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Is Green Infrastructure a Game Changer for Sustainable Regional Development? A Scenario Approach for Stuttgart Region

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1 INTRODUCTION

There are numerous challenges for municipalities and regions: affordable housing, overburdened infrastructure, air quality, increasing pressure on open spaces, expansion of renewable energies, climate adaptation. Certainly, the list is not complete. Moreover, these issues – as a typical characteristic of complex situations – interact with one another in various ways.

As one of Germany's most dynamic and densely populated locations the Stuttgart Region is particularly affected by these challenges. Therefore, protecting and developing the landscape is a longstanding concern of its overall spatial planning strategy (e.g. development-axes, regional green corridors, landscape park, public transport policy). In view of the sheer number of tasks, the ongoing dynamics as well as strong sectoral policy instruments, the question can be raised as to how far green infrastructure can be a game changer for a substantive transformation towards sustainability.

Against this background, a scenario-approach is carried out aiming for the integration of various knowledge-areas into a supra-sectoral and strategic view on regional transformation. Taking the example of the Stuttgart Region, the diversity and interdependencies of land use are taken into consideration and synthesised in form of a qualitative system analysis.

The scenario development is part of the RAMONA-project, which is funded by the Federal Ministry of Education and Research (BMBF) in the framework of the "Stadt-Land-Plus"-measure. The project deals with the intervention regulation under the Nature Conservation Act[1] ("Eingriffsregelung") and inherent opportunities for urban and regional development. The scenario based approach therefore starts with open-space-indicators such as "degree of imperviousness", "compensation measures" as well as "green infrastructures" and puts them into a wider perspective of socio-technical development (e. g. settlement structure, infrastructure, traffic volume, agriculture or health) in order to obtain comprehensive pictures of the Stuttgart Region in the year 2050.

Keywords: impact regulation, great transformation, spatial development, landscape, system analysis

2 CONSTRUCTING CONSISTENT SCENARIOS – METHODOLOGY AND PROCESS

Scenarios describe alternative, consistent future developments (Kosow & Gaßner 2008). They provide a platform to reflect, communicate and discuss the openness of the future, the interdependence of developments as well as the steering effects of possible policy interventions. When selecting a suitable scenario-technique for the RAMONA-project it was essential that it offers a formalised system-analytic structure to interconnect a wide variety of drivers (as land use is a highly interdisciplinary issue) but at the same time is capable of handling qualitative information (as units, scale levels and calculability differ).

According to these requirements, cross-impact-balance-analysis (CIB) (Weimer-Jehle 2018) offers a viable option. It constructs impact networks based on expert surveys and finds plausible configurations by applying a mathematical algorithm. These plausible configurations are taken as scenarios. Thus, qualitative insights in interdisciplinary questions can be formulated, documented and synthesised into overall pictures.

Among others, the method has been used several times for scenario analyses in the field of energy supply and sustainability research (Jenssen & Weimer-Jehle 2012; Renn et al. 2007).

To put emphasis on the communicative and facilitating quality within the group-process CIB was closely blended with metaplan-technique. The current case-study involves fifteen regional practitioners and academics and is based on a five-step procedure:

(1) Identification of sectoral indicators (named descriptors), each assigned with a range of possible alternative developments (or variants) by 2050, in a moderated group discussion within workshop I (14

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[1] RAMONA is an acronym for "Urban-regional compensation strategies as an engine of sustainable land use". For more information about the project and the institutions involved, see http://www.fona-ramona.de/

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persons, September 2019). The descriptors are chosen in order to sufficiently describe the system of land use in Stuttgart Region.

(2) Building a common understanding within the group as well as specifying and defining the descriptors with brief descriptions in desk-work subsequent to workshop I.

(3) Assessment of direct impacts between the system elements in pairs and on an ordinal scale by the involved experts as well as providing the reasons for the evaluation in a written questionnaire (October – November 2019). "0" is used if one element does not have any influence on the other one. A strongly promoting influence is indicated by using "+3", whereas "+2" and "+1" are used for minor effects. Vice versa, restricting impacts are assessed by negative values.

(4) In case of strong deviations between the written assessments, a clarification-process was carried out via group work (3 groups à 3 to 4 persons) and moderated group discussions (10 persons) in workshop II (November 2019). Mostly, the group found consensus on the assessments, in a small number of cases majority decisions were taken.

(5) Examination of all theoretical combinations and computer-aided selection of consistent scenarios and interpretation of the results.

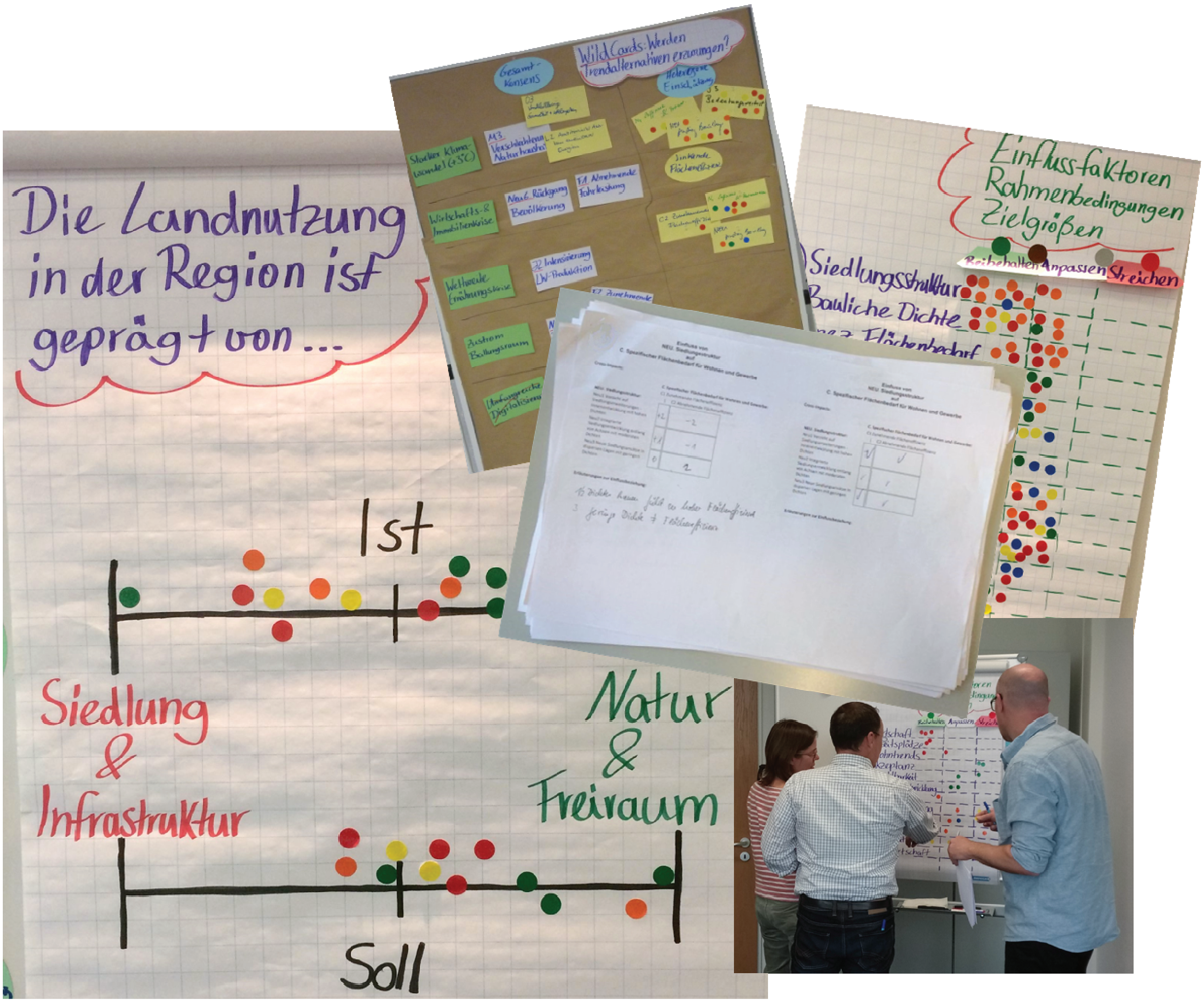

Fig. 1: Impressions of the scenario process

3 SYSTEM ELEMENTS AND THEIR ROLE – A FIRST GLANCE

Within the scenario-process 13 descriptors and 34 variants were identified as system variables for land use in 2050 by the involved experts. These variables are then arranged in a matrix-structure and produce a "morphological" box representing the mental mindset of the group. Examining each and every possible combination of the variants shown in table 1 would imply to check 186,624 assumption bundles by hand. As this would be very time consuming and error-prone, the computer software “scenario wizzard” is applied to check each system state for possible contradictions and to finally to “eliminate” implausible solutions.

Descriptors	Variants
a. Settlement	a1. Re-development of existing built up areas with high densities
	a2. Development axes with moderate densities
	a3. Development in dispersed locations with low densities
b. Floor Space Demand	b1. Increasing floor-space-efficiency
	b2. Decreasing floor-space-efficiency
c. Population	c1. Population increase
	c2. Constant population
	c3. Population decline
d. Traffic Volume	d1. Decreasing traffic volume
	d2. Increasing traffic volume
e. Degree of Imperviousness	e1. Constant degree of imperviousness
	e2. Increasing degree of imperviousness
f. Compensation Measures (Impact regulation)	f1. Compensation at the intervention site
	f2. Pooled substitution or compensation (within the region)
	f3. Disjointed substitution or compensation (within the region)
	f4. Substitution outside the region
g. Landscape Development	g1. Local development of open spaces
	g2. Coherent System of green Infrastructures
h. Agriculture	h1. Extensification and provision of public services
	h2. Intensification of agricultural production
	h3. Marginalisation
i. Transport Infrastructure	i1. Operation / Maintenance
	i2. Traffic reduction and expansion of public transport
	i3. Traffic management and expansion of roads
j. Energy Infrastructure	j1. Stagnation in expanding renewable energy
	j2. Major progress in expanding renewable energy
k. Natural Environment and Ecosystem Diversity	k1. Significant improvement
	k2. Constant level
	k3. Significant deterioration
l. Social Values and Consumer Behaviour	l. Sufficiency and postmaterialism
	l2. Hedonism and materialism
m. Health and Well-Being	l1. Significant improvement
	m2. Constant level
	m3. Significant deterioration

Table 1: Overview on descriptors and variants for future development until 2050.

The working-principle of the automated consistency-check can be highlighted by the example of three descriptors shown in figure 2. A scenario consisting of (a1, b1 and i1, coloured in green) is considered as consistent according to the mental setting of the group as it has the highest positive sum in each column (+4, +2 and +2). This matches the discussions during workshop II: the group argued for example that a limitation to the exisiting settlements (a1) – as a physical boundary for habitation – gives an impuls to increase floor space efficiency (+2). Moreover, the group agreed that maintaining current transport infrastructure limits settlement development and thus supports a re-development within the existing built-up areas (2). In contrast to the above-mentioned configuration, a combination of a3, b1 and i1 has a negative balance in one column (-4 in column a3, highlighted in red) and is therefore classified as implausible.

	a			b		i		
	a1	a2	a3	b1	b2	i1	i2	i3
a. Settlement								
a1 Re-development of existing built up areas with high densities				+2	-2	+3	0	-3
a2 Development axes with moderate densities				+1	-1	0	+2	+1
a3 Development in dispersed locations with low densities				0	+2	0	+1	+3
b. Floor space demand								
b1 Increasing floor-space-efficiency	+2	+1	-2			0	+1	-1
b2 Decreasing floor-space-efficiency	-2	+1	+2			0	-1	+1
i. Transport innfrastructure								
i1 Operation /Maintenance	+2	0	-2	0	0			
i2 Expansion of Public transport	0	+1	-1	0	0			
i3 Expansion of roads	-2	0	+2	0	0			
Balance:	+4	+1	-4	+2	-2	+3	+1	-4

Fig. 2: Exemplary impact balances for three descriptors

In addition to the consistency-check it is worth to look at the general role of the descriptors in order to find out how much effect they have ("activeness") and how much influence they receive ("passiveness"). To do so, all impacts exerted by one descriptor in a row ("active sum") and all impacts exerted onto a descriptor in a column ("passive sum") are summed up and shown in a system grid (see figure 3).

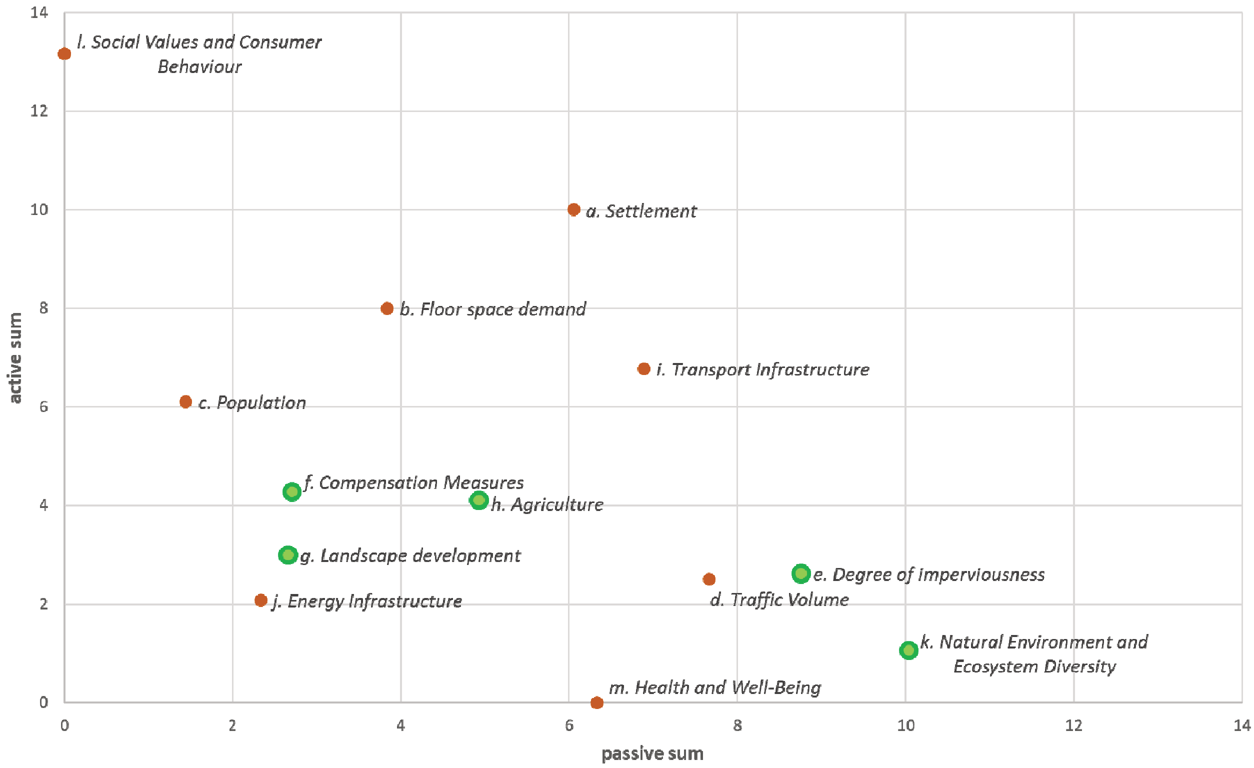

Fig. 3: System grid "land-use 2050 in Stuttgart Region"

The strongest position within the system grid holds descriptor l "social values and consumer behaviour" – a driver which is seen as independent from regional influences by the experts. Besides, the three most important forces in the grid belong to the built environment (settlement, floor space demand and transport infrastructure). In turn, open-space-indicators marked in green colour (imperviousness, compensation, landscape development, agriculture) have rather small effect. Descriptor k "natural environment and ecosystem diversity" is barely seen to exert activity at all but at the same time it is the descriptor receiving the highest influence. In summary, "land use" can be classified as a moderately complex system containing active, passive and bipolar elements.

4 A RANGE OF FUTURES – A DEEPER LOOK AT THE SCENARIO SPACE

Scanning the collected data for internal inconsistencies, twelve scenarios for land use by 2050 with completely consistent configurations in Stuttgart Region remain. These twelve descriptor-bundles leave a clearly reduced scenario space (compared to 186,624 possible combinations) but at the same time comprise a multitude of possible developments being determined systematically. They cover nearly all considered variants (e. g. increasing, constant and decreasing population levels), allthough in distinct combinations. Coming from an open space perspective it is, however, particularly noticeable that an improvement of natural environment (descriptor k1) does not appear at all in the scenario space of the consistent scenarios.

Taking settlement (descriptor a), floor space demand (descriptor b) and transport infrastructure (descriptor i) as the most influential and regionally internal drivers a scenario-taxonomy can be provided containing four fundamentally different types of regional development (see figure 4). This classification helps building a better understanding of the scenario-structure as well as uncovering similarities and differences in the scenario space. Type III- and IV-scenarios for example always co-occur with environmental degradation (k3) as well a significant deterioration in health and well-being (m3).

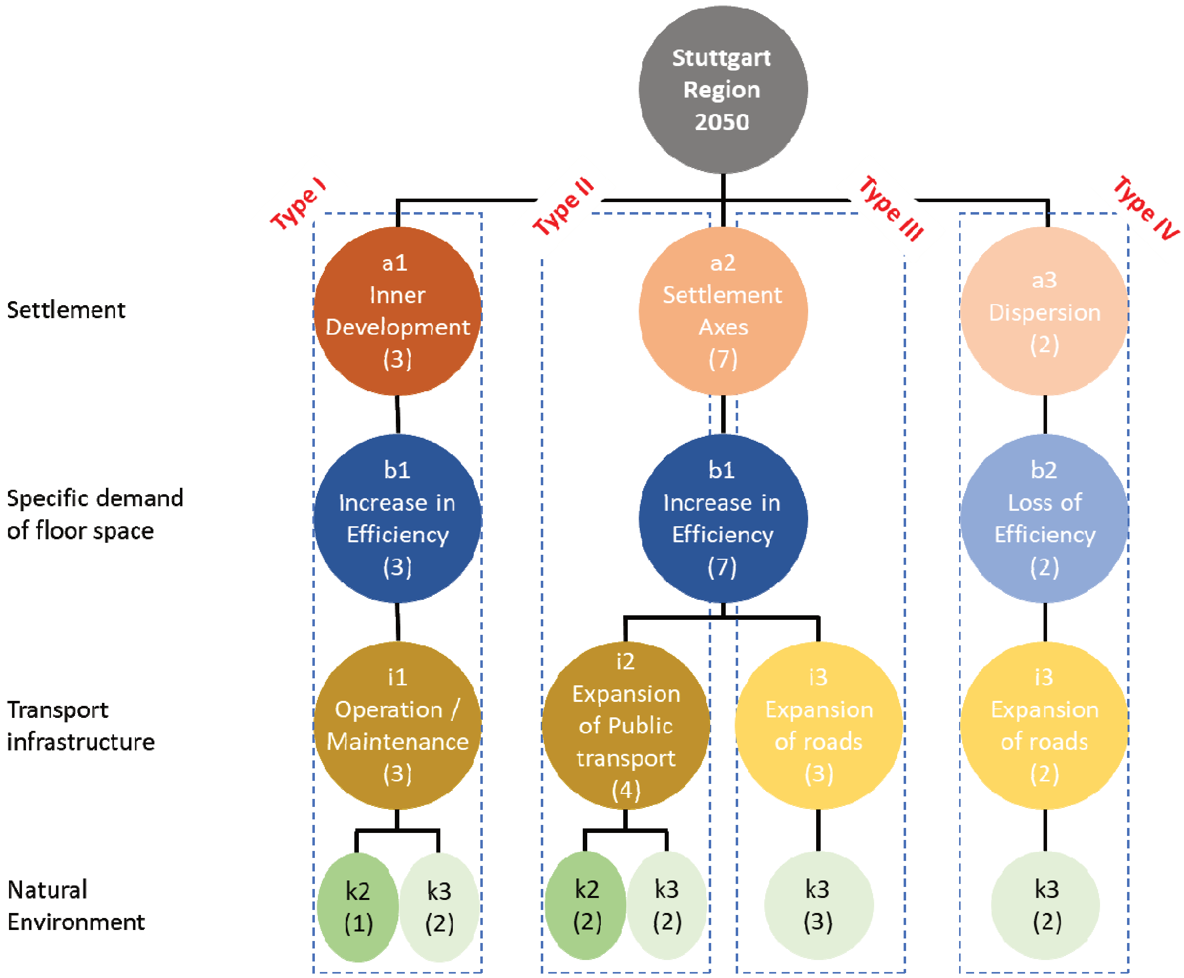

Fig. 4: Scenario tree of 12 completely consistent scenarios

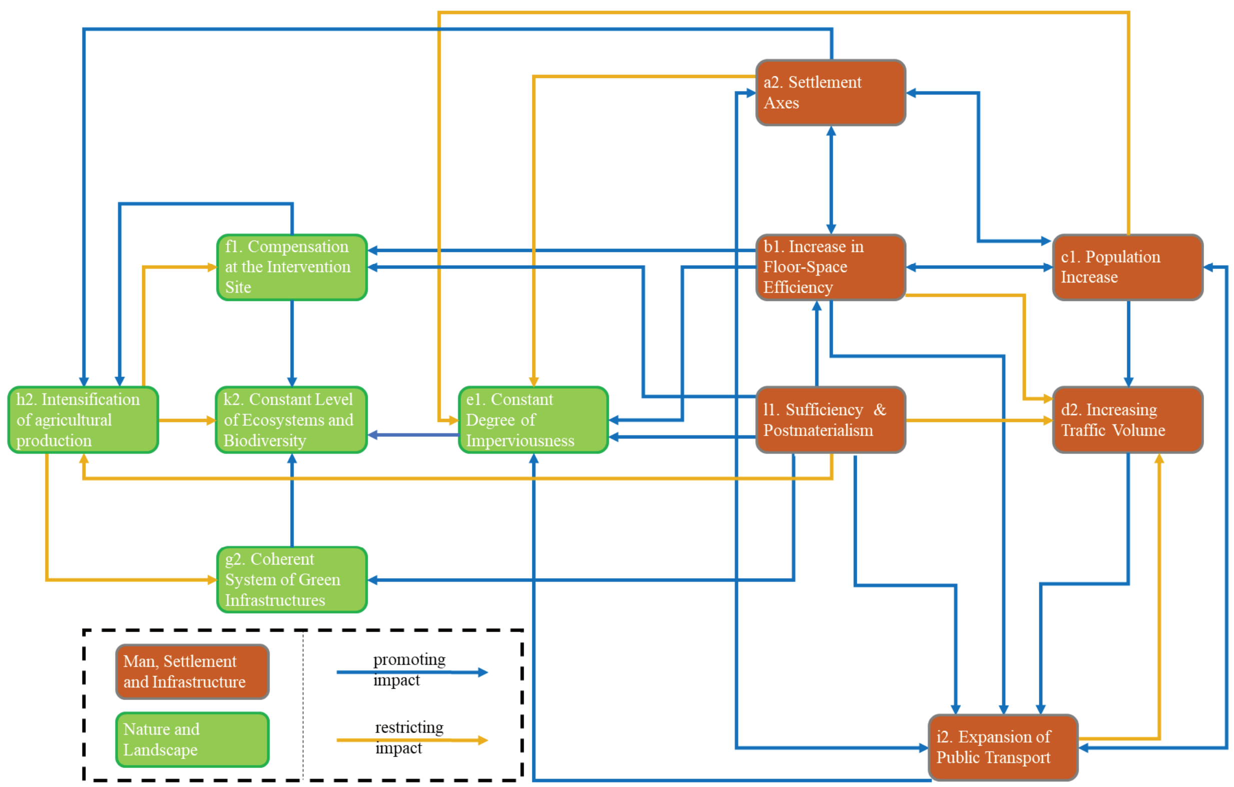

Fig. 5: Assortment of impacts within scenario # 9 “Unstable balance in the city region“ (type II)

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In contrast, type I- and II-scenarios generate more heterogenous results consisting of constancy or deterioration of natural resources (k 2 and k3) as well as – in a few cases – even improvements in health and well-being (m1). Actually, three type I- and II-scenarios come along with a stable ecosystem (k2). According to the way of thinking expressed in the CIB-matrix they achieve this under two prerequisites only:

- when compensating ecological interventions within regional borders (f1 or f3) and
- when establishing a coherent system of green infrastructures (g2).

Moreover, the scenarios suggest that a constant ecological status can be further enhanced if agriculture provides ecosystem services (h1) and if boundaries are set for further settlement development (a1 or a2). This can be interpreted in such a way that open space governance – in the sum of its effects – can play a significant role in growing agglomerations if it is carried out in a stringent and coordinated manner.

As shown in figure 5 impact relations can be promoting or restricting and they can be one-sided or reciprocal. As a whole, the system tends to configurations in which promoting impacts outbalance restricting ones. Scenario # 9 “Unstable balance in the city region” (type II) is such a scenario, although it includes some ambivalent and restricting drivers. The reason is that at the same time it includes plenty of reinforcing loops, especially between settlement axes (a2), floor-space efficiency (b1) and population growth (c1). These drivers are mutually supportive and therefore help generating and stabilising type II-scenarios.

5 CONCLUSION – PLANNING IN THE FACE OF MULTIPLE FUTURES

In contrast to common scenario development CIB correlates different parameters by developing, analysing and interpreting impact networks in a multidisciplinary, discourse-oriented and transparent manner. The application of this heuristic method thereby contributes to understanding land-use as a dynamic system with mututal impact relations as well as increasing transformation-knowledge for a sustainable regional development.

As a communicative and transparent toolkit, CIB is a good starting point for reflections on the current state of land use as well as on political goals and appropriate strategies (for different frame conditions) as it helps illuminating the space of possibilities thoroughly with well-founded assumptions instead of guessing “random” scenarios.

Looking at the land use in Stuttgart Region in the year 2050, each open-space descriptor seen individually shows rather small impact (“active sum”). Nonetheless, in combination they trigger noticeable effects and within the context of their systemic-interactions they pan out to be a necessary – but not sufficient – prerequisite for a constant or improving level of natural environment and human well-being.

Within the scope of this work a huge variety of future pathways for regional development could be constructed. In view of the discourse on the great transformation, the created scenarios will now be further explored with regards to change agents (who?), normative issues (why?), disruptive forces (what if?) as well as the context adequacy and adaptabillity of policy options (how to?).

The task of the scenario-process for Stuttgart Region, however, is not to come up with one definitive future but multiple possibilities – may they be seen as positive, neutral or negative – as well as raising awareness for essential obstacles, catalysts or amplifier. Thereby, clarity in the face of uncertainty can be gained helping planners to prepare their plans for regional transformation as well as to adjust or change them over time.

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