

Spatial data management

In the previous chapter you have seen how spatial data is entered in ILWIS via digitizing. Another method for obtaining spatial data is the conversion of digital data in other file formats. These data are often not directly usable in an analysis. The data may still need to be edited. The data may be in the wrong data type for a specific type of analysis. You may have to convert data from one vector type to another (e.g. from segments to polygons), or from vector to raster (rasterization). The data may also contain the wrong coordinates, georeference, domain or representation.

In this chapter the various spatial data management operations are shown, which precede the actual data analysis. The first part of this chapter (section 4.1) deals with the import of raster and vector maps from different file formats. Special attention is paid to the import of ILWIS 1.4 data. In section 4.2 the topic of map projections is treated, and how you can change maps from one projection to another. In section 4.3 tools for vector data management are shown, and in section 4.4 the vector to raster conversion is demonstrated. Then in section 4.5 the tools for the management of raster maps are explained.

The final section 4.7 focuses on the conversion of domains.

Before you can start with the exercises, you should start up ILWIS and change to the subdirectory `c:\ilwis21\data\usrguide\chap04`, where the data files for this chapter are stored.



- Double-click the ILWIS program icon in the ILWIS program group.
- Change the working drive and the working directory until you are in the directory `c:\ilwis21\data\usrguide\chap04`.

4.1 Importing digital data

In the previous chapter you have seen how to digitize maps. Maps may already be available in digital format, from another source. They may have been generated using different software, they may have resulted from scanning maps, or they may be available as digital satellite images or scanned images. In order to use these digital data in ILWIS, importing the files and changing them to the ILWIS file formats is required. Importing can be done with the **Import** module, in which you can select the import format. Importing many files from ILWIS 1.3, 1.4 or 1.41 can also be done using the **Batch Import** from ILWIS 1.4 operation.

Before you import files into ILWIS, you should know what type of data you are going to import. Whether it is a point, segment, polygon or raster map, and what type of information is stored inside the map. The content of a map determines the domain type (class, ID, value, image, picture, color etc.) that will be assigned to the imported map.

Importing raster maps

Raster maps can be imported from a number of file formats. Some of these formats do not allow for the storage of coordinates. This is the case for the frequently used file interchange formats: **Tag Image File Format (TIF)**, and the **Windows Bitmap format (BMP)**. When you import a raster map from these formats, the resulting ILWIS map will have a **Georeference None**. This means that the map is not georeferenced.

The TIF file format is frequently used as the storage type for scanned images. Here an example of importing a scanned aerial photograph of the city of Cochabamba is shown as example.



- From the **File** menu of the main window, select **Import**. The **Import** dialog box is opened.
- Select the import format: **Tag Image File Format .TIF**.
- Select the file: `Airphoto.tif`. Leave the **Output File name** as it is and click **OK**. The map `Airphoto` is now imported.
- Open the raster map `Airphoto` and check that it doesn't have coordinates.
- From the **Edit** menu of the map window, select **Properties**, and 1 map `Airphoto`. The **Properties** dialog box is opened. Check the size of the map. Check the domain.
- Close the dialog box and the map window.

As you can see the import of black and white TIFF images, results in an image domain for the output map.

When you import a TIFF image, the domain of the imported image depends on the storage type of the TIFF file. ILWIS can import raster data with 1 bit/pixel (into domain bit), 4 or 8 bits/pixel (into domain image), 4 or 8 bits/pixel with a color lookup table (into domain picture), up to 24 bits per pixel (RGB, into domain color). The same is true for files that are in Windows bitmap format (.BMP).

The user has no control over the selection of output domains of these maps. Methods to convert domains of maps are explained in exercise 4.6.

Now some examples of importing Windows bitmap files will be shown: One of a map showing the country of Bolivia (Bolmask). The other map is a hillshading image of Bolivia and its surroundings (Sashad) with 8 bits/pixel, with a color lookup table, resulting in an ILWIS map with a picture domain.



- From the **File** menu of the main window, select **Import**. The **Import dialog** box is opened.
- Select the import format: **Windows bitmap .BMP**.
- Select the file: **Bolmask.bmp**. Leave the **Output File name** as it is and click **OK**. The map **Bolmask** is now imported.
- Import also the Windows bitmap **Sashad**. Open the raster maps **Bolmasks** and **Sashad**. Check the domain types and other properties of both maps. Close the map windows. The maps will be used later on.

Other file formats, such as the ERDAS .GIS, ERDAS .LAN and IDRISI .IMG, also allow for the conversion of coordinate information. The conversion of these file formats will result in maps with a georeference corners.

Here an example is shown of the import of an ERDAS .LAN file (**Orthoim.lan**), containing a digital orthophoto of the Cochabamba study area, made with the orthorectification module that will be included in the next ILWIS version.



- From the **File** menu of the main window, select **Import**. The **Import dialog** box is opened.
- Select the import format: **Erdas .GIS .LAN**.
- Import the file: **Orthoim.lan**. As you can see after importing a raster map and a georeference are created, all with the same name (**Orthoim**).
- Open the **Properties** dialog box of the georeference **Orthoim**. Click the **Edit Properties** button and change the coordinate system to **Cochabam**.

- Display raster map *Orthoim* and add the vector maps *Contour* and *Drainage*, so that it is clear that the map has the correct coordinates.
- Close the map window.

If you have a raster image in a file format that is not in the list of import file formats in ILWIS, you may try to import it with the option **General Raster Format**. In order to do that you need to have detailed information on your raster map, such as the length of the header, the number of bands in the file, the number of columns, the storage type (bit, integer, floating point) etc.

Importing vector data

The most frequently used file formats for importing vector data in ILWIS, are the Arc/Info *.E00* format and the AutoCad *.DXF* format.

The conversion from Arc/Info *.E00* format depends on the contents of the file, and will either result in a segment map, possibly with a point map containing polygon labels, or a polygon map. The domain will always be identifier.

The conversion from AutoCad *.DXF* may be a segment map, a polygon map and/or a point map, depending on the contents of the file. If the codes in the *.DXF* file only contain numerical values (as is the case for contour lines), the output domain will be value. Otherwise it will be a class domain (if there is more than 1 code).

In this example a map of South America, in AutoCad *.DXF* format (*Samerica*), will be imported as a polygon map with a class domain. Note that in this case each polygon has a separate boundary line, without topology.



From the **File** menu of the main window, select **Import**. The **Import dialog** box is opened.

- Select the import format: **AutoCad .DXF**.
Select the file: *Samerica.dxf*. Leave the **Output map name** as it is and click **OK**. The map *Samerica* is now imported.
- Open the **Properties** dialog box of the polygon map *Samerica*, and change the coordinate system to **Latlon**. The coordinates in this map are geographical coordinates.
- Display the polygon map *Samerica*, and check the names of the polygons, and the coordinates.
- Close the map window.

For more information on the import of vector and raster data, see the **On-Line Help** or the **Reference Guide**.

Importing from ILWIS 1.41 or earlier

Data from ILWIS 1.3, 1.4 or 1.41 can be imported into ILWIS 2 for Windows. Depending on the type of ILWIS 1.4 data, and the file extension, a certain output domain will be suggested by the program.

When you import raster maps from ILWIS 1.4 you should select the following output domains:

- **Domain Class** when the elements in the original map are named by class names (e.g. mapping units in thematic maps). The .MPD, .MPI, .COL and .INF files should be available for domain Class raster maps.
- **Domain ID** when the elements in the original map are uniquely named (e.g. cadastral plots). The .MPD, .MPI, and .INF files should be available for domain ID raster maps.
- **Domain Value** when the elements in the original map refer to measurable values (e.g. altitude). The .MPD and .MPI files should be available for domain Value raster maps.

You will see the effect of the available file extensions on the suggested output domain, using four maps (all representing the land use in the Cochabamba area) in ILWIS 1.41 format. The first map (Map1) has .MPD, .MPI, .COL, and .INF files. The second map (Map2) only has .MPD, .MPI and .COL files. The third map (Map3) only has .MPD and .MPI files.



- From the **File** menu of the main window, select **Import**. The **Import dialog box** is opened.
- Select the import format: **ILWIS 1.4 raster map .MPD**.
- Select the file: **Map1.mpd**. Click **OK**. The **Input raster map from ILWIS 1.4 dialog box** is opened. The suggested output domain is **class**, since class names are found in the .INF table.
- Click **OK**. Raster map **Map1** is now imported.
- Open the **Import dialog box** again, select the same import format, and select raster map **Map2**. Click **OK**. The suggested output domain is now **Picture**, since no .INF is found. Click **OK**.
- Open the **Import dialog box** again, select the same import format, and select raster map **Map3**. Click **OK**. The suggested output domain is now **Image**, since no .INF, or .COL is found. Click **OK**.
- Display the three maps (**Map1**, **Map2** and **Map3**). Open the pixel information window, and compare the contents of the three maps.
- Close the map windows and the pixel information window when finished.

The following rules apply when you want to import other data:

- **Importing satellite images:** The .MPD and .MPI files of the satellite bands should be available. Any .COL files must be deleted, otherwise the suggested domain will be picture. During Import 1.4, select domain Image for satellite imagery with values ranging from 0-255. When the image is stored in ILWIS 1.4 as an integer map, you should select the domain NOAA when the image contains NOAA data, ranging from 0-1023, or the domain radar when the image contains radar data (JERS, ERS, Radarsat), ranging from 0-32767. Scanned raster data can be imported when the .MPD, .MPI are available. If the scanned data consists of gray values, select domain Image during Import 1.4. If the scanned data is in color, the .COL should also be available. Select domain Picture during Import 1.4.
- **Importing color composites:** The .MPD, .MPI, and .COL files of the color composite should be available. You may need to save the color composite's color look up table (.COL) in ILWIS 1.4; give it the same name as the color composite. During Import 1.4, select domain Picture for color composites.
- To import **bit maps**, the .MPD and .MPI files should be available. There is no need for a .COL file. Bit maps are automatically imported with domain Bit.
- To import **integer maps**, the .MPD and .MPI files should be available. Normally an integer map in ILWIS 1.4 represents values. In that case there is no .INF file, and the ILWIS 2 file will get the domain value. If the integer map represent classes or ID's an .INF file should also be available. In that case you can select as ILWIS 2 domain either class (which is unlikely, since you would normally not have more than 256 classes in a map) or ID domain.
- When importing **polygon maps** that were rasterized, the .SEG, .CRD, .TOP and .POL files should be available. All these files should have the same name.
- When importing **segment maps**, the .SEG and .CRD files should be available. In ILWIS 2.1, polygonized segment maps are only imported as polygon maps.
- When importing **point maps**: The .PNT should be available.

Summary: Importing data

- Raster maps can be imported from a number of file formats. Some of these formats do not allow for the storage of coordinates. This is the case for the frequently used file interchange formats: Tag Image File Format (TIF), and the Windows Bitmap format (BMP). Other file formats, such as the ERDAS .GIS, ERDAS .LAN and IDRISI .IMG, also allow for the conversion of coordinate information.
- The most frequently used file formats for importing vector data in ILWIS are the Arc/Info .E00 format and the AutoCad .DXF format.
- Data from ILWIS 1.3, 1.4 or 1.41 can be imported into ILWIS 2.1 for Windows. Depending on the type of ILWIS 1.4 data and the file extension, a certain output domain will be suggested by the program.

4.2 Map projections

The maps that you obtain after importing, often need to be changed before you can use them in combination with the rest of your data. The different tools that you can use to change vector and raster maps will be explained in the rest of this chapter. One of the most important changes that may have to be done is related to the coordinates of the map. The map may not have coordinates (in the case of raster maps imported from TIFF or BMP for example). In that case you will have to georeference and resample so that they have equal dimensions, pixel size and projection as the other maps. Also, for vector maps which have coordinates by definition, these coordinates may not be the ones that you use for other maps. In that case you will need to transform the coordinate system. The most important reason that coordinate may be different (apart from the fact that a local coordinate system may have been used), is that the original maps had different projections.

A map *projection* defines the relationship between the map coordinates and the geographic coordinates, latitude and longitude.

The *Geographic Coordinate* system is a spherical coordinate system composed of parallels of latitude (ϕ) and meridians of longitude (λ) (see figure 4.1.a).

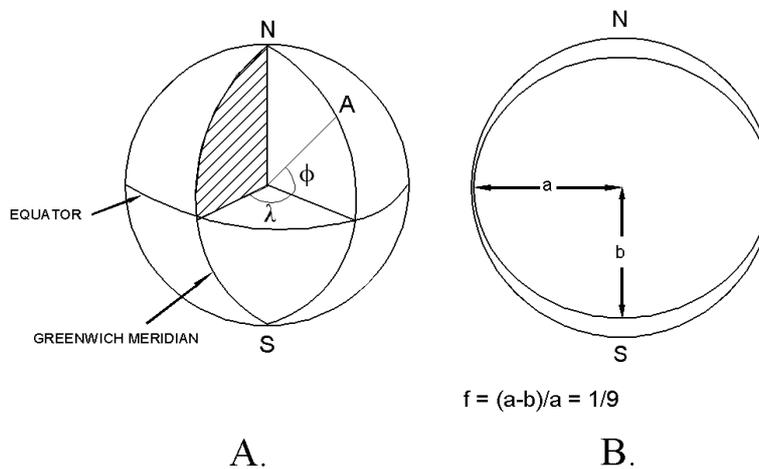


Figure 4.1: A: Geographic coordinate system: The location of A is determined by the longitude (λ) and the latitude (ϕ). B: The relationship between a sphere with radius a and an ellipse with major and semi-axis a and b

Because of the earth's rotation, the shape of the earth is not a perfect sphere. The earth is flattened towards the poles: The equatorial axis (line from the center to the equator) is longer than the polar axis. The earth's shape can be represented by an

ellipsoid, or as it is sometimes called, a spheroid (shapes that are generated by revolving an ellipse around its minor axis).

A *spheroid* has 2 different semi-axes a and b , where a is the radius of the equator circle and b is the half axis of rotation ($b < a$). See figure 4.1b.

The flattening of the ellipsoid is defined by:

$$f = (a-b)/a,$$

and the eccentricity:

$$e^2 = (a^2 - b^2) / a^2$$

It follows that the ellipsoid shape is also completely defined by a and f or by a and e . Nearly 93% of the earth's land surface is mapped using only four of these ellipsoids: International, Krassovsky, Bessel and Clarke (1880). Table 4.1 lists the ellipsoids available in ILWIS. They are stored in text file `Ellips.def`. In this file, for each ellipse the value of a (equatorial radius) and $1/f$ (the inverse of the flattening) are listed. If no ellipsoid is known, the choice by default is a sphere with $a = b = 6356007$ m.

The choice of the ellipsoid, which fits best a given region of the earth's surface to be mapped, depends on the surface curvature and *geoid* undulations in that region. Hence every country has its own "best" ellipsoid.

Table 4.1: Some reference ellipsoids which can be chosen in ILWIS

International 1924	Krassovsky 1940	Bessel 1841 (2x)	Clarke 1880
Sphere	Airy 1830	Helmert 1906	International (Hayford)
Australian National	WGS 72	WGS 84	Everest (5x)
Modified Airy	Modified Fischer 1960	Hough 1960	Indonesian 1924
GRS 1980	S.American 1969	Clarke (1866)	

The surface of the earth is curved but this should be presented in maps as a plain surface. This will always result in some deformation or distortion, unless you use a spheroidal map (a globe). To correctly represent the curved earth's surface on a flat map, you need a special *map projection*. With the help of a map projection, geographic coordinates are converted into a two dimensional metric coordinate system, measuring the X and Y directions in meters. Each map projection has unique equations for the transformation from geographic to metric coordinates.

Map projections can be subdivided according to three aspects: Class, aspect and properties.

There are three classes of map projections:

- *Cylindrical projections*

Cylindrical projections may be imagined, as the transformation to a plane that is wrapped around the globe in the form of a cylinder (see figure 4.2). Note that it is possible that the cylinder intersects the sphere (a secant cylinder). The outline of the world map would be rectangular in shape.

- *Azimuthal projections*

These projections may be imagined as the transformation on a plane tangent to the globe (figure 4.2). As with the cylindrical projections, here the plane may intersect the sphere (a secant plane). The characteristic outline of the world map would be circular.

- *Conical projections*

These projections may be imagined as the transformation to a plane that is wrapped like a cone around the globe (figure 4.2). The possibility of a secant cone is also present in this class. The outline of the world would be fan shaped.

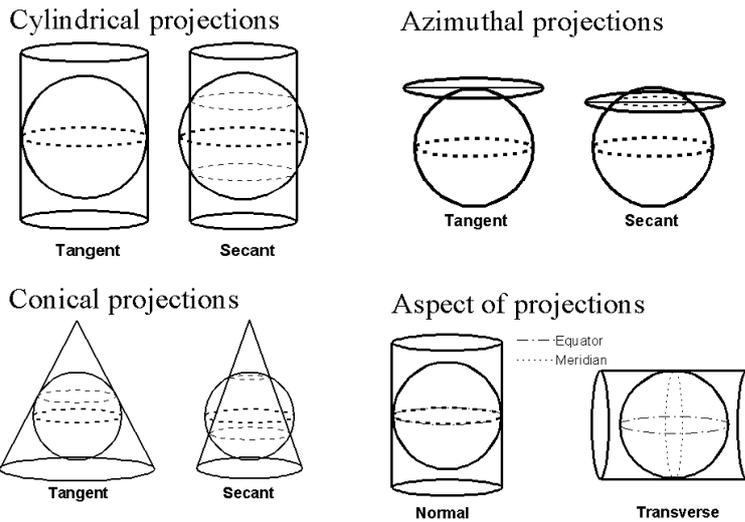


Figure 4.2: Cylindrical, azimuthal and conical projections. For each projection a tangent (touching the globe), and a secant (intersecting the globe) version is shown. The lower right part of the figure illustrates two aspects: Normal (oriented parallel to the earth's axis) and transversal (oriented perpendicular to the earth's axis)

Projections can also be subdivided according to their *aspect*: The direction in which a cylinder, plane or cone is oriented with respect to the globe. In figure 4.2 two possibilities are given: Normal and transverse aspects. For cylindrical projections a *normal aspect* is a cylinder that touches the equator. A *transverse aspect* is a cylinder that touches the poles. Similarly the normal and transverse aspects of azimuthal projections can be visualized. The aspect may also be *oblique*; in that case the cylinder, plane or cone is not horizontally or vertically oriented, but something in between.

Another important way to subdivide map projections is according to their *properties*. As mentioned before, a map projection always results in some

deformation or distortion. Depending on the type of projection, these distortions will be different. This is indicated by the so-called special properties. The most important properties are:

- **Conformality:** A conformal map is one in which all angles are indicated correctly. All angles measured on the earth's surface are measured with the same values in the map. As all angles are maintained, the shape of the objects is also preserved.
- **Equivalence:** A map with an equivalence property is called an *equal-area map*. Although the shape of objects is distorted, the area as measured on the globe is correctly indicated on the map.
- **Equidistance:** An equidistant map has the characteristic that in one direction the distances are preserved.

Map projections are named according to the class, the aspect, the property, the name of the originator and the nature of any modification. In table 4.2 an overview is given of the projections available in ILWIS.

Let us look at some map projections and see how the map of the world is displayed.



- Open the segment map `World`.
- From the **Edit** menu in the map window, select **Annotation**. The **Annotation Editor** is opened. The use of the **Annotation Editor** will be explained in detail in chapter 13. Here we only need to add a graticule.
- Click the **Graticule** button.  The **Display Options- Graticule** dialog box is opened. Click **OK**. The graticule is now added to the map window, showing parallels and meridians every 20 degrees.
- Click the **Exit Editor** button.

Now the effect of several map projections on the display of the world map will be demonstrated. For each projection a new coordinate system should be created.



- Drag the map window to the side of the screen.
- In the main window open the **File** menu and select **Create and Create Coordinate system**.
The **Create Coordsystem** dialog box is opened.
- Type for the Coordinate system name: `Centcyl`.
- Type for the description: `Using the central cylinder projection`.

Click OK. The Coordinate System Editor is opened.

- Click the Projection button.
- Select the projection: Central Cylindrical. Click OK.

The Coordinate System editor now displays more information, relevant for this projection. The Central Cylindrical uses the equatorial radius of the earth, since the cylinder touches the earth at the equator. See figure 4.2.

The *false easting*, *false northing* and *central meridian* are used to define the X, Y coordinates of the map. False easting: Overall increase of map x-coordinates ('eastings'), indicating the eastward shift of the origin of the projection relative to the redefined origin (negative if projection origin is west of false origin). False northing: Overall increase of map y-coordinates ('northings'), indicating the northward shift of the origin of the projection relative to the redefined origin (negative if projection origin is south of false origin). We won't change them now.



- Type some positive values for Max X,Y. These coordinates will be adapted anyway, based on the map displayed in the map window.
- Click OK in the Coordinate System Editor.
- Drag and drop coordinate system Centcyl to the map window in which the map World is displayed.
- Note how the World map and the 20 degrees graticules change.
- Zoom in on the central part of the world, around the equator.

The map you see is not conformal nor equal area. It is projected perspectively from the center of the earth onto a cylinder tangent to the equator (see figure 4.2). The equator and other parallels are straight lines (spacing increases towards the poles) and meet meridians (equally spaced straight lines) at right angles. Parallel spacing increases towards the poles than Equator. The poles cannot be shown. Scale is true along the equator. Shape, area and scale distortion increase rapidly away from the equator. This map projection only shows the areas surrounding the equator correctly. All other areas are too much distorted.



- Create another coordinate system: Lamazea. Select the projection: Lambert Azimuthal Equalarea.
- Type some positive numbers for Max X Y. These coordinates will be adapted anyway, based on the map displayed in the map window.
- Enter for the Sphere Radius: 6356007.
- Click OK. Drag and drop coordinate system Lamazea to the map window displaying the map World.

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Table 4.2: Some of the projections used in ILWIS

Projection	Remarks
Cylindrical	
Central cylindrical	Map is perspective but not conformal nor equal area. Projected perspectively from the center of the earth onto a cylinder tangent to the equator. Only used for teaching purposes.
Equidistant cylindrical	Also called Simple Cylindrical or Plate Carree. Used for raster maps which store information of the whole world: Each pixel represents a square block of LatLon coordinates, i.e. information is stored per degree, per minute, etc. Used for mapping the earth taken as a sphere.
EquiRectangular	Also called Plate Rectangle. Variant of Plate Carree. Used for raster maps which store information of the whole world: Each pixel represents a rectangular block of LatLong coordinates.
Mercator	Conformal. Designed for navigational use; standard for marine charts. Recommended use for conformal mapping of regions predominantly bordering the equator. Often inappropriately used as a world map.
Trasverse Mercator	Also called Gauss Conformal, or Gauss Krüger. Transverse form of the Mercator Projection (conformal). Used for many topographic maps at scales from 1: 20000 to 1: 250000. Recommended for mapping regions that are predominantly north-south in extent.
UTM	Universal Transverse Mercator. Map is conformal. Widely used for topographic maps and military maps.
Lambert Cylindrical Equal Area	Lambert Cylindrical Equal Area. Mainly used for educational purposes.
Miller Cylindrical	Compromise between Mercator and other cylindrical projections. Used in numerous world maps.
Mollweide	Pseudo-cylindrical projection. Map is equal area. Occasionally used in thematic world maps.
Azimuthal	
Lambert Azimuthal Equal Area	Lambert Azimuthal Equal Area. Used for maps of continents and hemispheres. Also suited for regions extending equally in all directions from a center point, such as Asia and the Pacific Ocean.
Hammer Aitoff	Hammer Aitoff Equal Area, variant of Lambert Azimuthal Equal Area.
Azimuthal Equidistant	Azimuthal Equidistant. Commonly used in the polar aspect for maps of polar regions and the Northern and Southern hemispheres. The oblique aspect is frequently used for world maps centered on important cities and occasionally for maps of continents.
Orthographic	Known by Egyptians and Greeks 2000 years ago. Map is perspective and neither conformal nor equal area. Only one hemisphere can be shown. The earth appears as it would on a photograph from space.
Stereographic	Apparently invented by Hipparchus (2nd century BC). Used in combination with UTM projection as Universal Polar Stereographic (UPS) for mapping poles and in navigation charts for latitudes above 80°. Recommended for conformal mapping of regions that are approximately circular in shape. For example, used for topographic maps of the Netherlands.
Gnomonic	Map is perspective and neither conformal nor equal area. It is used to show great circle paths as straight lines and thus to assist navigators and aviators.
Conical	
Albers Equal Area Conic	If the pole is one of the standard parallels, it is equal to Lambert's Equal Area Conic. Frequently used for maps of the United States, for thematic maps and for world atlases. Recommended for equal area maps of regions that are mainly east-west in extent.
Lambert Conformal Conical	Lambert Conformal Conic/Conical Orthomorphic (Lambert, 1972) (conformal). Extensively used for large-scale mapping of regions predominantly east-west in extent. Further widely used for topographic maps.
Equidistant Conic	Also called Simple Conic. The most common projection in atlases for small countries.
Polyconic	or American Polyconic (Hassler, ± 1820). Map is neither conformal nor equal area. The sole projection used for large scale mapping of the United States by the USGS until the 1950's.
Other projections	
Sinusoidal	used since 16th century. Also called Mercator Equal Area. Pseudo-cylindrical projection. Map is equal area. Used in atlas maps of South America and Africa. Occasionally used for world maps. Modifications are called sinusoidal interrupted and sinusoidal 3x interrupted.
Van der Grinten	Shows the entire earth within one circle. All areas, shapes and angles are greatly distorted

You will see that the world is projected in a circular way on a plane which touches the earth at 0 degrees latitude and longitude. Therefore, the equator and the 0 degrees meridian are straight lines.



- Open coordinate system: Lamazea.
- Enter for the **Central Meridian**: 60 00 00 W (this is in degrees, minutes, seconds).
- Enter for the **Central Parallel**: 20 00 00 N.
- Click OK. Press the redraw button in the map window.

Now the projection is such that the plane touches South America. The equator is no longer a straight line. Only the 60 degrees W meridian is now a straight line.

Now the effect of a conical projection will be demonstrated.



- Create another coordinate system: Laconco. Select the projection: **Lambert Conformal Conical**.
- Type some positive numbers for **Max X Y**.
- Enter for the **Sphere Radius**: 6356007.
- Click OK. Drag and drop coordinate system Laconco to the map window displaying the map World.

Now only the area surrounding the North pole is displayed, in a very distorted way.



- Open coordinate system: Laconco.
- Enter for the **Central Meridian**: 20 00 00 W.
- Enter for the **Central Parallel**: 50 00 00 S.
- Enter for the **Standard Parallel 1**: 40 00 00 S.
- Enter for the **Standard Parallel 2**: 60 00 00 S.
- Click OK.
- Press the redraw button in the map window.

The southern hemisphere is now shown in a conical projection.

Some projections will also be shown that are useful for displaying world maps.



- Create another coordinate system: Ortho. Select the projection: Orthographic.
- Type some positive numbers for Max X Y.
- Enter for the Sphere Radius: 6356007.
- Click OK.
- Drag and drop coordinate system Laconco to the map window displaying the map World.

The world map is now displayed as if you look at the earth from space.



- Open coordinate system: Ortho.
- Enter for the Central Meridian: 90 00 00 E.
- Enter for the Central Parallel: 30 00 00 N.
- Click OK.
- Press the redraw button in the map window.

You will now see the continent of Asia.



- See the effect of the Plate Carree projection.
- See the effect of the Mercator projection.
- See the effect of the Mollweide projection.
- See the effect of the Sinusoidal projection.
- Try other projections also, if you like.
- When finished, close the map window.

Up to now you have only seen the different projections displayed on the screen. To actually transform the map, you need to use the Transform Segment operation in this case, since the map world is a segment map. For points you use the Transform Points, and for polygons, the Transform polygons operation. They work basically the same.



Click segment map World with the right mouse button and select vector operations, Transform Segments. The Transform Segment

Map dialog box is opened.

- Select the Coordinate System: Lamazea.
- Type for Output Segment map: Wlamazea.
- Click on Show and OK.

The segment map Wlamazea is created. The Display options dialog box is opened.

- Click OK. The map is displayed.
- Add a graticule to the map window and look at the effect.
- Close the map window when you are finished.

The UTM projection

There is one map projection that will be treated in more detail, since that is the most used projection used in GIS and image processing, for relatively small study areas. The Universal Transverse Mercator projection system was developed in the late 1940s by the US Army. Since then, it has become standard in topographic mapping. The UTM comprises the following features:

- The projection is the “Gauss- Krüger” version of the Transverse Mercator.
- The projection is only intended for mapping between 84° N and 80° S. Beyond that there is too much distortion.
- The unit of measure is the meter.
- The world is divided into 60 zones of 6° of longitude in width. Zone 1 has its western edge at the 180° meridian. Zone 60 has its eastern edge on the same meridian. Consequently the zones are numbered from west to east. The zones are shown in figure 4.3. Cochabamba is located 66° 08' 52" W in longitude, and 17° 23' 30" S in latitude. So it is located on the boundary between UTM zones 19 and 20.
- A second zoning is made along the latitudes following 8° intervals (except for the most northern zone that has an interval of 12°). These zones have a better designation from south to north (see figure 4.3). So Cochabamba is located in zone 19K.
- The origin of each zone is located on a point at the equator, where it is intersected by the central meridian of that zone.
- The Easting of the origin of each zone is assigned a value 500,000 m.
- Each zone has its own coordinate system.

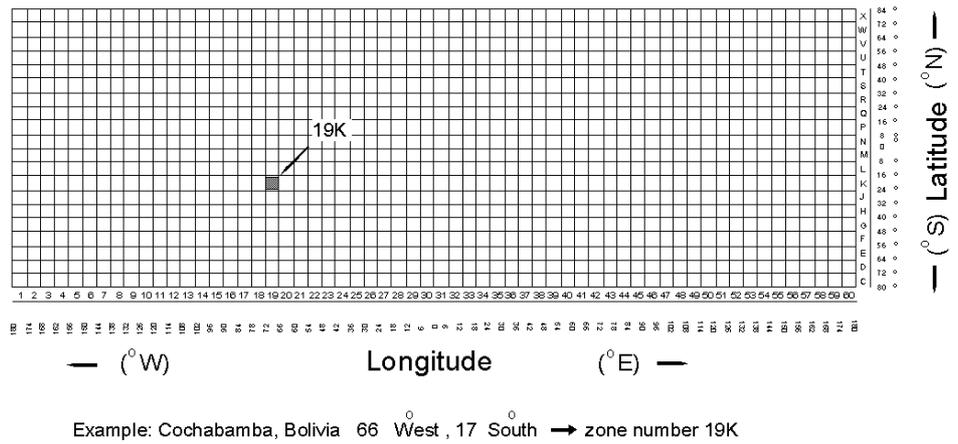


Figure 4.3: UTM grid zone designations for the world, shown on an equidistant cylindrical projection index map

- The UTM has a special convention for recording the Northings. For the southern hemisphere the equator is assigned the value 10,000,000. For the northern hemisphere the value at the equator is assigned as 0.
- The UTM might use one of the following definitions of the shape of the earth: International Spheroid, Clarke 1866 (Africa), Clarke 1880 (North America), Everest or Bessel (both for smaller parts of Southern and South East Asia).

One of the objections to the introduction of the UTM map projection, was the method of dividing the world into 60 zones. A country was likely to be divided into several UTM zones, each having its own coordinate definition and origin. Still the UTM system was accepted worldwide. Many maps show the coordinates of the national system as well as those of the UTM.

For large scale mapping, if an area lies within more than one UTM zone, the entire area has to be mapped as if it lies in that zone. One should select the zone that occupies the major part of the area, extending the borders of the zone over the +3° and -3° boundaries.

Likewise, if the country covers both sides of the equator, the coordinates from the southern hemisphere are extended for the part on the northern hemisphere (so larger than 10,000,000).

The data on the projection used should be found on the topographic map, from which you have digitized the information. On the topomap of Cochabamba, the following information is given:

- Ellipsoid: International.
- Projection: Transverse Mercator.
- Vertical Datum: Sea level.
- Horizontal datum: Provisional South America 1956.
- UTM zone: 19 K.



- Open the coordinate system: Cochabam.
- Click the Ellipsoid button and select the Ellipsoid: International 1924.
- Click the Datum button and select the Datum: Provisional South America 1956 and select the Area: Bolivia.
- Click OK.
- Clear the check box Northern Hemisphere.
- Enter for the (UTM) Zone: 19.
- Click OK in the Edit Coordinate System dialog box.

Now suppose you want to convert data from the Cochabamba area from UTM zone 20 to UTM zone 19. In order to do that you need to make a new coordinate system, in which the UTM zone 20 is indicated.



- Create a new coordinate system: Cocha20.
- Enter some positive values for Max X and Y.
- Click the Projection button and select the Projection: UTM.
- Click the Ellipsoid button and select the Ellipsoid: International 1924.
- Click the Datum button and select the Datum: Provisional South America 1956 and select the Area: Bolivia.
- Click OK.
- Clear the check box Northern Hemisphere.
- Enter for the UTM zone: 20.
- Click OK in the Edit Coordinate System dialog box.

Now that a new coordinate system is made for UTM zone 20, you can link this coordinate system to the maps digitized in that projection.

Checking coordinate transformation

Before making a coordinate transformation, it is wise to check the transformation for a few coordinate pairs. This can be done with the Transform Coordinates dialog box.

The following steps have to be done:

- Select a certain point on one of the paper maps and note its X and Y coordinates.
- Determine this point on the other paper map and note its X and Y coordinates.
- Enter one of the coordinate pairs in the ILWIS Transform Coordinates dialog box as the following:



- Double-click TransfCrd icon in the Operation-list.

The Transform Coordinate dialog box is opened. The options in this box can be used to check whether the transformation is correct. It allows you to select an input and output coordinate system, to type the X and Y coordinates of a point to be transformed and to interactively view the output coordinates for the selected point.

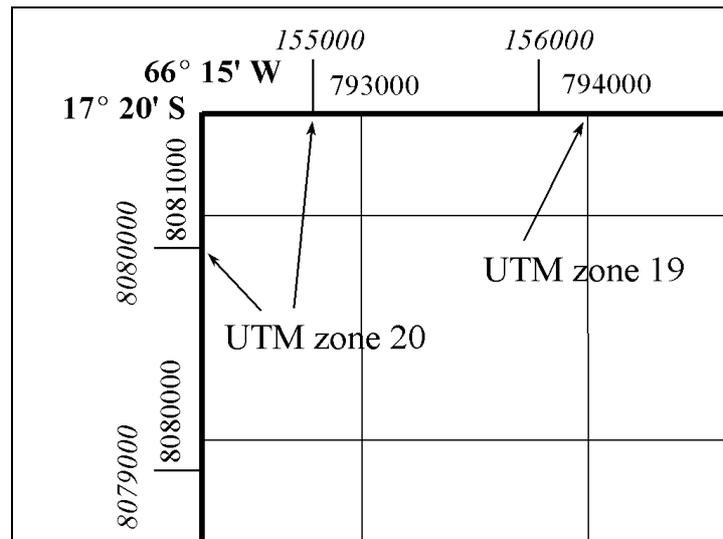


Figure 4.4: The corner of the topomap of sheet "Cochabamba" indicated the grid in UTM 19 coordinates, the tickmarks in UTM 20 coordinates and the upper left corner in Geographic coordinates

First you will check whether the conversion from latitude/longitude to metric coordinates of a certain UTM zone is correct.



- Select the coordinate system **Latlon**.
- Type the latitude and longitude as indicated in the corner of the map in figure 4.4.
- Select the coordinate system **Cochabam** in the list box **Output Coordinate System**.
- Check the metric coordinates of UTM zone 19 with those in the map in figure 4.4. Write them down.
- Select the coordinate system **Cocha20** list box **Output Coordinate System**.
- Check the metric coordinates of UTM zone 20 with those in the map in figure 4.4. Write them down.

Now you will check if the conversion of coordinates from UTM zone 20 to 19 is done correctly.



- In the **Transform Coordinates** dialog box select the input coordinate system **Cocha20**.
- Type the X and Y values that have been noted down for the conversion from **Latlon** to **UTM 20**.
- Select the coordinate system **Cochabam** in the list box **Output Coordinate System**.
- Check the metric coordinates of UTM zone 19 with those that you have written down for UTM 19.
- Close the **Transform coordinates** dialog box.

The calculated coordinates for this point in other projections will be displayed in the box. You should check the X and Y value with the ones you have noted from the paper map with the UTM projection. Small differences may occur, due to rounding errors. If the calculated coordinates are very different, you better check whether the projection parameters in the input coordinate system are correct. If the calculated coordinates are the same, follow the next steps to transform the actual map.

Transforming vectors

After checking that the transformation of some known points in two maps with different projections is done correctly, you can do the actual transformation. In this example, we have a map `City20`, in which the outline of the city of Cochabamba is digitized in UTM 20 coordinates. This polygon file will be transformed to UTM zone 19. There is also a segment map `City19`, with which you can check the result.



- Display polygon map `City20`. This map has coordinates in UTM 20.
- Display segment map `City19`. This map has coordinates in UTM 19.
- Try to drag-and-drop polygon map `City20` on the map window displaying `City19`. An error message will appear, since the two maps have different coordinate systems, and different UTM zones.

Now the actual transformation can be done.



- Close both map windows.
- Double-click `TransfPol` in the Operation-list.

The Transform Polygon Map dialog box is opened.



- Select the map `City20` in the list box `Polygon Map`.
- Select `Cochabam` in the list box `Coordinate System`.
- Type `City19` in the text box `Output Polygon Map`.
- Select the check box `Show`.
- Click `OK`. The `Display Options - Segment Map` dialog box is opened.
- Accept the defaults by clicking the `OK` button. Polygon map `City19` is displayed.
- Check the result by adding segment map `City19` to the map window.
- Zoom in where the lines are doubled.

- Add gridlines every 1000 meters (in blue), and a graticule (in green) every 5 minutes.
- Close the map window when you have finished the exercise.

Summary: Map projections

- After importing vector maps, their coordinates may not be the ones that you use for your other maps. In that case you will need to transform the coordinate system. The most important reason that coordinate may be different (apart from the fact that a local coordinate system may have been used) is that the original maps had different projections.
- A map *projection* defines the relationship between the map coordinates and the geographic coordinates latitude and longitude.
- Projections are classified according to their class (cylindrical, azimuthal, conical), their aspect (normal, transverse) and their properties (conformality, equivalence, equidistance).
- The Universal Transverse Mercator projection system, is the most used projection used in GIS and image processing, for relative small study areas. The world is divided into 60 zones of 6° of longitude in width.
- Before making a coordinate transformation, it is wise to check the transformation for a few coordinate pairs. This can be done with the **Transform Coordinates** dialog box.
- After checking that the transformation of some known points in two maps with different projections is done correctly, you can do the actual transformation.

4.3 Vector data management

A vector map can be obtained either via digitizing a paper map, as was explained in chapter 3, or from importing digital vector data, as was shown in exercise 4.1. A number of tools are available to adapt vector maps for the analysis. In order to be able to use vector maps of the same area together, all maps should have the same coordinate system. In the previous section the transformation from one coordinate system to another was explained. In this section a number of tools for further manipulating vector maps will be shown, such as the creation of a sub map, combining two or more vector maps into one map, copying selected information from a vector map using a mask, densifying coordinates, or thinning them using tunneling, editing vector maps, and the conversion from one type to another. The change of the domain type of the map will be explained in exercise 4.6.

Creating a sub map

The *sub map* operation makes it possible to select a certain window in a vector map and save it as a new map. This can be helpful if you want to use only a part of a larger map for your analysis. In this exercise, a selected window of the segment map *Drainage* will be saved as a new segment map.



- Double-click **SubSeg** in the **Operation** - list.
The **Sub Map of Segment Map** dialog box is opened.
- Select segment map *Drainage* in the list box **Segment Map**.
- Type 797200 for minimum X and 8078200 for minimum Y in the text box **Min X, Y**.
- Type 805300 for maximum X and 8083300 for maximum Y in the text box **Max X, Y**.
- Type *Drainsub* in the **Output Segment Map** text box.
- Click the Check box **Show**.
- Click **OK**.
After calculating the map the **Display Options - Segment Map** dialog box is opened.
Click **OK**.
The map is displayed.
- Compare it with the map *Drainage*.
- Close the map window when you have finished the exercise.

Glue two segment maps

This operation merges two or more segment maps of the same coordinate system and domain together. By default, it copies all segments of the input maps into the output map, unless a mask to select specific segment codes is specified. The operation also, by default, creates coordinate boundaries for the output map, based on the minimum and maximum X and Y coordinates of the input maps when it is not defined by the user. Note: If the user-defined coordinate boundaries are smaller, all segments of the input maps that fall within these coordinates are copied, and the segments outside this boundary are deleted.

! The output map of this operation may have double segments which can be removed by editing the map (see chapter 3 on how to edit segments). The segments that are supposed to continue in two or more sheets are not automatically connected to each other in the output map. They can be connected in the **Segment Editor** using the **Move points** option.

Suppose you have digitized contour lines for the Cochabamba area from two map sheets. Now you want to combine them into one single map. Suppose also that you only want the hundred meter contour lines. This means you have to use a mask.



- Display segment map `Connorth`. This segment map contains the contour lines for the northern part of the study area.
- Also display `Consouth`. This map contains the segments for the southern part of the area.
- Close both map windows.
- Double-click the item `GlueSeg` in the `Operation-list`.
The `Glue Segment Map` dialog box is opened.
- Select the option 2 for `Number of Input Maps`.
- Select the map `Connorth` and `Consouth` in the list boxes `Map`.
- Type `??00` in both text boxes `Mask`. This has the effect that only the contour lines with 100 meter contour interval are copied.
- Type `Concomb` in the text box `Output Segment Map`.
- Click the check box `Clip boundary`.

This check box is used when a user wants to specify different coordinate boundaries for the output map than those of the combination of the input maps. Otherwise, by default, the output map comprises the whole area of all input maps.



- Type for **Min Y**: 8071798. Type for **Max Y**: 8090600. Select the check box **Show**.
- Type the **Description**: 100 meter contour lines in the entire study area.
- Click **OK**.

The **Display Options - Segment Map** dialog box is opened. Accept the defaults by clicking the **OK** button in this dialog box. The new segment **Concomb** is displayed.

- Close the map window when have finished the exercise.

Masking vector data

This operation allows to selectively copy points, segments, or polygons into a vector map, by specifying a *mask* which lists the codes that are to be copied. A mask contains one or more codes, separated by a comma (spaces before or after a comma make no difference). Asterisks can be used as a wild card for zero or more characters (e.g. `grass*`, `forest*` or `1*`, `2*`). Also question marks may be used to replace only one character (e.g. the mask `??00` in a contour map, returns all contour lines with two numbers, followed by two zeros). For more information, open the **Help**, search for **Mask**, and open the Help topic: **How to use masks**. See also chapter 7, in which more examples of data retrieval with a mask will be given.

Any vector map (with domain type class, **ID**, value) can be used as input map in this operation. In fact there are three separate operations for points (**MaskPnt**), segments (**MaskSeg**) and polygons (**MaskPol**), but they work the same. The output map uses the same domain, coordinate system and coordinate boundaries as the input polygon map. In this example, the map **City19** will be used to extract only the grid lines.



- Display the segment map **City19**, and open the domain to look at the domain items. Close the domain editor and the map window.
- Double-click the **MaskSeg** item in the **Operations-list**.
The **Mask segments** dialog box is opened.
- Select segment map **City19** in the list box **Segment Map**.
- Type **Grid19** in the text box **Mask**.
- Type **Grid19** in the text box **Output Segment Map**.
- Click the check box **Show**.
- Click **OK**.
- The **Display Options - Segment Map** dialog box is opened.

- Accept the defaults by clicking the OK button in this dialog box. Now only the grid lines are shown.
- Close the map window when you have finished the exercise.

Densify segment coordinates

The operation **DensSeg** adds extra intermediate coordinates within segments of an input map, at a user-specified distance, and copies them to an output segment map. It is advised to use this operation before the **Transform segments** operation is performed. The segment map **Grid19**, which was created in the previous exercise, will be used as an example. This map contains gridlines, digitized for the Cochabamba area. Each gridline in the input map is defined by a starting and ending coordinate.



- Double-click **DensSeg** in the Operation-list.
The **Densify Segment Coordinates** dialog box is opened.
- Select the map **Grid19** in the list box **Segment Map**.
- Type 200 in the text box **Distance**. An intermediate coordinate will be added every 200 meters.
- Type **Grid19n** in the text box **Output Segment Map**.
- Click the check box **Show**.
- Accept the defaults by clicking the OK button.
The **Display Options - Segment Map** dialog box is opened.
- Accept the defaults by clicking the OK button in this dialog box.
The map is now displayed. Apparently there is no difference.
- Close the map window.

In order to be able to compare the output segment map (**Grid19n**) with the input map (**Grid19**), you need to look at both maps in the **Segment Editor**, which allows you to see the intermediate coordinates as crosses. The editor can only be used on maps that are not dependent, so the dependency link should be broken first, for both maps.



- Break the dependencies of the maps **Grid19** and **Grid19n** (by selecting the **Break Dependency Link** in the properties dialog box).
- Click the map **Grid19** with the right mouse button and select **Edit** from the **Context-sensitive** menu.

- Click OK in the Display Options dialog box. The Segment Editor is opened.
- Select the Move point mode and zoom in on a part of the map. As you can see each gridline only has a starting and ending point. Close the Segment Editor.
- Click the map Grid19n with the right mouse button and select Edit from the Context-sensitive menu. The Segment Editor is opened.
- Zoom in on a part of the map and select the Move point mode. As you can see there are now intermediate coordinates at regularly spaced intervals of 200 meter. Close the Segment Editor.
- Close the map windows when you have finished the exercise.

Tunnel segments

This is more or less the opposite of the densify coordinate operations. The aim of this operation, is to reduce the number of intermediate points and remove superfluous nodes within segments of the input map. This operation can also be used when you want to generalize your maps. The principle of tunneling was explained in chapter 3.



- Double-click TunnelSeg in the Operation-list. The Tunnel Segments dialog box is opened.
- Select the map Drainage in the list box Segment Map.
- Type 20 (meter) in the text box Tunnel Width.
- Type Drtun20 in the text box Output Segment Map. Click on the check box Show. Click OK. The Display Options - Segment Map dialog box is opened. Accept the defaults by clicking the OK button in this dialog box.
- Repeat the exercise twice: Once with a tunnel width of 50 meters (result map Drtun50), and the other with a tunnel width of 100 meters (result map Drtun100).
- Compare the results by displaying the maps Drtun20, Drtun50 and Drtun100 in the same map window, and zooming in on a part of the map.
- Close the map windows when you have finished the exercise.

Creating a polygon map from a segment map

In some cases you may have a segment map from which you want to generate a polygon map. This may be the case if you have imported a polygon map from

Arc/Info E00 format. The import results in a segment map and a point map, containing polygon labels.

When you want to generate a polygon map from a segment map, there are two possibilities:

- Using the **Segment Editor**. This method should be followed when you are not sure whether the segment map is error free. In the segment editor you can edit the segments, make a check of them, and then polygonize them. This method was explained in exercise 3.5.
- Using the **SegPol (Polygonize Segment Map)** operation. This method can be followed when you are sure that the segment map is correct. The advantage of this method is that it can be used in an automated way to periodically update files.

The last method will be shown.

In this example a segment map (Landuni2) will be used, similar to the map used in exercise 3.5, but without errors. To create a polygon map out of a segment map, all segments in the input map should be correctly digitized, that means no dead ends, no intersections, no double segments, etc. The output of this operation is a polygon map with an internal domain which contains class names or IDs such as pol1, pol2, pol3,..., etc. The domain type (class or ID) of the output polygon map is defined by the user.



- Double-click **SegPol** in the Operation-list. The **Polygonize Segment Map** dialog box is opened.
- Select segment map **Landuni2** in the list box **Segment Map**.
- Type **Landuni3** in the text box **Output Polygon Map**.
- Click the check box **Show**.
- Clear the **Label Point** box.
- Click **OK**. After creating the polygon map, the **Display Options - Polygon Map** dialog box is opened. Click **OK**.
- Check the meaning of the polygons by clicking them.
- Close the map window when you have finished the exercise.

The resulting polygon map has an internal domain, indicating the different polygons as **Pol1**, **Pol2** etc. You should still open the polygon map as a domain and change the names, or create an attribute table to reclassify them. A better option would be to polygonize the map using label points. The label points can be generated from another polygon map using the **PolPnt** operation, or digitized as a point map. In this case a label point map was already made (point map **Landunit**).



- Open polygon map Landuni3.
- Drag-and-drop point map Landunit in the map window. The Display Options dialog box is opened.
- Select the check box Text and click OK. The points are displayed on top of the polygons.
- Close the map window.

- Click polygon map Landuni3 with the right mouse button and select Vector Operations and Assign Labels. The Assign Labels to Polygons dialog box is opened.
- Select the Label Points: Landunit, and type for Output Polygon Map: Landunit. Click the check box Show and click OK.
- Click OK in the Display Options dialog box. The polygon map Landunit now contains the correct names. Close the map window.

Creating a segment map from a polygon map

The *extract boundaries* operation creates a new segment map out of a polygon map, containing all polygon boundaries. The input map for this operation is a polygon map with any domain type. The output map resulting from the conversion is a segment map with an internal class domain. The class name of a segment in the output map, is the combination of the name of the neighboring polygons. For example, the boundary between two polygons with the class name Lake and Mountain is codified in the output segment map as Lake | City.

In this exercise the polygon map Landuse is converted to a segment map.



- Display polygon map Landuse, and click several polygons to find out their names. Close the map window.
- Double-click PolSeg in the Operation-list. The Boundaries of Polygons dialog box is opened. Select the polygon map Landuse in the list box Polygon Map. Type Luse in the text box Output Segment Map.
- Clear the check box Single Name. If this check box is selected all segments get the name: Segments.
- Click the check box Show. Click OK. After creating the segment map the Display Options - Segment Map dialog box is opened.
- Select the check box Info. Click OK. Click several segments to find out the meaning of the codes.

- Close the map window when you have finished the exercise.

Several other conversion options between point, segment and polygon maps are possible. They are described in the Reference Guide and the On-line Help.

Summary: Vector data management

The following tools can be used to manage vector data:

- Creating a submap of a vector map and merging two or more vector maps.
- Selectively copying vector data using a mask.
- Obtain more intermediate coordinates within segments in a segment map.
- Tunneling: reduces the amount of coordinate data stored in a segment map.
- Creating a polygon map from a segment map, either using the segment editor or the SegPol operation.

4.4 Vector to Raster conversion

As has been mentioned already in chapter 1, most of the analyses in ILWIS are based on raster data. Therefore, conversion from vector to raster format (rasterization) is often a necessary step preceding the analysis. Points, segments and polygons are represented by grid cells (pixels) in the raster data structure. In order to convert a map from vector into raster format, a mesh with pre-defined cell size, is laid over the map. The size of the grid cells is a crucial aspect of the raster data structure.

Before starting the rasterization, a georeference should be created. A georeference contains the minimum and maximum X and Y coordinates of the raster map, the number of rows and columns and the pixel size. When rasterizing various maps of the same area, it is preferred to select the same **Georeference** for them.

The resulting raster maps have the same domain as the corresponding source vector map. Since the vector to raster operations is basically the same for point, segment or polygons maps, only the **Polygon to Raster** operation is shown here.

Creating georeferences

In this exercise the same polygon map will be rasterized three times, using three different georeferences with different pixel sizes, to show you the effect of the pixel size on the final result. The three georeferences will have pixel sizes of 10, 25 and 100 meters.



- Double-click the **NewGeoref** item in the **Operation-list**. The **Create Georeference** dialog box is opened.
- Type for **Georeference Name**: Cocha10.
- Select the **Coordinate System**: Cochabam.
- Type for **Pixel Size**: 10.
- Type for **Description**: Georeference with 10 meter pixel size.
- Click **OK**.
- Create also the georeference **Cocha25** with 25 meters pixel size and **Cocha100** with 100 meters pixel size.

Rasterization of a polygon map

The polygon to raster operation, creates a raster map from a polygon map. In this exercise the polygon map **Landuse** will be rasterized.



- Double-click the PolRas item in the Operation-list. The Rasterize Polygon Map dialog box is opened.
- Select polygon map Landuse in the list box Polygon Map.
- Type for Output Map: Land10.
- Click the check box Show.
- Type Raster map showing land use in the text box Description.
- Select the Georeference: Cocha10.
- Click the OK button of the Rasterize Polygon Map dialog box. The Display Options - Raster Map dialog box is opened.
- Accept the defaults by clicking the OK button of this dialog box. The raster map Land10 is displayed.
- Repeat the procedure, and create the raster map Land25 with the georeference Cocha25, and the raster map Land100 with the georeference Cocha100.
- Zoom in on the same part of the map in the three map windows. Drag-and-drop polygon map Landuse to each of the three map windows. Only display the boundary lines.
- Compare the three maps and evaluate the effect of different pixel sizes.
- Close all map windows when finished.

Summary: Vector to raster conversion

- Conversion from vector to raster format (rasterization) is often a necessary step preceding data analysis.
- Points, segments and polygons are represented by grid cells (pixels) in the raster data structure.
- In order to convert a map from vector into raster format, a mesh with pre-defined cell size is positioned over the map. The size of the grid cells is a crucial aspect of the raster data structure.
- Before starting the rasterization, a georeference should be created. A georeference contains the minimum and maximum X and Y coordinates of the raster map, the number of rows and columns and the pixel size.

4.5 Raster data management

A raster map can be obtained either via rasterizing a vector map, as was explained in the previous exercise, or from importing raster data, as was shown in exercise 4.1. A number of tools are available to adapt raster maps for the analysis. In order to be able to use raster maps of the same area together, all maps should have the same pixel size, and the same number of rows and columns. In this section a number of tools for manipulating raster maps will be shown, such as the creation of a sub map, combining two raster maps into one map, mirroring and rotating maps, resampling maps, editing raster maps, and the conversion from raster to vector.

Creating a sub map of a raster map

The *Sub Map* operation allows you to specify a rectangular part of a raster map and copy it into a new raster map. A raster map with any type of Domain can be used as input. The output map uses the same domain as the input map. The operation automatically creates a new georeference for the output map. This operation is very useful for creating subscenes from an entire frame of a satellite image, only covering the area of interest.

In this exercise, a selected window of a hillshading map of a part of south America (Sashad) will be saved as a new raster map (Sashads). We also have a map Bolmask, containing only the country of Bolivia. From this image the area that has to be extracted can be found.



- Open the map Bolmask, and find out the area that should be extracted (expressed in first line, first column, nr of lines, nr. of columns). Close the map window.
- Double-click SubRas in the Operation - list.
The Sub Map of Raster Map dialog box is opened.
- Select raster map Sashad in the list box Input Raster Map.
- Type 300 in the text box First line.
- Type 375 in the text box First column.
- Type 670 in the text box Number of lines.
- Type 650 in the text box Number of columns.
- Type for Output Raster Map: Sashads.
- Click the check box Show. Click OK.
- Click OK in the Display Options - Raster Map dialog box.
- Close the map window after seeing the result.

You can use the same method to extract the same area from the map Bolmask, and then create a final map only showing the hillshading for the country of Bolivia.

Glue two raster maps

The *Glue Raster Maps* operation merges two georeferenced raster maps. The input maps should have a georeference and a domain which can be merged. The input maps can have different georeferences, coordinate systems and pixel size. In the case of different georeferences, the output map will use the georeference of the first input map. If needed, the second input map will then first be resampled to the georeference of the first input map. If the georeferences of the two input maps have different coordinate systems, the coordinate system of the second input map will be transformed into the coordinate system of the first input map. In the resampling process, the size of the pixels in the second input map will be adjusted to the size of the pixels in the first input map, if they are different.

If the maps have different domains, the possible combinations for merging of the two input domains, are given in the table 4.3.

The output map is sized to allow both maps to fit in. In this way, you can glue two adjacent or partly overlapping georeferenced raster maps, derived from different sources. The output map uses a new georeference in which both input georeferences fit. The map uses the coordinate system and pixel size of the first input map. It is, therefore, important to make a careful choice of the input map.

In case two input maps overlap, users can define a pixel value that should be used for overlapping parts. By default, the pixel values of the first input map are used.

Table 4.3: Possible combinations of domains of input maps and the resulting domain of the output map

	value	class	ID	color	picture	image
value	value					value
class		class				
ID			ID			
color				color	color	color
picture				color	picture	
image	value			color		image

In this exercise two parts of a TM image, one covering the northern (Tmb1n) and the other covering the southern part (Tmb1s) of the study area, are glued together. Both maps have the image domain.



- Double-click **GlueRas** in the **Operation - list**.
The **Glue Raster Maps** dialog box is opened.
- Select raster map **Tmb1n** in the list box **1st Map**.
- Select raster map **Tmb1s** in the list box **2nd Map**.
- Type **Tmb1com** in the text box **Output Raster Map**.
- Click on the check box **Show**. Click **OK**. The map is created.

- Click OK in the Display Options - Raster Map dialog box. The map is shown.
- Close the map window when you have finished the exercise.

If you leave selected MAP 2 on top button, the values of the pixels defining the overlap are taken from the second input map. Clear this check box if these values should be taken from the first input map.

Mirror rotate

The *MirrorRotate* operation allows you to mirror a raster map in a horizontal, vertical, or diagonal line, to transpose (switch) the map's rows and columns, or to rotate a raster map 90°, 180°, 270° (clock-wise). There are no special requirements for the input map. The output raster map uses the same domain as the input raster map. The operation creates a new georeference for the output map which obtains the same name as the output map. The new georeference depends on the georeference of the input map. This operation may be needed if you get an input raster map from another source, which is rotated or mirrored. For example, when you use a scanned image and the image was not properly oriented on the scanner. As an example there is a 3D view, which is upside down.



- Display the map `View3d`. Close the map window again.
- Double-click `MirrorRotate` in the Operation-list. The Mirror Rotate Raster Map dialog box is opened.
- Select raster map `View3d` in the list box Input Raster Map.
- Select the option Mirror horizontal.
- Type `View3dok` in the text box Output Raster Map.
- Click the check box Show.
- Click the OK button. The map `View3dok` is created.
- Click OK in the Display Options - Raster Map dialog box. The map is displayed now in the correct form.
- Close the map window when you have finished the exercise.

Resampling

In many cases, the raster operations shown above will not be sufficient to get your imported raster data in the correct form, to combine them with other maps. The pixel size may be different from the other maps, or the map may lack coordinates. To overcome these problems, the map should be resampled to another existing raster map in your data base. Resampling will be explained in more detail in chapter 6, dealing with image processing. Here it is important to note that many of

the tools, originally designed for image processing, are equally valuable when working with other types of raster maps.

Suppose that you have received a geological map from someone else. Suppose that apart from the digital file you also received a table with a series of control points. If these are missing you would have to find out control points yourself by comparing the raster map with a topographic map, or with another digital map. This is shown in chapter 6. Here it is assumed that 10 control points are known. The next thing to do is to make a georeference for this map, using the control points listed in table 4.4.



- From the **File** menu of the main window select **Create** and **Create Georeference**.

The **Create Georeference** dialog box is opened.

- Type for the **Georeference Name**: *Geology*.
- Select the option **Georef Tiepoints**.
- Select the **Coordinate System**: *Cochabam*.
- Select the **Background map**: *Geology*.
- Click **OK**.
- Open the georeference *Geology*.

The **Georeference Editor** is opened, and the **Display Options** dialog box is opened.

- Click **OK**.
- From the **Edit** menu in the **Georeference Editor** select **Add Tiepoint**.

The **Add Tiepoint** dialog box is opened.

- Type the row, column, X and Y coordinates for the first point as shown in table 4.4.
- Repeat this for the other 9 tiepoints. The transformation should display **Affine**, and the **Sigma** (the error) should be lower than 1.
- Close the **Georeference Editor**. Raster map *Geology* is now georeferenced.
- Close the map window.

Table 4.4: Tiepoint locations for the raster map geology

X	Y	Row	Column
797955	8088615	127	165
804195	8087085	229	581
804915	8080185	689	629
797415	8080335	679	129
800078	8083830	446	306
802343	8081985	569	457
800835	8073450	1138	357
796455	8072865	1177	65
796050	8083628	460	38
802973	8089080	96	499

Now that the raster map Geology is georeferenced, you can resample it to another raster map, for example Landuse, which uses the georeference Cochabam.



- Double-click Resample in the Operation-list.
The Resample Raster Map dialog box is opened.
- Select raster map Geology in the list box Input Raster Map.
- Type for Output raster map: Geolout.
- Select the Georeference: Cochabam.
- Make sure the resampling method Nearest Neighbor is selected.
- Click the check box Show.
- Click OK.
The map Geolout is created.
- Click OK in the Display Options - Raster Map dialog box. The map which is now displayed has the same pixel size, rows and columns as the raster map Landuse.
- Close the map window when you have finished the exercise.

! If you want to practice some more with resampling, you can generate control points from the polygon map Citybl (city blocks of Cochabamba), and use these to georeference the raster map airphoto (scanned airphoto of the center of Cochabamba). Then rasterize the polygon map Citybl (with a pixel size of 5 meters) and resample the map airphoto.

Editing raster maps

Maps often contain errors, which are introduced during digitizing, or which are in the original imported data coming from other packages. Maps also need to be updated, when changes have occurred in an area, for example when the land use has changed. In those situations you will need to edit maps. When you use the Pixel Editor you can change the value, IDs or class name of pixels in a raster map. In the Pixel Editor, only the mouse pointer can be used, not the digitizer cursor.

Editors can only be used to edit *source maps*. *Dependent maps* (e.g. the raster map created by rasterizing a polygon map), or maps which are defined in their properties form as *read only*, can not be edited. Conceptually, it would not be a good idea to edit a dependent map, since such a map is derived from source maps, which are not changed in that case. To edit a dependent map, you should either edit the source map(s) or remove the dependency. To edit a read-only map, you should edit the properties and deselect the check box **Read-only**.

Editing raster maps using the pixel editor, is only useful if you want to make relatively small changes to a raster map. Since you can only edit pixel by pixel (including the possibility to select multiple pixels, and rectangular groups of pixels), changing irregular shapes in a raster map is rather time consuming. In that case it would be better to convert the raster map to vector (as will be explained in the next exercise) and do the editing in the segment editor. Another option would be to digitize the areas that should be changed as lines or polygons, rasterize these vector maps and use them in a map calculation statement to mask away the wrong areas in the raster map. In this exercise you will edit a raster map (called `Wrong`) with a class domain.



- Display the raster map `Wrong`. As you can see there is a part that needs to be edited: the word `Edit`.
- From the **Edit** menu in the map window, select **Edit Layer**, and `1` . map `Wrong`.
The **Pixel Editor** is opened. It asks you to zoom in on the raster map. When you have zoomed in sufficiently, the pixel values of the individual pixels are displayed.
- Click the **OK** button in the box asking you to zoom in.
- Zoom in on the word `Edit` the raster map.
- Select with the left mouse button a part of the letter `E` which is surrounded by green pixels and drag the box to the lower right part of the green area.
- Press the right mouse button and select **Edit** from the **Context-sensitive** menu. The **Edit** dialog box is opened.
- Type for **New Value**: `4`. Click **OK**.

In the pixel editor, you can select one or more pixels by clicking them or dragging a box around them, in order to change their class name, ID, or value. You can add pixels to a selection, clear a part of a selection or toggle between select and deselect pixels. To add pixels to a selection: Press and hold the **CTRL** key and click the other pixels you want to select. To clear a part of a selection: Press and hold the **CTRL+SHIFT** keys, then click previously selected pixels or drag a box around them. To toggle between select and deselect pixels: Press and hold the **SHIFT** key, then click pixels or drag a box around pixels (selected pixels are deselected and non-selected pixels are selected).



- Practice with these various options. Edit the map so that the word **EDIT** is replaced by the pixel values of the areas surrounding it.
- Exit the **Polygon Editor** when you have finished the exercise.
- Close the map window.

Raster to Vector conversion

Sometimes it is also necessary to convert raster maps back to vector maps. This can be the case, if you obtain a thematic raster map by importing a digital file from other sources. If you want to edit the map extensively, it is better not to do that with the pixel editor. It is best to convert the raster map to polygons first, then extract segments and create labels, and do the editing in the segment editor, after which you polygonize and rasterize the map again. It may also be useful to convert raster maps back to vector maps if you want to use them for high quality map production.

To convert raster data to vector data format, a 3 X 3 matrix moves over the input map and assigns a code (class name, ID or value) to the center pixel of the matrix in the output map, which depends on the class name, ID or value of the center pixel and its 4 or 8 neighbors. See chapter 9 for more information about 4 or 8-connectivity. Undefined pixels will not be vectorized. The result of the conversion depends on the homogeneity of the raster map and the pixel size compared to the size of the mapping units. The program is provided with a smoothing facility, to remove the sharp corners formed by the boundaries between mapping units of the raster map. Automatic tunneling (see chapter 3) is performed on the coordinates of the vector data to delete the redundant ones. The input map is a raster map with domain class, ID, value, or group.

In this exercise the raster map `Slopec1` is converted to a polygon map.



- Double-click **RasPol** in the Operation-list.
- The **Polygons of Raster Map** dialog box is opened.
- Select raster map `Slopec1` in the list box **Raster Map**.

- Type Slopecl in the text box Output Polygon Map.
- Click the check box Show.
- Type Polygon map slope classes in the text box Description.
- Click OK.
The calculation will take some time. After that the Display Options - Polygon Map is opened.
- Accept the defaults by clicking the OK button.
The polygon map is shown.
- Close the map window when you have finished the exercise.

Now you will see the effect of converting a raster map to segments. When you convert from raster to segments, only the boundary lines between mapping units are stored, but in such a way that it is still possible to find out what the mapping units on both sides of the line are.

The output map resulting from the raster to segment conversion, uses an internal class domain. In the next section you will learn more about internal domains. The class name of a segment between two areas, is the combination of names (class name, ID or value), of the areas on both sides of the segment. For example, the class name of the segment between an area with class name a and an area with class name b is a|b (figure 4.5).

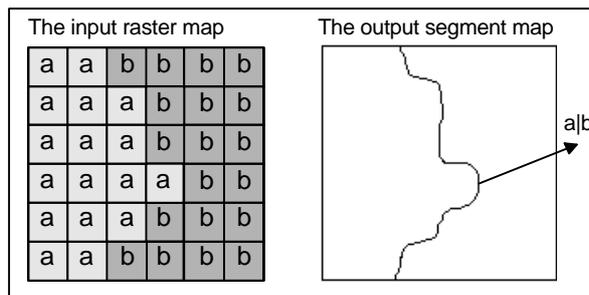


Figure 4.5: Conversion of a raster map to a segment map (see the text for explanation)



- Double-click RasSeg in the Operation-list.
The Segments from Raster Map dialog box is opened.
- Select raster map Slopecl in the list box Raster Map.
- Type Slopeseg in the text box Output Segment Map.
- Click the check box Show.
- Type Segment map slope class in the text box Description.

- Clear the **Single Names** check box. Click the **OK** button.
The **Display Options - Segment Map** is opened.
- Select the check box **Info** and click **OK**.
- Find out the class names of the segments.
- Close the map window when you have finished the exercise.

Summary: Raster data management

The following tools can be used for raster data management:

- Copying a rectangular part of a raster map into a new raster map, using the **SubMap** operation.
- Merge two raster maps (**GlueMaps** operation).
- Mirror, transpose or rotate a raster map (**MirrorRotate** operation).
- Resampling a raster map to another georeference.
- Editing a raster map using the **Pixel Editor**.
- Converting a raster map to a polygon or a segment map.

4.6 Domain conversion

In the previous exercise, especially during the exercise dealing with import, you have seen that in ILWIS your map may have another domain than you would like. Sometimes the domain of a map should be changed, e.g., converting a domain Value to a domain Class. In this exercise the various methods for domain conversion are treated.

A warning about changing domains

Apparently the easiest solution for changing the domain type would be to simply change the domain in the **Edit Properties** dialog box of the map. This should be done with care! This method is only recommended for converting between domains of the same type (e.g. for converting a class domain Landuse1 with a class domain Landuse). You should make sure, however, that the two domains have the same ordering of the raw values. If the ordering is different, than the names in the map will be mixed after changing the domain.

Changing domains of maps via the **Edit Properties** dialog box, is not recommended for changing from one domain type to another (e.g. from domain class to domain value). If you do that your file may become corrupted. For changing domain types, follow the guidelines described below.

Conversion between an ID domain and a class domain

Class domains and identifier domains are not so very different. It is, therefore, easy to convert from one type to the other. The conversion from a class domain to an identifier domain can be done by clicking the button **Convert to Classes** in the **Properties** dialog box of the domain. The conversion from an identifier domain to a class domain can be done by clicking the button **Convert to Identifiers** in the **Properties** dialog box of the domain.

Take for example the polygon map Landuse, containing the land use types in the study area. This is a class map.



- Click the domain Landuse with the right mouse button and select **Properties**.
The **Properties** dialog box is opened. As you can see the domain contains 12 domain items.
- Press the **Convert to Identifiers** button. The domain is converted to an identifier domain.
- Open the **Properties** dialog box of the domain Landuse again. Now you can see that it reads: **Domain Identifier Landuse**.
- Press the **Convert to Classes** button. The domain is converted back to a class domain.

The conversion from classes to identifiers is not very logical for the map `Landuse`, since each land use class contains various polygons. An identifier domain is generally useful if each domain item is linked to one map feature (point, segment, polygon, or group of connected pixels in a raster map).

There is, however, a way to convert a class map to a Unique ID map, using the **Unique ID** operation. This operation can be used to give a unique ID to all features in a segment, polygon or point map. The results of the operation are a map and an attribute table with the same name. The output map uses an ID. The output table has the same ID domain as the output map and consists of one column, containing the original class names. The information in the column consists of the classes, IDs or values of the original map per ID in the output map.



- Double-click `UniqueID` in the Operation-list. The `Unique ID` dialog box is opened.
- Select polygon map `Landuse` in the list box `Input Map`.
- Type `Landid` in the text box `Output Map`.
- Type `Landid` in the text box `New Domain`.
- Select the check box `Show`. Click `OK`. The map `Landid` is made and the `Display Options` dialog box is opened. Click `OK`.
- Click the polygons in the map window to view the IDs.
- Open the table `Landid` to view the original class name of the polygons and the assigned ID.
- Close the map window and the table when you have finished the exercise.

The `UniqueID` operation can only be performed on vector maps. The equivalent operation for raster maps is called `Areanumbering`, and will be treated in chapter 9.

Converting a class or ID domain to a value domain

The conversion from a class or an identifier domain to a value domain, can best be done by creating another map through renumbering the original class or ID map with a column from the attribute table. Conversion from a class map to a value map is mostly forming part of an analysis, in which the original class or ID map is renumbered with attribute information from a table linked to a map.

Take for example the map `Citybl`, which is a map using an identifier domain, in which each building block of the city of Cochabamba has a separate code. Linked to that map is an attribute table (`Citybl`) which contains, amongst others,

information on the number of persons living in each cityblock (column Population).



- Open the polygon map `Citybl` and double-click some units to find out the information from the attribute table `Citybl`.

In this case the conversion from identifier to value only makes sense when you want to create for example a population map.



- Close polygon map `Citybl`.
- Click polygon map `Citybl` with the right mouse button and select **Vector Operations and Attribute Map**.
The **Attribute Map** dialog box of **Polygon Map** is opened.
- Select the **Attribute:** `Population` and type for **Output Polygon map:** `Populat`. Click on **Show** and **OK**. The map `Populat` is created and the **Display Options** dialog box opened. Click **OK**.
- The map `Populat` is a value map. Check this by clicking some units and looking at the **Properties** dialog box of the map `Populat`.
- Close the map window and the dialog box.

The simple conversion of the map `Citybl` from identifier to value domain would make no sense. If you do that the values have no logical meaning, and besides of that the map can no longer be linked to an attribute table.

Converting a value domain to a class or ID domain

The conversion from a value or an image domain to a class domain may sometimes be necessary. For example, when you have imported an ILWIS 1.4 map which only had the `.MPD` and `.MPI` files, and the information of the class names in the `.INF` files was lost. It is also possible that you imported a scanned thematic map as a gray scale TIF file. When you want to convert from a value map to a class map, you should know the names of the legend units that should be assigned to the different values.

For the conversion from a value map to a class or ID map, there are two possibilities:

- When you have a value map that has values with a precision other than 1, you should create a **Group** domain (in which the boundary values and the class names are indicated) and use the **Slicing** operation as described in chapter 7.

An example of this is the classification of a Digital Elevation Model into a classified altitude map.

- When you have a value map that has values with a precision of 1, which actually display thematic information instead of measured data, the procedure is as follows:

1. Create an ID domain with a sufficient number of items.
2. Change the domain from value to the ID domain in the Properties dialog box of the map.
3. Edit the ID while keeping the map open.

This is illustrated with a map which was imported from ILWIS 1.4 in exercise 4.1. The map `Map3` only had a `.MPD` and a `.MPI` file when it was imported. It was imported as with an image domain. It is, however, not an image but a class map with information on land use types.



- Open the raster map `Map3`. Click some pixels in the map. As you can see the map displays numbers instead of class names. Close the map window.
- From the **File** menu in the main window, select **Create** and **Create Domain**. The **Create Domain** dialog box is opened.
- Type for the **Domain Name**: `Luse`. Select the option **Identifier**, and type for the number of items: 20. Click **OK**. The **Domain Editor** is opened. No changes will be made now. Close the **Domain Editor**.
- Open the **Properties** dialog box of the map `Map3` and press the button **Edit Properties**. The **Edit Properties** dialog box is opened.
- Select the domain `Luse`. Click **OK**. Note the change in the **Properties** dialog box.
- Click **OK** in the **Properties** dialog box.
- Open the map `Map3` and the domain `Luse`. Click a unit to find out its ID. Change the name of this ID to the class name, according to table 4.5.
- Change all the domain items and replace them by the land use type, according to table 4.5. Delete the domain items that are not used. Close the domain editor.

- Open the Properties dialog box of the domain `Luse` and press the **Convert to Classes** button.
Now a representation is also created with the same name (`Luse`).
Close the Properties dialog box.
- Now you can edit the representation and the conversion from value to classes is ready. Close the map window.

Table 4.5: Relation ID and Class names

ID	Class name
nr 1	Agriculture
nr 2	Agriculture (irrigated)
nr 3	Airport
nr 4	Bare rock
nr 5	Bare soils
nr 6	Forest
nr 7	Grassland
nr 8	Lake
nr 9	Riverbed
nr 10	Shrubs
nr 11	Urban centre
nr 12	Urban periphery

Converting a picture domain to a class domain

The conversion from a picture domain to a class domain, can be done by clicking the button **Convert to Classes** in the Properties dialog box of the domain. If you want to convert a picture domain to an identifier domain, you first convert it to classes and then press the button **Convert to Identifiers** in the Properties dialog box of the domain.

This type of conversion is also quite common, after importing a windows bitmap .BMP or .TIF file, or after importing an ILWIS 1.4 raster map that had a .MPD, .MPI, and .COL file, but no .INF. Similarly for the conversion from value to class, you should know which pixel values represent which classes.

This is also illustrated with a map which was imported from ILWIS 1.4 in exercise 4.1. The map `Map2` had a .MPD, an .MPI, and a .COL file when it was imported. The file containing the class names (.INF) was missing. It was imported with a picture domain. It should be a class map, with information on land use types.



- Double-click raster map `Map2`. In the Display Options dialog box select the check box **Info** and click **OK**. Click some pixels in the map. As you can see the map displays a combination of red, green and blue instead of class names. Close the map window.
- Open the Properties dialog box of the domain `Map2` and press the

button **Convert to Classes**.

- Open the map `Map2` and the domain `Map2`. Click a unit to find out its class name.
- Change all the domain items and replace them by the land use type according to table 4.5. Deleting the domain items that are not used is not necessary (there are in total 256 classes). Close the domain editor.
- Now you can edit the representation and the conversion from picture to classes is ready. Close the map window.

Converting a picture domain to a value domain

The conversion from a map with a picture domain to a value domain may sometimes be necessary. For example, when you have imported from ILWIS 1.4 a byte map, which was actually an image or a value map (.MPD and .MPI files without a .INF file), but which also had a color lookup table (.COL file). In that case the default output domain during the conversion is the picture domain. The import of TIF color files or BMP files also results in a picture domain for the output map, while in fact it should be value (in the case of a slope map for example), or image (in the case of a satellite image). So the conversion from picture to value, or to image, may happen quite often. Since a picture domain is used for byte maps, the conversion can simply be done by changing the domain type in the **Properties** dialog box.

This can be demonstrated with the hillshading map of Bolivia (`Sashad`), which was imported in exercise 4.1 from Windows bitmap .BMP format. This map has a picture domain. It will be converted to an image domain.



- Open raster map `Sashad`. Check that the map has a **Picture** domain. Close the map window.
- Click raster map `Sashad` with the right mouse button and select **Properties**.
The **Properties** dialog box is opened.
- Press the **Edit Properties** button. The **Edit Properties** dialog box is opened.
- Change the **Domain** to **Image**. Click **OK** in the **Properties** dialog box.
- Click **OK**.
- Open raster map `Sashad` again. From the **Display Options** dialog box you can see that the map has domain image. Check this by clicking some units and looking at the **Properties** dialog box.
- Close the map window and the dialog box.

Converting a color domain to a value domain

Finally, there is a possibility that you have imported a 24 bits/pixel Windows bitmap. This is converted in ILWIS to the color domain. The colors of a map with a color domain, can only be seen correctly when your screen uses a 24 bits/pixel display (millions of colors). You can convert maps with a color domain easily to an image domain, with the **Color Separation** operation (which will be explained in chapter 13).

Summary: Domain conversion

You should be careful when changing the domain of a map. If you do not follow the guidelines described in this section, the file may be corrupted.

The following domain conversions are possible in ILWIS:

- Conversions between class and ID maps, is easily done by pressing the Convert to Identifiers button or the Convert to Classes button, in the Properties dialog box of the domain.
- Conversion from class or ID to value, is done by renumbering the class/ID map with a value column from an attribute table.
- Conversion from a value domain to a class/ID domain, can be done either by using the Slicing operation (when the value map has a precision other than 1), or by creating an ID domain, and replacing this in the Properties dialog box of the map (when the value map has a precision of 1).
- Conversion from a picture domain to a class domain can be done, by pressing the Convert to Classes button in the Properties dialog box of the domain. Conversion to ID domain can then also be done (see above).
- Conversion from a picture domain to a value domain can be done, by changing the domain in the Properties dialog box of the map.
- Conversion from a color domain to an image domain can be done with the Color Separation operation.

