CHAPTER 22

Cibodas: analysing the fuelwood demand

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Summary

To be able to construct a model which is calculating and displaying the spatial and temporal variation of the expected demand and production of fuelwood in the Cibodas Biosphere Reserve, Java, Indonesia, data concerning the fuelwood production of various land cover types, and the fuelwood demand or consumption in the area has to be collected and analysed first.

The fuelwood demand is determined by the population size and the fuelwood consumption per capita. Therefore, it is necessary to know where the settlements are located and the number of people inhabiting the settlements. As the population statistics refer to the smallest administrative unit in the area, the administrative unit map has to be compiled first and later on linked to the settlement map to calculate the population density (and thus the demand) per settlement.

Getting started

The data for this case study are stored on the ILWIS 2.1 CD-ROM in the directory d:\appguide\chap22. If you have already installed the data on your hard-disk, you should start up ILWIS and change to the subdirectory where the data files for this chapter are stored, c:\ilwis21\data\appguide\chap22. If you did not install the data for this case study yet, please run the ILWIS installation program (see ILWIS Installation Guide).

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- Double-click the ILWIS program icon in the ILWIS program group and change the working drive and the working directory until you are in the directory c:\ilwis21\data\appguide\chap22.

22.1 The Cibodas Biosphere Reserve

The Cibodas Biosphere Reserve is located in the province of West Java, Indonesia and lies within the administrative districts (Kabupaten) Bogor, Cianjur and Sukabumi. The Biosphere Reserve has a core area, the Gudung Gede-Pangrango National Park (approximately 150 km2), a buffer zone partly surrounding the core area (approximately 48 km2) and a transition area that is strongly influenced by human activities. The altitude ranges from about 300 m to over 3000 m. The Gudung Gede-Pangrango has a mean annual rainfall between 3000 and 4200 mm. The wettest season is from October until May, coinciding with the NW monsoon; in the driest months (June to September) the average monthly rainfall drops below 100 mm. The annual average temperature varies from 18° to 10°. The core area is covered by various types of mountain forest; the buffer zone contains mainly tea plantations and production forests; the transition zone contains mainly irrigated rice fields, vegetable fields, small scale tea plantations and homestead gardens. Wet rice cultivation ("sawahs") are mainly found in the lower areas, especially in valleys below 900 m. Small parts of dryland cultivation (cassava, maize, sweet potatoes, beans) can be found in these areas also. There are no people permanently living in the core and buffer zones while the transition zone is heavily populated and is one of the most densely populated areas of Java.

22.2 Available data

The following data set is available for analysing the fuelwood demand:

`Adminis`	Map with the administrative units of the Cibodas area.
`Cbrb`	Raster map with the boundaries of the Cibodas Biosphere Reserve.
`Contour`	Map with the contour lines digitized from existing topographic maps.
`Infra`	Vector map containing the infrastructure in the area.
`Landuse`	Land use map of the study area, derived from the classification of multispectral image, improved with an air photo-interpretation and fieldwork.
`Popstat`	Table with information about the population in the area from 1984 to 1992.
`Settleme`	Map with the settlements in the area.

22.3 Some basic calculations

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- Display the raster map Adminis and check the map and the accompanying attribute table using the pixel information window.

  It is also possible to check the map by displaying the legend belonging to the map by selecting the check box Legend in the Display Options dialog box.

- Check the size of the units (the area is in m^2) by creating a histogram table (select Histogram from the operations list).

! How many km^2 is the National Park (NP)?
What is the smallest unit?

The population statistics from 1984 to 1992 are available in the table Popstat. This table has the same domain as the map Adminis (Adminis). This means that the population data is only known for each administrative unit. However, some of the settlements within the administrative units are located outside the area of interest: the Cibodas Biosphere Reserve (CBR).

To calculate the actual population within each administrative unit that lives within the CBR, we will use the following formula:

$$P_x = P_t * (A_x / A_t) \qquad [22.1]$$

P_x =	Population within the CBR of an administrative unit;
A_x =	Settlement area within the CBR of an administrative unit;
P_t =	Total population in an administrative unit;
A_t =	Total settlement area within an administrative unit.
A_x / A_t =	The ratio of the settlement area within the CBR over the total settlement area of an administrative unit.

First you will calculate A_t.

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- Cross the maps Adminis and Settleme to create a cross table Admnsetl.

- Open the cross table Admnsetl and type the following formula on the command line:

  `Areaset:=iff(isundef(Settleme),0,Area)↵`

- Aggregate the areas of the settlements to get the total settlement area in each administrative unit.
- To do so, select Column, Aggregation; select column Areaset; select function Sum. Select Group by: Adminis, since we want to calculate it for each administrative unit. Enter the output table name Popstat and the output column name At.
- Close the cross table Admnset1 and open the table Popstat.
- Aggregate At to get the total area of the settlements in all administrative units.

! The sum of the total settlement area for all the administrative units should be about 63.125 km^2. Check it!

The next step is to know the area of the settlements within the CBR of each administrative unit; the parameter A_x. For that a map which contains only the settlements within the CBR should be made. The area of the CBR is shown in the map Cbrb.

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- Close the table Popstat.
- Apply the MapCalc equation:

  `Settcbr=iff(Cbrb,Settleme,"?")↵`

In this case, you have to use "?" (instead of ?), because the calculation is referring to a class domain, and not a value domain.

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- Cross the maps Adminis and Settcbr to create a cross table Admcbset.
- Open the cross table Admcbset and type the following formula on the command line:

  `Areaset:=iff(isundef(Settcbr),0,Area)↵`

- Aggregate the areas of the settlements to get the total settlement area in the CBR of each administrative unit. To do so, select Column, Aggregation; select column `Areaset`; select function Sum; Select Group by: `Adminis`; give the output table name `Popstat` and the output column name Ax.
- Close the cross table `Admcbset` and open the table `Popstat`.
- Aggregate Ax to get the sum ofthe settlement areas within the CBR.

! The sum of the total settlement area within the CBR should be about 48,554 km^2. Check!

Now you know the area of the settlements in each of the administrative units (`At`) and in the CBR part of the administrative units (Ax).

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- Apply the equation:

  `Cbrfract:=At/Ax↵`

- Apply this factor `Cbrfract` to the population numbers `Pop9192` to get the total population of the settlements within the CBR.

  `Cbrpop92:=Cbrfract*Pop9192↵`

To be able to calculate the fuelwood demand for the CBR in the future, an estimated population growth of 3.1 percent will be used for extrapolation of the population values to the year of calculation:

$$\text{Pnew} = \text{Padmin} * \left\{ \left(\text{Pgrowth}/100 \right) + 1 \right\}^{(\text{year-1992})} \qquad [22.2]$$

where:

Pnew =	Estimated population within the administrative unit for a certain year in the future.
Padmin=	Population within the administrative unit for the year 1991/92.
Pgrowth =	Estimated annual population growth (%).

You will calculate as an example the expected population in 1998:

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- Calculate the population for each administrative unit for the year 1997/98, by applying the equation:

  `Cbrpop98=Cbrpop92*POW(((3.1/100)+1),6)↵`

  Select a value range from `0` to `1000000` and a precision of `1`.

For any year, the population numbers per administrative unit can be multiplied with the fuelwood consumption per capita to obtain the fuelwood demand of the corresponding population :

$$\text{FWDpop} = \text{Pnew} * \text{Ccap} \qquad [22.3]$$

where:

FWDpop = Fuelwood demand of the population in an administrative unit, (m^3/y).

Pnew = Estimated population in the administrative unit for a given year.

Ccap = Average annual fuelwood consumption per capita (m^3/y).

The average fuelwood consumption is estimated as 0.6 m^3 per capita per year.

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- Calculate the fuelwood consumption (m^3/year) for each administrative unit for the year 1997/98. Name the output column `Fwdpop98`.

The home- and other small scale industries consume about 4.1% of the total amount of fuelwood. This means that the population account for 95.9% to the total fuelwood consumption. And therefore, FWDpop represents only 95.9% of the total fuelwood demand.

The total fuelwood consumption (demand) per administrative unit can be estimated (m^3/year/settlement) as follows:

$$\text{FWDtot} = \text{FWDpop} * \left\{ (100\%) / \text{HomeCons}(\%) \right\} \qquad [22.4]$$

where,

FWDtot = Total fuelwood consumption (demand) within the administrative units (m^3/y).

HomeCons= Contribution of the households to the total fuelwood consumption within the administrative units (%).

FWDpop= Fuelwood demand per administrative unit, based on the population size within the administrative units (m^3/y).

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- Calculate the total fuelwood demand for each administrative unit:

  `Fwdtot98=Fwdpop98*100/95.9 ↵`

Now, you can link the total fuelwood demand of 1997/98 (as calculated in the table `Popstat`) for each administrative unit to the administrative unit raster map (`Adminis`).

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- Close the table `Popstat`.
- Open the table `Adminis` and select Columns, Join to the table `Popstat`; select the column `Fwdtot98`. Click OK.
- Use the operation AttribRas to renumber the map `Adminis` with the column `Fwdtot98` of the table `Adminis`, and create a map `Fwdtot98`, representing the total fuelwood demand (m^3/y) to each administrative unit for the year 1997/98.
- Display the map `Fwdtot98` with a Pseudo representation.

22.4 The fuelwood production aspect

The land cover in the Cibodas Biosphere Reserve has been classified using satellite imagery, aerial photographs (scale 1:50000) and other existing maps. Furthermore, field surveys have been carried out to verify and update the classification. This resulted in the classification of seventeen different land cover types.

Together with additional research and analysis of existing literature, the fuelwood production per hectare per year for the different land cover types has been estimated.

Although the National Park is producing a considerable amount of wood (woody biomass of undisturbed natural forest is about 250m^3/ha), which is also suitable for fuelwood, this area is strictly protected and, therefore, the fuelwood production is considered to be zero for the purpose of the model.

Table 22.1. Fuelwood production (m^3/ha/year) per land cover type in the Cibodas Biosphere Reserve

Land cover type	Fuelwood production (m^3/ha/year)
1x Rice +, Vegetables (sawah)	0.5
2x Rice +, Vegetables (sawah)	0.3
3x Rice + Vegetables (sawah:)	0.1
Crater lahar (NP)	0.0
Crater shrubs (NP)	0.0
Dryland cashcrops	0.7
Dryland tumpang sari	4.0
Dryland vegetables	0.7
Fidh ponds	0.0
Homestead garden	5.2
Irrigated land with vegetables	0.7
Lake	0.0
Mixed garden	3.5
National Park forest	0.0
Production forest	2.2
Sec. forest or abandoned tea	7.5
Settlements	0.0
Tea estate	1.2

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- Open the table `Landuse`.
- Create a column `Fwpha` and enter the values of table 22.1 (m^3/ha/year).
- Recalculate the column `Area` (m^2) to hectares and give the name `Areaha` to the new column.
- Calculate the annual fuelwood production (m^3) for each land unit. Name the new column `Fwplunit`.
- Create an attribute map with the fuelwood production values (`Fwpha`) (m^3/ha/year). Name the new output map `Fwpcbr`.

In order to calculate the fuelwood production per administrative unit based on the land use types in the area, the administrative unit map has to be combined with the fuelwood production map.

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- Cross the maps `Adminis` and `Fwpcbr`. Name the cross table `Adminfwp`.

From the cross table you can calculate the fuelwood production per administrative unit.

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- Open the cross table `Adminfwp` and check the different columns.
- Recalculate the area (m^2) to hectares. Name the column `Areaha`.
- Calculate the total fuelwood production (m^3/year) for each combination. Use the equation:

  `Fwpcross=Areaha*Fwpcbr`↵

- Aggregate the fuelwood production values per administrative unit. Select Column, Aggregation. Select column `Fwpcross` and the function Sum. Select Group by: `Adminis`. Name the output table `Adminis` and name the output column `Fwptot91`.
- Close the cross table.
- Create an attribute map with the fuelwood production (m^3/year) for each administrative unit. Name the output map `Fwptot`.

22.5 Fuelwood surplus or shortage

The combination of the fuelwood production and the fuelwood consumption per administrative unit results in spatial information concerning the amount of fuelwood surplus or fuelwood shortage per unit. Therefore, the fuelwood demand is subtracted from the fuelwood availability (production per administrative unit) and distributed over the settlements within each administrative unit (inside the Cibodas Biosphere Reserve).

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- Compare the maps with the fuelwood demand `Fwdtot98` and the fuelwood production `Fwptot`.
- Calculate in MapCalc the actual fuelwood situation (surplus or shortage in m^3 fuelwood/year) within the CBR for each

administrative unit. Name the new map Fwbadmin.

- Use the MapCalc equation:

  `Fwbadmin=Fwptot-Fwdtot98↵`

You don't have to calculate the surplus or shortage with map calculation. It is easier to do it as a table calculation operation.

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- Open the table Adminis, and type the following formula:

  `Fwbcbr=Fwptot-Fwdtot98↵`

- Check the difference in results!

! What is causing the difference?
Which methodology is more accurate?

As there are many settlements per administrative unit and all the people are assumed to live in any of these settlements, extrapolation of the shortage/surplus over the settlements in each administrative unit is based on the proportion of each settlement area per administrative unit.

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- Open the table Settleme.
- Join the column Fwbcbr of table Adminis with key column Adminis.
- Calculate the histogram of the map Settleme, and type the following formula in the table Settleme:

  `Areaset:=Settleme.His.Area ↵`
  This is another way of joining columns.

- Use Column, Aggregate, for column Areaset, select the function SUM and Group by: Adminis. Name the output column: Sareaadmin. (adjust the value range : 0 to 1.e11)
- Calculate the fuelwood balance for each settlement within the CBR using the TabCalc equation:

  `Fwbsettl=(Areaset/Sareaadmin)*Fwbcbr↵`

- Make an attribute map using map Settcbr and column

Fwbsettl from table Settleme. Name the output map Fwbsettl.

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- Classify the settlement map Fwbsett according to their fuelwood surplus and shortage.
- Create a group domain Fwbclfy and add suitable classnames and upper boundaries.
- Use the Slicing operation with the input map Fwbsett1 and the domain Fwbclfy, and create the map Fwbclfy.
- Create an appropriate representation for the map.

If there is an estimated fuelwood shortage in a certain area (settlement), it is assumed, that the still needed amount of fuelwood will be collected from nearby settlements with a surplus or from the tropical rainforest in the core zone (National park).

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- When analysing your settlement map Fwbsettl or Fwbclfy, where can impact in the NP, due to illegal fuelwood collection, be expected?
- It might be useful to add (through Options, Data layer management) the segment map of the administrative units to the displayed settlement map Fwbsettl for location of the National Park boundary.

22.6 Accessibility to the National Park

Another aspect of the model is the accessibility to the National Park. The more easier the access, the more people tend to go into the National Park for collecting fuelwood, especially if there is a shortage.

Therefore, the existence of infrastructure, different types of land cover, the protective function of a buffer zone, the slope steepness and of course the location of the settlements are taken into consideration. In other words the travel time from a certain settlement with fuelwood shortage to areas with surplus fuelwood (e.g., the National Park) is related to the slope steepness, infrastructure, land cover type, buffer function and distance. The infrastructure in the area was classified in three different road types, each with a specific travelling speed (in km/hour).

As distance calculations (the use of which will be explained later) have to run along the roads, which should be without interruptions, the raster map Infra has to be filtered to make the lines (roads) a little bit thicker (without interruptions).

Both the Dilate4 filter or the Conn8to4 filter can be applied to create a suitable thickness of the rasterized lines representing the roads. However, filtering accepts only one class/value at a time. Therefore, the segment map Infra has to be filtered repeatedly according to the different segment names.

Table 22.2 The travelling speed per infrastructure (road) type in the Cibodas Biosphere Reserve

Road type	Travelling speed (km/hr)
Trail	3.0
Second road	6.0
Main road	6.0

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- Make three different road maps through selecting MaskSeg from the operations list. Input segment map Infra; mask Main road; output segment map Main .
- Do the same for segment maps Secund and Trail.
- Rasterize the three segment maps Main, Secund and Trail.
- Give the output raster maps the same names as their respective segment maps.
- Break the dependency links and change the maps to value domain.
- Filter the raster maps Main, Secund and Trail by applying a suitable filter: Select Filter from the Operation list. Input map Main (also Secund and Trail). Select filter type Binary. Select filter Conn8to4. Name the output maps: Mainflt, Secunflt and Trailflt. Select Domain Infra .
- Combine the three maps again through MapCalc and name the map Infraflt.
- Assign the travelling speed values to the filtered raster map Infraflt. Use an appropriate MapCalc equation. Name the new map Spdinfra

The different land cover types were also classified according to the expected walking speed (table 22.3).

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- Assign the travelling speed values to the raster map `Landuse`. First create a new column in the table `Landuse` called `Speedlu` and add the travel speed values for each land unit.

Table 22.3. Travelling speed per land cover type in the Cibodas Biosphere Reserve

Land cover type	Travelling speed (km/hr)
Settlements	6.0
Lake and fish ponds	0.0
Sawah	2.0
Dryland vegetables and cashcrop	2.0
Mixed - and homestead garden	1.5
Dryland tumpang sari	2.0
Irrigated land and vegetables	2.0
Tea estate	2.5
Production forest and fuelwood plantations	1.0
Unproductive forest and abandoned tea	0.7
National Park	0.5

The introduced buffer function, expressed in percentages, is an assumption for the fraction of the population, that will go to the National Park by crossing the buffer zone. This function does not really delays the travel, but has a discouraging function for people who want to cross the zone.

For production forest, people who are not employed, are not allowed to be in this area. The same is true for the tea estates, but as people crossing the tea estates are more easy to detect, the discouraging function is much higher.

Based on personal observations and interviews with local authorities, the "buffer function" for production forest is assumed to be effective to only 50 percent, and for the tea estates to only 20 percent of the population, that are expected to pass through. There will then be a reduction of 50 and 80 percent of the travelling speed in these landuse types respectively.

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- The travelling speed in two landuse types (production forest and tea estates) have to be recalculated according to their buffer function.
- Recalculate the column `Speedlu` in the table `Landuse` by assigning the buffering values for the production forest (* 0.5) and tea estate (* 0.2). Name the new column `Spdlubf`.

- Create an attribute map of the raster map Landuse using the column Spdlubf with the new travelling speed per landunit type. Name the output map Spdlubf.
- Combine the road map Spdinfra with the landunit map Spdlubf in such a way that the roads are included (overlaid on top of) in the land units. Apply the MapCalc equation:

  ```
  Spdrdlu=iff(isundef(Spdinfra),Spdlubf,Spdinfra)
  ↵
  ```

The slope steepness of the area will also influence the accessibility to the National Park. By interpolating the contour lines of the map Contour (a map representing the slope steepness, in percentages) can be created.

Note that the area covered by the map Contour is bigger than the CBR boundary. This is, because during interpolation strange effects might occur along the edge of the map. To avoid these mistakes, a larger area has to be digitized.

You will create a digital elevation model of the Cibodas Biosphere Resource, using the digitized segment contour map Contour. In fact this map contains isolines and, therefore, it is also called an *isoline* segment map.

Interpolation can be done via the option InterpolSeg in the operation list, where you have to enter a contour map.

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- From the Operations-list select Interpolation, Contour Interpolation in the Operations menu to open the Interpolate Contour Map dialog box. Select contour map Contour. Click on Show to see the results directly after the calculation. Select the appropriate Georeference Georef. Optionally you can describe the new map. Name the new output map Demtot.
- Check the results of the map (altitude in meters).
- Optionally, in Layer Management you can add the segment contour map and check, if the values of the contours correspond with the values of the map Demtot.
- Mask out the area outside the CBR by combining the map Demtot with the map Cbrb, using MapCalc. Name the new elevation map Dem.

To calculate the slope percentages of the map Dem, ILWIS uses two steps. Apply digital gradient filters dfdx and dfdy to create two so called x-gradient and y-gradient maps. These two gradient maps are used to derive differences in elevation in all directions in the construction of a slope map.

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- Create the slope map (in percentages) `Slope` from the digital elevation map `Dem`. To do so, select Filter in the Operations-list and enter the raster map `Dem` as input map.
- Open the linear filter list box and select dfdx to create the x-gradient map `Dx` (accept the default Domain, Range and Step).
- Repeat the same operation to create the y-gradient map `Dy` by selecting the dfdy filter.
- To create the slope map `Slope` in percentages, apply the MapCalc equation:

  `Slope=(HYP(dx,dy)/pixsize(dem))*100↵`

  (pixel size = 50).
- Display the slope map using pseudo representation and adjust the stretch from 0 to 50.

The steeper the slope the more it will reduce the travelling speed. Therefore, the slope steepness corresponds to its expected influence on the travelling speed, called the slope correction factor.

Table 22.4. The slope steepness classes and the correction factors applied to the travelling speed in the Cibodas Biosphere Reserve

Slope steepness class	Slope correction
0% - 5%	1.00
5% - 10%	0.96
10% - 20%	0.82
20% - 30%	0.65
30% - 45%	0.50
45% - 65%	0.41
65% and higher	0.29

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- Classify the slope map `Slope` according to the left column in table 22.4. First create a new group domain `Slopecls` with classes corresponding to table 22.4. Then apply the Slicing operation on map `Slope`, using the domain `Slopecl`; name the new (classified) map Slopecls.

Create a new slope factor map by applying the slope-steepness factor in table 22.4 to the classified slope map Slopecls.

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- Make a new (attribute) table Slopecls using the same domain as the map Slopecls.
- Create a new column with domain Value. Name the column Slopefct. Enter the values from the right column of table 22.4.
- Create a new (attribute) map from the Slopecls map using column Slopefct from the table Slopecls. Name the new map Slopefct.

These slope steepness correction factors will be used to estimate the final travelling speed per land cover type. By combining the accessibility factors with the settlement locations map, the expected travelling time from each settlement to the National Park can be calculated.

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- Apply the slope factor map Slopefct to the travel speed map Spdrdlu to get the actual travelling speed in the CBR area. Use the MapCalc equation:

  Speedcbr=Slopefct*Spdrdlu↵

As high values increase the travelling speed, the distance calculated will be shorter compared to areas with low speed values. To correct this effect, the inverse values of the travelling speed should be used to get a base map with low values for easy access conditions and high values for difficult access conditions.

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- Apply the inverse values from the travelling speed map Speedcbr to create a base map expressing the accessibility. Name the map Reldist.

22.7 Impact assessment of the Cibodas National Park

To estimate the vulnerability of the National Park, the calculated expected travelling time from each settlement to the National Park has to be combined with the "motivation" of the local people per settlement to collect fuelwood from the National Park. The "motivation" is based on the relative fuelwood shortage for that specific settlement.

The settlements with a fuelwood shortage will be used as starting points for an accessibility calculation, taking as weight the "travelling speed" values per cover type, reduced by the slope steepness. The settlements with shortage will have boundaries with values proportional to the inverse shortage of the settlements, to simulate the so called "motivation". This means, when the shortage is low, the values of the surrounding boundaries should be high. High values are reducing the "travelling speed" in the distance calculation process. Therefore, the lowers the fuelwood shortage, the higher the resistance values around settlements (low motivation). The higher the fuelwood shortage, the lower the resistance values around settlements (high motivation).

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- Use the values of the settlement attribute map `Fwbsettl` to estimate the motivation of each settlement.
- Create a segment map `Settlecbr` from the raster map `Settlecbr`.
- Assign proper values to each segment in the segment map, through Edit, Edit object, using the values of the map `Fwbsettl`.
- Rasterize the segment map `Settlcbr` giving the output name `Settlring`.
- Check if the values are corresponding correctly with the values of the raster map `Fwdsettl`.
- Apply a suitable filter to make sure the motivation rings are well connected (see Section 22.5). Name the output map `Ringflt`.

Note: There are several different possibilities to assign the values to the motivation rings, before or after filtering, to the segment map or to the filtered raster map.

If the values are assigned to the segment map first, make sure the dependency has been broken, otherwise the segment map can not be edited! Break Dependency link through Properties.

As high fuelwood shortage per settlement stands for high motivation, the values of these rings should be low, low fuelwood shortage settlement rings should have corresponding high values.

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- Apply inverted values to the motivation rings.
- Use the histogram of `Fwbsettl` to estimate the range of values and to invert these values. Use a proper MapCalc equation to invert the values in the raster map `Ringflt`.
- Combine the map `Ringflt` with the base map `Reldist` (Section 22.5) to create the weight map to be used in the distance calculation later on. Name the output map `Weight`.
- Create a polygon map from the raster map `Settlcbr` through RasPol from the Operation list.
- Create a point map of the polygon map `Settlcbr` using PolPoint and activate Assign Label. Name the point map `Settcbr`.

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- Rasterize this point map using PntRas from the operation list. Select a point size of `1`. Name output map `Settpnt`.

Note: The source map for distance calculations should always be a raster map!

This point map can be used to apply the distance calculation. Each point (settlement location) is now surrounded by a motivation ring with a certain value.

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- Apply the Distance calculation from the Operation list. Enter for source map `Settpnt`. Select Weight Map `Weight` and name the output map `Distance`. Accept the other default items and click OK.
- Display the raster map `Distance`.
- Add, through Data layer Management, the segment map of the N.P. boundary.
- Check, where the values of the distance map are penetrating most into the N.P.

Note: Creating a N.P. boundary map is possible through many ways: through MapCalc equations, through selectively copying segments from the map `Adminis` (using Mask), etc.

The classes used for the spatial display of the expected impact in the National Park are derived from the amount of fuelwood shortage, calculated for the Cibodas Biosphere Reserve. Their upper boundaries are established according to the rules given in Table 22.5.

Table 22.5: Fuelwood limits to establish the boundaries of the Cibodas Biosphere Reserve

Class	Total fuelwood shortage
1	0.1
2	0.05
3	0.01
4	0.01]

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- Make a new map showing the `Impact` classes as described above. Name the map `Impactcl`
- Make a representation and save this as a view map `Impactnp`.

The displayed result of the model represents the expected impact on the National Park in the year 1997/98. It is expressed in four classes: 1 (severe), 2 (moderate), 3 (low) and 4 (no impact).

By using this classification, the impact class 2 (moderate) will use a (display) area 2x larger than that of class 1 (severe). Impact class 3 (low) will use a (display) area 10x larger than impact class 1 (severe). In the final output map the displayed impact areas (class 1, 2 and 3) will cover about 20% of the total displayed National Park area. This will give a visually good interpretation of the actual situation in the national park, although the displayed impact areas are inflated. Furthermore, as soon as the fuelwood shortage becomes lower or higher, the displayed impact will cover a smaller or larger area as well, proportional to the change in the fuelwood shortage. For statistical data (real data) on the amount of fuelwood available, the demand for fuelwood and the shortage of fuelwood, the user is referred to the references.

The estimated impact on the natural vegetation in the National Park is based on the expected loss of woody biomass (m^3/ha) per sample per year, compared to (% of) the estimated woody biomass (250 m^3/ha) of undisturbed forest of the Natural Park. The estimated woody biomass of the undisturbed forest is an averaging or a range of estimations of the woody biomass in undisturbed tropical evergreen rainforests.

References

Bekkering, T.D. and Rusmanhadi. (1987). *Issues on fuelwood*. Kali Konto River Project, Working Paper no. 12, malang, Indonesia, 26 pp.

Gier, A. de. (1989). *Woody biomass for fuel, estimating the supply in natural woodlands and shrublands*, ITC publication no. 9, 142 pp.

Hueruman, H. (1979). *Consumption and availability of energy in rural areas in relation with the environmental situation in West Java*. Forest Faculty IPB, Bogor, Indonesia, 22 pp.

Toxopeus, A.G. (1996). *ISM, an Interactive Spatial and temporal Modelling system as a tool in ecosystem management*. PhD-thesis, ITC, Enschede, The Netherlands, 250 pp.

Whittaker, A.D. and Woodwell. (1971). Measurement of net primary production of forest. pp: 159-175. In: P. Duvigneand (ed.), *Productivity of forest ecosystems*. UNESCO, Paris.

Wiersum, K.F. (1976). *The fuelwood situation in the Upper Bengawan Solo*. Upper Solo Watershed Management Development project, Solo, Indonesia.