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Settlement growth and densification within a peri-urban poly-centric region
- driving forces analysis, model development and preliminary simulation results

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Abstract. The Observatory Spatial Planning (OSP), which is part of the Integrated Project **geoland**, will generate products and services based on Earth Observation (EO), geo-spatial and statistical data. Among these products urban growth models and scenarios play an important role. This paper discusses the model preparation tasks - analysing the regional structure, modifying the already developed model, quantifying the factors and parameters – the model concept and its application and first results for the Rhine Valley region in Vorarlberg, the most western province of Austria.
In contrast to typical urban-suburban landscapes with a dominating core city in the centre, the study area consists of several sub centres and a large number of small rural settlements all growing in different ways. Analyses of settlement growth in the Rhine Valley showed that migration is not the major driver for enlargement of residential areas. Other driving forces were identified and a cause-effect-chain was proofed statistically and quantified.
The settlement growth model is based on a multi agent system which simulates the allocation decisions of households and companies. Validation of the model is performed by control runs for the past decade comparing model results with corresponding land-use classifications derived from earth observation. The results shown in this paper will focus on the comparison of statistical parameters on the municipal level.

Keywords: land use change, urban sprawl, driving forces, simulation models, multi-agent systems

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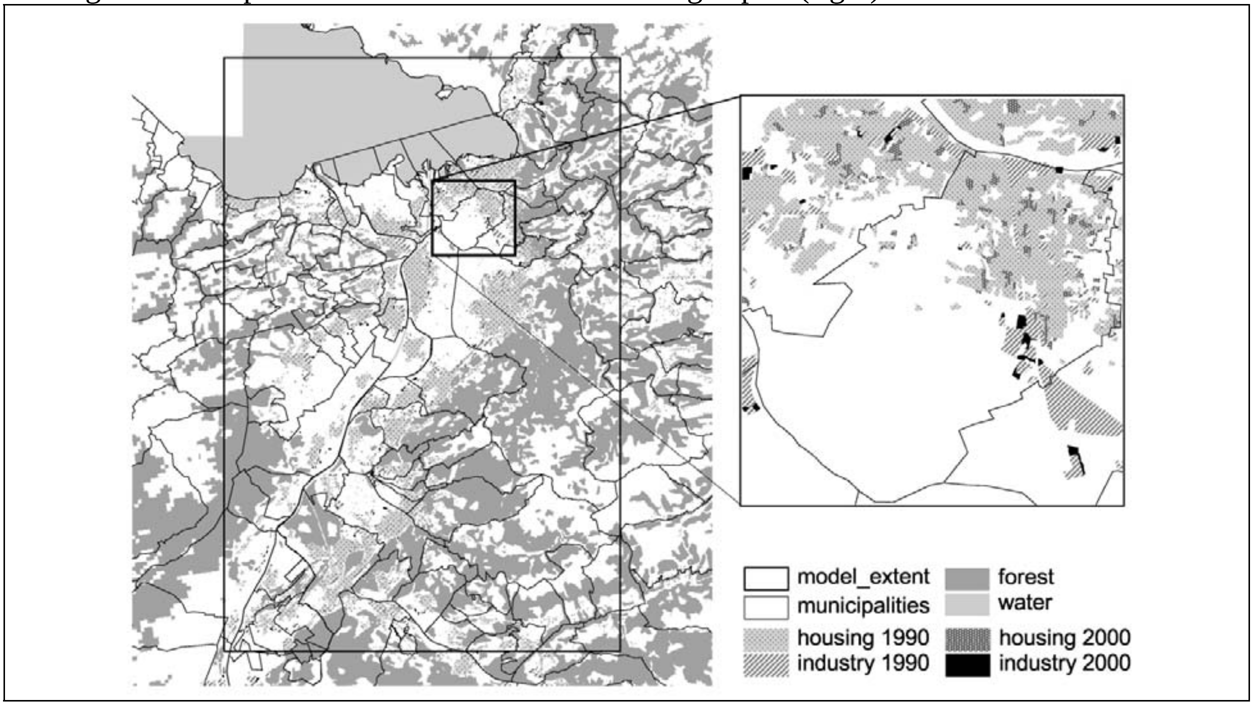
1. Introduction

Settlement growth has for decades been the major landscape transition process in Europes industrialized areas. The extension of built-up areas is driven by new residents searching for attractive residential areas and fuelled by enterprise start-ups in prosperous areas. The growth of population, households and workplaces and the continuous dispersion of residential areas and commercial facilities lead to an increase of traffic flows causing further environmental threads. Landscape attractiveness and the accessibility of the employment centres rather than distance to it, might increasingly influence future decisions about living places or company locations. Thus the major environmental pressures referring to settlement growth are loss of open space and increasing traffic (cf. Batty et al., 2003; Brake et al., 2001). Urban planning and regional development plans need scenario results as a basis for decision-making to foresee potential environmental threats as a consequence of inappropriate planning activities or to show the effects of strategies designed to mitigate unfavourable impacts of urban sprawl. (Loibl, 2004).

The investigation of driving forces of built-up area, related to polycentric dynamics, might help to solve the problems within dispersed settlement regions. To simulate land-use change patterns with high spatial accuracy, the different behaviours of migrating households and entrepreneurs have to be considered. This behaviour can be modelled by means of a multi agent system which simulates the allocation decisions of households and companies. Some years ago the authors have developed such a model that allows the simulation of land-use change based on in-migration and commercial start-ups (Loibl & Tötzer, 2003). This land use change model has now been extensively modified to simulate settlement growth not in a typical urban-fringe landscape with a dominant central core city, but in the Austrian Rhine Valley, a peri-urban region without an outstanding growth pole (see fig.1).

The model performs the simulation agent by agent and thus triggers continuously land use change and change in spatial attractiveness. The iterative process allows introducing temporal aspects and makes the decisions of later settlers dependent on the behaviour of previous ones. The model´s virtual "game board" is a cellular landscape (of 50x50m cells) characterised by several grid cell layers, which deliver land use information of different historic dates derived from high resolution earth observation data, demographic and employment data from official statistics, landscape attractiveness and workplace accessibility.

Fig. 1: The Austrian Rhine Valley as study region for the model application (left) – and the change of built-up area 1990 – 2000 shown as enlarged part (right)



2. Background

The Austrian Rhine valley is a peri-urban region with various medium and small sized municipalities without a central core city but with several small district centres (see Fig. 1). The region comprises three districts: the northern district Bregenz with the province Capital Bregenz and Lake Constance, the most southern district Feldkirch adjacent to the Silvretta mountain ridges and the district Dornbirn in the centre of the region. Table 1 shows the characteristics of the study area relevant for settlement growth and related driving forces: one can see the states and changes in demography and landscape for 1991 and 2001. Table 1 illustrates the increase of built-up area and growth of population and households. In particular, the growth of households can be seen as major driving force for settlement growth.

Tab. 1: Demography, employment, and land use in the Rhine Valley study region 1991/2001

	population (in 1000)	households (in 1000)	workplaces (in 1000)	flats (in 1000)	buildings (in 1000)	residential area (ha)	industrial area (ha)	settlement area (ha)	residential area zoning (ha)	industrial area zoning (ha)	reserve residential area (ha)	reserve industrial area (ha)
1991	246	86	97	89	51	6.508	824	7.332	7.867	1.070	5.492	979
2001	261	102	114	107	61	7.138	932	8.070	7.867	1.070	2.949	539
diff. abs.	15	16	17	19	10	630	108	738	0	0	-2.543	-440
diff. rel.	6,1	19,1	17,6	21,1	19,3	9,7	13,1	10,1	0,0	0,0	-46,3	-44,9

Population is growing slowly in the Vorarlberg Rhine valley and does not grow because of migration but because of birth surplus – a rare situation for mid-European industrialized regions. In the prior decade migration was an essential contributor to population and settlement growth. The following table shows that trends have changed fundamentally from decade 1981-91 to decade 1991-01. The once considerable in-migration numbers turned to a slightly negative migration balance.

Tab. 2: Elements of population dynamics in the Vorarlberg Rhine valley

	Birth-Death balance 1981_1991	Birth-Death balance 1991_2001	Migration balance 1981_1991	Migration balance 1991_2001
Austrian Rhine Valley total	17.698	16.690	4.770	- 594
Bregenz	6.676	6.239	3.479	- 616
Dornbirn	5.291	4.430	-1.249	-1.279
Feldkirch	5.731	6.021	2.540	1.301

The analysis of migration flows shows, that there is little migration into the region. Table 3 presents a migration matrix at district level for 1996 and 2001. It indicates that the majority of people and households actually move within their home districts. The percentage of migration within the district is highest in the districts Bregenz (73%) and Feldkirch (65%). Just the district Dornbirn, located in the centre of the study site, with internal migration-flows of around 30 % shows a different picture. Due to the particular situation in the Rhine Valley the earlier developed model (Loibl & Tötzer, 2003) that simulates residential growth mostly based on in-migration, had to be modified extensively.

Table 3: Migration flows in Rhine valley districts for 1996 and 2001

1996 from/to	Pop01	Bludenz96	Bregenz96	Dornbirn96	Feldkirch96	total migration	pct movement within district
Bregenz	121.127	98	3987	1015	303	5403	73,79
Dornbirn	75.997	117	1011	844	621	2593	32,55
Feldkirch	93.567	577	338	634	2912	4461	65,28
	290.691						

2001 from/to	Pop01	Bludenz01	Bregenz01	Dornbirn01	Feldkirch01	total migration	pct movement within district
Bregenz	121.127	127	3604	844	352	4927	73,15
Dornbirn	75.997	117	890	725	550	2282	31,77
Feldkirch	93.567	539	341	608	2939	4427	66,39
	290.691						

The moderate increase in population of 15.000 (or 6%) through birth surplus does not cause the 9.7% residential area growth. Spatial analyses reveal, that household numbers growing by 19 % (!) are the main driving forces for residential area growth. That means, not the absolute population growth is triggering the high demand for flats but the increasing number of (smaller) households. Thus the trends in household structure have to be investigated in detail.

Fig. 2 Change of household size in the Rhine valley

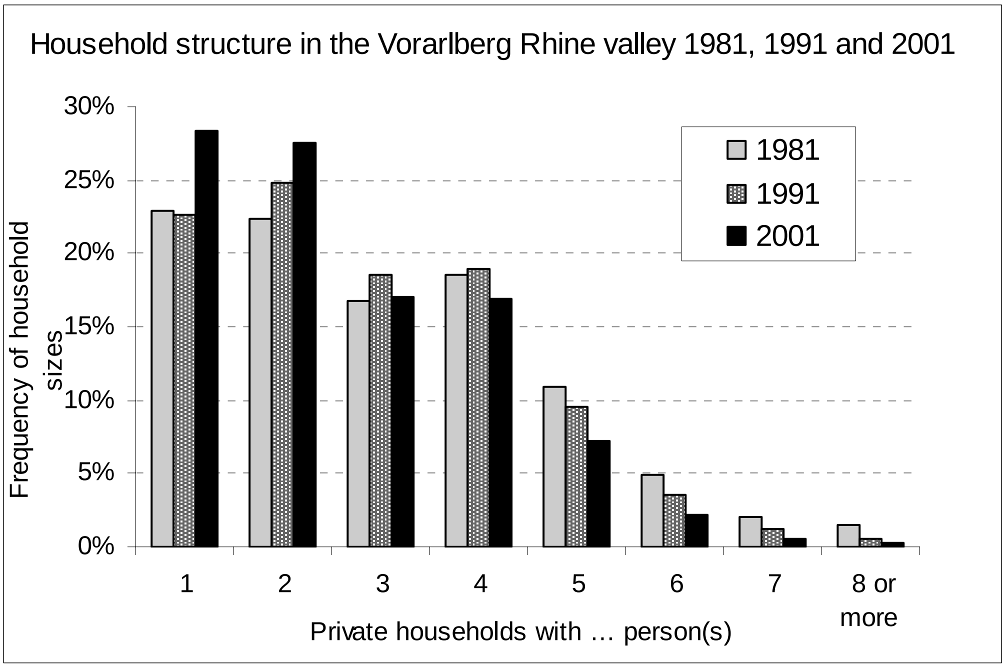
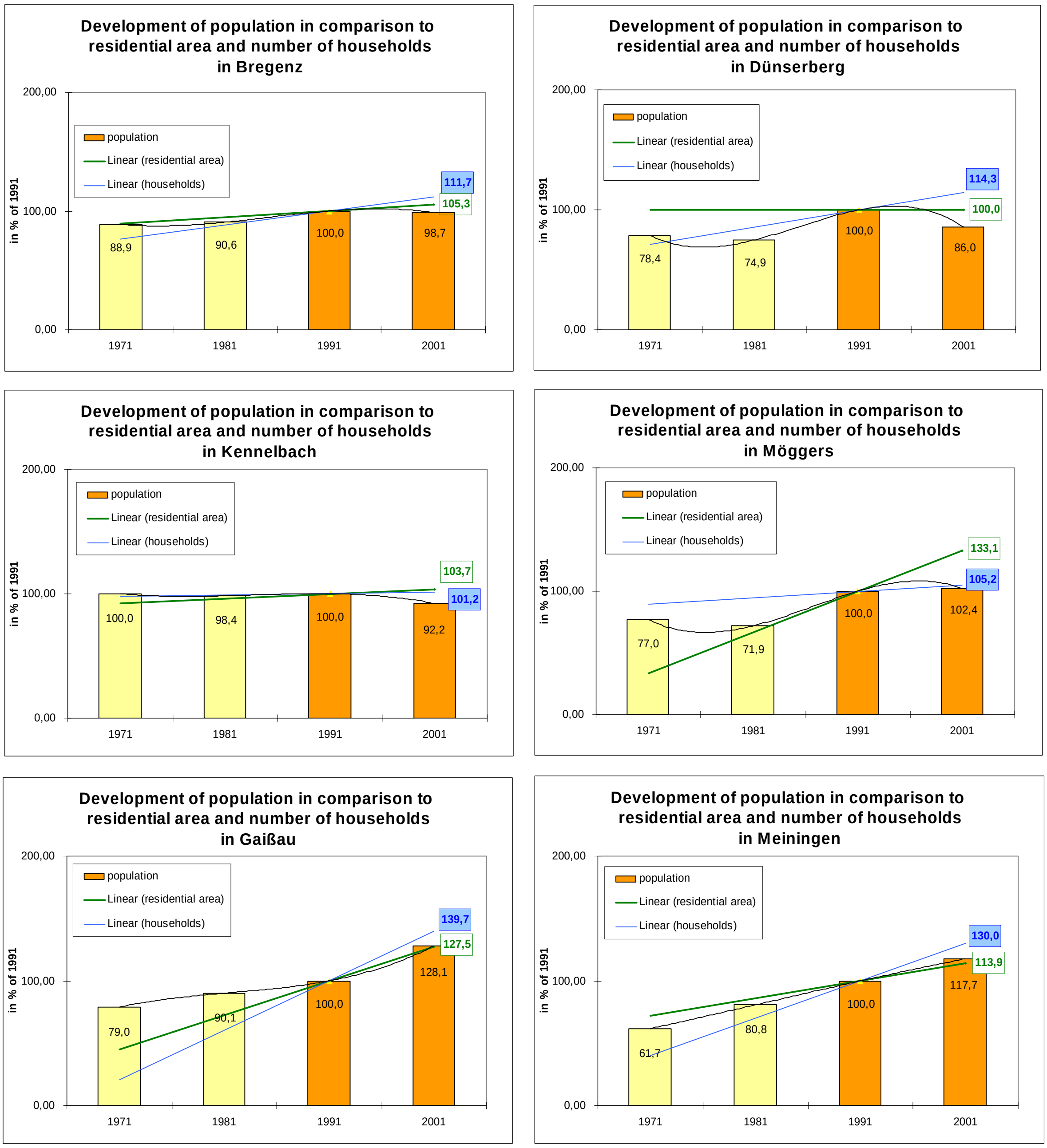


Figure 2 shows the household structure analysis for the Vorarlberg Rhine Valley municipalities from the Census years 1981, 1991 and 2001. A tremendous increase of single, couple or single parent households can be observed during the last 20 years. A decrease of the percentage of households with 3 and more persons can be observed since 1991. In the entire province of Vorarlberg the average household size declines constantly: 5.6 % between 1981 and 1991, and 9.4 % between 1991 and 2001. Thus, residential area growth and densification in the Rhine valley is caused not by migration into the region but by the increasing number of smaller households that generate a significant demand for new residential areas.

Figure 3 shows the dependencies of household growth and residential area growth for six sample municipalities, with different population development. All have in common that residential areas are growing due to allocation of new households whereas the number of population varies.

Fig 3: Comparison of population, number of households and residential areas



4. Model concept

Traditional (macro-scale) models are ineffective in handling micro-scale phenomena (see Stillwell & Congdon, 1991; Torrens, 2001). To simulate residential area growth with high spatial accuracy, the model must consider the diversity of decisions of the potential settlers. Following a behavioural modelling approach, migration patterns and land-use change are the results of many individual actors' activities. Spatial environment is perceived and judged by actors who live in the environment and who – according to their (varying) perceptions and desires – behave differently within this region (Ruppert & Schaffer, 1969). Thus multi-agent systems are well suited for modelling regional development, as agents are "systems situated within and part of an environment that sense that environment and act on it, over time" (Franklin & Graesser, 1996). Therefore an agent-based model approach was selected that simulates the actors' behaviour as reactions of local states and pressures within the region.

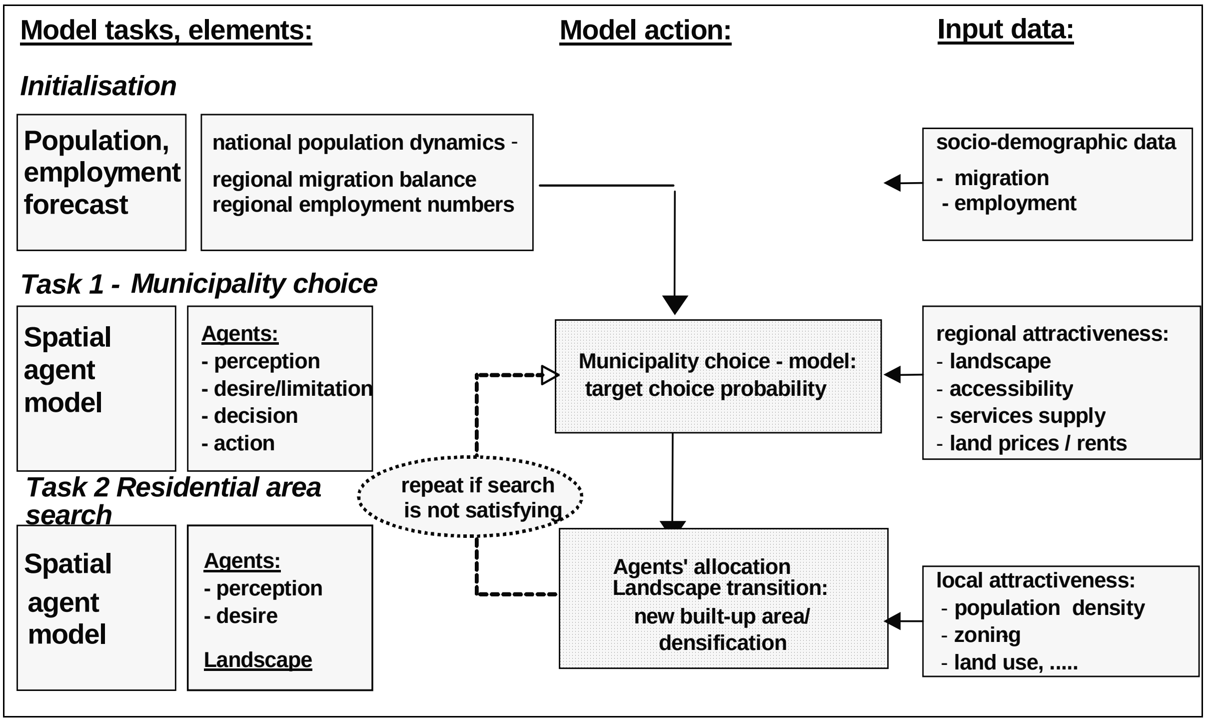
Multi-agent systems that simulate land-use change (see Portugali, 2000; Benenson & Torrens, 2004) are often market- and (mostly) neighbourhood-oriented and concentrate on steady core city surroundings growth. Settlement growth in poly-centric peri-urban regions has not been introduced in detail. The model applied here performs a municipality target search of single households and entrepreneurs in a peri-urban region with a no distinctive central place - hierarchy and the occupation of new lots in those target municipalities.

The approach concentrates on a multi agent system to simulate the allocation decisions of households and companies causing built-up area densification and land-use changes. Originally the model was expected to simulate population migration and commercial start-ups controlled by regional and local factors (attractiveness / constraints). Unexpectedly migration is – as shown above - not the driving force for residential area growth and densification. Instead, the emergence of new households, through persons leaving their former larger household, cause an increasing demand for further settlement areas.

In particular, the model concentrates on local household numbers growth triggering demand for new flats and houses and on commercial start-ups - both controlled by regional and local factors (attractiveness / constraints) in the Rhine valley such as large and small scale accessibility (travelling time to the province capital, to district centres, access to motorways), landscape attractiveness (access to recreation areas), as well as planning constraints.

The model takes into account different settlement development velocities due to different location factors influencing household settling / commercial start-up decisions. The suitability and relevance of the attractiveness criteria is examined via regression models, which explain regional household settling - and commercial start-up patterns through various attractiveness factors and workplace accessibility. The very local decision where to settle is carried out by local attractiveness surface layers considering suitability for housing or commercial sites on a block level. The model concept developed by Loibl & Tötzer (2003) is presented in figure 4.

Fig. 4: Concept of suburban land-use change simulation



The built-up area growth simulation is based on household and entrepreneurs decisions to settle and consists of two major tasks that start after a initialisation task. This initialisation task defines the reservoir of acting agents which represent households and entrepreneurs establishing workplaces. The decision where to go, depends on regional and local attractiveness patterns and the household's and entrepreneur's desires and expectations on the new location. In the original model the households where divided into 4 different household categories. To allow easy model application for different regions with only basic demographic and employment data, the model has been simplified. Now two agent types are modelled: an average household agent (with varying household size) and the entrepreneur agent. The settling decision of each household and entrepreneur is carried out in two tasks that refer first to municipality choice and then to "residential" area search (ref. to Loibl, 2004).

Task 1: municipality choice:

As mentioned above the agents' choice of a municipality target is assumed to be driven by several attractiveness factors. So the first step is to examine the municipalities regarding certain regional attractiveness patterns influencing migration and settling (ref. to Bogue,

1969) and possible matches with agents' settling behaviour. It can be expected that certain municipalities are selected more often than others. The municipality selection is carried out by random choice of a municipality within the agent's specific target municipality choice probability distribution. This probability distribution has to be quantified in advance for both agent classes.

Task 2: residential area search

The agent's search of a residential area within the selected target municipality is assumed to be triggered by local attractiveness factors. The local search takes place within a "cellular world" where several layers provide information about various spatial characteristics. The search starts in a random cell within the selected municipality where the agents start to move in direction of the nearest residential area looking for an appropriate target cell. The cells' suitability for depends on the certain pull factors and the importance weights as judged by the moving households. The local settling decision by the agents is supported by a cellular automaton to consider neighbourhood characteristics during the decision process leading either to built-up area densification or to change from open space to new built-up area.

The model concept in Fig. 4 from Loibl & Tötzer (2003) is still valid. What has been modified since 2003 is the municipality choice probability distribution, now referring to new household settling instead of large distance migration behaviour of different socio-economic population classes (4.1) and attractiveness assessment methods for local search (4.3).

Each agent's action changes local attractiveness and influences the decision of future moving agents. A "common memory" allows a simple communication between the agents so that new movers can learn from the experience of previous successful movers. The effect of the "memory" is that it leads to less (stochastic) spread of new residential area within a municipality as new movers search in a first step near cells where prior movers have already settled successfully. Thus, the pattern of newly occupied lots within a municipality is less scattered and matches the observations in reality.

4.1 Examing drivers for new household settling and workplace establishing

Model step 1 requires to estimate a probability distribution of household settling - and entrepreneurs start-up decisions within the study region. The tables 2 and 3 and figures 2 and 3 have shown that migration flows and population growth are not the major driving forces for residential area growth in the study area – this is household numbers growth due to increasing number of small households. Thus split and emergence of new households within the entire population is most important. The probability distribution has now to consider household settling instead of in-migration. The probability distribution for occupying new commercial areas and employing additional has to be estimated out of the growth of workplaces. Table 4 below shows the dependencies of the major forces for residential and industrial / commercial area growth referring to the responsible drivers by Pearson Correlation Coefficients.

Tab. 4: Pearson correlations: growth of residential and industrial area versus demographic and job numbers and dynamics, availability of lots to be occupied.

	GROW_RES_AREA	GROW_IND_AREA
POP91	**0.893**	**0.660**
HOUSEH91	0.878	0.636
WORKPL91	0.842	**0.640**
DIF_POP	0.848	**0.650**
DIF_HOUSEH	**0.924**	0.695
DIF_WORK	0.778	**0.543**
RSRV_RES90	**0.814**	0.532
RSRV_IND90	0.742	**0.555**

The correlation coefficients of variables with a causal dependence are marked in bold type. The results confirm the (well-known) high dependence of residential area growth 1990-2000 due to actual population numbers (POP91), population growth (DIF_POP), and over all household growth (DIF_HOUSEH) and residential area reserve / availability (RSRV_RES90).

Referring to commercial and industrial area growth the investigation shows following results: it is also confirmed that there is (a well-known) high interdependence of industrial area growth 1990-2000 with population (POP91), workplace numbers (WORKPL91), current workplace numbers (WORKPL91), population growth (DIF_POP), workplace growth (DIF_WORK) and industrial area reserve (RSRV_IND90).

The following table 5 shows the dependencies between the population, household and workplace allocation on the one hand and landscape related location factors that might influence the decisions triggering built-up area growth, on the other hand. The correlation coefficients of variables with causal dependence are again marked by bold fonts. Non-causal cross-dependencies will not be discussed in detail.

The results confirm again the (well-known) high dependence of **population numbers growth** 1991-2001 (DIF_POP) due to current population numbers (POP91), residential area (RESIDAR91), residential zoning area (ZONING_RES) and residential area reserve / availability (RSRV_RES90). The assumed attractiveness of recreation area in the vicinity of residential area growth, which was verified by Loibl & Kramar (2001) for the Vienna suburban region, can not be proved to influence population allocation in the Rhine Valley significantly. Recreation area quality was quantified as distance to nearest recreation areas and as share of recreation area within a certain neighbourhood. The moderate correlation of population numbers growth with distance to forest areas (DIS_FORST) and the negative correlation with share of recreation area (PCT_FOREST) indicate that there is forest in the vicinity of settlements with increasing population numbers, but only small forest patches leading to a small share of forest areas in the surroundings. The percentage of open green land in the residential area surroundings (PCT_GREEN) shows a moderate correlation with population growth. Accessibility indicators (TRVL_CNTR, TRVL_CPTL) show low correlation with population growth, obviously due to its contradicting variation of population change and recreational area share.

Tab.5: Pearson correlations: characteristics influencing population, households and workplaces allocation

	DIF_POP	DIF_HOUSEH	DIF_WORKPL
POP91	**0.657**	**0.976**	**0.907**
HOUSEH91	0.632	0.968	**0.919**
WORKPL91	0.569	**0.942**	**0.909**
RESIDAR91	**0.794**	**0.985**	0.858
SETTLEAR91	0.793	0.986	**0.867**
ZONING_RES	**0.832**	**0.974**	0.835
ZONING_IND	**0.754**	0.884	**0.797**
RSRV_RES90	**0.783**	**0.731**	0.624
RSRV_IND90	0.594	0.740	**0.653**
TRVL_CPTL	-0.170	-0.332	-0.322
TRVL_CNTR	-0.390	**-0.653**	**-0.646**
DIST_FORST	**0.564**	0.413	0.149
DIST_HWY	-0.150	-0.233	-0.241
PCT_FOREST	***-0.480***	*-0.381*	-0.272
PCT_WATER	0.077	0.155	0.163
PCT_GREEN	**0.531**	0.285	0.108
MIGRAT_BAL	*0.124*	*-0.177*	-0.277

The dependence of **household numbers growth** 1991-2001 (DIF_HOUSH) shows more plausible causal relations. The results confirm again the (well-known) high dependence of household growth 1991-2001 due to actual population numbers (POP91), household numbers, workplace numbers (HOUSEH91, WORKPL91), residential area, industrial area (RESIDAR91, INDAR91), built-up area zoning (ZONING_RES, ZONING_IND) and built-up area reserve / availability (RSRV_RES90, RSRV_IND91), further a significantly higher correlation of household numbers growth with accessibility of the next district centre (TRVL_CNTR - the high negative correlation coefficient means: the shorter the travel-time, the higher the household growth), but rather low correlation with accessibility of the state capital Bregenz (TRVL_CPTL). This stresses the tendency of household growth variation independent from travel distance to Bregenz. The assumed attractiveness of recreation area in the vicinity of areas with household numbers growth can not be verified. This allows the general conclusion that in the Rhine Valley – by lack of a large core city but by containing of small core cities within the region – a low level of centrality is more important than near recreation area access – and/or it indicates that recreation area access in the study region is generally sufficient and shows low variation which leads to low correlation with household numbers growth.

Referring to dependence of **workplace numbers growth** (DIF_WORKPL) and thus start-up of new or extending of established enterprises it is confirmed that there is a high interdependence of workplace growth with current population- household- and workplace-numbers, built-up area size, built-up zoning area size, and built-up area reserve size indicating larger municipalities as commercial growth poles. Travel time to centres shows the same tendency that new workplaces are rather located nearby (or even in) the district centres than in the state capital serving somehow as core city. Further accessibility variables or attractiveness variables are of less importance at municipality level.

All population and job related growth variables show no significant correlation with migration balance (MIGRAT_BAL) which indicates, that migration does not play a significant role in the study area or at least proves, that there is no coincidence of migration-balance variation with built-up area growth variation.

In order to consider the limited scale of the paper but nevertheless give detailed insights into concept, behaviour and results of the model the further presentation picks out the simulation of residential area growth and skips all aspects dealing with commercial area growth.

4. 2 Performing households' regional search: target municipality choice

The work carried out here is based on a model, developed previously as prototype (Loibl & Tötzer, 2003). This prototype has to be modified to allow further application for several study areas without major later model changes.

The first model task refers to simulation of the household's target municipality choice. It was decided to simulate built-up area growth considering the reaction of the actors (that wich to move) on states and pressures reflected by landscape attractiveness layers aiming in the occupation of new lots or in built-up area densification in already occupied blocks for (in the case described here) residential purposes.

As shown above the major drivers for residential area occupation in the study region are emergence and allocation of households demanding new flats as well as start-up or extension of enterprises creating new jobs.

The municipality target choice probability will be estimated through regression models with the variables presented in the correlation tables (Tables 4 and 5) that reflect the influencing characteristics triggering the selection decision process.

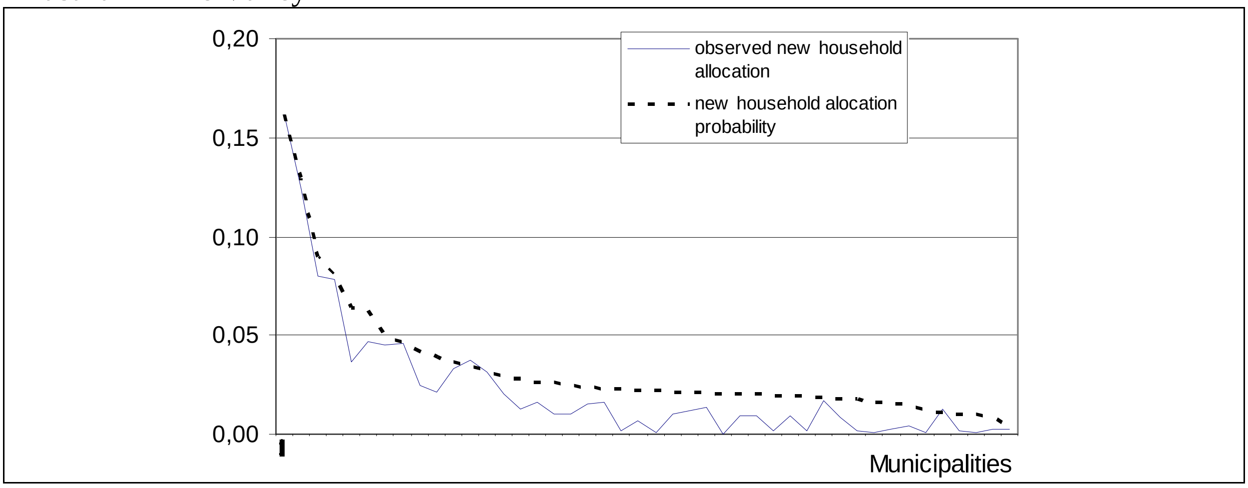
The finally selected regression models for households and for entrepreneurs are the following:

Tab. 6: Regression models as basis to derive settling probability distributions

dependent variable: DIF_HOUSEH		dependent variable: DIF_WORKPL	
R^2= 0.979, std error 79,3		R^2=0.818, std error 320	
explaining variables	standardized coefficients	expaining. variables	standardized coefficients
POP91	0.553	POP91	0.203
ZONING_RES	0.462	WORKPL91	0.583
TRVL_CNTR	0.016	ZONING_IND	0.110
TRVL_CPTL	0.008	TRVL_CTR	-0.052
PCT_GREEN	0.012		

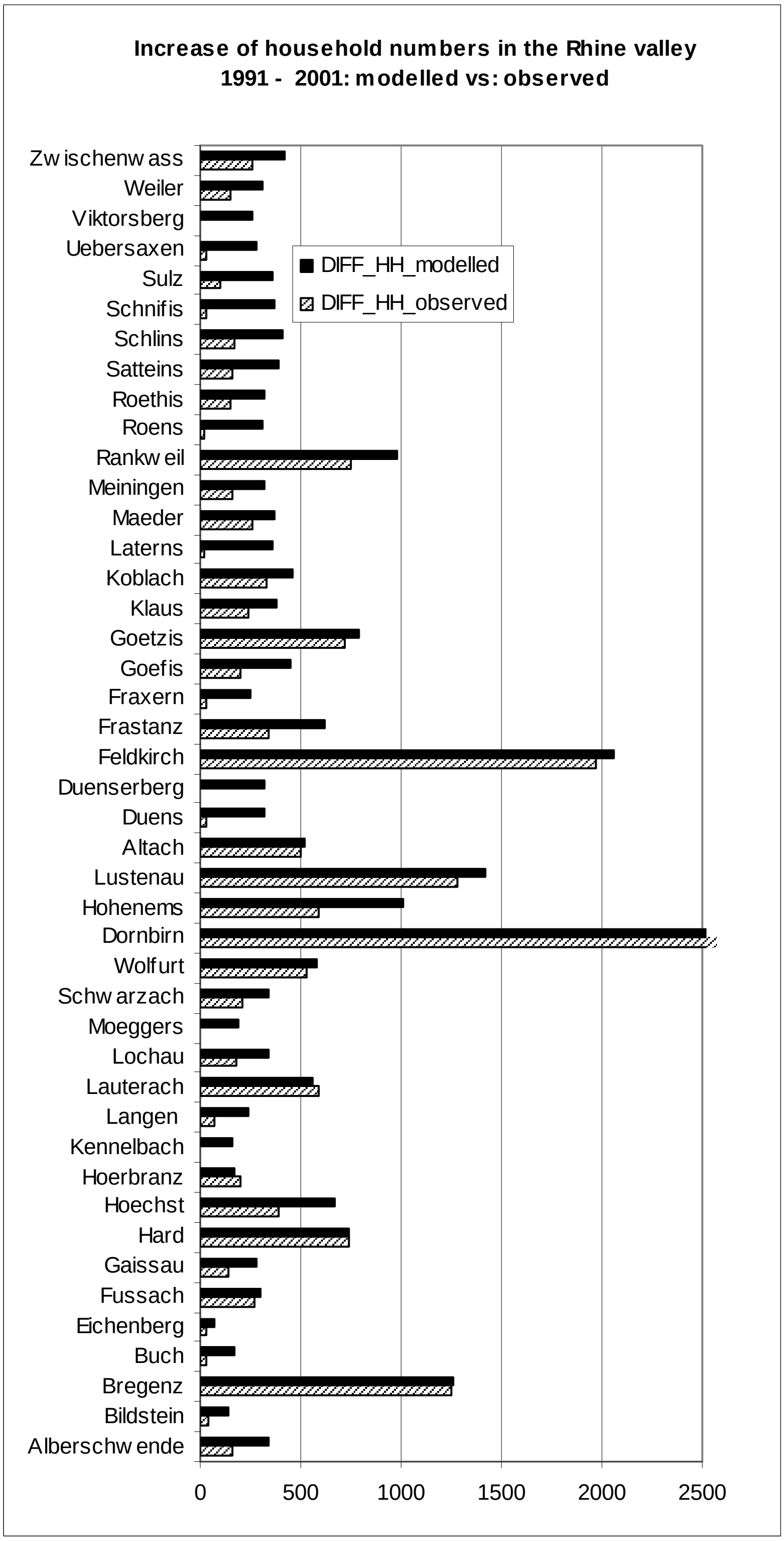
Figure 6 now depicts the probability distribution of household settling for the Rhine Valley municipalities, calculated by the regression model shown above, based on those attractiveness criteria that have high influence on actor's behaviour. The dashed line shows the probability distribution, the straight line the observed relative frequency of settling in the various municipalities.

Fig. 6: Probability distribution for households' municipality choice as future home in the Austrian Rhine Valley



The target municipality choice is performed agent by agent: a target municipality is picked by each agent randomly making use of the households settling probability distribution.

Fig. 7: Modelled and observed settling of new households 1991 – 2001 in the Austrian Rhine valley municipalities



The decision of each household agent I which municipality to settle is taken once – one target municipality will be selected – inside this municipality the further search is performed considering local attractiveness criteria (see 4.3). The model runs for the validation period

1991 to 2001 considering the emergence of more than 16.000 new households, which requires at least 16.000 search and settling iterations.

The prior figure 7 shows the outcomes for household settling for all municipalities in the study region. The comparison of observed versus modelled data allows a better examination than through a correlation coefficient, as the coincidence of observations and model results can be checked municipality-wise. The household numbers growth for each municipality is shown by two bars, the upper bar (black) shows model results, the hatched bar below shows the household numbers growth as observed. The figure confirms a rather high accuracy of the household settling simulation meeting the observations at municipality level very well.

4. 3 Households's local search: residential area selection

The target choice simulation at municipality level is the major step to reach sufficient regional simulation accuracy. But the migration action of a household agent has to be continued until a proper lot, house or flat is found within a residential area of the selected municipality. This action can only be finished as far as the housing demand meets the housing supply and an appropriate lot or flat in a suitable and attractive neighbourhood can be occupied. Since the model has been developed the model steps for tasks 2 have been modified slightly referring to details regarding attractiveness layers, parameters, assessment weights. The search algorithm is described in Loibl & Tötzer (2003) and with more detail in Loibl (2004). The local residential target cell search takes place in the cellular model landscape and consists of several steps:

After the selection of the target municipality in task 1, the search for an appropriate residential area will be continued. The household agent starts the final search from a random point inside the selected municipality "looking around" and moving to the nearest settlement. There he further seeks for residential area cells with low household densities, and if no appropriate built-up area cell could be found, he searches open space cells with residential zoning, nearby the already occupied residential areas. Low household density indicates the availability of vacant flats or lots and sufficient attractive green space.

Within a neighbourhood covering 17x17 (=289) cells surrounding the selected minimum household density cell, a search for further attractive cells is carried out by examining additional (weighted) attractiveness criteria, which are: (1) households-growth potential as difference between current and targeted household density maximum in the respective cell, (2) current adjacent land use, (3) zoning regulations, (4) distance to nearest residential area,

(5) distance to major roads, (6) shares of attractive versus in-attractive land use in the neighbourhood residential-, industrial- , forest-, open space- and water body- cells.

The cell with the highest total attractiveness is finally selected. The successful household settles, the household density in the respective cell is increased by 1 and population density is increased by the number of members the particular household and - if the cell was unoccupied, the land use class will be changed to residential area. If the search is not successful, up to 50 search attempts are performed starting from a new random start. within in the selected municipality. If the search is still not successful a different municipality is picked from the probability distribution and the search starts again (Loibl, 2004).

As each agent's action changes local attractiveness, it influences the decision of future moving agents. A common memory serves as communication media between already moved agents and agents that are seeking a residential area so new movers can learn from the experience of successfully migrating previous agents: new movers search in a first step near "landscape cells" where the last movers have settled successfully, otherwise they search longer and settle more scattered..

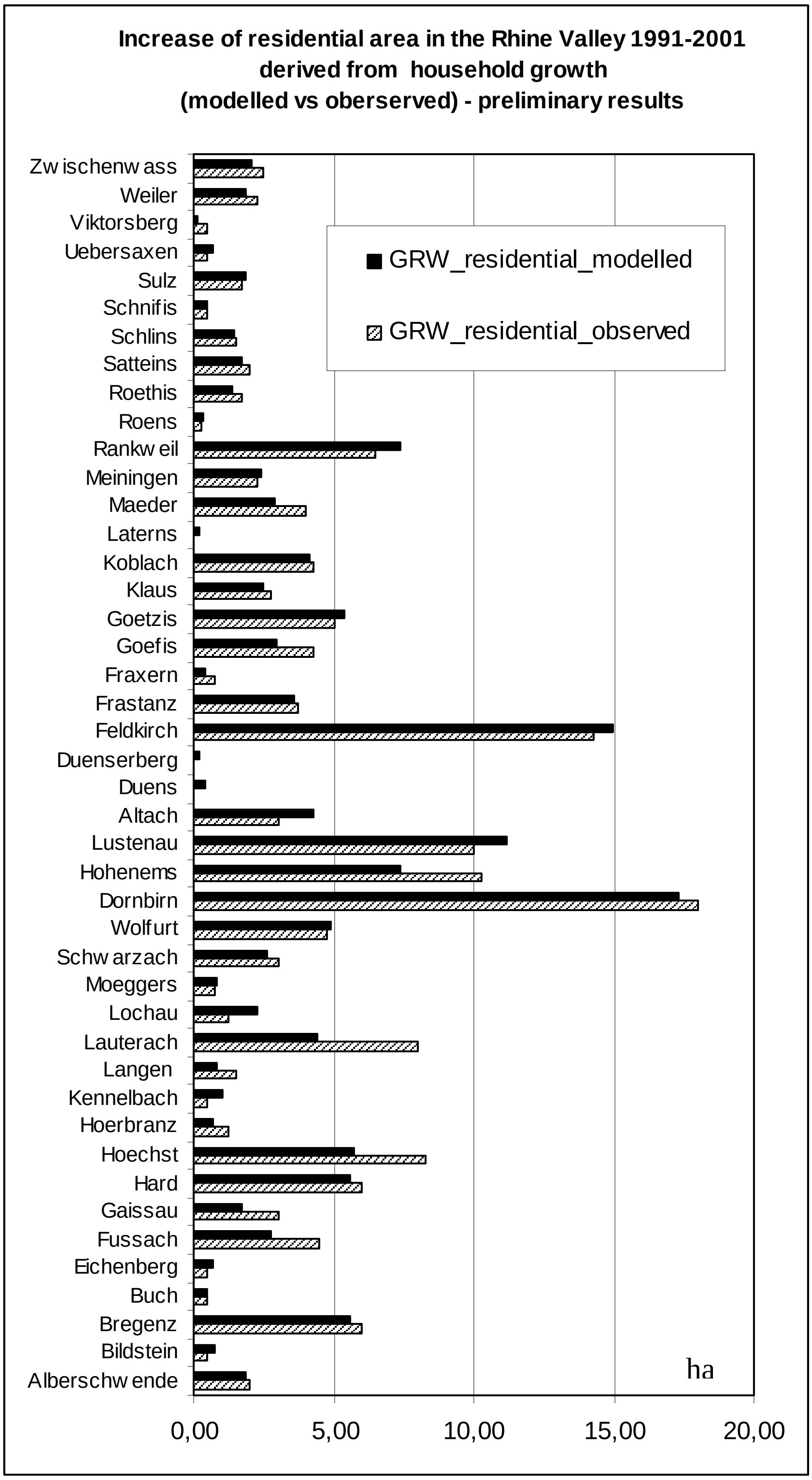
The residential area cell growth is rather little in the study region. Therefore the increase of residential area has been summarized for municipalities and depicted in the following figure 8. Again a high coincidence of modelled versus observed residential area growth can be observed which is even higher as the results for household numbers growth shown in figure 7.

5. Conclusions and outlook

Applying this model approach, the simulation leads to results for household settling and residential area occupation which high spatial accuracy. The regional built-up area growth patterns show very stable conditions during many model runs as they refer to the migration target municipality choice probabilities for the 2 agent classes.

To achieve accurate results it is important to derive the appropriate attractiveness criteria to quantify the "true" migration behaviour characteristics at the local scale. Here intensive tests are necessary to adapt the weights and parameters in order to achieve proper results. The model application will be further continued for some more peri-urban regions in order to improve the model referring to a stable attractiveness layer selection and parameter structure to achieve robust results with few input data to be easily derived through spatial analysis of remote sensing results and further geo-spatial and statistical data for the region of interest.

Fig. 8: Modelled and observed residential area increase 1991-2001 (in ha) in the Austrian Rhine valley municipalities



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