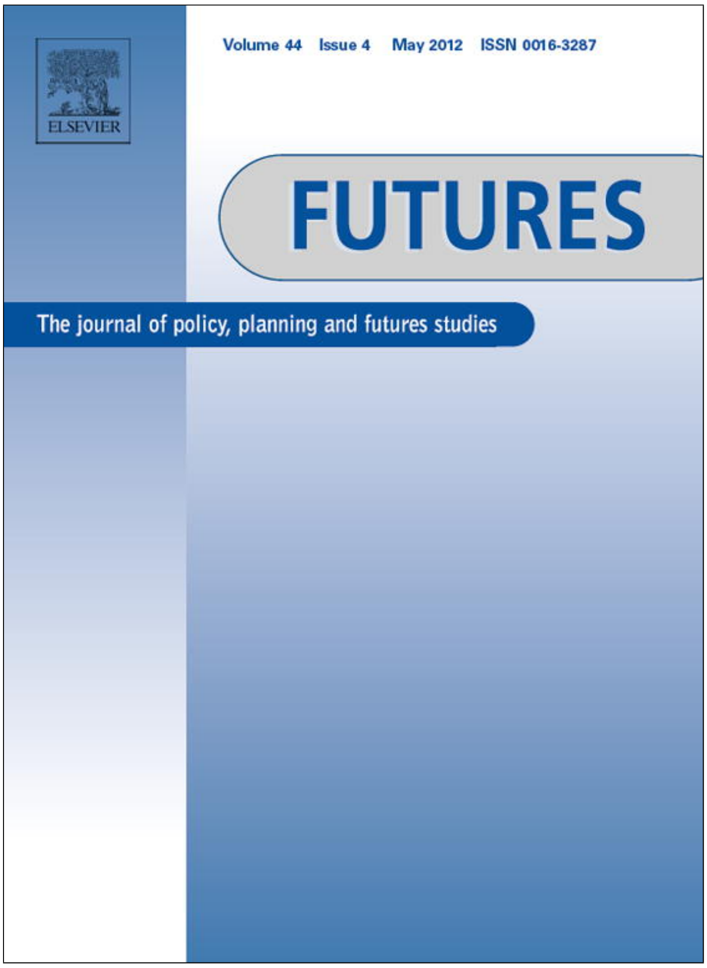
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GIS-based Backcasting: An innovative method for parameterisation of sustainable spatial planning and resource management

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ABSTRACT

Mankind has been making predictions since the earliest recorded history. From the astrologers of antiquity to the climate specialists of today, all have attempted to make predictions about future events. These attempts include assessments of whether or not these outcomes are probable or possible, desirable or undesirable. This paper concentrates on describing a methodology for the development and analysis of scenarios by refining and expanding existing methods. The approach is called Backcasting and was conceptually developed to support sustainable decisions in the energy sector. Backcasting works backwards from the envisioned future goals to the present, setting milestones to achieve the desired objective. These milestones are small interim scenarios along the way between the future scenario, usually 20–50 years ahead, and the present situation. Our Backcasting methodology is implemented in a modelling environment based on Geoinformation-System (GIS-based) using the scripting language Python. The methodology is demonstrated for an example of urban sprawl in rural areas, which often results in high infrastructure costs, large commuting distances and long travel times. To act against environmental degradation of rural areas, sustainable planning has to be the "overarching goal" [5], and will be supported with the developed approach.

1. Introduction

The origin of Backcasting goes back to the 1970s, when it was introduced by Amory Lovins as a planning method for electricity supply and demand. At that time he referred to it as "backwards-looking-analysis". Since then, this method has been regularly used in energy studies, often being referred to with the expression of "energy analysis of the final consumption" [6,23]. Backcasting was first used as a term by Robinson in 1982, as a method for analysing options in the future [28].

Backcasting is a process working backwards from future scenarios, usually 25–50 years ahead, to the present situation consisting of a rule-based analysis and resulting in normative policies in order to achieve the desired goals, which are independent of present limitations and problems [24,26]. However Backcasting should not be used to try and reveal what the future may bring, or to predict future situations, but instead should be used to assess the feasibility and impacts of different strategies [26].

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In Quist [23] the following different Backcasting approaches and different methodologies of Backcasting are compared:

- the approach proposed by Robinson in 1990 [23,27]
- the "Natural Step"Backcasting method [13]
- the STD (Sustainable Technology Development) Backcasting approach [23,42]
- the Backcasting approach used in the SusHouse Project [23,40]
- approach presented by Höjer & Mattsson [12].

Robinson includes in his approach the definition of future objectives, the creation of future scenarios based on an analysis of the present situation and the socio-economic evaluation of scenarios as well as the assessment of technical feasibility. Who sets the future targets or how they are set is not specified. The participation of stakeholders in this approach is not mandatory [23,27]. Later on this approach was upgraded by Robinson to participatory Backcasting, which had an additional step for the involvement of external groups and was applied in the Georgia Basin Future Project [25].

The Backcasting method used in the "Natural Step" is specified by:

1. Step: definition of sustainability criteria associated with a specific issue,
2. Step: analysis of the present situation, as well as present activities and competencies of the company,
3. Step: creation of future visions in cooperation with employees,
4. Step: development of progress strategies in order to reach an ideal state.

In this method the employment of "trainers" and "consultants" is proposed [13,23].

The STD approach focuses on 7 steps which include (1) the strategic problem orientation, (2) development of sustainable future visions, (3) setting out of alternative solutions for the Backcasting analysis, (4) exploration of options and identification of bottlenecks, (5) selection of options, setting up an action plan, (6) stakeholder cooperation agreements and (7) implementation of the agenda.

In this approach Backcasting analysis is considered in a separate step, also the definition of short-term activities and the implementation of issues and the involvement of stakeholders [23,42].

In the SUS House Project the approach includes steps for: (a) the definition and analysis of the problem, (b) the analysis and participation of stakeholder, (c) the organization of creativity workshops for stakeholder, (d) the development and assessment of scenarios, (e) Backcasting analysis and strategy workshops and (f) the realisation of follow-up activities as well as their implementation [23,40].

Höjer and Mattsson [12,23] propose in their approach (a) the definition of visions and desirable future states, (b) the definition and comparison of visions and forecasts, (c) scenario building and as a separate step (d) the Backcasting analysis. They further suppose to use fore- and Backcasting against each other: Backcasting, according to their opinion, becomes relevant, if it is evident, that the forecasted future targets will not be met.

1.1. Conclusions for the development of the Backcasting methodology

In summary, the approaches according to Höjer and Mattsson, of the STD, and the SusHouse Project include separate Backcasting steps, in the other two approaches the entire methodology is referred to as Backcasting. Four of these five approaches include the participation of stakeholder. They all develop scenarios and/or visions in separate steps and in four of five approaches the analysis of the present situation is taken into account. With exception of the approaches of Robinson [23,27] and Höjer and Mattsson [12], the implementation is processed separately.

Since none of these Backcasting approaches present methods for implementation, one can conclude that Backcasting is a rather underdeveloped method for sustainable planning, requiring further detailed consideration, preparation and analysis. Based on these approaches presented in Section 1, the following procedures have been set for the implementation of a Backcasting analysis in GIS for the parameterisation of sustainable spatial planning and resource management:

- problem analysis and analysis of the present situation
- creation of an "optimal future solution" (vision)
- determination of endogenous and exogenous indicators
- development of future scenarios including a SWOT analysis, different values (best-case, worst-case scenarios) and integration of stakeholders' interests
- Leitbild[1] development and further guideline principles and indicators
- development of a stochastic model in ArcGIS[2]

[1] Leitbilder in this context are models for supporting task-based and trend-setting decisions. For further explanation of this expression see Section 1.1.

[2] A stochastic model is a mathematical model, the SSA [31] describes it as a "[. . .] *tool for estimating probability distributions of potential outcomes by allowing for random variation in one or more inputs over time. The random variation is usually based on fluctuations observed in historical data for a selected period using standard time-series techniques. Distributions of potential outcomes are derived from a large number of simulations* (*stochastic projections*) *which reflect the random variation in the input*(*s*)" [29,31]. *Stochastic* is a synonym for *random* [19].

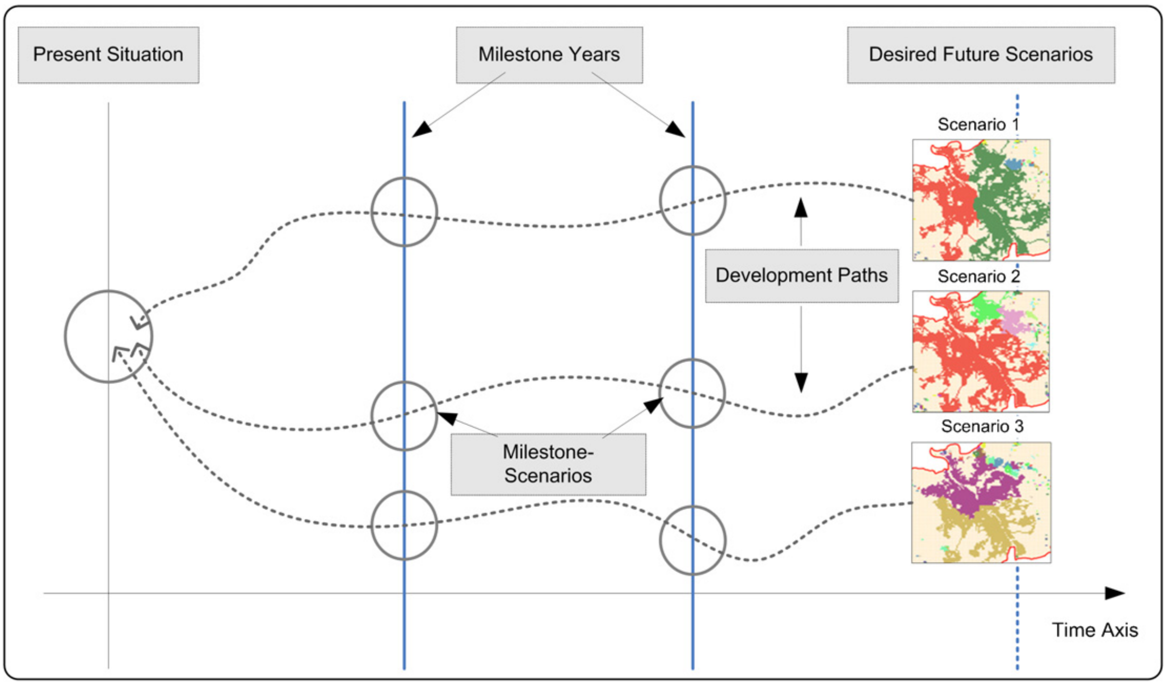

Fig. 1. Backcasting strategy.

- implementation of a Backcasting analysis of the case study on urban sprawl
- setting up the agenda and milestone scenarios
- iterative reframing.

To be mentioned here, "Leitbilder", are models for supporting task-based and trend-setting decisions. They refer to specified states or situations based on "*benchmarking and evaluation of present situations and new developments*" [15]. They sum up guidelines and describe desirable states for special topics and individual matters [15 see p. A16; 21, 6]. The expression "Leitbild", according to Potschin et al. [21], has been widely discussed in the German-speaking planning literature. Although the term has often been translated with *vision*, Potschin et al. [21] show that its meaning is even more extensive than the meaning of *vision*. A Leitbild, as it is considered in this research, is a kind of pattern or prototype in landscape planning that represents transdisciplinary approaches in which experts, stakeholders and laymen work out strategies and objectives to reach their common targets. Leitbilder are usually based on visions but culminate in firm objectives and specific activities.

2. Development of a GIS-based Backcasting methodology

The prediction of future developments and circumstances is today often carried out by either forecasting or prediction. Both approaches make use of statistical methods, such as time series (e.g. trend estimation, extrapolation, growth curve) or cross sections and involve risk and uncertainty assessments [1]. Forecasting is traditionally based on current trends, makes use of trend extrapolation, can have various possible outcomes and is therefore less likely to present suitable solutions, as these often result from breaks in existing trends. Prediction on the other hand is more general, more subjective and intuitive and involves the anticipation of change. Moreover prediction expects a certain outcome [6,23,37].

Backcasting is an approach that analyzes different future scenarios in the light of various influencing and limiting factors. Indicators are at first identified in the present, and extrapolated or forecasted into the future (e.g. number of inhabitants). These indicators are related to other indicators in a particular way, this means, that they have a certain connection with each other or dependency from each other. By defining these connections, the missing indicators, in order to describe a desired scenario in more detail, can be calculated. Starting from these desired future scenarios, which are usually about 20–50 years ahead, the process progresses backwards, step by step (via milestones), to the present situation (see right to left in Fig. 1).

By doing this, the values of indicators are backcasted until present time. If these indicators are then similar to the present situation, the model works appropriately. If not, either the scenarios have to be changed (esp. the values of the indicators or the correlations between them) or the rule-based methodology how to work backwards to the present time has to be adapted.

During the Backcasting process interim milestone-scenarios are developed, whose feasibility, as well as the processes and the organization required to achieve these scenarios, are analysed, tested and assigned different weightings for different solutions. With the implementation of milestone-scenarios on different paths, working backwards along the time axis, mandatory targets can be set in order to achieve the desired end-scenario [26].

2.1. General approach

The model system developed for a Backcasting analysis must be able to carry out simulations of different future scenarios until the desired scenario can be achieved. This can be verified by comparing back-casted values of the scenario-indicators with real values of these indicators at present. It is furthermore important that the models do not try to improve their outcomes, for example with regard to lowering costs or reaching equilibrium. They should not reflect the most likely or optimal solution, but should simply demonstrate the effects of the various scenarios selected [26]. It seems to be obvious that widely available geospatial data and GIS technology needs to be utilized for such an approach. Further the amount and quality of data needs to be assessed in order to reach comprehensible and reproducible outputs.

Developments in geographic information science, particularly in spatial databases, database access, spatial analysis, positioning technologies, remote sensing, and geo-visualization, have made an enormous progress throughout the 1990s [10,16]. Today a host of techniques has been implemented in GIS for mining data in search of patterns and anomalies, making inferences, and testing hypotheses about causes. GIS is now an important tool for simulating future changes on the Earth's surface through the implementation of digital representations of landscape-modifying processes [10].

In our spatio-temporal Backcasting methodology, extrapolation along the time axis poses a specific scientific and technical challenge, especially where it concerns the correlation of different sites during the course of developments over time. Specific approaches and methodologies are required to assist in the continuation of current trends and situations towards a future situation.

Different quantitative (e.g. demographic) and qualitative (e.g. location quality) approaches, as well as their development paths need to be analysed. Making use of relevant literature [3,41] an innovative approach will be developed for a model-based implementation of spatio-temporal correlations on different spatial scales.

The initial application/GIS implementation of Backcasting in the field of geographic information systems with regard to layer-based analysis and "Geo-Design" [18] involves the

- first test implementation A
- evaluation of the first test implementation A
- assessment of the framework for GIS implementation and the results from the case study
- analysis of new results from the case study
- second test implementation B (revised A-version)
- evaluation of the second test implementation B
- assessment of the revised framework, the revised GIS implementation and analysis of new results from the case study
- third test implementation C (revised B-version)
- evaluation of the third test implementation C
- . . . and so on.

The so-called "iterative reframing" that will be applied in this work, results in the construction of stable structures. Through constant reviews of the implementations, procedures and applications, an effective framework for research methods can be formed.

2.2. Step 1: Problem analysis and analysis of the present situation

As a first step, the issue itself is defined, as well as the period of time in which the scenario construction is to take place and the strategies to be implemented. Before designing an ideal future state the question of why this future state needs to be investigated must be addressed, after which its likely impacts can be analysed [36].

2.3. Step 2: Developing a future vision

Visions are often an idealistic conception of the future. A vision may be described as geographically referenced information serving as basis for describing and creating different values, shapes or characteristics of future states rather close to reality [14]. Vergragt [40] describes a future vision as strategies and actions with the goal of bridging present and future states. Berkhout [2] describes visions in the context of transition management as "[. . .] *devices for specifying a desired end-state in the form of a particular socio-technical regime* (*urban mass transit systems, for instance*), *supported by an effective* '*coalition of the willing*', *around which processes of technological, institutional and behavioural change can be guided and motivated*" [2].

The future visions are developed through creative workshops in cooperation with stakeholders. These visions may be quite utopian and based on qualitative studies. They define the ideal and desired scenarios for future settlements.

2.4. Step 3: Development of scenarios and Leitbilder

The schematic view of the development of scenarios and Leitbilder is given in Fig. 2.

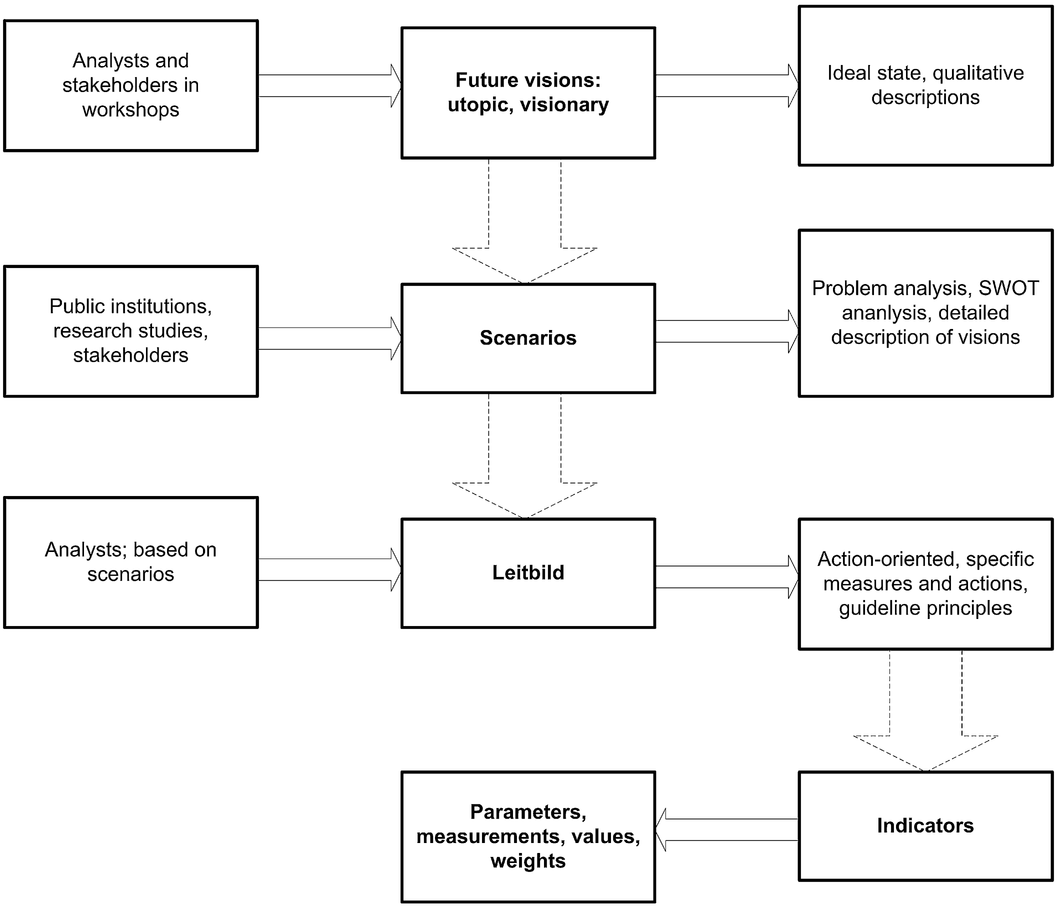

Fig. 2. Thematic Scheme "From Vision to Leitbild".

The firstly developed future visions are the source for scenario design and will therefore be described in detail. Scenarios often contain a SWOT analysis defining the strengths, weaknesses, opportunities and threats of the desired future state [30]. Scenarios can be developed from the research topic itself, which determines the criteria for the desirable and possible future state. This method is mostly chosen in the so-called "soft energy path" or "sustainable society" approaches. Backcasting rules are defined externally, for example by formal studies, by visions of future scenarios for various stakeholders or by own assumptions.

Scenario development can also be carried out in cooperation with stakeholder groups or the general public by inviting them to participate in the process of establishing and evaluating desirable future scenarios [26]. The development of scenarios is typically being carried out on the basis of existing (research) studies by public institutions in cooperation with other parties and stakeholders in the course of creativity workshops. Instancing the following three scenario-developing organizations are mentioned:

- The Austrian Spatial Planning Conference (Österreichische Raumordnungskonferenz ÖROK) developed "Scenarios of Spatial Development for Austria 2030" in 2009 to deal with regional challenges. In each of the four scenarios developed ("Overall Growth", "Overall Competition", "Overall Security" and "Overall Risk") the driving forces of spatial development (economy, population, tourism, mobility and transport) were considered in terms of their projected changes. Whereas the indicators for the "Overall Growth" scenario grew strongly, the development in the "Overall Security" scenario was rather slow. Assessment of the different scenarios led to the identification of more or less likely developments, risks, opportunities and challenges [20].
- The ESPON (European Spatial Planning Observation Network) 2013 Program of the "European Observation Network for Development and Territorial Cohesion" was adopted by the European Commission in November 2007. The aim of this program is to "*Support policy development in relation to the aim of territorial cohesion and a harmonious development of the European territory by* (1) *providing comparable information, evidence, analyses and scenarios on territorial dynamics and* (2) *revealing territorial capital and potentials for development of regions and larger territories contributing to European competitiveness, territorial cooperation and a sustainable and balanced development*" [8]. In this context the ESPON project 3.2 "Spatial Scenarios and Orientations in relation to the ESDP and Cohesion Policy" has been implemented. This project developed scenarios for the spatial development in Europe until 2030: the Trend-Scenario, the Cohesion-Scenario and the Competition-Scenario. All have been analysed for the planning dimensions of population, economy &

tourism, sustainable spatial development, agglomeration & urbanity and rural areas. The strengths and weaknesses of various regions are analysed and identified. The main objectives of this program are (1) to demonstrate EU-wide trends, (2) to allow territorial analysis of EU policies and their impact on cohesion and the EU territory, (3) the creation of maps of spatial structures and spatial disparities, (4) scenario development allowing previsions on possible future developments, (5) development of indicators for a balanced European territory, (6) development of tools and instruments to assist in the spatial coordination of sectoral strategies [8].

- The BBR, the German Federal Office of Civil Engineering and Spatial Planning (Bundesamt für Bauwesen and Raumordnung), has developed scenarios in 2003 to describe spatial and settlement structures in Germany until 2015/2040. These topics are analysed considering the planning dimensions of population & society, economy, sustainable spatial development & environment, and agglomeration & urbanity. These scenarios have been modelled in terms of long-time and medium-term impacts [35].

Leitbilder are afterwards created based on the developed scenarios and taking into account principles of the research foresight. A Leitbild in spatial planning is, according to Potschin et al. [21] "[. . .] *something that describes a desired future state for a landscape or region, and a set of proposals or guidelines about how that state can be realised or achieved.* [. . .] *It combines both a* '*call for action*' *and proposals for how that plans of action can be achieved*." In summary therefore, a Leitbild is action-oriented and consists of guideline principles as well as specific methods and tasks [30], in this work referred to as indicators and specific parameters and measurements.

Research foresight is, as defined by Ben Martin [17 quoted after 38], as "the process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits" [38]. Akin to Martin [17], Luke Georghiou [9] describes the method as "a systematic means of assessing those specific and technological developments which could have a strong impact on industrial competitiveness, wealth creation and quality of life" [9 quoted after 38]. Güell [11] states that foresight is mainly used in economic and technology policy but not yet established in the field of urban and regional planning. He developed a working methodology, which includes the scenario methodology in the foresight approach [11].

3. Application to a case study

The Backcasting methodology, i.e. the GIS based model framework, will be completely implemented and tested for the example of urban sprawl of Alpine cities. Here, the problem is different from the widely known phenomena of urban sprawl of Mega-cities. The Alpine topography means that only the valleys and plateaus are suitable for settlement systems, with centres and sub-centres. Where larger suitable areas are available within the Alpine region, development tends to produce dispersed structures resulting in the need for a high degree of mobility in motorized individual traffic (MIT), since public transport may not be an economic proposition under these conditions. This in turn requires additional investment in road networks, sidewalks, bicycle tracks, etc. Due to the restricted availability of suitable space in the Alps, the cost of land for housing within urban centres is often higher than in other topographic regions. These high costs, together with a common desire to live in the green countryside (which is a major factor in many decisions regarding the location of residential developments), lead to an increasing settlement in the urban hinterland.

3.1. The problem of urban sprawl

Urban sprawl is a complex topic and difficult to define or parameterise (cf. [33]). Squires [34] defined urban sprawl as "A pattern of urban and metropolitan growth that reflects low-density, automobile-dependent, exclusionary new development on the fringe of settled areas often surrounding a deteriorating city."

Recurring definition components and descriptions of the characteristics of urban sprawl can be found in Spitzer [33]. He summarizes iterative elements in an extensive list. The following are excerpts of definitions, characteristics and attributes for the term "urban sprawl":

- disproportionate increase in land consumption compared to population growth;
- low density (building density, population density, etc.) and hence scattered and no compact structures, aesthetic damage and chaotic urbanization;
- separation/segregation of functions of life (home/office/supply/recreation) and of land use which results in low centrality/activities close to the point of the highest settlement density (peak);
- low connective/extensive road network and therefore an increase in traffic/car-dependence/non-viable public transport due to low population and housing density;
- unsystematic development and devolution of settlement over wide areas, declustering of settlement structure;
- ribbon-like commercial development along roads of higher order;
- and so on.

The above-mentioned main characteristics of urban sprawl, including dispersed, low-density structures, the increasing traffic networks, and the development of suburban (and hence green) areas are, amongst other things, leading to the development of "edge" cities, fragmented land use [34], and increased traffic due to greater separation of housing and jobs. All of these results have additional impacts on the climate as well as social effects on, for example, segregation processes between cultural and social groups, and limit participation in community networks by those with restricted mobility. They also add to the cost of public services, the cost of providing infrastructure, and the costs involved in individual medical treatment and the provision of basic living requirements [33].

The future development of traffic and other related consequences such as increases in energy consumption, noise, pollution, private and public transport costs and infrastructure costs, will be dependent to some extent on the choices of location, including choices made by both private individuals and by companies regarding residential and industrial locations. Each location decision sets a long-term course for the future development of all involved parties. In the private sector in particular, location decisions are often based on the cost of a building site.

The decisions are therefore based on favourable short-term impacts with little regard for the longer term impacts concerning costs and expenses. Improvements to the quality of life by living in a green surrounding, and to housing due to lower building costs are often in the foreground. It is therefore essential to raise the awareness of people who have to come to a location decision concerning the long-term effects of business and residential location decisions and the negative consequences (e.g. longer travel times) that may arise as a result of these decisions. The investigation of the likely effects of different options is thus very important for a long-term perspective on the sustainable development of spatial structures. The ever-changing choice of transport utilities and the rising costs involved in meeting the basic functions of life (home, work, education, utilities and recreation) are additional factors that should not be underestimated.

The issues addressed in this research concerning urban sprawl in the Alpine region, together with all associated changes, impacts and developments, will require consideration of the following factors:

- population development (general increase in population, comparing the development in the countryside with the development in cities or urban locations, the composition of the population – i.e. the proportion of young, working and elderly people);
- construction activity (increases in construction activity, especially in the countryside);
- spatial planning (zoning plans, development of the situation in the countryside, expansion of land available for development, duration of settlement expansion, changes in settlement and development requirements);
- changes to the workforce;
- developments in mobility (development of public transport, increases in the motorized individual transport, number of commuters, travel times, travel costs, infrastructure costs);
- economic development (subsidies for energy-saving concepts in housing construction, promotion of local public transport, optimization of traffic connections, suppression of further of motorized individual transport);
- user-group specific cost assessment of the activities of individuals, of settlement areas or single locations;
- and so on.

3.2. Sustainable planning

When developing an urban planning instrument in the field of mobility and accessibility it shall be according to sustainable development[3] and correspondingly its main objectives in this paper are:

- to assure and achieve a balanced access to facilities for public transport or other environmentally friendly mobility options;
- to support a sustainable quality of life and mobility opportunities through innovative strategies for sustainable human settlement development;
- to start a long-term reduction in commuting;
- to support and improve access to existing environmental infrastructure and improve spatial/temporal accessibility.

An ideal and desired settlement in terms of various indicators, such as distances, attractive residential location, housing quality, living and mobility costs, access to public transport, and the "green factor" will be designed. This means, the future vision, and consequently also the milestone-scenarios, are defined and identified by endogenous and exogenous indicators. The definition will be carried out without reference to any guidelines and under assumption of permanent settlement area, decoupled from endogenous indicators or settlement patterns and influenced only by exogenous indicators.

Endogenous indicators consist of factors arising from the development of scenarios, which are then modelled. They incorporate, for example, path lengths, travel times, public transport accessibility, percentage of built-up areas, percentage of green space, dynamics of population/employees/buildings, etc. but also soft indicators concerning values for quality of life, etc.

[3] *"Believing that sustainable development, which implies meeting the needs of the present without compromising the ability of future generations to meet their own needs, should become a central guiding principle of the United Nations, Governments and private institutions, organizations and enterprises* [...]" [39].

Exogenous indicators include all the factors that are determined externally and hence cannot be influenced. These include topography, climatic factors (precipitation, temperature, etc.), land use areas (e.g. national parks, nature reserves, and landscape protection), types of land cover (rock, water, etc.), and so on [see therefore 22,32,33].

These individually defined and carefully selected indicators will also form the basis for further developments. Depending on the randomly assigned and changing values of the different indicators in each scenario, a weighting will be assigned to all indicators in the scenarios. On the basis of this weighting, scenarios with the highest weights will then be selected as the next, most likely milestone-scenario.

3.3. GIS implementation

To date there has been no spatially explicit technique available to translate future scenarios into maps. The proposed Backcasting methodology is based on the conceptual approach by Blaschke [4] and is implemented in the GIS-based modelling environment of ArcGIS using the scripting language Python. Python is "*an open-source, extensible, general-purpose programming language that is used as a scripting language in ArcGIS. Python is widely used and supported across many disciplines because of its simple syntax and powerful constructs, making it easy to learn and productive to deploy*" [7]. A stochastic model[4] will be developed, which is based on probabilities as opposed to deterministic models which are based on rules. This developed model will assign values at random to the different indicators.

As a first step for the GIS implementation, the difference is calculated between each future scenario and the present-day situation. The development along the time axis from a future situation back to the present situation will then be simulated through the stochastic model. The spatial reference implemented in the stochastic model will refer to communes or spatial grids. Within the model, course changes in and around the spatial reference defined (communes or raster cells) will be calculated as well as interactions (reciprocal influences) between each spatial system. During the simulation, the implemented stochastic model describes the process and the transition of the settlement: how it evolves back over time with regard to, for example, the decrease in size and number of buildings, changes to the extent of the settlement (in which grid cells it is expanding, in which cells reducing), and the direction in which the settlement moves, extends, etc. The model, bounded just by the start and end point, starts from future scenarios and develops a pool of randomly assigned values for indicators in each milestone-scenario; see left to right in Fig. 3.

The milestone-scenarios are generated by the developed model, and are based on changes in individual indicators. The most recent milestone scenarios on the path of development will be evaluated and ranked. The weighting will be dependent on their proximity/similarity to the present situation: the closer the indicators (and at last the milestone scenario) are to the present situation, the higher the weighting, and the farther away they are, the lower the weighting. The most highly weighted indicators will be selected to describe the next milestone-scenario. These milestone-scenarios need to be increasingly accurately evaluated on the way back to the present, as they approach the current situation. The development of milestone-scenarios approaching the present will be repeated until the present time is reached. The milestone years will be chosen arbitrarily to be 3, 5 or 10 years. How many milestone-scenarios are developed depends on the model created, the assigned values, and the weighting.

4. Results

The constituent parameters of urban sprawl are analysed in relation to their location specificity versus their generic meaning, and the most important factors will be parameterised and incorporated into a spatially explicit but generically applicable and transferable software framework. The developed framework consists of the following tasks:

- the creation of future visions (desirable states for the future)
- scenario development
- development of "Leitbilder"
  - in consultation with stakeholders
  - describing sustainable spatial indicators for settlement [22,32]
  - delineation of parameters for the measurement of changes
- (still to be developed) the development of a Python-model for application of the Backcasting approach, taking into consideration:
  - iterative reframing
  - layer-based analysis
  - geo-design
  - reasonableness, reliability, interpretability, transparency, flexibility, efficiency
- application to a specific planning case in the province of Salzburg, Austria, relating to case study on "urban sprawl in the Alps"

[4] In stochastic systems the input(s) vary randomly – here: from a pool of solutions. For the potential outcome(s) probability distributions are calculated [31]. In deterministic systems, on the other hand, the reaction to the input can be explicitly determined. See also Section 1.1.

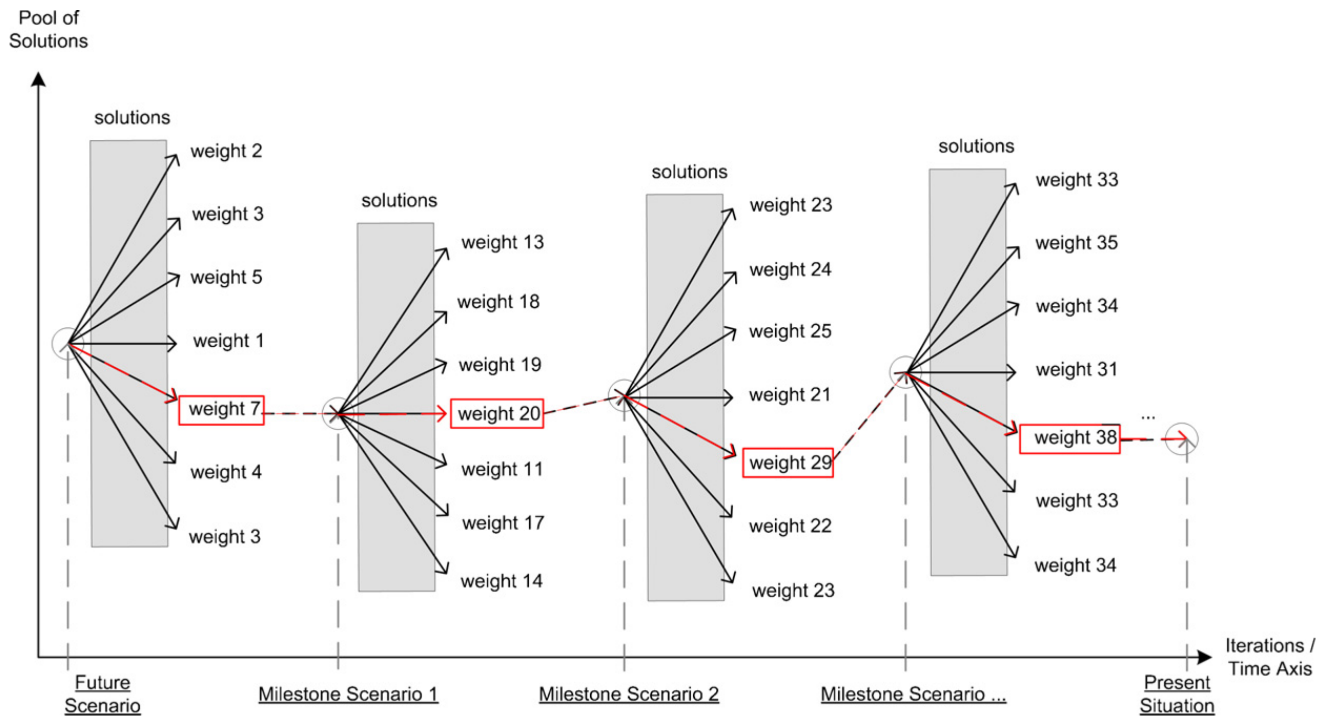

Fig. 3. Scheme of a Backcasting analysis [3].

- implementation of the developed framework within this context
- validation and assessment of the applicability and feasibility of the Backcasting approach in the context of spatial planning, and assessment of the methods application in sustainable spatial development
- model assessment

In the example of urban sprawl, which is discussed in this article, three scenarios were developed based upon the ESPON-, ÖROK- and BBR-Scenarios which define different characteristics and lead to varying parameter values. They can be described as (1) Scenario of "Maximum Standard of Living", (2) Scenario of "Maximum Sustainability" and (3) Scenario of "Minimal Settlement Requirements/Maximal Compactness". The visions developed describe qualitatively ideal future states. The proposed themes with their specific characteristics are listed below:

- Vision concerning optimal standard of living: dispersed settlement patterns have developed; the formerly high potentials of building land have become less due to extensive site development around cities and metropolitan centres. In the public transport sector many axes cannot be served economically any more → loss of quality. Instead the road network is expanded and as a consequence the motorized individual traffic increases (families living in "the green" have up to three cars). A result of the extended road network is also the fragmentation of the living space. The competition between agricultural use, tourism, nature conservation and use for planting energy crops in rural areas increases. This is a scenario of regulation in which the spatial planning has to act as a mediator [8,20,35].
- Vision concerning sustainability: cities and metropolitans have dissolved into regional cities and territorial networks. Building land in suburbs is affordable and has a good connection to the public transport system, which connects them with city centres. Farther away of centres you find agricultural and conservational areas as well as land for biomass production. These areas stay untapped from settlement development. Innovative land use, city planning and architecture with minimal soil sealing are the main tasks of spatial and city planners. Families mostly live in the suburbs or green belt around cities or in regional centres, the younger working generation and elderly people live in centres due to the excellent roadwork, short travel times to working places, infrastructural and social facilities [8,20,35].
- Vision concerning settlement compactness: functional areas are getting more and more important. Mobility costs are high due to road pricing, high fuel costs, CO_2 taxes and city-tolls and therefore the settlement development in the suburbs of cities is not that extensive. Spatial planning focuses on the further development, aggregation and compression of existing centres → reurbanisation processes increase. The public transport system has risen in quality and accessibility is guaranteed to all. Settlement development can be controlled very well by spatial planning due to high mobility and energy costs. The urban sprawl has diminished and the formerly favoured "living in the green" has become unaffordable for most of the people. The spatial planning institutions are also agencies advising site selections [8,20,35].

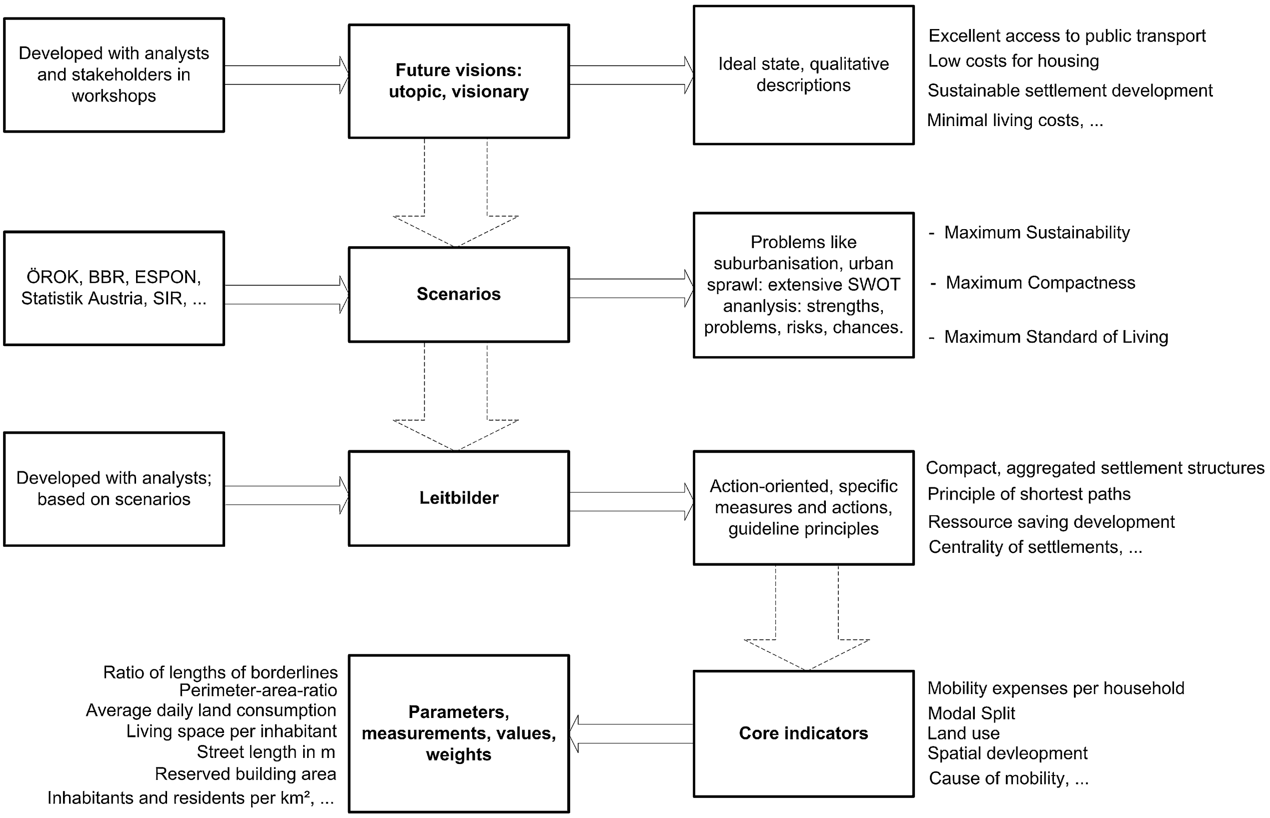

Fig. 4. Enriched Scheme: "From Visions to Indicators".

In Fig. 4 the visualization of Fig. 2 is enriched with descriptions, proposed scenarios, core indicators and parameters derived from the above characterized scenario-themes. These themes are strongly affected by created visions, serve afterwards as a basis for "Leitbilder" and are resulting in indicators, parameters and measures.

5. Discussion

The development and integration of this new method was demonstrated for the example of urban sprawl but it reveals new perspectives and opportunities that will also be applicable to other research topics, such as safety, construction and health care. The methodology provides possibilities for the integration of decision support systems into the workflow processes of specialists and decision makers. As previously discussed, although the basic ideas are relatively old, no consistent methodology has been developed and no tangible method exists for the application of the Backcasting concept. Problems relating to the effects of spatial planning – and lack of planning – represent some of the most significant and challenging problems in landscape ecology and Geographic Information Science. Only recently has proactive spatial planning based on GIS-tools started to tackle these problems in an operational way, developing GIS-based solutions, although these have not been related to a Backcasting concept. To the authors, this methodology forms a bridge between spatial planning concepts and Geographic Information Science and adds a new dimension to GIS while, at the same time, contributing to the provision of innovative solutions and improving the understanding of the afore-mentioned challenges. This conceptual work and its implementation are critically linked to the effects of changes in land use on natural resources, biodiversity, and human centred consumption patterns, and may provide essential support for sustainable planning practices.

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