A Process-Oriented Decision Support System for Sustainable Urban Development Strategies

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About my Person

- **Education**
- Diploma in Civil Engineering at the University of Trient, Italy
- PhD at the Swiss Federal Institute of Technology Zurich (2005) in the area of e-learning
- **Position**
- Since 2012 lecturer at the Eastern Switzerland University of Applied Sciences
- Focus on Process Management, Process Automation and Low Code Applications

Research activities and topics of research interest

Current research activities

- Strategic tools for sustainable urban planning /

  Development of process management and rule systems /

  Low Code Programming

Topics of research interest of my group

- Digital business /

  Digital health /

  Digital society

Project objectives

1. Development of an **intuitive** and **easy to use digital decision support tool** to assist political decision-makers in **formulating sustainable urban development strategies** through a transparent, **process-oriented** approach and **easy access** to the required **specialist knowledge**.

2. Integration of a **comprehensive catalog of criteria** into the tool, allowing the urban development scenarios to be assessed according to the most relevant perspectives and strategic goals.

3. **Transparent modeling of rules**, i.e., heuristics and calculations, for the systematic assessment of urban development scenarios, central management of the rules, and easy adaptation of the rules without specific IT skills.

4. Easy adaptation and scaling of the IT tool with little or no IT knowledge if new process steps or thematic aspects are to be considered.

Project consortium

Business Partner

GEOINFO

Research Partner

OST
Eastern Switzerland
University of Applied Sciences

Other Partner: User representatives

STADT WIL

STADT RORSCHACH

Stadt Gossau

kantonschwyz
Amt für Raumentwicklung

Kanton St.Gallen
Amt für Wirtschaft
und Arbeit

Experts

BÄNZIGER
PARTNER

Duration: 2019 - 2022

Funding

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Commission for Technology and Innovation CTI

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Research questions

1. What is the feasibility of a digital expert decision support system in aiding political decision-makers to formulate and evaluate sustainable urban development scenarios, using a transparent and procedural approach that is user-friendly, intuitive, and requires minimal time for data collection, recording, and analysis?

2. How can a comprehensive catalog of criteria for assessing urban development scenarios be integrated, considering the most relevant perspectives and strategic goals across different urban contexts?

3. How can rules, heuristics, and calculations for the assessment of urban development scenarios be transparently modeled, centrally managed, and executed?

4. How can the IT tool be easily adapted and scaled to incorporate additional process steps, thematic aspects, or assessment criteria without requiring extensive IT knowledge?

State of the Art (1)

Inspiration from decision support systems in spatial planning with integrated expert systems:

- Addressing complex, unstructured urban planning problems with multiple actors and high uncertainty.
- Creating scenarios to balance environmental, social, and economic factors.
- Supporting long-term decisions by analyzing impacts.
- Engaging stakeholder through diverse perspectives.
- Providing access to expert knowledge such as theories, rules of thumb, estimates and computational methods of experts .

State of the Art (2)

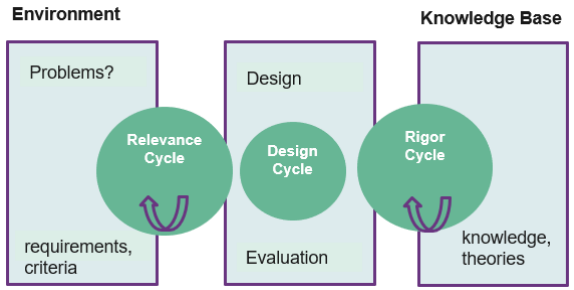
Challenges and Gaps

- Decision support systems still face challenges such as being specific, requiring specialist knowledge, being time-consuming, complex, and less intuitive. (M. Schindler, R. Dionisio, and S. Kingham, 2020)
- Their integration is insufficient for a holistic view, which is essential for sustainable urban development. (Z. Kapelan, S. Dragan, and W. G. A, 2005)
- Decision support systems focus on the design and evaluation of possible urban solutions, but only a few focus on the decision-making process itself: “Decision-making processes for sustainable urban development require structure and flexible guidance to support argumentation and communication between stakeholders”. (P. Lombardi, 2015)

Method

Employment of the Design Science Research Framework according to Hevner, which aims to create an artifact to solve a problem and analyze its performance. This methodology consists of three cycles:

- **The relevance cycle:** Establishes the application context, determines the requirements for the artifact and defines the criteria for its success.
- **The rigor cycle:** Existing knowledge and theory is used to influence the design process and expand the knowledge base
- **The design cycle:** The artifact is designed, evaluated and, if the criteria are met, released into practice.

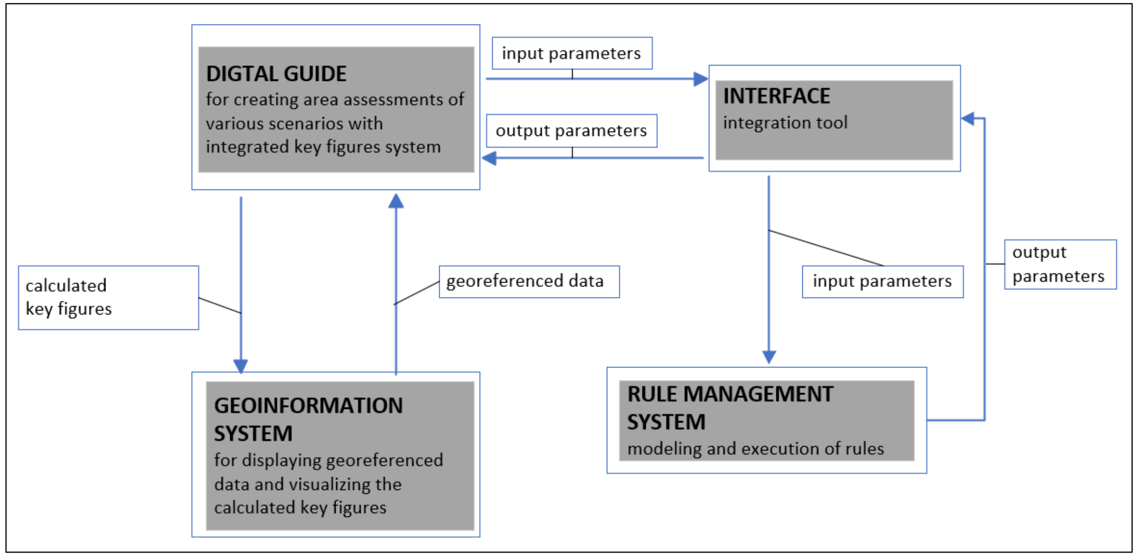


Design Science Research Framework accordnig to Hevner A. R. Hevner, S. T. March, J. Park, and S. Ram, 2004), modified picture

Solution

Components of the developed solution

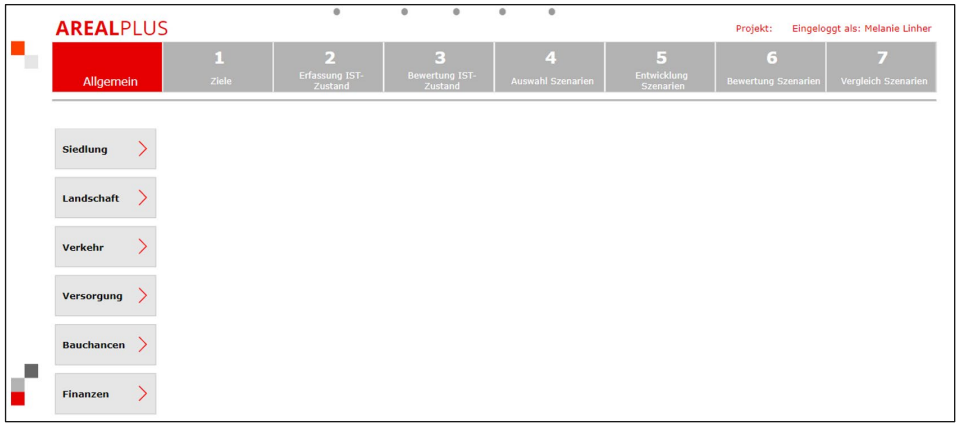
- A digital guideline for process-oriented recording and assessment of urban development scenarios.
- An integrated system of targets and metrics for a holistic, balanced and strategy-conform assessment of the scenarios.
- A separate ‘set of rules’ communicating with the digital guide via an interface.
- A geoinformation system linked to the digital guide for georeferenced recording of the scenarios and visualization of the key figures (e.g., visualization of land density).



Solution Software Architecture

Digital Guide

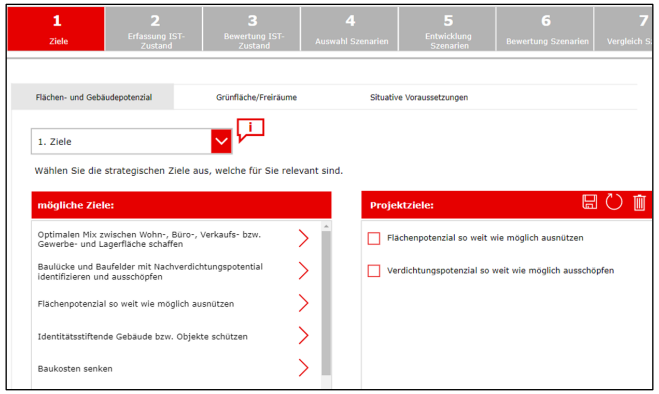
- The prototype is a web-based application utilizing the Microsoft PowerApps low-code platform.
- Similar to a digital guide, it leads users horizontally through the process, which consists of seven main steps, with further sub-steps as shown in Figure on the right side.
- Each process step can be carried out for each of the defined topics with the respective sub-topics of the urban development (vertical navigation).



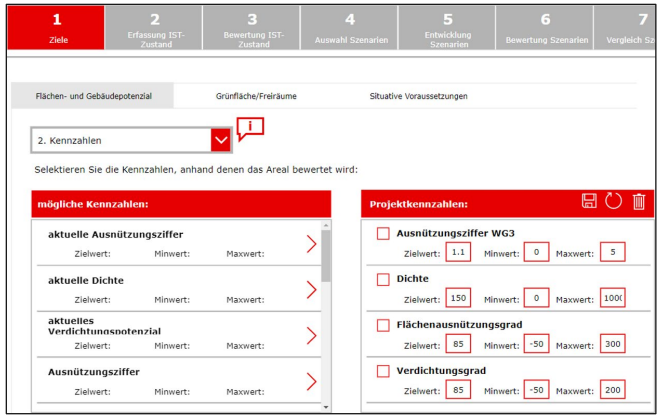
Process flow with seven main steps and six topic areas

- **7 horizontal steps:** Step 1: Selection of the project-specific development goals and key figures; Step 2: Recording the current status (e.g. land parcel and buildings attributes); Step 3: Evaluation of the current scenario, with automatic calculation of the key figures; Step 4:Choice of Szenario , Step 5: Building of scenarios, Step 6: Evaluation of scenarios; Step 7: Comparison of scenarios
- **6 vertical topics**: urban settlements, landscape, traffic, supply, constructions chances, finance

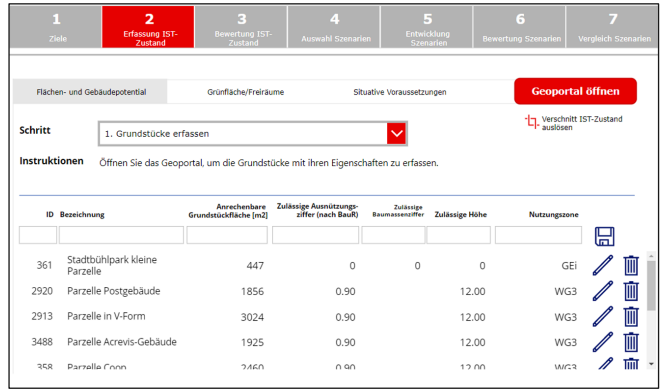
Digital Guide: some selected views



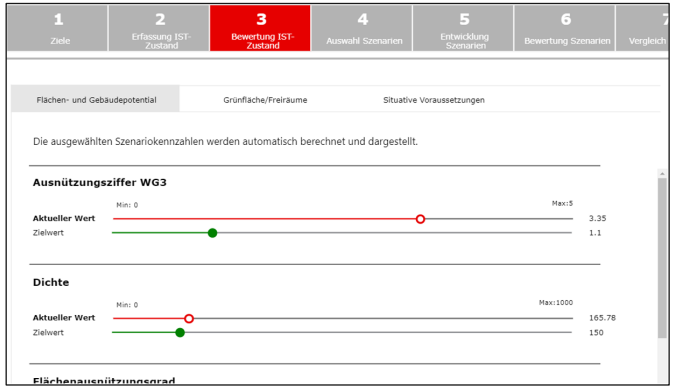
Step 1: Selection of the project-specific development goals



Step 1: Selection of the project-specific key figures



Step 2: Recording the current status (e.g., land parcel and buildings attributes).

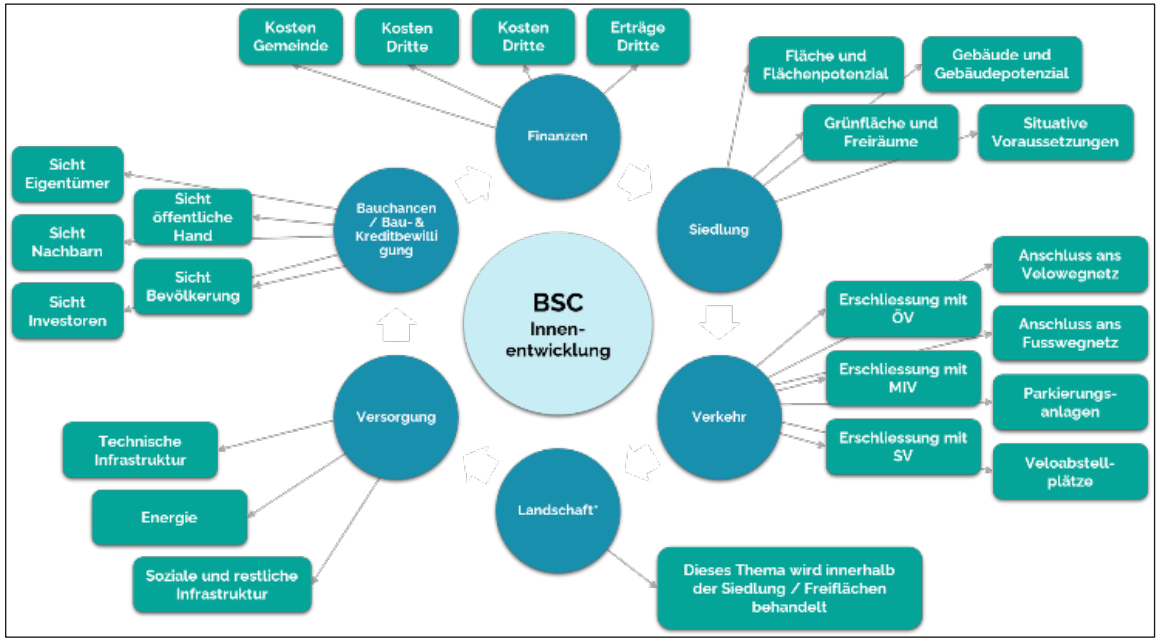


Step 3: Evaluation of the current scenario, with automatic calculation of the key figures e.g., ‘land utilization rate’ and ‘land density’

Step 7: Comparison of scenarios’

Target and Indicators System

- System of targets and indicators for a holistic and balanced assessment of the urban development scenarios **grouped** according to the **themes** and **sub-themes** of the digital guide
  - The indicators are generally quantitative: e.g. land utilization rate', 'land density.
  - Qualitative key figures are also included: e.g., assessment of the risk in a scale from 1 till 6.



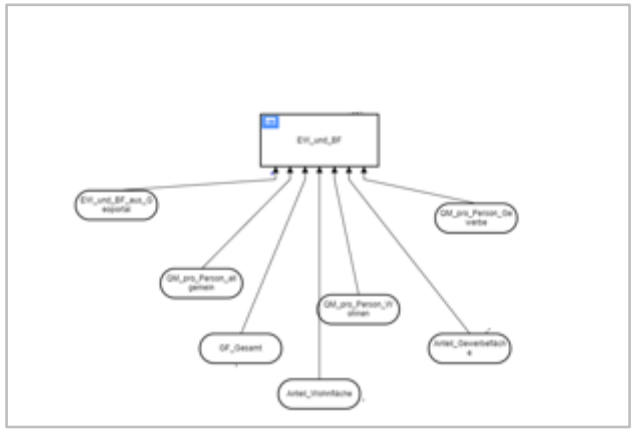
Target system for a holistic and balanced evaluation of scenarios

Rules for Evaluating the Scenarios

- Automatic calculation of the key figures for assessing the scenarios according to the selected objectives
- Use of the standard language Decision Modeling and Notation (DMN) for formalizing the calculations rules.
- Modeling and Execution of the rules in Camunda low-code application called ‘The Universal Process Orchestrator’

Example of calculation of the key figure “Number of inhabitants and employee”

- the key figure (rectangle) depends on logical combination of different input parameters (ovals).



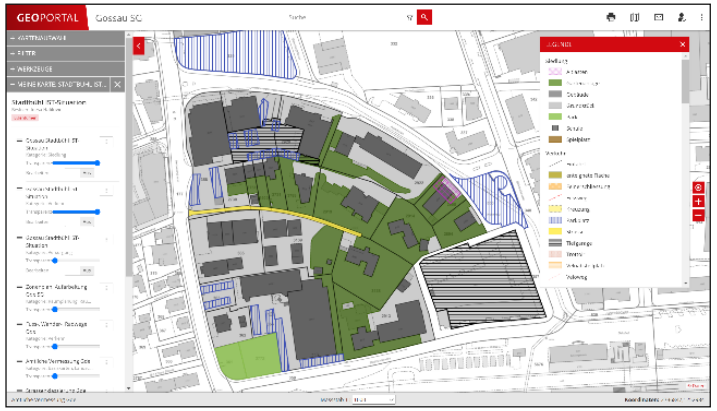
DMN model for the key figure 'Number of inhabitants and employees'.

Geoinformation system: georeferenced recording of scenarios

- Integration of the digital guide with a geoinformation system, enabling the easy and intuitive creation of various urban development scenarios with georeferenced data. Specific aspects for each scenario can be specified using a set of user levels, which are selectable on the left-hand side

Example

- Within the 'Settlement' user level, green areas or buildings can be created, while new roads can be recorded within the 'Supply' user level → automatic import of the georeferenced data into the digital guide.
- Once key figures (such as 'land density') have been calculated in steps 3 and 6 of the digital guide, they can be displayed in the geoinformation system.



Snapshot of the geoinformation system

Different shades of green represent the land density of each land parcel

Conclusions (1)

- First objective: successfully achieved
  - **User-Friendly and Intuitive**: The tool is easy to use due to its process-oriented approach and integration with a geoinformation system interface.
  - **Automatic Data Handling:** Facilitates the creation of georeferenced scenarios and automatic retrieval of data, reducing the need for extensive data preparation and analysis.
  - **Transparent and Systematic Approach**: Enables political decision-makers to understand and evaluate sustainable urban development scenarios clearly.
  - **Support of Competent Discussions**: Facilitates professional discussions with experts and stakeholders.

However, the **tool cannot replace the creative process** required to generate scenarios. Therefore, the development of sustainable and plausible scenarios still requires the involvement of experts.

Conclusions (2)

- Second objective: successfully achieved
  - **Comprehensive Criteria Catalog**: Holistic approach to evaluating urban development scenarios with real-time impact visualization, expediting the decision-making process.
- Third objective: successfully achieved
  - **Transparent Rule Management**
  - **Modeled and Executed Calculations**: Using standard DML language and a dedicated tool.
- Fourth objective: successfully achieved
  - **Adaptability and Scalability**:
    - **Low-Code Technologies**: Utilizes Camunda for rule management and PowerApps for the digital guide.
    - **Flexible Customization**: Concepts from workflow management software ensure easy adaptation and customization.

Future work

- Deep Learning Integration
  - Potential to optimize planning and implementation of sustainable urban developments by
    - automatically suggesting targets and target values,
    - identifying areas with similar characteristics,
    - generating indications for the development of plausible scenarios,
    - continually refinement estimated values by subsequently recording of scenarios implemented in reality.
- This combination of traditional estimation methods with the advanced analysis capabilities of deep learning would enable the tool to fully realize its potential.