCatalog)

# EXERCISE 4: GETTING NEW DATA INTO GIS

In this exercise you will learn how to create new GIS data. We will use an aerial photograph and GPS recordings as data sources.

## Step 1 Creating a new layer with ArcCatalog

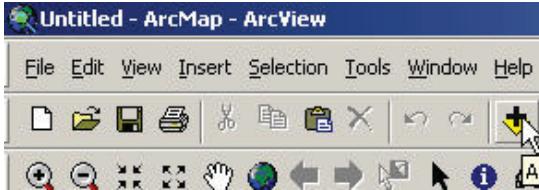
In step 4 of the previous exercise, we have created a new shapefile, called 'mangrove'. Remember we have defined the feature type as 'polygons' and added one attribute, called 'Class'. Until now this shapefile has no features yet. In this exercise, we will produce spatial data to store in that layer.

## Step 2 Digitise in ArcMap

Start ArcMap and open with a new map.

- *Start -> All programs -> ArcGIS -> ArcMap*
- *Click on the ArcMap icon*
- *Select 'With a new empty map' and click 'OK'*

To this empty Map document we will add the newly created 'mangrove' shapefile. In this still empty shapefile, we will store the new spatial data that we are going to produce. Also, we will add the aerial photograph that we will use as the data source to the Map document.

- *Click the 'Add data' tool from the standard toolbar*  

  - *Navigate to 'C:', the folder 'student', then the folder 'data'*
  - *Select mnazi.tif and mangrove.shp and click 'Add'.*
- TIP: You can select more than one layer if you hold down the Ctrl-key while you select a layer.*

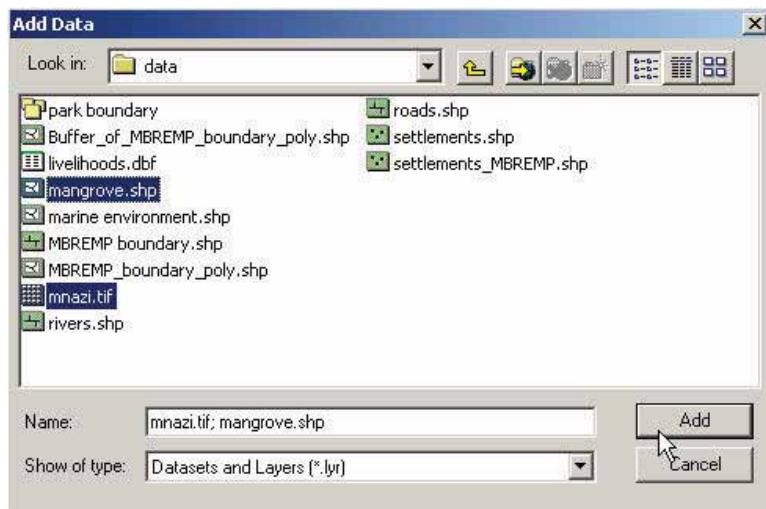


Figure 32: Load image *mnazi.tif* and your new GIS layer *mangrove.shp*

You will see that a new symbol is introduced here (Raster). This indicates a 'tif' file, here an aerial photograph. This is an example of raster data. (For a fresh-up on vector and raster data, have a look at the theoretic part of the course.)

Your screen will look as in Figure 33.

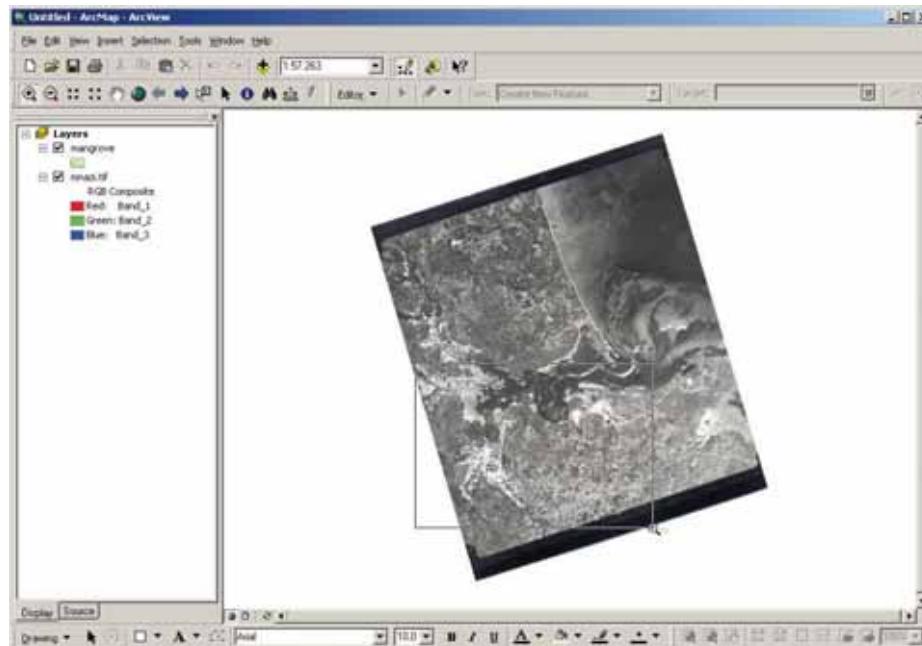


Figure 33: '*Mnazi.tif*' and '*mangroves*' are loaded into the new ArcMap document

Now you are ready to add new spatial information to the 'mangrove' GIS layer. We will 'digitize' new data from the aerial photograph. Because the aerial photograph already holds spatial information, the GIS software will take the coordinate information from the aerial photograph for the 'mangrove' layer.

The most obvious features on this aerial photograph are the salt pans. Zoom in to the picture to see more detail. In this exercise we will store the spatial information of all salt pans seen on this photograph. We will ‘digitize’ the salt pans on the aerial photograph and store the produced spatial data in the empty ‘mangrove’ shapefile.

- Try to find the salt pan you see in Figure 34 and zoom in so you can see it very well



*Figure 34: Zoom into this salt pan*

To add data to or to modify a shapefile, we need to start an 'edit session'. Only during an edit session shapefiles can be modified. This is to protect the layers from accidental modifications.

- Click on 'View' in the menu
  - Select toolbars and select the 'Editor' toolbar if that is not selected yet

The Editor toolbar, shown in Figure 35, will now appear.



*Figure 35: Editor toolbar*

- In the Editor toolbar click the ‘Editor’ menu
  - From the dropdown menu, select ‘Start Editing’. The different tools in the toolbar now become active.
  - Select ‘Create New Feature’ in the ‘Task’ box
  - Select ‘mangrove’ in the ‘Target’ box (Figure 36)



Figure 36: Active editor toolbar

Now you will start to digitize the first salt pan.

- In the Editor toolbar click the 'Sketch tool' ( )

If you now move over the aerial photograph your cursor will become a cross with a small circle in the middle as in Figure 37.

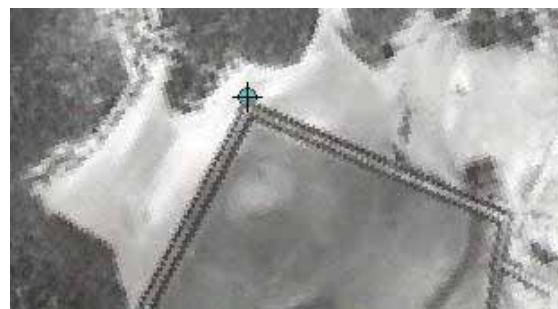


Figure 37: Mouse layout when sketch tool is made active

To start digitizing,

- Click in a corner of the salt pan
- Now move your mouse along the border of the salt pan. If you come to the next corner, click the left mouse button. Each time you click, the coordinates of that point will be saved and you start a new line.

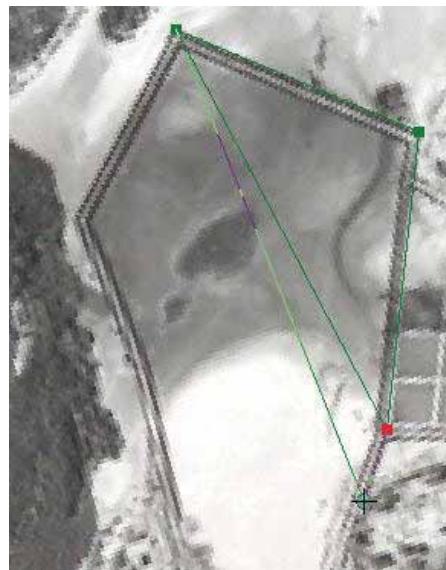


Figure 38: Click the mouse button each time you come across a corner or a change of the shape

- 
- Try to follow the shape of the salt pan as good as possible, as we did in Figure 40. Every time the line changes direction, click the left mouse button.
  - If you have digitized the entire area of the salt pan (you are back at your starting point), right click the right mouse button and select 'Finish Sketch' from the menu (Figure 39). You can also end the sketch by double-clicking at the last point.

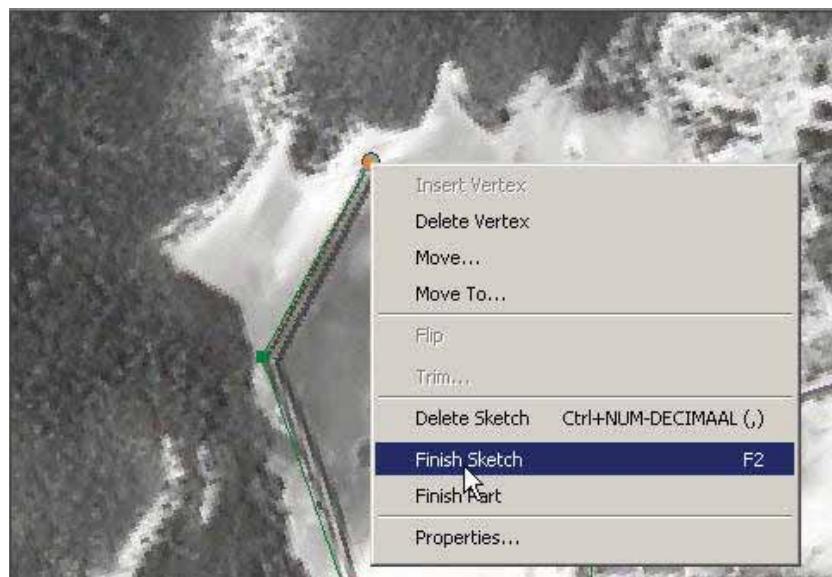


Figure 39: 'Finish sketch' ends the first digitizing session

You will now see the polygon you have digitized for this salt pan Figure 40.



Figure 40: Polygon digitized from the first salt pan

Before we continue digitizing the next feature we will first fill in the attributes for this feature. Therefore:

- Right click on the layer 'mangrove' in the Table of Contents (left hand window)
- Select 'Open attribute table'

Now you will see the attribute table. Note that two fieldnames have a white background the other two in dark grey. Only the two white fields can be modified. (The other ones are generated by the software as we already explained.) You can see that the first record, which is the feature you have just digitized, is already selected (=highlighted in a certain colour).

	FID	Shape*	Id	Class
▶	0	Polygon	0	

Figure 41: The attribute table while editing a layer

To fill in the attribute data:

- Click in the cell of the 'Id' field and type number '1' in stead of the zero
- Use the enter key to confirm
- Click in the cell of the 'class' attribute and type 'salt pan'

The first record will now look as below.

	FID	Shape*	Id	Class
▶	0	Polygon	1	salt pan

- Close the attribute table

Now you can go back to the map and continue with digitizing the next salt pan. Do this for all the salt pans you see on the aerial photograph and fill in the attribute information for every salt pan digitized. The second salt pan you digitize has 'Id' '2', the third one '3' and so on... Under 'class', fill in 'salt pan' every time. At the end your ArcMap session should look like the figure below.

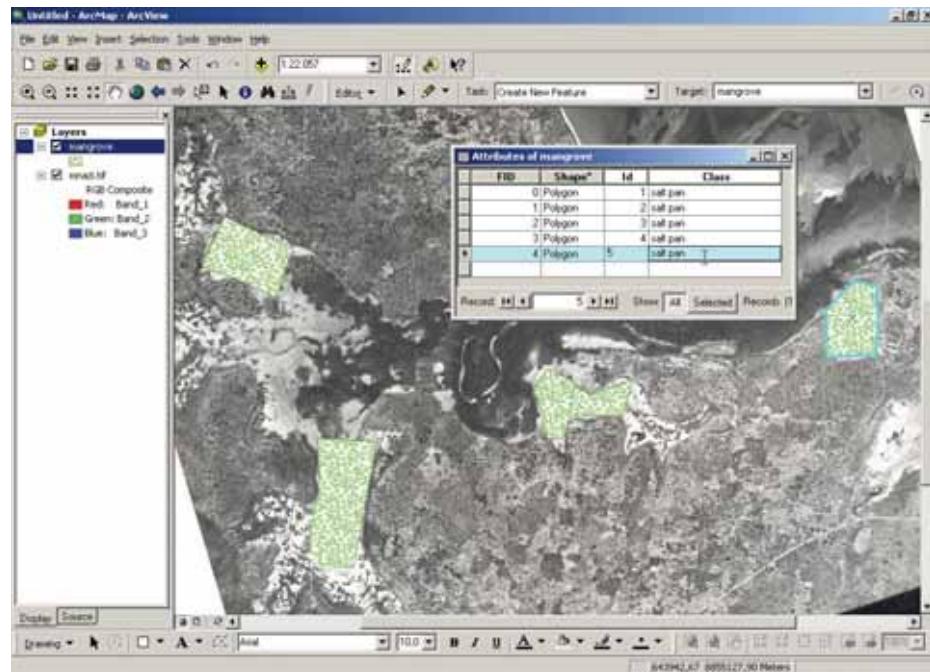
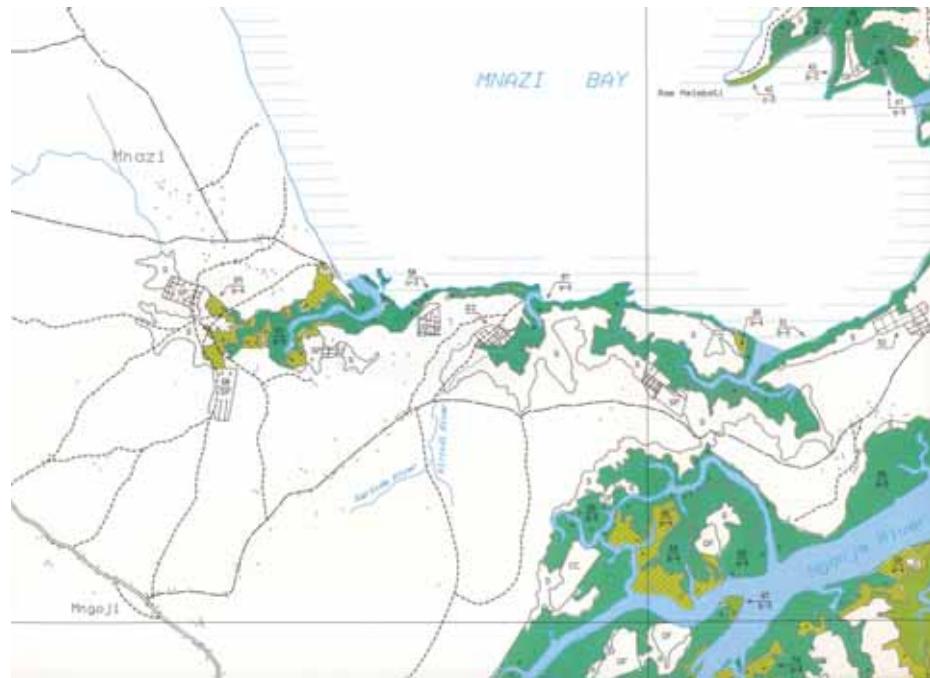


Figure 42: All salt pans are digitized and the 'mangrove' attribute table is filled in

In the same way you could digitize other polygons, like mangrove forest, bare areas, non-mangrove areas, etc. Each time the corresponding attribute has to be filled out in the 'Class' field of the attribute table. Before we stop digitizing we have to close the editing session:

- From the Editor toolbar select 'Stop editing' in the Editor drop down menu
- Click 'Yes,' to save your changes
- Close your map document and save changes

In this exercise we have digitized spatial information from an aerial photograph. Hard copy maps (maps on paper) are another much used source of digital data. The aerial photograph used in this exercise is part of a whole series of photographs which were used to produce a map on the mangrove forest of Tanzania. Figure 43 shows the area of that map that was presented in the aerial photograph.



*Figure 43: Mangrove map showing the area around Mnazi village (source: Ministry of Lands, Natural Resources and Tourism, Forest and Beekeeping Division, The Catchment Forestry Project, Dar-es-Salaam, 1990)*

Just as you have digitized features from the aerial photograph, you could scan this hard copy map and digitize the features of the map on the computer screen. Either way the data is collected, the final result would be a 'mangrove' layer of polygons as in Figure 44. To see this map

- Open ArcMap again and go to the 'student' folder, then to the 'exercises' folder
- Open the 'mangrove' document

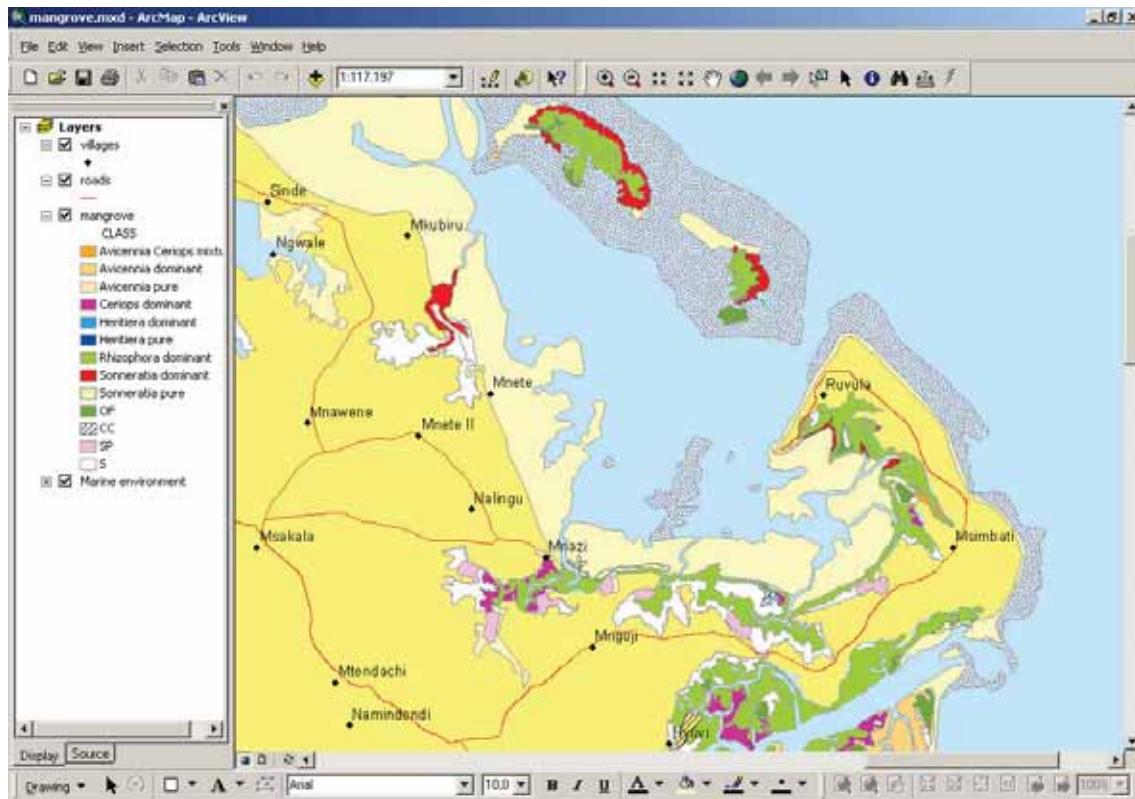


Figure 44: ArcMap document showing the mangrove polygon layer for Mnazi Bay

The attribute ‘Class’ can be read from the legend. The polygons that we digitized (salt pans) are here called ‘SP’. In the next chapter you will learn how to use symbols to indicate attribute information on a map.

Some additional tips:

- Remember you can select a polygon in the attribute table to check where it is on the map.
- You can clear selections using the ‘Clear Selected Features’ in the ‘Selection’ menu.
- You can select an object with the selection tool ().
- You can modify features by selecting ‘Modify Feature’ as task and using the ‘Edit’ tool () instead of the ‘Sketch’ tool.
- Make sure that the polygons are closed, otherwise the GIS software will recognize them as lines in stead of polygons.

There is much more to learn about digitizing information from existing maps or aerial photographs. As an introduction, however, the above exercise will do. The most important steps of the digitizing work were hereby introduced. If you want to learn more about digitizing we refer to the ‘Help’ section of the software. There is a special chapter on editing in ArcMap.



Figure 45: Starting ArcGIS help

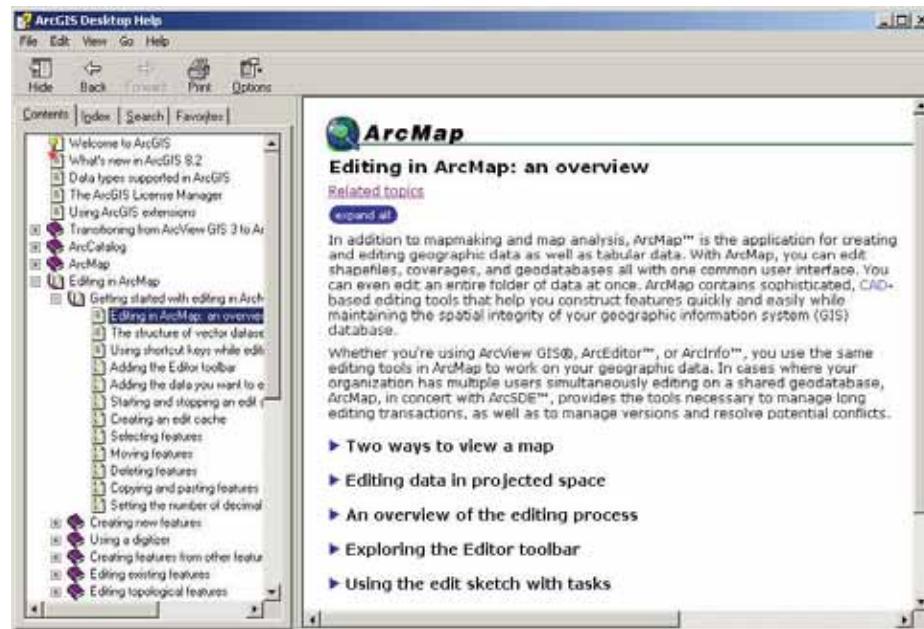


Figure 46: The ArcGIS help interface

Much more information can be looked up in the 'Help' section. You can browse through the table of contents, search the index or do a general search and store your favorite pages. Take some time to have a closer look in the help file.

**After this training, the Help section will become your main source of information** to increase your skills and to solve any problems you encounter.

Next,

- Close the ArcGIS help.
- Close ArcMap without saving

### Step 3

### Add GPS data to GIS

Next to aerial photographs and hard copy maps, another important source of GIS data is coordinates measured on the earth's surface using a GPS receiver.

In this step we will go outside and measure a location with the GPS. We will be using the GPS of the Mnazi Bay – Ruvuma Estuary Marine Park (Garmin GPS 72) (Figure 47). As you learned in the theoretic part of this course, GPS can be used for many things: for measuring locations, for orientation, to determine speed, to determine a track,... In the area of marine conservation, GPS will be mainly used to measure certain locations, so this is what we will do in this exercise. For the other options of GPS, we refer to the GPS's 'Owner's manual & Reference guide' which explains the operation of the GPS receiver in detail.



Figure 47: The Garmin GPS 72, showing the buttons and the screen

To measure a location with the ‘Garmin GPS 72’, do the following steps:

- Switch on the GPS by pressing the button with the red bulb
- Press ‘Page’ to agree (if you don’t press it the next screen will be displayed automatically after a time)
- You have to go outside and stand in front of the office entrance. Measuring a location from inside a building or car will not work well. Make sure your view to the sky is not obstructed by any trees.
  - Point the GPS towards the sky
  - In the ‘Receiver Status’ area (see Figure 48) you will see ‘Acquiring Satellites’. The GPS receiver is trying to contact the satellites. This can take from a few seconds to a few minutes, depending how strong the satellite signals are.
  - When you see ‘2D GPS Location’ appear in the ‘Receiver Status’ area, the GPS is receiving the signal of 3 satellites. This is enough to display the location, but the GPS can’t provide an altitude reading.
  - When ‘3D GPS Location’ appears, the GPS is using the signal of at least 4 satellites and is capable of providing an altitude reading as well. This is displayed in the ‘Altitude’ area at the top left.
  - As soon as the GPS has determined the location, a map showing the point will be displayed. Navigate back to your information screen by pressing the ‘Page’ button.
  - In the ‘Location’ area at the bottom of the screen (see Figure 48) the coordinates of your location will appear.

- As long as the GPS receiver is still detecting more satellites, the coordinate values will still change. When the values remain stable, write down both values. When measuring in UTM ARC 1960, the values are displayed in metres. E.g. 0627609, 8855236 (these are the location of the ARI at Naliendele). The first value gives the 'x' value of the position; the second value the 'y' value.
- In between 2 measurements, switch off the GPS receiver to save battery power. Switch off by pressing the button with the red bulb.

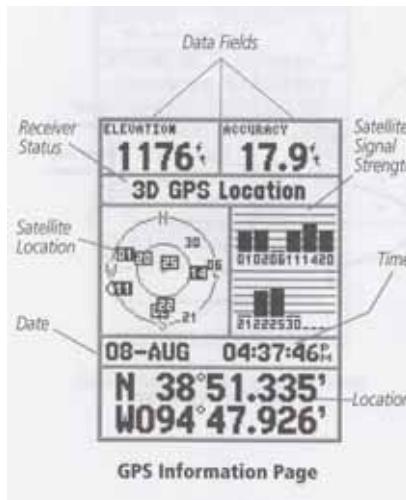


Figure 48: The GPS Information Page of the Garmin GPS 72 (Source: Owner's manual & Reference guide)



Note 1: In the 'Satellite Location' area (Figure 48), you can follow the status of the GPS signal. On the small map in Figure 48 (the 2 circles), 7 satellites (indicated by the numbers) are displayed in a black box. This means the GPS is using the signal of 7 satellites to calculate the position.

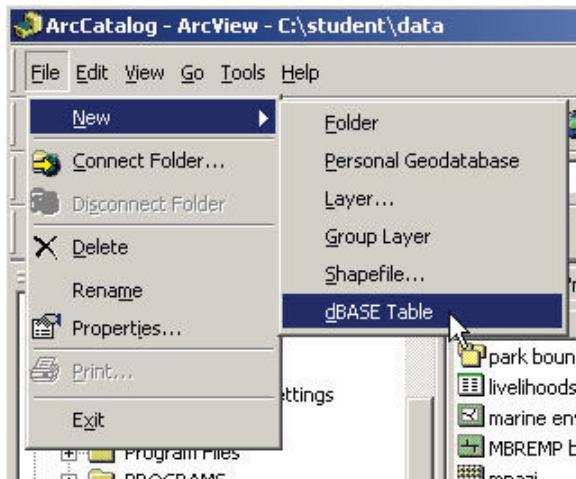
Note 2: You will be measuring locations with UTM, with 'ARC 1960' set as datum for locations in Tanzania and Kenya. When measured in UTM, the locations can be transferred into the GIS without conversions. If you want to set another datum, go through the following steps:

- Go to 'Main Menu'
- Select 'Setup' by pressing the Enter key
- Press the 'Location' tab
- Go to 'Map Datum' and press the Enter key
- From the appearing list, select a datum, for example 'WGS 84'
- In the same way, you can alter the measurement units under 'Location Format'. With ARC 1960, we are using 'UTM UPS'

Now you have measured your location, the next step is to get it into GIS. We will first put the coordinates in a 'dBase' table. First we have to make the empty dBase table in ArcCatalog:

- Go to Start -> All Programs -> ArcGIS -> ArcCatalog
- Navigate to drive 'C:', folder 'student', folder 'data'; select the data folder
- Click 'File', then select and click 'New'; click 'dBase Table'

A new dBase table will be added to your folder.



- Change the name from 'New\_dBase\_Table' into 'coordinates'

Name	Type
park boundary	PC ArcInfo Coverage
<b>coordinates</b>	dBASE Table
livelihoods	dBASE Table
marine environment	Shapefile
MBREMP boundary	Shapefile
mnazi	Raster Dataset
rivers	Shapefile
roads	Shapefile
settlements	Shapefile

Figure 49: The dBase table 'coordinates' is added to your 'data' folder

Remark in Figure 49 that the livelihood data you have used in exercise 1 is also stored in a dBase Table. We now have to define some new field for the 'coordinates' dBase table:

- Double-click on the file 'coordinates' to open the 'dBase Table Properties' window
- Select the 'New Field' record by clicking on it and delete it by using the 'Delete' key
- Now, in the second cell under Field Name, type 'x', as in Figure 50
- Change the 'Data Type' into 'Long Integer'
- Don't change the 'Field Properties'
- In the third cell, type 'y'
- Again, put 'Long Integer' as the data type
- Don't change the 'Field Properties'
- Click 'OK'
- Close ArcCatalog

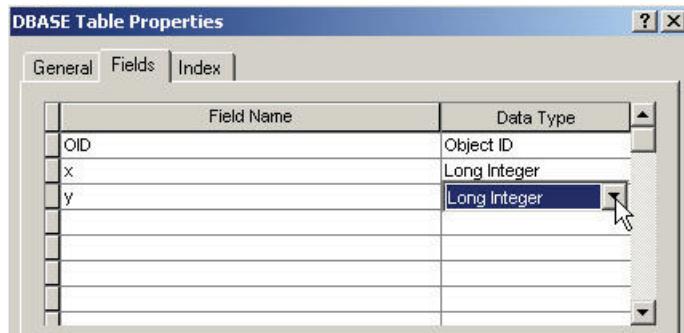


Figure 50: Add new fields to the ‘coordinates’ dBase table

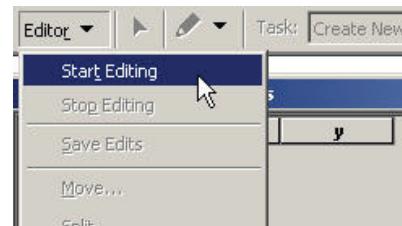
- Click ‘OK’ to close the dBase Table Properties window
- Close ArcCatalog

You have now prepared your empty dBase table. Now you will fill in the table using ArcMap.

- Start ArcMap with a New Empty Map
- Click the ‘Add Data’ button (  )
- Navigate to drive ‘C:’, folder ‘student’, folder ‘data’ and select ‘coordinates’. Add this file to your map document.

Nothing new is displayed in your data display area. This is because the table is still empty. We will now fill in the coordinates you just measured with your GPS.

- Select the ‘coordinates’ table and click your right mouse button
- In the list that appears, click ‘Open’. Your empty ‘dBase’ table opens. Recognize the fields you have just determined.
- Activate the ‘Editor’ bar if that isn’t activated yet
- Click on ‘Editor’ and click ‘Start Editing’



You will now see a first record appearing in your table. This is still empty. Fill in the coordinates you have measured.

**Attributes of coordinates**

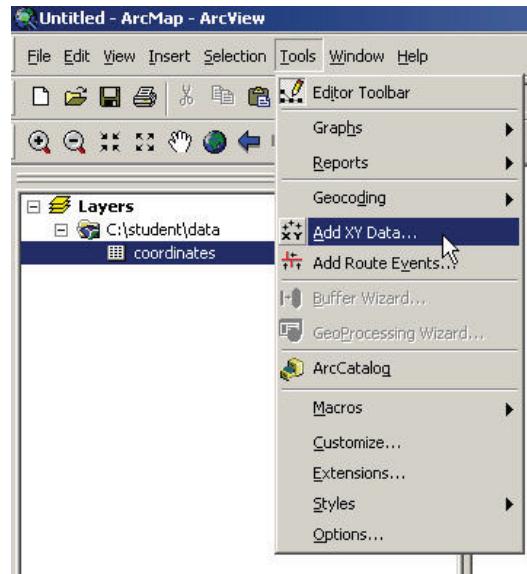
OID	x	y

**Attributes of coordinates**

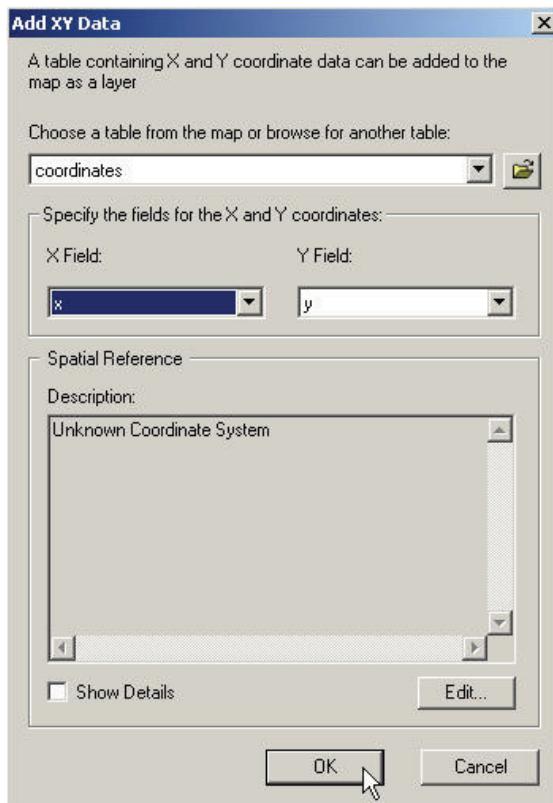
OID	x	y
0	627609	8855236

- Click on the cell under 'x' to select it
- Fill in your first coordinate value
- Do the same for the y value
- When you filled in your table, click on 'Editor' and select 'Stop Editing'
- Click 'OK' to save your edits
- Now close the table
- Next, click 'Tools' and click 'Add XY Data...'



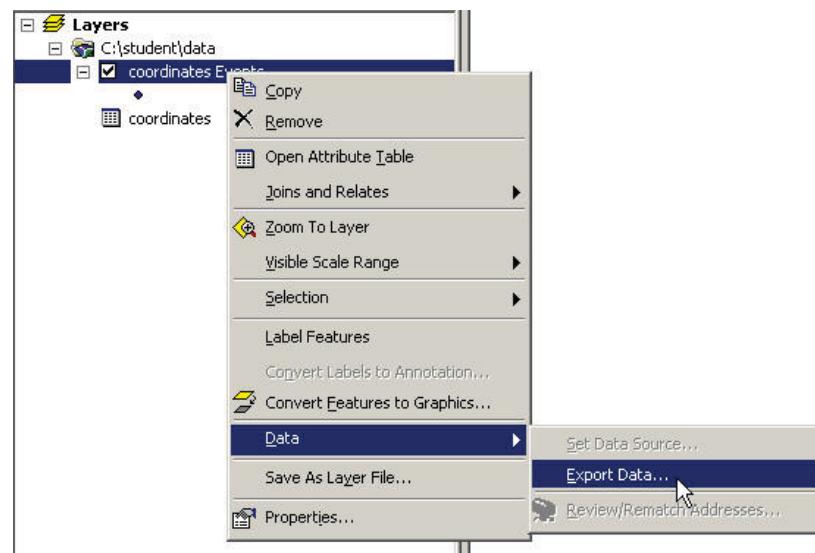
Because we have given the column names 'x' and 'y', ArcMap is assigning automatically the x attribute to the X field and the y attribute to the Y field. If you would have used other column names, you would have to select the X and Y fields manually.

- In the 'Add XY Data' window, click 'OK'

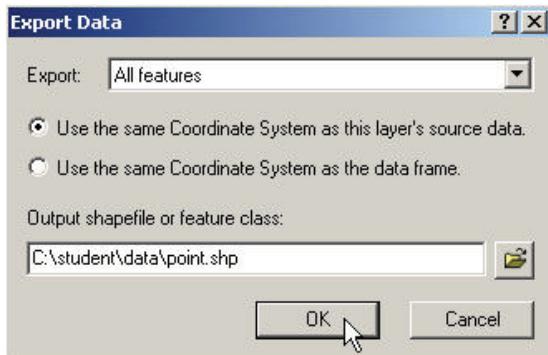


Your point will now be displayed in the Data Display Area. The last thing you have to do is to convert your data to a shapefile. To do that,

- Click with the right mouse button on 'coordinates Events'
- Select 'Data', 'Export Data...'



- In the ‘Export Data’ window, click the ‘browse’ button (
- Go to drive ‘C:’, folder ‘student’, folder ‘data’
- Name your file ‘point’
- Click ‘Save’
- Click ‘OK’



- Choose ‘Yes’ to add the exported data to the map as a layer

Now your point is added to the map as a shapefile. To see the location of the point on a map,

- Add the ‘marine environment’ layer and the ‘roads’ layer

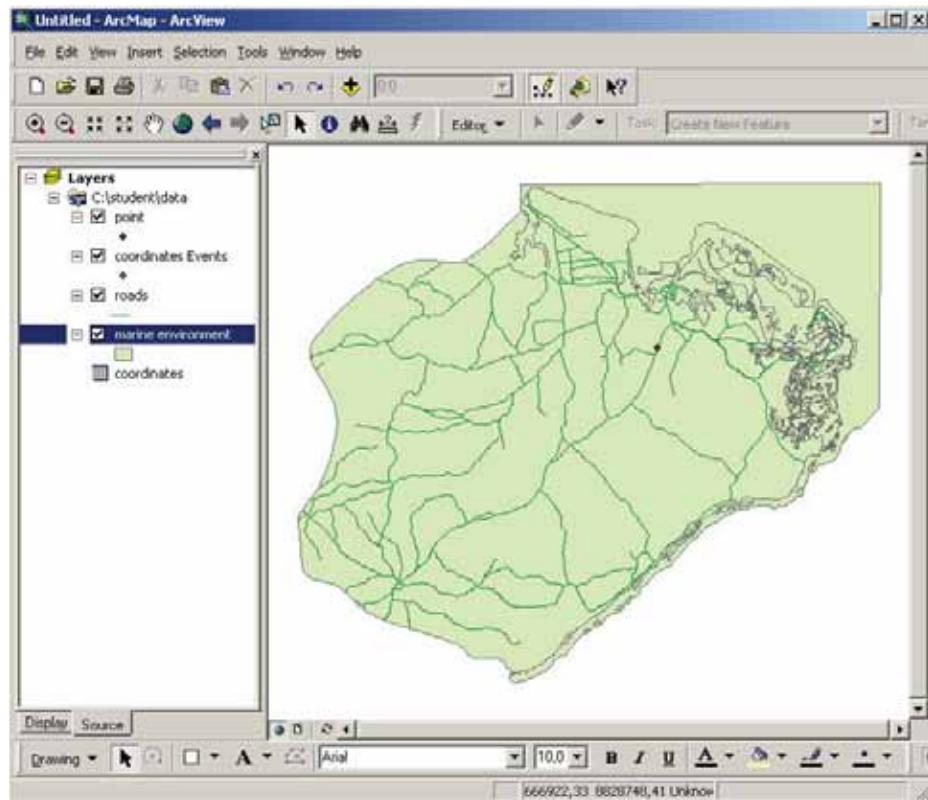


Figure 51: The point we measured with the GPS is now located on the map. (The point you see in this figure is the Research Institute in Naliendele.)

- Close the document
- Save your changes

---

# EXERCISE 5: CREATE YOUR OWN MAP

Map making has become one of the most important tasks handled by GIS software. Therefore it is important that you also get familiar with the procedures and concepts of making a map. In this exercise you will use existing data to produce a map. You will learn the different steps you have to take to produce and lay-out a map in ArcMap.

In this exercise you will produce an A4 size tourist map of the Mnazi Bay – Ruvuma Estuary Marine Park that can be used both to take into the field as well as to distribute to visitors.

<b>Step 1</b>	<b>Open a new ArcMap session and load the data</b>
---------------	--

To open your ArcMap, go to

- *Start -> All Programs -> ArcGis -> ArcMap*
- *Click on the ArcMap icon*
- *Select 'With a new empty map' and click 'OK'*
- *Click the 'Add data' tool (  )*
- *Go to drive 'C:', folder 'student', folder 'data' and select the following data layers*
  - *marine environment*
  - *MBREMP boundary*
  - *rivers*
  - *roads*
  - *settlements*

*(You can select more than one data layer by clicking and holding the 'Ctrl' key while selecting the layers.)*

The selected layers will be displayed on the map document, but the symbology will not be well chosen. This still looks far from a map! In this exercise we will learn how to change the symbology so that the document becomes a map that provides the user with information.

<b>Step 2</b>	<b>Changing symbols</b>
---------------	-------------------------

The symbol properties of a layer can be accessed in two ways:

1. By double-clicking on the symbol
2. By clicking with the right mouse button on the layer and selecting 'Properties'

In this exercise, we will use the second way through ‘Properties’ as this gives access to all possible settings. First we will change the symbology for the ‘settlements’ layer.

- *Click with the right mouse button on the ‘settlements’ layer*
- *Click on ‘Properties’*
- *In the ‘Layer Properties’ window, select the ‘Symbology’ tab*
- *Click on the ‘Symbol’ button (see Figure 52)*

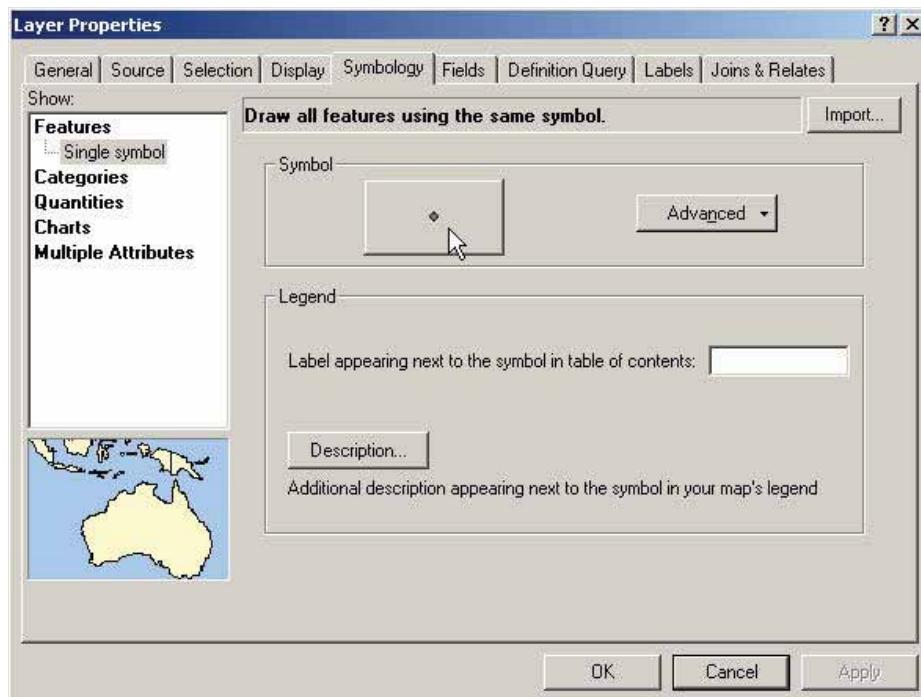
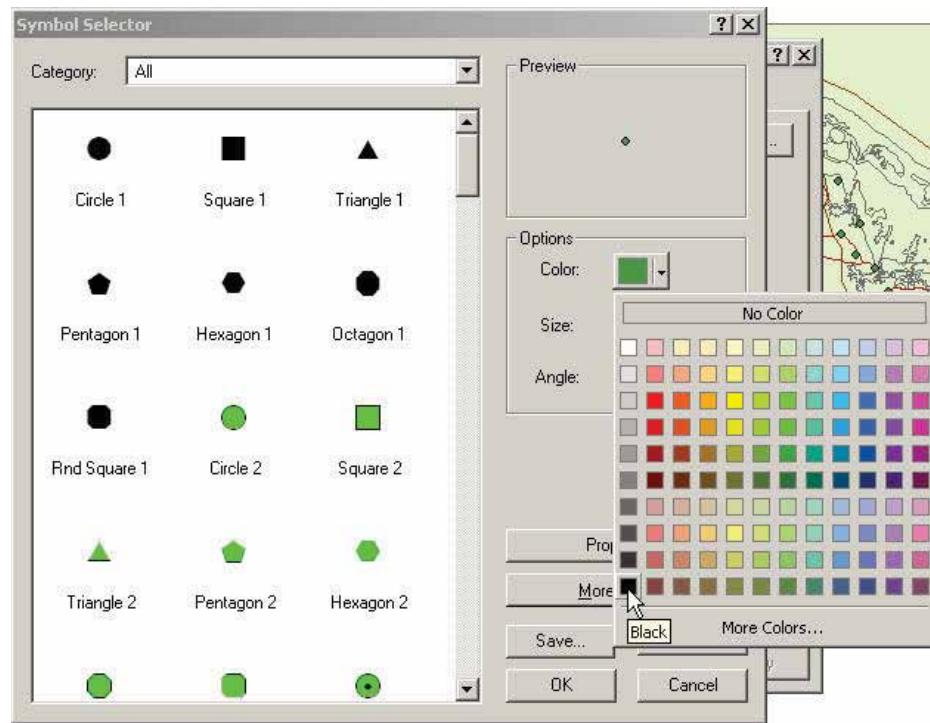


Figure 52: Click on the symbol button to select the color palette

This will open the ‘Symbol Selector’ window. To change the color of the ‘settlements’ symbol:

- *Click on the arrow behind ‘Color’ to display the color palette*
- *Choose ‘Black’*
- *Click ‘OK’*
- *To apply the selected symbology to the layer, click ‘OK’*

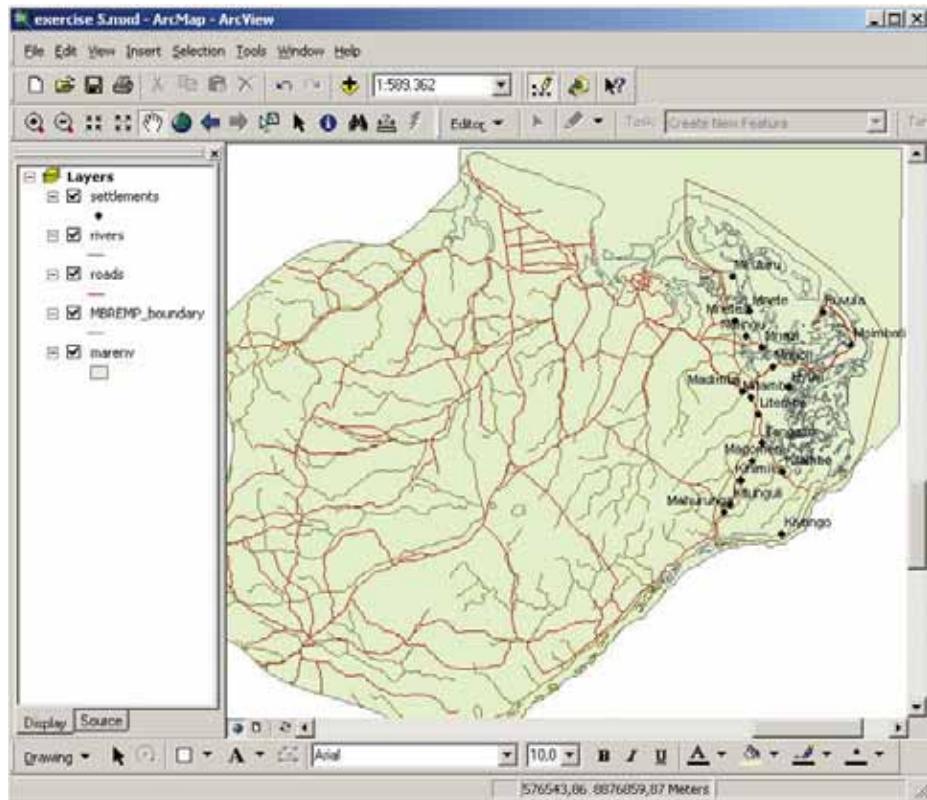


The 'settlements' features will now be displayed in black.

On our park map, we just want to show the 12 park villages and the neighboring town of Mtwara. Therefore,

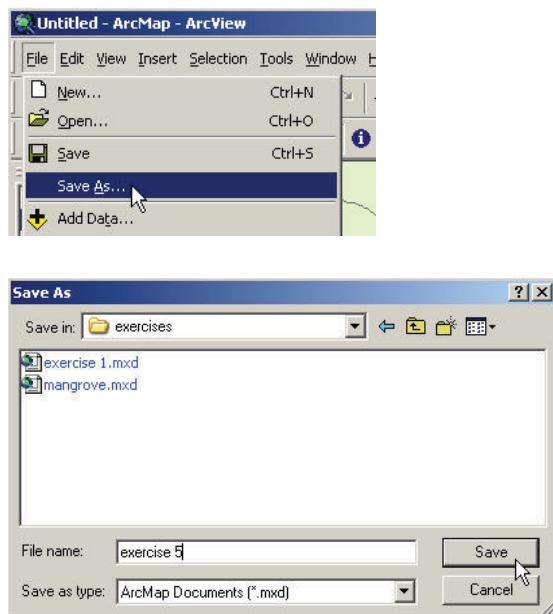
- Use the 'Definition Query' to select those settlements that meet the criteria "inpark" = 1 AND ("viltype" = 'vil' OR "vilname" = 'Mtwara') (see Exercise 1, step 6)
- Display the villages' names on the map by as labels as you learned earlier (Exercise 1, step 4)

At this stage, your map will look as in Figure 53.



*Figure 53: An early stage of your map*

This is a good moment to save the map document you have made so far.



- Click 'File', then select 'Save As...'
  - Navigate to drive 'C:', folder 'student', folder 'exercises'
  - As 'File name' enter 'exercise 5'
  - Click 'Save'

Rivers in maps are always represented by blue lines. Change the color as you did for the settlements, but select '*Mooria Blue*' as color. Keep the width set to '1'.

Next we will change the symbology of the road layer. We want to give the users of the map information about the type of the road.

- Select the 'roads' layer by clicking it
- Click the right mouse button to go to 'Layer Properties' and select 'Symbology'
- Under 'Show', select 'Categories', 'Unique values'
- Under 'Value Field', select 'Type'
- Below, click 'Add All Values'. The four categories of 'road type' will appear.
- Click on 'tarmac' and use the arrows on the right to move the line to the top of the list. Move 'footpath' to the end of the list.
- Next, double-click on the line symbol in front of tarmac
- As color, select 'Mars red', as width, select '3'
- Click 'OK'
- Set the other symbols as follows:
  - All weather: 'Mars red, width '2'
  - Minor: 'Mars red', width '1'
- Double-click the symbol in front of 'footpath'. In the 'Symbol Selector' click on 'Properties'. Then select 'Dotted' as Style, as in Figure 54. Set the color to 'Mars Red' as well.
- Click 'OK'
- Click 'OK' to apply the selected symbology to the 'roads' layer

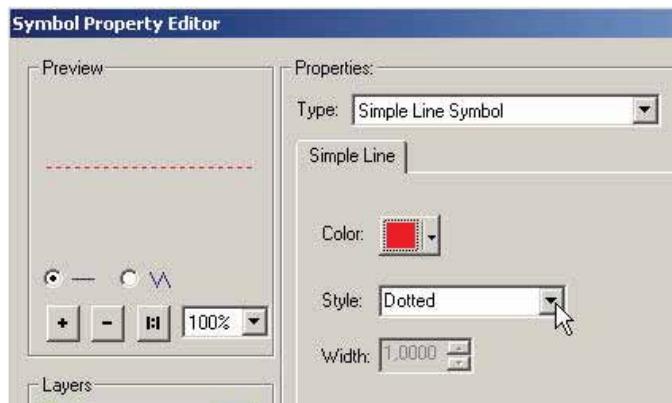


Figure 54: Selecting the symbology for footpaths

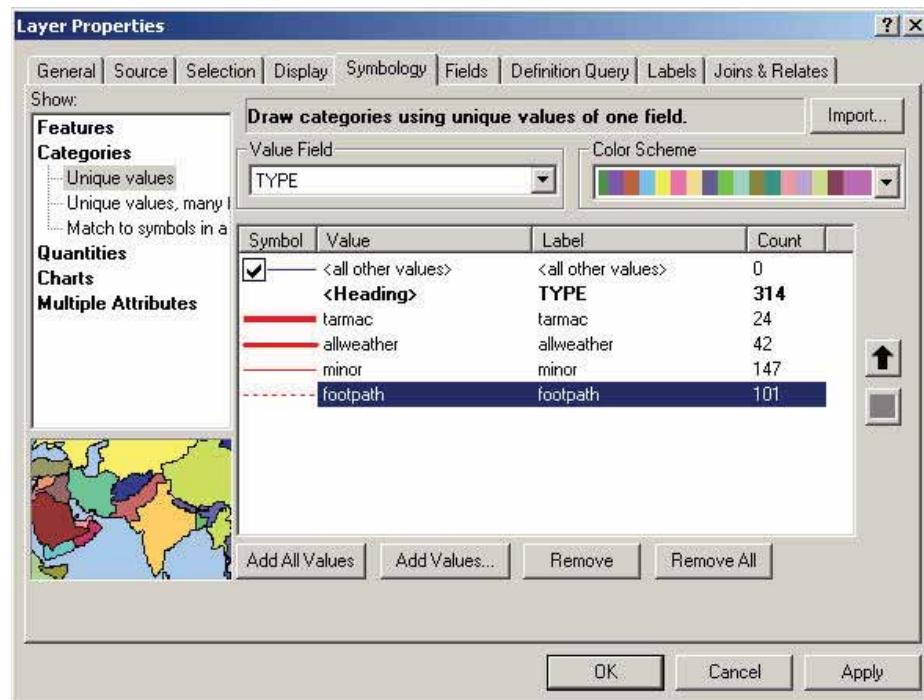


Figure 55: The final road symbology

On your map the roads are now given symbols according to their type.

In the same way, select a color and width to create an appropriate symbol for the MBREMP boundary.

Finally, you still have to assign appropriate colors to the 'marine environment' layer.

- Open the 'Properties window' by clicking with the right mouse button on marine environment
- Under 'Show', select 'Categories', 'Unique values'
- Under 'Value Field', select 'Class'
- Click 'Add All Values'. The six classes of 'marine environment' will appear.
- Change the colors in order to produce an attractive and clear map. Use appropriate colors: blue for water, yellowish for land, green for mangrove...

When your map has the desired symbology, you are ready to start with the map lay-out.

---

### Step 3

### Creating the map

ArcMap has two main viewing possibilities, the '*Data*' view and '*Layout*' view. You can switch between both through:

- Selecting '*View*' from the menu. Choose between '*Data view*' or '*Layout View*'.
- or
- Selecting either '*Data view*' or '*Layout view*' from the buttons in the lower left corner of the Data Display Area (

The '*Data View*' is designed for viewing data during analysis and to define the symbology of the different layers. The '*Layout View*' is designed to create a map.

In what follows we will finally create a map. We will first switch from '*Data view*' to '*Layout View*'.

- Select '*Layout View*'

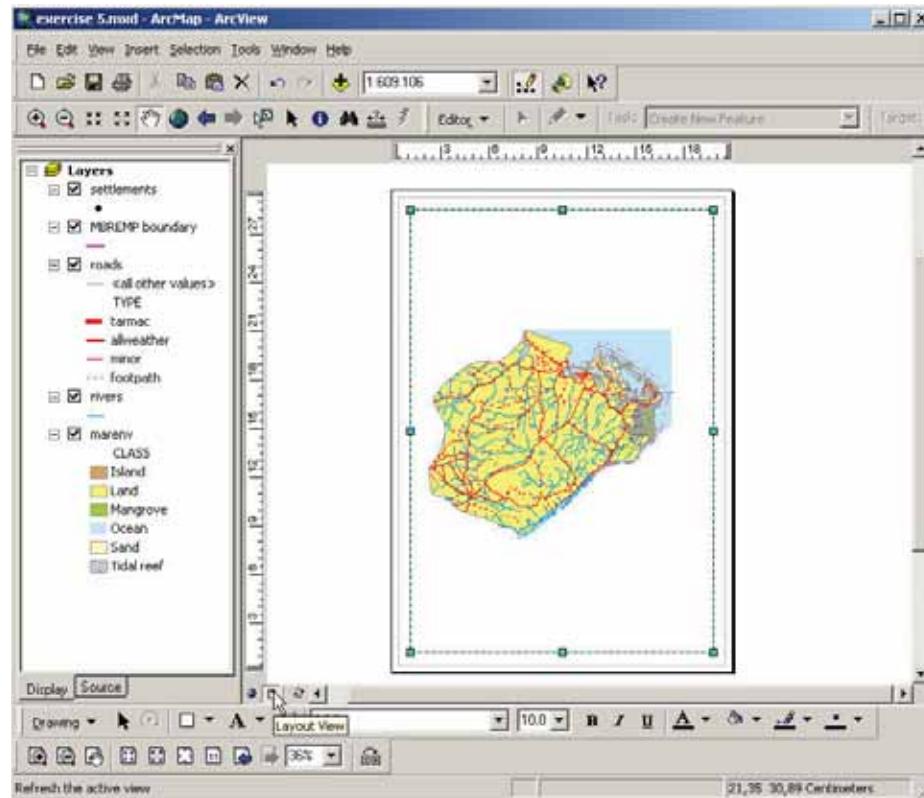
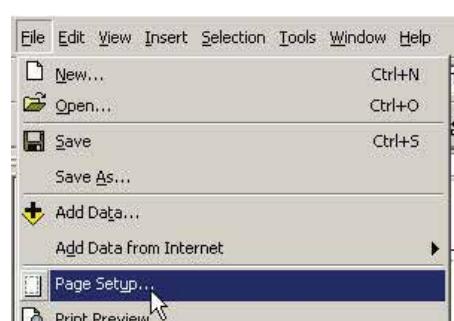


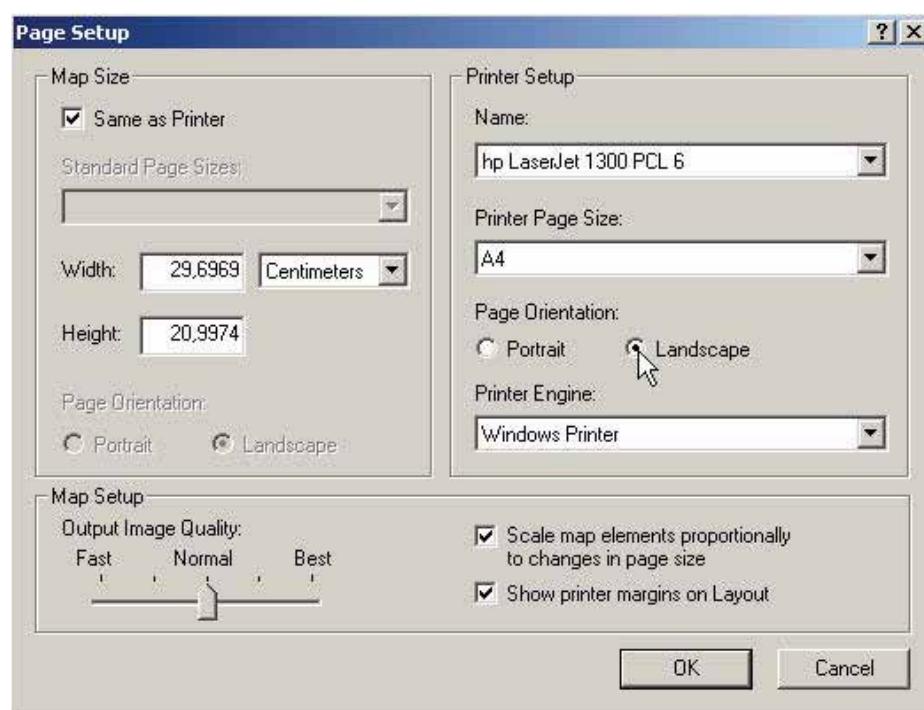
Figure 56: First version of the map in '*Layout View*'

Your map document should now look like in Figure 56. On the right side you see a sheet with a frame that contains the map we prepared. The current orientation of the page is 'portrait'. Change the setup of the page to 'landscape'.



- Select 'File'
- Click 'Page Setup'

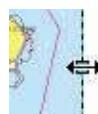
- Set the 'Page Orientation' to 'Landscape'
- Click 'OK'



Now your page will be displayed in landscape.

You can change the size of the frame that contains the map.

- Select the frame by clicking on it
- Reduce the frame by clicking on one of the small squares

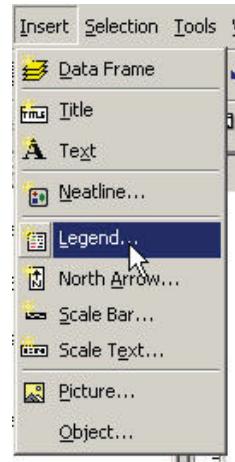


- Drag the frame while holding your mouse button
- Reduce the frame so that it fills the left 3/4<sup>th</sup> of your sheet; in the right part we will have to put the legend and other map elements

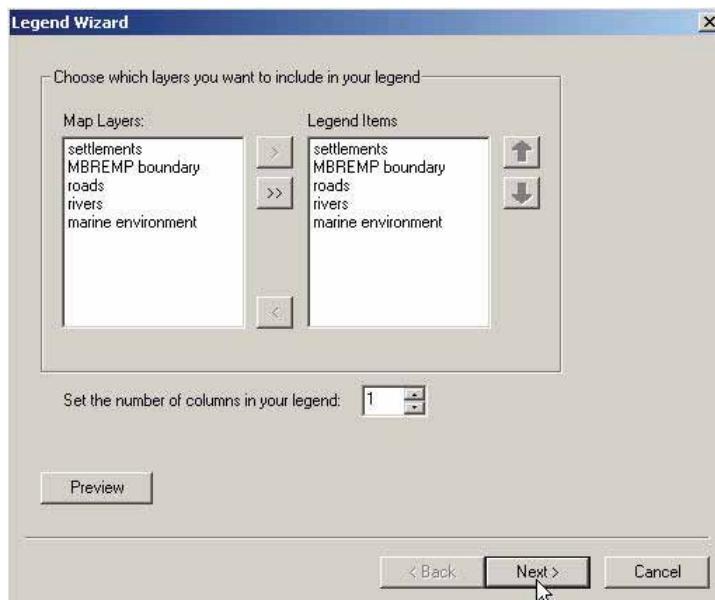
We will now zoom into the part of the area that we would like to display on the map, here the marine park. Use the 'Zoom in' and 'Zoom out' tools from the 'Tools toolbox' as you used in previous exercises.

Now we will add the different map elements.

- In the 'Menu Bar' click 'Insert'
- Select 'Legend...' and click



With the 'Legend Wizard' you can now add or remove layers to build the legend. In this case we will include all layers in the legend.



- Click 'Next'
- Go through the rest of the wizard without making any changes and click 'Next' in every window
- At the end, click 'Finish'

After doing this, the legend will be added to the layout document.

- Click on the legend and drag it to the blank space at the right of the map

Your sheet now looks as in Figure 57.

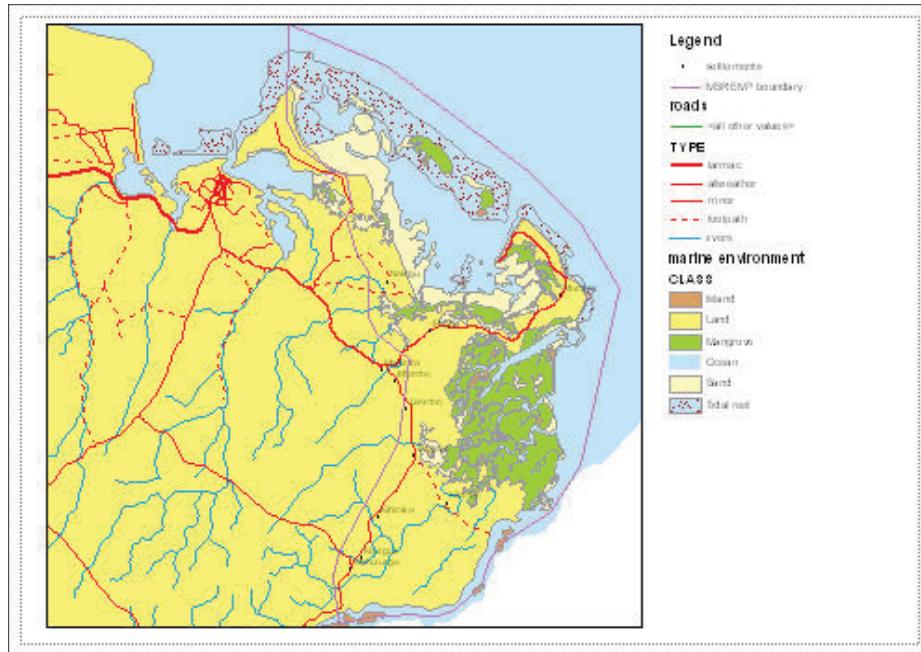


Figure 57: A more advanced version of your map

The next element we add is a ‘Scale Bar’.

- *In the ‘Menu Bar’ click ‘Insert’*
- *Click on ‘Scale Bar’*
- *From the ‘Scale Bar Selector’ select the scale bar you want to use*
- *Click ‘OK’*
- *Drag the scale bar to the place where you want to have it*

Now we can still adjust the properties of the scale bar to make it more useful and to have it fit better in our layout.

- *Double-click the scale bar to reveal the ‘Scale Line Properties’*
- *Under ‘When resizing’ select ‘Adjust number of divisions’*
- *Set ‘Division Units’ to ‘Kilometers’*
- *At the top, set the ‘Division Value’ to ‘5 km’*
- *‘Number of subdivision’ has to be ‘zero’*
- *Click ‘OK’*

The scale bar will now be updated in the document.

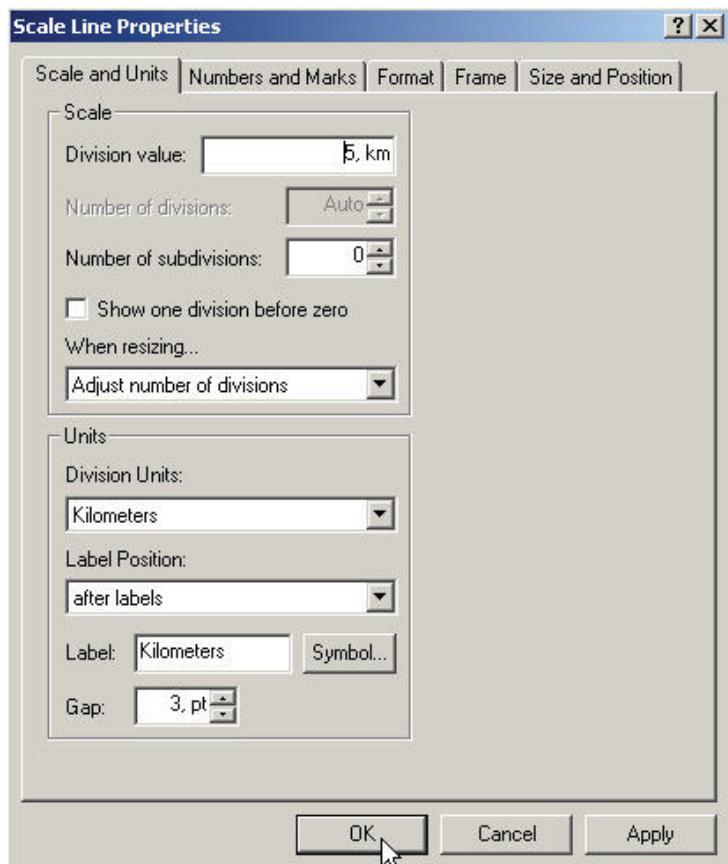


Figure 58: In the 'Scale Line Properties' window you can change properties of the scale bar

As you learned during the theoretic course, a map needs an indication of the north. We can do this by adding a 'North Arrow'.

- Click 'Insert' from the Menu Bar
- Click 'North Arrow'
- Select a north arrow
- Click 'OK'
- Drag the north arrow to the right location

The map you have now produced has all the necessary components. It should look as in Figure 59.

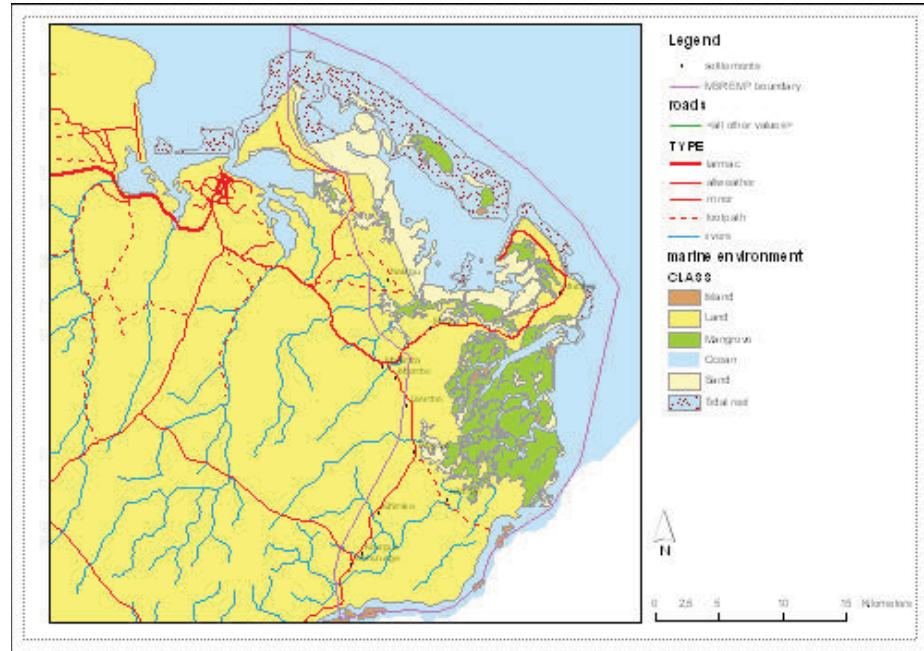


Figure 59: Your final map

You can still insert some text like a title or other additional information. Furthermore you can also use the drawing tools (Figure 60) to add frames to indicate the legend area and other items on the map. These are issues that can make the map look nicer, but not more correct.



Figure 60: Drawing toolbar

More info on mapping can be looked up in the ArcGIS help section.

- When you are satisfied with your map, close ArcMap
- Save your changes

Congratulations!! You can now work with the basic  
ArcGIS tools!

---

# APPENDIX

## Answers to the Quizzes

### Chapter 1

1. What are the components of GIS?

A GIS consists of hardware, software, data, analysis and people.

2. Which questions can GIS answer?

Questions about:

- Location: what is at...?
- Condition: where is it...?
- Trends: what has changed since...?
- Patterns: what spatial pattern exists?
- Modelling: what happens if...?

3. How is information of real-world objects represented in GIS?

Information of objects is grouped in thematic layers. Spatial information is represented by features. Descriptive information is stored in tables. Spatial and descriptive information are linked using the geo-relational model.

4. What is the difference between spatial information and geographic information?

Spatial information describes the shape and location of features. In addition to spatial information geographic information also includes descriptive information on features.

5. Which are the three types of features in GIS?

The three types of features in GIS are points, lines and polygons.

6. How can spatial and attribute data be linked in GIS?

Spatial and attribute data are linked using relational tables. When spatial and attribute data are stored using the same ID for the same objects, both types of data can be linked using the unique ID as the common field. This principle is called the geo-relational model.

7. Which components define the budget of a GIS project?

The budget of a GIS project is defined by the cost of hardware, software, labour, data and maintenance.

8. How can you collect new spatial data for your GIS?

New spatial data can be collected in the field using a GPS. Another possibility is digitizing hard copy maps to produce digital spatial data.

9. What makes GIS different from a spreadsheet program like Excel?

GIS allows for spatial operations. GIS can handle spatial information (shape and location of features) and answer spatial questions, like "How far is one feature located from another?" or "Where is a specific feature located?" These spatial questions can not be answered with Excel, so it is not GIS.

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10. What are metadata and why are they important?

Metadata are data about data, describing data type, content, format, accuracy, quality etc. this information is especially important for people from other organisations or people that will use the data in the future.

11. Describe the three components that make up the interface of each ArcGIS package.

ArcMap is a viewer for visualizing data, cartographic operations and a number of analysis functions. ArcCatalog is the component used to manage and update all the files and databases. ArcToolbox is the component where data can be analyzed without visualizing them.

## Chapter 2

12. What can GPS be used for?

GPS can be used to determine locations on the earth's surface, to determine the speed of a moving object and as a real-time navigation instrument.

13. Why are three satellites needed to measure a location?

When we know the location and distance between us and three satellites, the cross-cutting of the imaginary spheres drawn around each of the satellites determines our position on earth.

14. How can a GPS receiver determine the distance of satellites?

A GPS receiver can measure the travel time of a radio signal transmitted by the satellites. Knowing that the travel speed of a radio signal is 300 000 km per second, the GPS receiver can calculate the distance of the satellite using the equation:  
distance = speed x travel time.

15. Describe the Lat/Lon Geographic Coordinate System.

The Lat/Lon Geographic Coordinate System is a reference system to determine positions on earth. For that purpose a network is laid over the earth that consists of lines of latitude and lines of longitude. A position at the earth's surface is then determined by measuring the latitude and the longitude values and expressed as a coordinate pair.

16. Which steps are taken when measuring coordinates?

17. Adjust or check the settings: most important is to select an appropriate datum, which is ARC 1960 in Tanzania.
18. Hold the GPS receiver in the right position, assure an unobstructed view to the sky, wait for a proper signal strength
19. Determine relevant position(s) to measure and stand as close as possible. Measure the coordinates.
20. Save or write down the coordinates using a unique ID. Collect attribute data and store them using the same ID.

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## Chapter 3

1. How would you briefly define a map?  
A map is a graphical representation of a spatial setting.
2. Which elements can be found on a map?  
On every map the following elements have to be indicated: the map projection, scale and legend. Author and publication year can also be given. On the map, shapes are used to represent the locations of objects, symbols to represent their nature.
3. What is a map projection? Could you give an example?  
A map projection is the mathematical formula and related parameters that are used to transform the three-dimensional surface of the earth to a two-dimensional surface. Examples are the Mercator projection, the Peters projection and the UTM or Universal Transverse Mercator projection.
4. What is the scale of a map and why is it important?  
The scale of a map is the ratio between a distance on a map and the distance in the real world. The scale of a map is used to compare distances on a map with distances in reality. On a classical (non GIS) map the scale is also an indication of the precision of the map.
5. What is a contour line on a map and which information can they provide?  
A contour line is an imaginary line on a map, every point of which is at the same elevation above sea level. On a map contour lines can give information about the elevation of a location and indicate the steepness of slopes.