Chapter 16
Population

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Abstract This chapter presents the method developed for modelling absolute population trends and dividing the absolute population numbers into household size and income, parameters incorporated in the DANUBIA model *Demography*. The model provides information about the overall population and the summarized household incomes by district. The population trend was integrated in RIWU in an individually adjustable time trend separate from the model that determined the absolute population trend for the entire drainage basin. Unpooling of values for population and income determined by RIWU by district is done by means of remote sensing, and the disaggregated values are then assigned to proxels. Results show that, on average, 1,142.2 people live in a modelled, populated proxel. The results obtained with the aid of remote sensing represent a close approximation of reality.

Keywords GLOWA-Danube • Upper Danube • Economics

16.1 Introduction

In the context of modelling the global change scenarios, population is a key factor in determining household water demand. In addition to absolute population trends, key determinants for calculating specific water requirements include household size and income. Both parameters are incorporated in the DANUBIA model *Demography*.

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Table 16.1 Mean percentage distribution of population in Germany

Households	Income						
	<1,100€ (%)	1,100–1,999€ (%)	2,000–2,999€ (%)	3,000–5,000€ (%)	>5,000€ (%)	Total Germany (%)	Total Austria (%)
1 person	14.86	14.60	3.71	1.03	0.18	34.37	33.53
2 persons	1.90	10.91	10.38	6.86	1.75	31.79	28.55
3 persons	0.18	3.22	5.65	5.68	1.43	16.16	16.30
4 persons	0.00	1.76	4.13	4.94	1.76	12.59	13.91
=5 persons	0.00	0.38	1.63	2.17	0.91	5.09	7.71
Total	16.93	30.86	25.49	20.68	6.02	100.00	100.00

STATISTIK AUSTRIA (2003) and Federal Statistical Office (1998)

The method developed for dividing absolute population numbers between these two determinants is introduced below.

The environmental economics subproject developed the regional economic simulation model RIWU (Regional Industrial Water Use) as a basis for the DANUBIA model *Economy*. In addition to modelling economic development and industrial water use (see Chaps. 17 and 45), this model provides information about the total population and the sum of the household incomes by district. The goal of the independent DANUBIA model *Demography* is to divide the population by proxel into one of five categories for household size and income onto a 5×5 matrix (see Table 16.1). The data calculated by the RIWU model for population and household income are read into each calculated time increment (month) in *Demography*. In order to prepare the 5×5 matrix, it is first necessary to disaggregate the values for population and income determined by RIWU at the district level onto the proxel and then to assign these to the 25 fields on the matrix. These two steps are described below.

16.2 Preparation of the Data

The data for the RIWU model are introduced in the caption for the "Gross Domestic Product" map (see Chap. 17). The statistics from the economic calculation of the Federal Statistics Office (Statistisches Bundesamt 1998) form the basis for calculating the 5×5 matrix. These statistics are based on a representative population survey conducted in Germany in 1993 (28,917 households); each household size category listed in Table 16.1 is assigned to 28 income categories. For simplification, these 28 income categories from the official statistics are summarized into five categories in the model presented here. Table 16.1 reveals the concise averaged population distribution according to the official statistics.

Algorithms were developed within the DANUBIA model *Demography* that adapt for each proxel this average distribution or the average income on which it is

Table 16.2 Percentage distribution for Switzerland

Households	Income					
	<1,985€ (%)	1,985–3,308€ (%)	3,309–4,632€ (%)	4,633–5,956€ (%)	>5,956€ (%)	Total (%)
1 person	5.52	7.21	5.83	3.40	3.18	25.15
2 persons	0.93	5.79	6.65	6.63	14.78	34.78
3 persons	0.07	0.35	2.40	4.75	7.08	14.65
4 persons	0.00	0.82	3.79	3.09	10.90	18.59
=5 persons	0.00	0.18	1.06	1.54	4.05	6.83
Total	6.52	14.34	19.74	19.42	39.99	100

based. That is, a 5×5 matrix is determined for every possible average income (combination of the variables household income and population) that can be calculated by RIWA (see Sect. 16.3).

A comparison of available values about household size and income distribution for Austria indicates good consistency with comparable values for Germany. Thus, the percentage of individual household size categories in the overall population is consistent with the distribution in Germany, differing by only a few percentage points (see the two right-hand columns of Table 16.1). Even the Gini coefficient as a proxy variable for the income distribution is almost identical in both countries (Germany: 30; Austria: 31; Central Intelligence Agency 2004). Therefore, the average matrix used for Germany and the algorithms on which it is based can be applied to the Austrian portion of the drainage basin.

This approach cannot be applied for Switzerland. Both the population distribution into household size categories and the absolute incomes deviate too much from the German and Austrian values. Thus, a separate method for determining the 5×5 matrix was developed for Switzerland. Because Switzerland constitutes only a very small portion of the drainage basin and even there only a few proxels are populated, the simplest method possible was selected. A 5×5 matrix was developed based on official statistics (Schweizerisches Bundesamt für Statistik 2003); in contrast to the German and Austrian portions of the basin, the percentage allocations in this matrix were independent of the modelled average incomes of each proxel. The percentage distribution shown in Table 16.2 is thus constant for all simulations for each populated proxel in the Swiss portion of the basin (Grisons).

16.3 Description of the Model

The population trend was integrated in RIWU in an individually adjustable time trend separate from the model. In addition to the economic development, this time trend also determines the absolute population trend for the entire drainage basin. The distribution of population by district is positively associated with the level of economic activity of a region. Thus, in the relatively socially homogenous region of the Upper Danube basin, it is assumed that the dominant effect on population trend is from population movements to take up job offers.

16.3.1 Calculation of Proxel Values

Since a uniform distribution of the district values calculated in RIWU over all proxels would yield meaningless results because all proxels would falsely appear populated at a uniform density, a tool for disaggregating the data was developed for DANUBIA. The tool is applied in its general form for all variables calculated by the environmental economy subproject. The important steps of this tool to calculate proxel values for the population variable are presented below:

Remote sensing is the key tool for unpooling the district values. Their images make it possible to estimate the distribution of administrative parameters by means of the land use classifications. For the distribution of the population values, a GIS was prepared based on the CORINE land use data from the hydrology/remote sensing subproject; within a municipality, this GIS matches linearly the population known from the official statistics to the CORINE land use category designated as "development with residential buildings". For example, this means that a proxel with 40 % of its area built-up has four times as large a population as one with only 10 % built-up.

However, this procedure is not sufficient, since in many municipalities that are populated according to statistics, there are no populated areas included in the land use category, since the community is too small or too thinly populated for the 250×250 m CORINE classification to identify. This applies predominantly to regions in the Central Alps. For this reason, a GIS and decision rules were used to seek an "optimum" population proxel for these communities. All inhabitants listed in the community statistics are assigned to this "artificial" population proxel. In locating all such proxels, it is first assumed that proxels with large areas of water, frozen or rocky areas should have no artificially placed populations. This assumption already excludes many proxels as regions for "artificial" population. Of the remaining proxels, the minimum of the so-called population index is sought for each community concerned:

$$\text{Population index} = \text{Altitude above sea level} + \left(\text{slope}\left[^\circ\right] * 50\right)$$

All inhabitants from this community are assigned to the appropriate proxel. The distribution that results serves as a relative, constant key to distributing the district values for population and household income calculated in RIWU to the proxels. The percentage of the population out of the total population of a district calculated in this way is deemed to be fixed. The population and its income therefore develop proportional to the proxels populated from the outset.

16.3.2 Configuration of the 5×5 Matrix

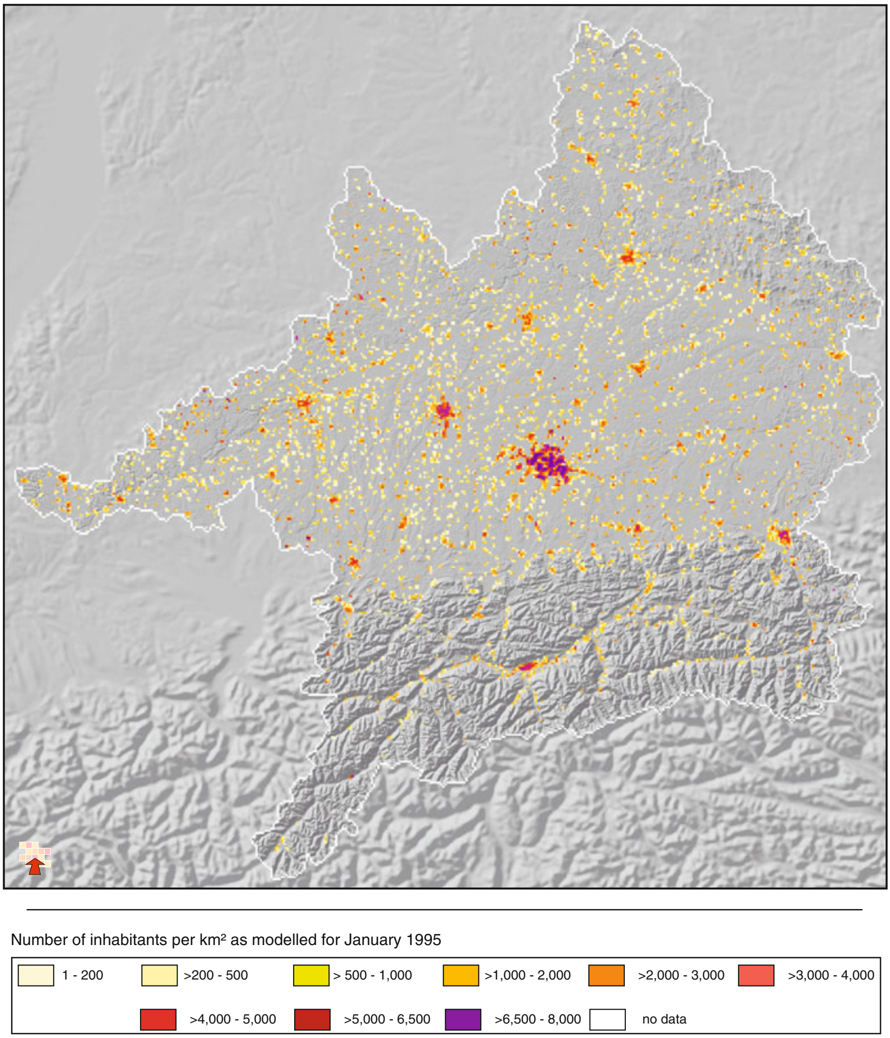
The goal of the DANUBIA *Demography* model is the allocation of the calculated proxel populations into each of five income and household size categories. To do this, the population is transferred to the *Demography* model from RIWU as the total number of inhabitants of a proxel and the household income as the sum of the available incomes in the entire population of the same proxel. The starting point is the consideration that the 5×5 matrix is calculated based on the average income of a proxel in relation to the distribution of the official statistic. It is therefore first necessary to determine the average income for the distribution of the national average presented in Table 16.1. For simplicity it is assumed that the incomes within individual categories in the official statistic are uniformly distributed. In the "under 1,100€" income category, a minimum income of 200€ is assumed, in order to match the depiction of social welfare benefits. In the income category with more than 5,000€, a maximum income of 10,000€ is assumed for simplifying the calculation. Under these assumptions, the average household income of the distribution given in Table 16.1 is 2,504.25€.

The distribution of population into the 25 fields is finally adjusted either up or down for each proxel according to a fixed algorithm depending on the difference between the proxel-specific average income and the statistical average income.

16.4 Presentation of the Results

Map 16.1 depicts the proxel population for January 1995 generated by RIWU. The RIWU district values were assigned to the proxels using the method described above. Large cities like Munich or Innsbruck are thus easy to pick out. On average, 1,142.2 people live in a modelled, populated proxel.

The RIWU model is calibrated for 1995. A model simulation for 2001 serves as a test of the predictive power. The comparison with statistical values yields an average forecasting error of −10 % with a variance of 18 % for the population. Precise validation of the proxel values is not possible because of missing statistical values. However, it can be assumed that the results obtained with the aid of remote sensing represent a close approximation of reality.



Map 16.1 Population (Data sources: © Bavarian State Office for Statistics and Data Processing, Munich, 2004; Federal Statistical Office, Wiesbaden, 2004; @ State Statistical Office Baden-Württemberg, Stuttgart, 2004; © STATISTIK AUSTRIA; Federal Statistical Office, Neuchâtel 2003; EEA, European Environment Agency, CORINE Land Cover, Copenhagen, 2005)

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