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How can tourism use land more efficiently? A model-based approach to land-use efficiency for tourist destinations

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A B S T R A C T

In densely populated areas of Central Europe, many successful tourist destinations face the problem of approaching the limit of their growth potential. Solutions to this problem commonly refer to the idea of "smart growth" based on increasing efficiency in the use of nature for economic production (eco-efficiency). In this paper, we show how eco-efficiency can be used to evaluate tourism strategies on local scale based on an augmented regional input–output model that delivers information on economic performance, land use (as indicator for environmental pressure), and employment. We illustrate this approach via a case study of the tourist destination of Davos in the Swiss Alps. The model predicts that the key drivers of land-use efficiency are: (i) the economic impact of tourists, (ii) occupancy intensity, and (iii) the density of beds per area covered by residential buildings and hotels. The economic impact of increasing bed capacity is highly dependent on the tourist category triggering the development; this can also be used to attract new tourist categories at the expense of tourist categories that make inefficient use of available land. As the impact of an increased density of beds per ground floor area is as high as an improved occupancy rate over during the year, spatial planning, building design, and facility management also play a major role in improving land efficiency in the tourism sector.

1. Introduction

Since the 1950s, the tourism sector has increased dramatically and has become a mass phenomenon. In 2000, about 700 million tourist arrivals were counted worldwide (Gossling, 2002). In Switzerland, tourism is considered one of the most important economic sectors. In 1998, tourism accounted for 5.2% of all full-time equivalent jobs and 3.4% of the gross domestic product, ahead of chemical industries (2.9%), insurance (2.9%), and communications (3.1%) (Gaillard, Rütter, & Berwert, 2003). When mass tourism first began in the mountainous area of Switzerland in the early 1960s, it was particularly beneficial for remote and impoverished regions that had previously been prone to emigration (Messerli, 1983). However, in the 1970s, tourism development was also considered a major threat to these regions because of the negative effects of land consumption, deprivation of cultural identity, power structures, and visual impact on the traditional mountain landscape (Messerli, 1989).

Today, solutions to such problems are discussed in terms of sustainable tourism. Several authors have provided comprehensive and critical reviews of the development of this notion (Hardy, Beeton, & Pearson, 2002; Hunter, 1997; Sharpely, 2000). Hardy et al. (2002, p. 409) state that sustainable tourism is a reactive concept that has been developed in reaction to prevailing environmental problems. This view is mirrored in studies of tourism sustainability assessment that focus primarily on the *status quo* of the destination of interest (Ceron & Dubois, 2003; Ko, 2005; Sheng-Hshiung, Yu-Chiang, & Jo-Hui, 2006; Vera Rebollo & Ivars Baidal, 2003). The assessment itself does not look into the future, and its impacts on future development emerge primarily from the political and social processes triggered by the sustainability assessment; e.g., through stakeholder involvement (Hezri, 2004).

Yet, an assessment of future development is a core issue of sustainability (e.g. Giljum, Behrens, Hinterberger, Lutz, & Meyer, 2008; Rotmans et al., 2000) and it can further stimulate the debate among stakeholders as well as between stakeholders and scientists. It requires, however, an understanding of cause–effect relations underlying economic, social and ecosystem development. If this understanding is captured in a formal model, it is possible to project currently observed trends into the future and illustrate consequences of changes in human behaviour as well as changes of boundary conditions (e.g. climate change). van Notten, Rotmans, van Asselt, and Rothman (2003) and Förster, Maibach, Pohl, and

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Kytzia (2003) provide overviews of the use of models and scenarios in decision-making processes in the field of regional development. This issue has also been investigated in the context of sustainable regional development in tourist destinations (Förster & Kytzia, 2004; Walz et al., 2007).

Recent publications have proposed a number of different approaches to assess aspects of sustainable development based on model calculations and different types of indicators. Firstly, there are models providing estimates for a single indicator (e.g. carbon dioxide emissions such as Walz et al., 2008), but they are often criticized for their limited scope. Secondly, there are models delivering estimates for a more comprehensive set of indicators; yet, the results of such model calculations remain somehow ambiguous (e.g. Lundström, Kytzia, Walz, Grêt-Regamey, & Bebi, 2007). A third alternative are composite indices that combine different aspects of sustainability in one single indicator value (e.g. Wackernagel & Rees, 1996). Such composite indices may not be truly comprehensive but they can illuminate interdependencies between the different dimensions of sustainable development and, thereby, attract attention of different stakeholders (Costanza, 2000).

Based on the idea of economically efficient resource use, eco-efficiency is one prominent example of a concept on which such composite indicators can be based, for instance land use per financial unit GPD or energy use per full-time equivalent. It suggests to increase the efficiency in the use of nature for economic production. In the German-language literature, this idea was originally introduced as “qualitative growth”, a concept that captures a wide range of different aspects of sustainability via qualitative assessment methods (Krippendorf, 1986; Renn, Goble, & Kastenholz, 1998; Zimmermann, 1976). But more recently, quantitative assessment methods have been favored, stimulating a debate concerning the best indicator to capture environmental pressure (Huppes & Ishikawa, 2005; van der Voet, van Oers, & Nikolic, 2004). Most studies use either material consumption (Bringezu, Schutz, Steger, & Baudisch, 2004; Canas, Ferrão, & Conceição, 2003) and energy consumption (Schipper, Unander, Murtishaw, & Ting, 2001) as indicators. Such methods of calculating eco-efficiency have been applied to assess enterprises (Moller & Schaltegger, 2005), products and processes (Rudenauer, Gensch, Griesshammer, & Bunke, 2005), and regions (Seppalaa et al., 2005). In the sustainable tourism debate, the idea of eco-efficiency was introduced by Gossling et al. (2005) who provide an overview of a number of studies with a focus on tourism that use energy and carbon dioxide as indicators for eco-efficiency.

But we are unaware of any application of the eco-efficiency concept to tourism in a local-scale scenario analysis or as input for discussions with local stakeholders. A simple explanation for this phenomenon may be the lack of local-scale data, for economic as well as environmental indicators. In addition to that, the concept of eco-efficiency requires a shift of perspective in the sustainability debate in the local-scale planning. We no longer want to ask how to protect nature from human interferences, but how to use our limited natural resources with utmost economic benefit. In many communities, sustainable development is still associated with nature protection, and eco-efficiency is considered as unconventional.

In this paper, we show how the concept of eco-efficiency can be used to evaluate tourism strategies that aim for sustainable development on a local scale. For this purpose, we focus on land as a natural resource that is clearly perceived as limited by local planers. In many tourist destinations, land use is constantly a major issue on the local political agenda due to its imminent limitation and related competition between land-use options. For this reason, the concept of ‘land-use efficiency’ is much easier to communicate to local stakeholders than other environmental pressures such as carbon dioxide emissions or material consumption. In addition, land-use transition is one of the most urgent problems on global as well as on local scale, and has – in sum – a major impact on global climate change by causing about 33% of CO_2 emissions since 1850 (Watson et al., 2000).

The indicator we suggest is based on a formal model that represents interactions between the population, the regional economy, and the natural environment. The model was developed by a research project funded by the Swiss Science Foundation that focuses on the mountain resort area of Davos in Switzerland (Bebi et al., 2005; Lundström et al., 2007; Von Ballmoos & Bebi, 2003). The original project emphasized the multitude of effects of different regional future scenarios on the local economy, resource sufficiency, land use and the provision of ecosystem services. Within this context, this article focuses on one key development problem of the case-study region, namely the limited land resources highly under pressure by the local tourism industry.

Section 2 provides a definition of the indicator and introduces both the model and the database. In Section 3, we introduce our case study of the Davos region and outline challenges in the future development of tourism in this region. Presentation of the model results in Section 4 is divided into a parameter variation and a scenario analysis that compares three potential future pathways for the development of tourism in Davos. Finally, Section 5 is devoted to a discussion of the strengths and weaknesses of this model-based approach to eco-efficiency.

2. Selected indicators and model-based approach to eco-efficiency

In general, eco-efficiency can be described by the ratio of an indicator for environmental pressure (numerator) to an indicator for economic development (denominator). The ratio is defined as shown in Equation (1).

Indicator for environmental pressure (numerator): The model follows an input-oriented approach to sustainable regional development assuming that environmental pressure is most effectively reduced by consuming fewer natural resources such as biomass, mineral ores, fossil fuels, and land. A reduction in any one of these inputs usually relieves pressure in several different fields of environmental concern. For example, reduced consumption of fuel lowers carbon dioxide emissions and reduces environmental risks and disturbances related to fuel extraction, production, and transport. In theory, eco-efficiency should take care of all the natural resources listed above. In most studies, however, the focus lies solely on the use of fossil fuels and CO_2 emissions.

In this paper, we focus on land use. Although land use is as limited as CO_2 emissions to fully capture the environmental impacts of tourism, it seems an appropriate indicator due to its relevance in local decision-making in our study area, but also in many other tourist destinations. Different to the concept of Ecological Footprint, we look at the actual land occupied by residential buildings and hotels within the study area and do not include any external land-use requirements through food, material or energy consumption (Hunter & Shaw, 2007; Wiedmann, Minx, Barrett, & Wackernagel, 2006).

The indicator chosen for land use in our model is the land covered by buildings which are related to tourist accommodation. All buildings were included into the study that were categorized as either hotels or residential buildings (in both cases plus their side buildings, such garages) according to a spatially explicit local database (LIS Davos, 2005). It can be assumed that certainly all hotels and about 48.5% of the residential floor space is used for tourist accommodation in the study region (G.-P. Calonder, 2005, pers. comm.). Further information on the comfort class was added to each hotel in the database. A spatially explicit differentiation between permanently and temporarily occupied residential buildings was not possible due to missing information on that matter.

For two reasons our analysis does not include any further land uses besides the built-up land to accommodate tourists. First, the area allocated to traffic is only indirectly related to tourism, as the road system is mostly used by the local population. Second, areas for skiing and mountaineering are not nearly as highly impacted as built-upon area, which is sealed and thereby distinct from open areas, including gardens.

Indicator for economic development (denominator): The most well-known and readily available indicators of economic development are indicators of national accounts such as Gross Domestic Product (GDP) and National Income (NI). Most studies of eco-efficiency at a national scale rely on these data-sets despite the known limitations of GDP as a sole indicator of economic development (Costanza, Cumberland, Goodland, & Norgaard, 1998). Critics note that GDP excludes the non-market economy and ignores changes in production capital (human, natural, and financial). In the case of Davos, tourism is a highly developed industry in which non-market activities play a minor role. Changes in production capital are important, however, as the development of tourism relies on skilled workers and modern tourist facilities. Accordingly, employment is chosen as an additional indicator to provide a more comprehensive view of economic development.

The values for these two indicators are estimated using an augmented regional input–output model. This type of model is commonly used in regional economics (Dwyer, Forsyth, & Spurr, 2004; Eiser & Roberts, 2002; Thomson & Psatopoulos, 2005), as it describes the interactions between different industries within a region. In the late 1960s, input–output models were first used as environmental planning tools by incorporating environmental commodities, including land requirements, into the model system (Lonergan & Cocklin, 1985). In recent years, this technique has been used to calculate land appropriation for production and consumption activities, commonly related to ecological footprint research (Bicknell, Ball, Cullen, & Bigsby, 1998; Hubacek & Giljum, 2003; Lenzen, Lundie, Bransgrove, Charet, & Sack, 2003). With an exclusive focus on the land requirements within the region, Eiser and Roberts (2002) use an augmented input–output model to compare alternative forestry strategies in term of their effectiveness in area appropriation. In a similar approach, we focus on direct area requirements through tourism accommodation and derive comparable values of factor income per area unit for alternative tourism categories.

The augmented input–output model consists of the following modules (see Box 1):

(a) **Input–Output Analysis (IOA)**: This module shows the interrelationships between industries within an economy with respect to production and the use of products and services, including imports, exports, and capital formation. The database of an IOA is an Input–Output Table (IOT), which provides data on the monetary value of all products and services as well as their origin and destination within the regional economy. In most OECD countries, such tables are provided at the national level by the respective statistical offices. At a regional level, however, they are mostly constructed for research purposes only. A common approach for the construction of a regional IOT is the so-called hybrid table, which is based on surveys and adaptations of other IOTs. We apply this technique to our case-study region (see Wegmann & Kytzia, 2005, for details). Full surveys were carried out for mountain railways, public administration, forestry, water supply, sewage and refuse disposal, sanitation and similar activities – covering a share of 12% of all employees in the region. Data for construction industries, hotels and restaurants and health and social work was gathered with sample survey, partly in combination with industry accounting data. These industries account for a share of 58% of all employees. For wholesale and retail trade as well as manufacture of food and beverages interviews were carried out to assess key values such as total production, salaries or import shares. These values were used to estimate the input–output data for these industries (covering another 12% of all employees). These industries cover approximately 80% of all employees and 70% of the total factor income (Wegmann & Kytzia, 2005). Basic data for the remaining industries is taken from the regional IOT for Steiermark, Austria (Fritz, Kurzmann, Zakarias, & Streicher, 2003). To achieve a balancing of inputs and outputs, we constructed a consistent model of the Davos economy for 2002 in which the value of the input of each industry equals the value of that industry's output. A simplified version of the 2002 IOT is shown in Table 1. This IOT is then used to calculate a matrix of technology coefficients (A) that represent linear input–output coefficients for each industry relation within the economy. The IOT is used to relate output from the economic system (consumption, exports, and capital formation) to inputs into the system (factor income and imports). This relation is represented in Equations (2) and (3), and is used to manipulate the output (e.g., increased tourist demand) and calculate effects on the input (e.g., factor income).

(b) **Model for tourist behaviour and tourist industries**: This model is based on a survey of consumer behaviour in the Canton of Valais (Rütter, Berwert, Rütter-Fischerbacher, & Landolt, 2001, p. 77). It defines 12 different categories of tourists and estimates the average amount spent per day in different areas such as accommodation, food, skiing, etc. (see Table 2). In our model, we assume that these values can be used as best estimates for tourism in Davos and that they remain constant over time (vector of consumption coefficients c_i in Equation (4)). We then substitute the final demand column, "tourist demand", in the IOT (see above) with a new column for "tourist demand" ($Y^{tourism}$) based on the vector of consumption coefficient for each tourist category and the number of overnight stays or day trips in each category within Davos (see Equation (4)). In addition, we categorize the hotel industry in the IOT into five different types of accommodation that correspond to the categories of tourists: three types of hotels (low-, medium-, and high class), vacation rentals and second homes, and group accommodation. We assume that the input–output coefficients of the hotel industry in the IOT can be used as best estimates for the input–output coefficients of all three types of hotels and group accommodations. For vacation rentals/second homes, we define new input–output coefficients according to data on the occupancy costs of second homes derived from Rütter et al. (2001). The difference in final demand from tourism between the IOT estimates for Davos (see above) and calculations based on the Valais data amounts to just 7%. The new augmented IOA is again balanced, resulting in an increase in production value of 3% compared to the original IOT for Davos. The augmented model shows how variation in the number and mix of tourists affects the factor income for Davos (see Equation (2)).

(c) **Model of area requirements of tourist activity**: This model is based on geodetic data from the Davos municipality that contains the ground floor areas of all buildings and planning zones. The model relates the ground floor area required for tourist accommodation to the prevailing area consumption and the currently available accommodation capacity. The density of tourist accommodations is influenced by local spatial planning and building design (floor plan, number of floors, etc.) and use (size of bedrooms, number of common rooms, etc.). We

Box 1. Model equations.

$$QG^{land\ use}_{tourism} = \frac{FI}{FA_{tourism}} \quad (1)$$

$QG^{land\ use}_{tourism}$: qualitative growth of tourist industries with respect to land use
$FA_{tourism}$: ground floor area for tourist accommodations (m^2 per year)
FI: sum of regional factor income

$$FI = \sum_{j=1}^{m} X_j v_j \quad (2)$$

X_j: total input into industry j (thousand CHF per year)
v_j: share of factor income in the total input of industry j (in %)

$$X = (I - A)^{-1}\left(\sum_{i=1}^{n} Y^{tourism}_i + Y^{remaining}\right) \quad (3)$$

X: vector of input into industries of the regional economy (thousand CHF per year)
I: identity matrix
A: technology matrix containing the input–output relations between all industries
$Y^{tourism}_i$: vector of final demand from tourists in category i (thousand CHF per year)
$Y^{remaining}$: vector of remaining final demand e.g. private consumption (thousand CHF per year)

$$Em = \sum_{j=1}^{m} X_j e_j \quad (4)$$

Em: total employment in the regional economy (in full-time equivalents)
e_j: employment per unit of input (full-time equivalents per thousand CHF)

$$Y^{tourism}_i = c_i Frequ^{total}_i \quad (5)$$

c_i: vector of consumption coefficients for tourist category i (in thousand CHF per day)
$Frequ^{total}_i$: number of day trips and overnight stays (in days per year)

$$FA_{tourism} = \sum_{i=1}^{n} AC_i DF_i \quad (6)$$

AC_i: accommodation capacity for tourist category i (in number of beds)
$Frequ^{total}_i$: number of day trips and overnight stays (in m^2 ground floor area per bed)
DF_i: density factor for accommodation for tourist category i (in m^2 ground floor area per bed)

$$\text{if } Frequ^{overnight}_i < AC_i \quad \text{then } FA_{tourism} = C_{status\ quo} \quad (7)$$

$Frequ^{overnight}_i$: number of overnight stays (in m^2 ground floor area per bed)
$C_{status\ quo}$: groundfloor area for tourist accommodation in the status quo (in m^2 ground floor area)

$$\text{if } Frequ^{overnight}_i > AC_i \quad \text{then } FA_{tourism} = C_{status\ quo} + C_{addition} \quad (8)$$

$C_{addition}$: ground floor area required for new construction (in m^2 ground floor area)

$$C_{addition} = \sum_{i=1}^{n}\left(Frequ^{overnight}_i - AC_i\right)DF_i \quad (9)$$

$$\text{if } C_{addition} > 0 \quad \text{then } Y^{remaining} = \overline{Y}^{remaining} + C_{addition}CF \quad (10)$$

$\overline{Y}^{remaining}$: vector of remaining final demand in the status quo (thousand CHF per year)
CF: capital formation resulting from the new construction per ground floor area (thousand CHF per m^2)

distinguish separate density factors (DF_i) for each tourist category. Accommodation in a high-class hotel, for example, consumes more ground floor area than group accommodation. Table 3 shows data for the *status quo*. It suggests that density of accommodation is not only related to its price (luxury) but also to utilisation rate (e.g. for second homes) and building design.

(d) **Productivity functions for land and labor**: To calculate the way in which changes in tourist activities affect land use and employment, we formulate productivity functions that relate the total production of each industry X_j with the land and labor required for this production. For labor, we assume a linear relationship between production volume and employment (measured in full-time equivalents), as shown in Equation (6). For land use, however, a linear relationship does not capture the true cause–effect relation. Provided that accommodation capacity is not fully exploited in the peak season for all types of tourists, production can still increase without additional land use; only a shortage of beds will lead to new construction activity. The ground floor area required for any new construction is determined by the density factor derived from spatial planning, architectural design, and facility management. The productivity function is therefore defined as a step function (see Fig. 1), with the length of each step indicating the buffer provided by capacities that are not fully utilised.

Equations (7)–(9) show how the point of expanding capacities is determined and how the additional ground floor area is calculated. We do not consider any limits to capacity expansion, but compare the simulated area expansion with the existing potential determined from the spatial database and spatial planning. Additional construction creates more factor income from construction industries; this effect is captured in Equation (10).

3. Study area in Davos

Davos is a mountain resort town at 1560 m above sea level in the canton of Grisons, Switzerland. The town has a population of around 11 000 permanent residents and accommodates up to 28 000 tourists during the peak winter season.

Our investigations concentrate on a study area that includes the principal settlement of the Davos valley (see Fig. 2). Based on the dataset described above (LIS Davos, 2005) and the rate of 48.5% use of residential buildings for vacation rentals or second homes (G.-P. Calonder, 2005, pers. comm.), approximately 35% of the total Gross

Table 1
Input–Output Table for Davos in 2002 in thousand Swiss Francs (kCHF) per year.

	Agriculture and forestry	Manufacturing	Wholesale trade, retail trades and repair	Accommodation and restaurants	Vacation rentals	Transportation (incl. mountain railway)	Other services	Intermediates	Tourist demand	Capital formation	Other demands	Production volume
Agriculture and forestry	252	3995	185	203	–	82	451	5167	–	136	5600	10 903
Manufacturing	2041	19 604	5897	25 364	8573	6338	18 224	86 043	–	54 306	47 008	187 357
Wholesale trade, retail trades and repair	906	2949	3388	35 893	1914	1538	2759	49 347	64 372	16 542	87 208	217 469
Accommodation and restaurants	–	728	710	659	105	487	2759	5447	212 840	–	34 231	252 518
Vacation rentals and second homes	–	–	–	–	–	–	–	–	40 199	–	–	40 199
Transportation (incl. mountain railway)	199	2274	847	448	–	660	1668	6097	48 525	–	10 468	65 089
Other services	3116	10 885	15 476	35 206	4946	3331	34 866	107 827	19 769	13 671	270 835	412 102
Intermediates	6515	40 434	26 504	97 774	15 539	12 435	60 658					
Factor income	2105	79 581	93 502	120 186	15 832	43 679	276 742					
Imports	2282	67 342	97 362	34 558	8828	9007	74 702					
Production volume	10 903	187 357	217 367	252 518	40 199	65 121	412 102					
Employees	117	1002	784	1567	249	287	2413					

Table 2
Consumption coefficients (c_i) for all tourist categories considered in the model not including hospitals and doctors.

Expenses (in kCHF)	Day trippers		Overnight stays									
			In hotels						In vacation rentals and second homes		In group accommodation	
			Low class		Medium class		High class					
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Accommodation	–	–	0.0715	0.0715	0.0836	0.0908	0.1960	0.1741	0.0329	0.0410	0.0394	0.0485
Food	0.0375	0.0304	0.0283	0.0304	0.0342	0.0347	0.0439	0.0546	0.0221	0.0246	0.0267	0.0186
Transport	0.0014	0.0011	0.0040	0.0011	0.0055	0.0026	0.0036	0.0044	0.0042	0.0012	0.0032	0.0033
Mountain railways	0.0071	0.0098	0.0085	0.0257	0.0084	0.0136	0.0126	0.0287	0.0061	0.0194	0.0048	0.0182
Sport courses	0.0017	0.0006	0.0014	0.0029	0.0013	0.0039	0.0014	0.0059	0.0024	0.0041	0.0081	0.0021
Education	0.0002	0.0002	–	–	0.0000	0.0006	–	0.0022	–	0.0001	–	0.0005
Retailing	0.0247	0.0176	0.0100	0.0101	0.0131	0.0115	0.0429	0.0267	0.0151	0.0201	0.0069	0.0062
Entrance fees	0.0028	0.0008	0.0004	0.0002	0.0007	0.0005	0.0002	0.0006	0.0004	0.0003	0.0004	0.0004
Health services (1)	0.0011	0.0006	0.0002	0.0004	0.0006	0.0019	0.0024	0.0003	0.0006	0.0009	0.0004	0.0002
Rental equipment	0.0001	0.0008	–	0.0048	0.0004	0.0027	0.0059	0.0075	0.0002	0.0031	0.0000	0.0025
Others	0.0014	0.0027	0.0018	0.0012	0.0063	0.0010	0.0081	0.0017	0.0015	0.0009	0.0017	0.0000
Sum per capita and day	0.0779	0.0645	0.1261	0.1485	0.1541	0.1638	0.3170	0.3067	0.0854	0.1154	0.0918	0.1006
Number of day trips or overnight stays	258 000	601 000	56 000	99 000	138 000	186 000	177 000	231 000	376 000	670 000	27 000	89 000
Sum	20 109	38 758	7059	14 698	21 269	30 465	56 116	70 850	32 114	77 298	2478	8950

Table 3
Accommodation capacity, ground floor area and density factor for the different types of tourists.

Category		Ground floor area [m^2]	Capacity [number of beds]	Ground floor area per bed [m^2/bed]	Season	Number of overnight stays [number of o-nights]	Occupancy rate [%]	Ground floor area per overnight stay [m^2/o-night]
Hotels	High class	21 460	2690	7.98	Summer	224 800	46%	0.10
					Winter	273 800	56%	0.08
	Medium class	17 600	2270	7.75	Summer	374 300	45%	0.05
					Winter	458 300	55%	0.04
	Low class	10 150	1140	8.90	Summer	13 540	35%	0.75
					Winter	21 500	55%	0.47
Group accommodation		2540	930	2.73	Summer	51 600	30%	0.05
					Winter	83 700	49%	0.03
Vacation rentals and second homes		146 170	16 100	9.08	Summer	372 600	12%	0.39
					Winter	646 400	22%	0.23

External Floor Area is used for tourist accommodation. Thus, the expansion of tourist accommodation capacity plays an important role in the development of the settlement.

The Davos economy relies on three major sectors: (i) tourism (44% of all employees), (ii) health services (19% of all employees), and (iii) the construction industry (11% of all employees). Research and development also plays a significant role, with 7% of all employees. Davos has a strong regional economy with an annual regional income (sum of factor income or value added) of approximately 619 million CHF or 47 600 CHF per inhabitant. This value is below the Swiss average of 48 844 CHF per inhabitant but well above the average for the Grisons Canton of 44 000 CHF. Davos is strongly dependent on the outside world, with 42% of final demand directly originating from tourism and another 14% from subsidies (agriculture and forestry) and transfers from health security (health services).

Tourism in Davos began as health tourism in the 1860s. The establishment of tourism had a strong impact on the area, which previously suffered from impoverishment and emigration. From a scattered rural settlement, Davos rapidly developed into a major health resort that attracted tuberculosis patients from all over Europe. By 1900, Davos was accommodating about 600 000 overnight stays per year. When antibiotics were developed in the 1940s, the number of tuberculosis patients decreased markedly; this has a serious negative impact on the Davos economy. By undergoing a profound structural change, Davos established itself as one of the first winter sports resorts. In the 1980s, Davos reached a maximum of 2.59 million overnight stays. Since this peak, the number of overnight stays has remained largely stagnant, with a slight tendency toward decreasing stays. Despite this stagnation, accommodation capacity has expanded over the past several decades (Davos Tourismus, 2002).

An important reason for this continued development is the construction of second homes and vacation rentals (see Fig. 3); these have a much lower utilisation rate (below 20%) than hotels (45%).

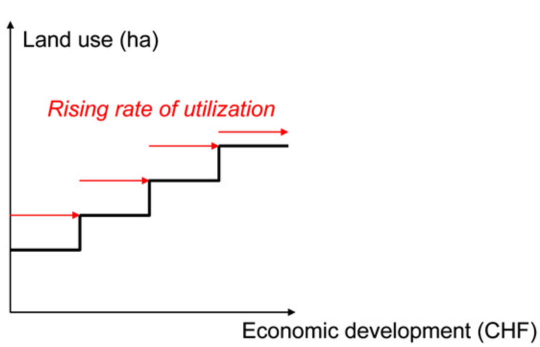

Fig. 1. Productivity function for land use in tourism.

Consequently, the settlement increased by 12.3% between 1985 (512 ha) and 1997 (566 ha), as recorded by the official Land Use Statistics of the Swiss Federal Statistical Office (SFSO, 2001). This increase in developed land is a major concern to local stakeholders (Von Ballmoos & Bebi, 2003) and has led to the implementation of a new spatial planning initiative that restricts future development to the area of the existing settlement. Despite these restrictions, existing development areas still allow for significant growth of the ground floor area. Davos is considered to be one of the most favorable locations in Switzerland for investing in real estate (Wüest & Partner, 2004, p. 58f).

4. Results

The model calculation for the *status quo* (year 2002) reveals that different tourist categories vary markedly in terms of how efficiently the tourist industry uses land to meet their demands. In addition to Table 3 where ground floor area per bed and the per overnight stay are given, Table 4 shows the ratio between the additional factor income for an increase of 1000 persons in each tourist category and the ground floor area required to host these people. The most land-efficient tourist categories are visitors who stay in high-class hotels and those who stay in group accommodation. These two categories of visitors are land-efficient for different reasons. Tourists in high-class hotels create the greatest factor income (0.41 kCHF per overnight stay during both summer and winter seasons) and require only 0.1 m^2 ground floor area per overnight stay because high-class hotels in Davos are relatively tall buildings that require little ground floor area per bed. Overnight stays in group accommodation require the least ground floor area (0.05/0.03 m^2 per overnight stay) because the ground floor area per bed is small (2.73 m^2 per bed compared to 7.98 m^2 per bed in high-class hotels); however, they create the second-highest amount of factor income (2.93 kCHF per overnight stay in summer and 3.28 kCHF in winter) after high-class hotels. All other hotel guests require more ground floor area to generate factor income. Visitors staying in vacation rentals or second homes use area in a much less efficient way. Because of the low occupancy rate in this sector, visitors require a large ground floor area (0.39 m^2 per overnight stay in summer and 0.23 m^2 per overnight stay in winter), while creating the least amount of factor income (0.41 kCHF per overnight stay in summer and 0.55 kCHF in winter).

These figures, however, show only a snapshot of the year 2002: they do not provide information on how land-use efficiency might change in the future or how it can be influenced by strategies in the tourist industry. To investigate these questions, we first apply our model to analyzing the system of tourism in Davos using a parameter variation (Section 4.1). Second, we define different scenarios that represent pathways for future development and show how the

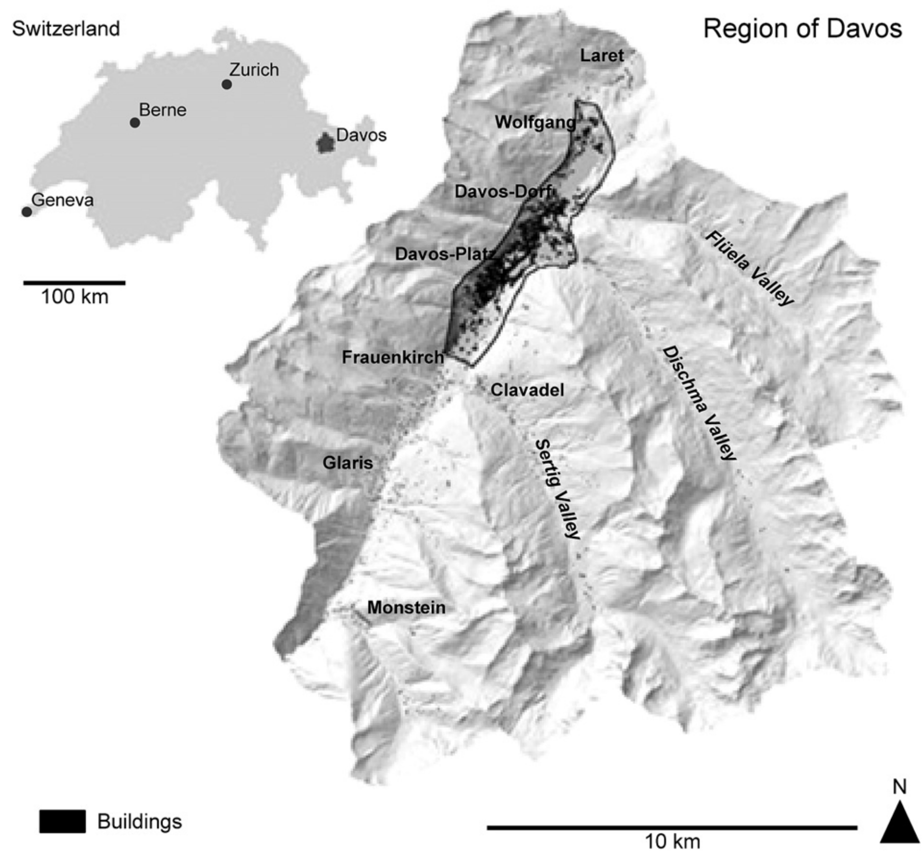

Fig. 2. Location and study area within the region of Davos.

efficiency of land use in tourism is influenced by these pathways (Section 4.2).

4.1. Parameter variation

The parameter variation reveals those parameters in the models that have the greatest effect on: (a) land efficiency of tourist industries and (b) employment. In our analysis, we focus on model parameters that directly relate to strategies in tourism (e.g., what kind of tourists does Davos wish to attract?) and density factors for the different tourist categories. All other parameters are kept constant.

Table 4 shows the degree to which the indicators for land efficiency and employment are affected by a change in the parameter values of 10% compared to the *status quo*. The indicator for land efficiency is most sensitive to parameters related to vacation rentals and second homes. A 10% increase in the density factor for this tourist category results in an approximately 8% change in the indicator value. A 10% increase in the number of overnight stays in

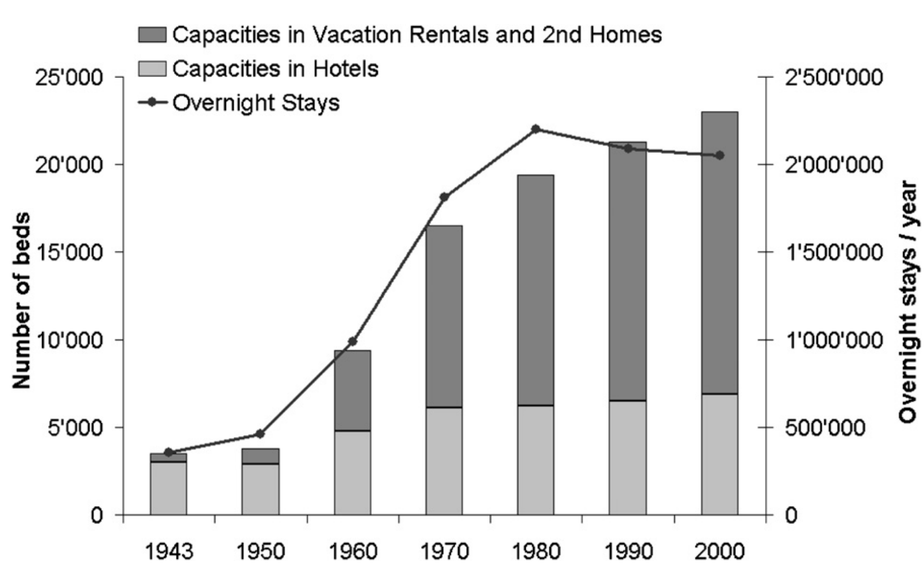

Fig. 3. Tourism development with increase of accommodation capacities and overnight stays since 1943 (Davos Tourismus, 2001).

Table 4
Results of the model calculation in the status quo and the parameter variations.

Parameters				Indicators		
				Factor income per ground floor area in the status quo	Relative changes in factor income per ground floor area caused by 10% variation of the parameter	Relative changes in employment caused by 10% variation of the parameter
Day trippers and overnight stays per year	Day trippers		Summer	–	–	0.21%
			Winter	–	–	0.39%
	Hotels	Low class	Summer	1.34	0.25%	0.08%
			Winter	1.60	0.52%	0.16%
		Medium class	Summer	1.92	0.73%	0.24%
			Winter	2.12	1.08%	0.35%
		High class	Summer	4.10	1.93%	0.64%
			Winter	4.09	2.51%	0.81%
	Vacation rentals and second homes		Summer	0.41	1.08%	0.36%
			Winter	0.55	2.62%	0.84%
	Group accommodation		Summer	2.93	0.09%	0.03%
			Winter	3.28	0.32%	0.10%
Density factor	Low class hotels			–	0.52%	–
	Medium class hotels			–	0.90%	–
	High-class hotels			–	1.10%	–
	Vacation rentals and second homes			–	7.97%	–
	Group accommodation			–	0.13%	–

this category during the winter season accounts for the second-highest change in the indicator value (2.6%); the same increase for the summer season results in the fifth-highest change (1.1%). High-class hotels are the second import tourist category related to the number of overnight stays in both seasons (2.5% change in winter and 1.9% in summer) and density (1.1% change in the indicator value). Variations in employment show the same pattern of dominance by vacation rentals/second homes and high-class hotels.

This dominant influence of vacation rentals/second homes and high-class hotels arises from two different factors: the large number of overnight stays in vacation rentals/second homes (approximately 50% of all overnight stays) and the large amount of money that high-class tourists spend per day (two to three times as much as any other tourist category). Yet vacation rentals and second homes are of prime importance to issues of land efficiency because the land use per overnight stay in this category far exceeds that of any other tourist category. Consequently, it is of paramount importance to both monitor and influence the development of vacation rentals and second homes in the future.

The results of the parameter variation can also be used to discuss the robustness of the results of the model calculation. Such an analysis shows that the model does not deliver a very robust total indicator value for land efficiency (factor income to ground floor area) because the indicator value is very sensitive to changes in the parameters related to vacation rentals and second homes. Unfortunately, the quality of data available for estimating the values of these parameters for the *status quo* is poor. Visitors in this category are not always registered in local statistics and the ground floor area for their accommodation cannot be explicitly identified in the spatial database because it overlaps with permanent housing. If we assume a possible range for parameter values of ±30% for both the number of overnight stays in vacation rentals/second homes and their ground floor area, the total indicator value for land efficiency varies between 2.4 and 4.7 m^2 per kCHF. An indicator value with such a high degree of uncertainty clearly cannot be used to monitor regional development, however, most of the differentiated indicator values for tourist categories in Table 4 are not affected by this uncertainty. The quality of data for the number of overnight stays in hotels and group accommodation is very good, and the ground floor areas for these facilities can be clearly identified. Consequently, the uncertainty range for these indicator values is much smaller than that for vacation rentals/second homes. The ranking of land-use efficiency for different tourist categories also provides a robust result. As the indicator value for vacation rentals/second homes is an order of magnitude smaller than all other indicator values, this remains the least efficient category even if overnight stays and ground floor area values for this category vary by as much as ±50%.

4.2. Scenario analysis: pathways for the future

The use of scenarios enables us to combine parameters and draw a more complex picture of possible futures. The intention is not to predict future developments, but to demonstrate principle pathways.

We define the following three scenarios for tourism in Davos that either capture widely known tourism marketing strategies (Scenarios 1 and 2) or on-going development (Scenario 3).

(1) **Curbing seasonal fluctuations**: As shown in Fig. 4, the occupancy rate of tourist accommodation changes considerably over the year. There are two peak seasons, winter and summer, where occupancy rates rise to 40–75%, and a low season where rates fall to 10–30%. A favorable strategy for future tourism development could therefore aim at a decrease in seasonal fluctuations and a higher level of utilisation. The first scenario follows this path by assuming that accommodation for all categories of tourists achieves the average winter occupancy rate for the entire year (see Table 5).
(2) **Increase in high-class tourism**: The results of the parameter variation reveal that an increase in high-class tourism will lead to increased land-use efficiency. The second scenario takes up this idea by assuming that high-class hotels have occupancy rates of 80% for the entire year (see Table 5).
(3) **Increasing capacity**: The final scenario represents the "worse case" for future development with respect to land-use efficiency. We assume that the capacity for tourist accommodation will be augmented to better serve the demand during the peak seasons. Accordingly, an additional capacity for 250 000 overnight stays during the peak season will be added over the next 20 years. We vary this projected growth by specifying the category of tourists that trigger the additional construction. In Scenario 3a, we assume that the additional capacity is evenly

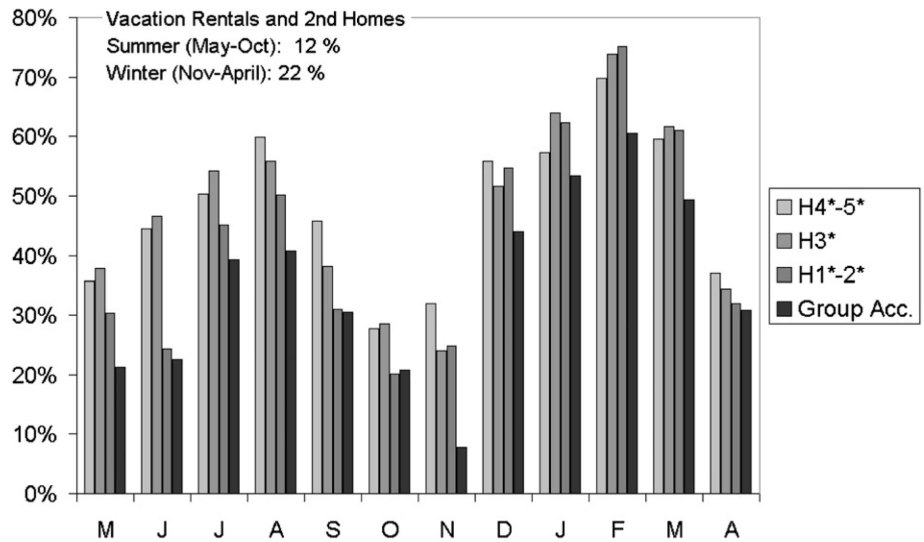

Fig. 4. Seasonal fluctuation in utilisation ratio for accommodation types (Davos Tourismus, 2001).

distributed between all tourist categories. In Scenarios 3b–d, we assume that all additional capacity is devoted to a single category, either group accommodation (3b), high-class hotels (3c), or vacation rentals/second homes (3d) (see Table 5).

The results of the scenario calculations for land-use efficiency are shown in Fig. 5.

The results reveal that the first two scenarios have approximately the same positive impact on the indicator value: curbed seasonal fluctuation (+9.3%) and an increase in the number of high-class tourists (+8.2%). The same results were attained for employment. The results for increasing capacity (Scenario 3) differ significantly with the variations in tourist categories. If all additional capacity is built for high-class tourists, the growing capacity has a positive effect on land-use efficiency (+5.4%) because the increase in factor income is higher than the increase in ground floor area. Additional capacity for group accommodation has practically no effect (+0.5%), whereas additional capacity for vacation rentals/second homes leads to a reduction in efficiency (−10.6%). Employment increases in all four variations of Scenario 3, from +9% for high-class hotels to +3% for group accommodation and vacation rentals/second homes.

It is also interesting to note which industries profit most from the increasing demand. In Scenario 1 (curbed seasonal fluctuations), the gains are fairly distributed between different types of hotels, restaurants, retailing, and mountain railways; whereas in Scenario 2, high-class hotels enjoy by far the greatest gains. In Scenario 3, the distribution of profits depends largely on the tourist category for which the additional construction is intended. Evidently, industries that provide services for each category gain most from the relevant scenario calculation. Gains in the construction industry also play a major role. If the additional capacity is used for high-class hotels, 31.4% of the total increase in factor income results from construction. This share is even higher (42.7%) if the additional capacity is used for vacation rentals/second homes.

5. Discussion

The results of our model calculation show that an augmented input–output model helps to better understand the dynamics of the regional economy and its impact on land use.

The application of the model to a case study of Davos in 2002 reveals that an increase in the density of beds per ground floor area has as great an impact on land-use efficiency as an increase in occupancy intensity during the year. Spatial planning, building design, and facility management therefore play a major role in improving land efficiency in the tourism sector. For vacation rentals

Table 5
Parameter values for the scenario calculation. All numbers are in number of overnight stays or day trips.

Tourist category			Status quo	Scenarios					
				Curbed seasonal fluctuations	Increase of high-class tourists	Growing capacities: evenly distributed	Growing capacities: group accommodation	Growing capacities: high-class hotels	Growing capacities: vacation rentals/ second homes
Day trippers		Summer	258 000	601 000	258 000	258 000	258 000	258 000	258 000
		Winter	601 000	601 000	601 000	601 000	601 000	601 000	601 000
Hotels	Low class	Summer	560 000	99 000	56 000	56 000	56 000	56 000	56 000
		Winter	99 000	99 000	99 000	118 412	99 000	99 000	99 000
	Medium class	Summer	138 000	186 000	138 000	138 000	138 000	138 000	138 000
		Winter	186 000	186 000	186 000	222 471	186 000	186 000	186 000
	High class	Summer	177 000	231 000	314 666	177 000	177 000	177 000	177 000
		Winter	231 000	231 000	314 666	276 294	231 000	481 000	231 000
Vacation rentals and second homes		Summer	376 000	670 000	376 000	376 000	376 000	376 000	376 000
		Winter	670 000	670 000	670 000	801 373	670 000	670 000	920 000
Group accommodation		Summer	27 000	89 000	27 000	27 000	27 000	27 000	27 000
		Winter	89 000	89 000	89 000	106 451	339 000	89 000	89 000
Total			2 908 000	3 752 000	3 129 333	3 158 000	3 158 000	3 158 000	3 158 000

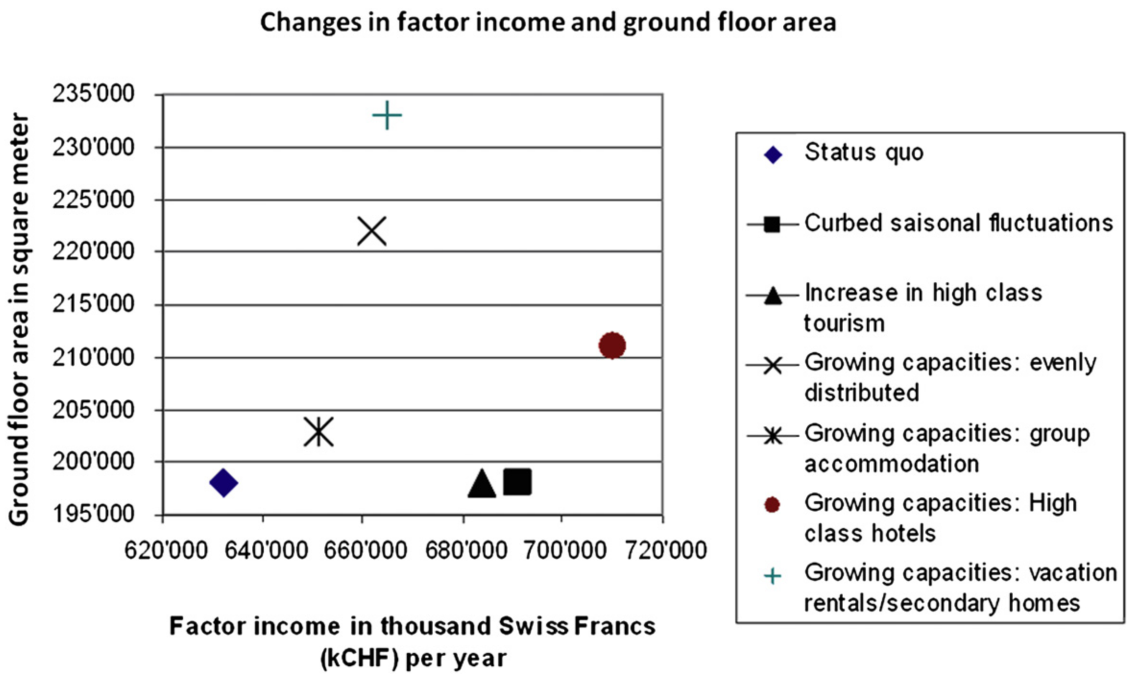

Fig. 5. Results from the scenario calculations.

and second homes in particular, increasing the density of beds appears to be more important than increasing the occupancy rate; however, given the poor quality of data for parameters related to this tourist category, this finding is considered to be unreliable.

Tourists staying in high-class hotels and group accommodation contribute most to the regional economy per square-meter ground floor area that they require. High-class hotels also have a significant impact on the dynamics of land-use efficiency, whereas changes related to group accommodation have little effect. This result confirms finding of Becken et al. (2001) who show that low cost accommodations need little space per bed. This makes luxury tourism a most interesting development option. Even an increase in capacity for high-class hotels is favorable for the overall efficiency because the additional proportion of factor income exceeds the additional proportion of ground floor area.

Vacation rentals and second homes are clearly the most unfavorable tourist category with respect to land efficiency. In addition, this category of accommodation has a profound impact on the dynamics of land efficiency. This finding confirms the general perception of stakeholders in Davos who have in recent years observed increasing land consumption—despite stagnant tourism growth—caused mainly by the on-going development of second homes (e.g. Bebi et al., 2005; Davos Tourismus, 2001). Poor data quality for parameters related to this tourist category does not seriously impair the validity of this finding because the differences in land-use efficiency between this category and all other tourist categories exceed the range of uncertainty. It is alarming that local authorities do not maintain an adequate database of on-going development in second homes/vacation rentals despite its paramount importance in determining land-use efficiency.

The model-based indicator also proves to be an appropriate tool for evaluating future strategies of tourism development. The indicator enables a sufficient degree of differentiation of: (i) parameters being subject to variation and (ii) variables that characterize the new system to “play” with different options for future development and thereby gain deeper insights into the system dynamics. In the scenarios used for the case study of Davos, it is interesting to note that an expansion of capacities is not negative *per se* in terms of land-use efficiency. The impact of such an expansion is highly dependent on the tourist category that triggers the development, and could also be used to attract new tourist categories that replace those tourist categories with poor land-use efficiency (e.g., vacation rentals and second homes). Land efficiency, therefore, does not automatically imply conservation of the existing building stock as suggested in Scenario 1 and 2; it can also be achieved via reconstruction.

Yet, an increase of land-use efficiency is only favorable as long as the total amount of land occupied by tourist accommodations does not exceed an acceptable level. In this reasoning we follow the general idea of limits to growth as suggested by the concepts of the carrying (Jennings, 2004; McCool & Lime, 2001; O'Reilly, 1986; Simon, Narangajavana, & Marques, 2004) or limits of acceptable change (Ahn, Lee, & Shafer, 2002). Beyond such limits, the system behaviour might change because of losses in scenic beauty, changes in the social fabric, deterioration of natural capital or other factors. And, such changes might be irreversible or very costly – in money and time – to reverse. For this reason, an assessment of land-use efficiency should be combined with a definition of limits for an acceptable change in the use of natural resources.

An interesting outcome of the scenario calculations is the analysis of which industry profits most from the development involved in each scenario. It becomes clear that a development strategy that favors one specific type of tourist accommodation (e.g., high-class hotels) will not bring about a fair distribution of benefits to the regional economy. Only with an overarching strategy as drafted in the scenario “curbed seasonal fluctuation” can we avoid initiating redistribution processes within the regional economy that might prove a hindrance to policy implementation.

The shortcomings of this model-based indicator approach to land efficiency include its restriction to: (i) land use, respectively the ground floor area dedicated to accommodate tourists, (ii) analyzing the effectiveness of development strategies rather than their efficiency or feasibility, and (iii) the fact that the model-based approach is extremely data-intensive and may therefore not be feasible for many regions.

Our focus on land use may indicate misplaced priorities for regional development, as it neglects other important impacts such as energy consumption and welfare. In our case study of Davos, the ranking of favorable tourist categories will probably be quite different if assessed on the basis of energy efficiency where passenger transportation and heated-building volume are the most important drivers. In such a case, tourists in high-class hotels might no longer be favorable because they require a large floor area per bed and probably travel large distances to visit Davos. In principle, such calculations could be carried out using the augmented input–output model if we defined an additional productivity function for energy.

Our restriction to analyzing the effectiveness of development strategies is more difficult to overcome. The augmented input–output model only tells us how development strategies influence the regional economy and the impact on resource consumption. It falls short of analyzing the costs and feasibilities of these development strategies; additional analytic tools must be introduced to fill this gap. The model-based indicator can then be one module in a wider cost–benefit approach.

The most fundamental shortcoming of the present model concerns the resources required to establish such an augmented input–output model, as this is a very time-consuming endeavor. In the case study of Davos, the model was based on existing data from a regional IOT as well as an existing spatial database; both were developed to analyze and evaluate a larger set of development strategies in the context of an interdisciplinary research project (Bebi et al., 2005). Without this basis, establishing the model-based indicator approach would be too expensive for planning activities at a local scale. However, such an exercise does yield a substantial return by promoting a more systematic and objective debate on possible futures for tourist destinations.

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