3.
Four Scenarios for Lower Saxony 2050

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3.1. Introduction

As planning tools, scenarios have been differently defined by numerous scholars. The Millennium Ecosystem Assessment report explicitly differentiated scenarios from predictions or projections and defined the former as a "plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces … and relationships" (Carpenter et al. 2005: 603). According to Porter (1985: 446), a scenario is "an internally consistent view of what the future might turn out to be". With assumptions about key driving forces and their interrelationships, scenarios consider past, present, and future states (Rotmans et al. 2000). Schwartz (1996: 4) defined scenarios as "tool[s] for ordering one's perceptions about alternative future environments in which one's decisions might be played out". While most definitions depict scenarios as stories about the future (Ogilvy 2002), others characterize scenarios as a process that portrays the chronology of events from a current state to a point in time in the future (Steinmüller 2018).

Scenarios can either be qualitative or quantitative in nature. Qualitative scenarios consist of words, texts, images, and maps that describe future developments. While deemed "unscientific" and irreproducible (Alcamo 2008), qualitative scenarios are commonly used in participatory workshops given their communicability and ability to raise awareness while prompting stakeholders to think beyond disciplinary boundaries (van Notten et al. 2003). Quantitative scenarios consist of data and numerical outcomes largely generated through models. Certain quantitative

scenarios may reflect the consequences of policies on the environment, while others explore shifts in key driving forces. Despite their accuracy and wide adoption in the scientific community, quantitative scenarios are sometimes difficult to communicate to diverse stakeholders and non-experts.

Scenarios and future thinking remain fundamental to urban planning and design – a discipline centered on devising plans that aim to prepare for a better future. Scenarios in urban planning are rooted in the tradition of visioning, where designers and communities envision a desirable future (Avin, Cambridge Systematica, and Patnode 2016; Brück and Million 2018). Indeed, early visions illustrated by planners, architects, and artists imagined future cities and depicted a shift towards better prospects. Examples of these utopian visions include Ebenezer Howard's Garden City, Le Corbusier's Ville Radieuse (Radiant City), Ludwig Hilbersheimer's Highrise City, Frank Lloyd Wright's Broadacre City, Archigram's Instant City, Yona Friedmann's La Ville Spatiale, and Constant Nieuwenhuys' New Babylon, among others. These socio-spatial blueprints and aspirations resonated throughout the years and introduced transformative concepts that intended to reconfigure architecture, transportation, public spaces, buildings, and the society. Some visions were driven by advancements in building technology and the rise of new forms of mobility – shifts that largely influenced city form and gave rise to vertical cities with extensive infrastructural systems. Others visualized rural or urban realms, provided aerial views, or addressed environmental concerns. Conceived on the urban or regional scale, these visions illustrated interdependencies between the context and existing conditions while also expanding possibilities and opening up new prospects (Dunn, Cureton, and Pollastri 2014). However, utopian images, which prevailed across the 20th century, ceased and were gradually substituted by unidimensional futures disconnected from political realities and historic events (Myers and Kitsuse 2000). Lamenting the loss of spatial utopias, Isserman (1985: 483) raised a plea to "Dare to Plan", urging the return of visionary thinking to urban planning.

Apart from the normative tradition, other approaches and traditions have been adopted in urban planning over time. Examples of these include forecasting (Isserman 2007), consensus building (Susskind, McKearnan, and Thomas-Larmer 1999), strategic planning (Albrechts 2004), scenario planning (Avin 2007; Goodspeed 2020) etc. Each approach represents a different mode of thinking and has its own advantages and limitations. Normative traditions have been widely applied in local participatory workshops and charettes where the environment is controllable (Avin 2007). Such participatory workshops and charettes are common in the US, where local governments retain land use authority and manage or control implementation (Barbour and Deakin 2012; Sciara 2014). In the recent past, scenario planning approaches have been increasingly used in participatory workshops to explore multiple alternatives. These approaches are also integrated with other traditions, particularly forecasting and visioning, to develop a reference scenario or a vision, respectively. Scenario planning workshops are less common in Germany, where the application of approaches and implementation of ensuing solutions are hindered by bureaucratic structures and functional silos. Overall, participatory workshops not only actively engage stakeholders, experts, and the public

3.1 METAPOLIS Initial Workshop
Representatives of the partner municipalities in dialogue with the scientists involved to discuss challenges and opportunities

3.2 Scenario Development Workshop
Experts of the METAPOLIS research group discussing drivers and uncertainties of future development

to collaboratively explore scenarios and identify strategies (Innes and Booher 1999); they also allow planners to refine and advance scenario approaches and practice.

In the following section, we elaborate on scenario planning and its use in urban planning. We later discuss a case study where scenario planning was implemented in a participatory workshop to identify critical drivers and their impact on urban and rural development, and create qualitative scenarios for Lower Saxony, Germany. Thereafter, we discuss the participants' evaluation of the scenario planning workshop and the tools used and elaborate on the qualitative narratives generated.

3.2. Scenario Planning Approaches

There is a growing urgency in urban planning and design to address the future of cities and rural areas alike. In this regard, new approaches, techniques, and tools are key to understand and respond to increasingly complex and multifaceted challenges. For decades, a handful of studies have sought to review and distinguish between different scenario types and methods (Chermack, Lynham, and Ruona 2001; Bradfield et al. 2005; Börjeson et al. 2006; Bishop, Hines, and Collins 2007; Amer, Daim, and Jetter 2013). While some work compared the advantages and disadvantages of different traditions and techniques (Dreborg 2004; Bishop, Hines, and Collins 2007), others proposed typologies or systematized processes with different components to facilitate decision-making during scenario-based projects (van Notten et al. 2003; Chakraborty and McMillan 2015). In this context, Börjeson et al. (2006) discussed a tripartite division of scenarios that differentiated between: probable scenarios that predict future outcomes based on probability and likelihood of occurrence; exploratory scenarios that explore alternative long-term future developments from diverse perspectives; and normative scenarios that consider how to attain a certain vision or desirable end-state in the long term. In this section, we focus on scenario planning approaches, particularly exploratory scenario planning.

Scenario planning was developed at the Research and Development (RAND) Corporation by Herman Kahn, who used game theory and simulation models to create scenarios during the Cold War (Bradfield et al. 2005). The approach, which evolved from the intuitive logics school, was further popularized through the work of Wack (1985a, 1985b) and his colleagues at Royal Dutch Shell. Later known as the "Shell approach", the method's success lay in its ability to prepare Shell's management for the 1973 oil crisis (Wack 1985a). Scenario planning's acclaim extended beyond the business sector to other fields, where it was implemented, for example, to formulate scenarios of a democratic post-apartheid South Africa in 1992 – a workshop widely known as the *Mont Fleur Scenario Exercise* (Kahane 2012).

Scenario planning, which originated from military war games and corporate strategic planning, was subsequently adopted in urban planning (Bartholomew and Ewing 2008). The literature on scenario planning is largely associated with the work of experts in the business sector, namely van der Heijden (2005), Schwartz (1996), Schoemaker (1995), Ogilvy (2002), among others. In this regard, a plethora of applications and methods have evolved in the corporate

context but have lacked theoretical and methodological robustness (Chermack, Lynham, and Ruona 2001). The corporate sector often uses scenario planning to adapt to future uncertainties and increasing competition. More specifically, scenario planning is used to guide the strategy of a corporation that mainly pursues its own interests. In contrast, urban planning incorporates stakeholders' values, seeks to impact the future to serve the public good, and adopts long timeframes and broad issues. Urban planning aims to shape the transactional environment (where the community is an important actor) and makes use of scenario planning to inform actions or generate a plan (Avin and Dembner 2001; Avin 2007).

Chermack and Lynham (2002: 376) asserted that scenario planning is "a process of positing several informed, plausible, and imagined alternative future environments in which decisions about the future may be played out for the purpose of changing current thinking, improving decision making, enhancing human and organization learning, and improving performance". The approach seeks to explore a wide range of possibilities, develop multiple alternatives, identify indicators and performance metrics to evaluate and compare scenarios, and integrate transformative learning and change as outcomes (Goodspeed 2020). Scenario planning is not about predictions, forecasts, or the rightness of the scenarios. Multiple alternatives generated through a scenario planning process should neither be categorized simply as "good" or "bad" alternatives nor considered as low or high variations of a certain driver (Avin 2007: 107).

Scenario planning considers past and present events and the interdependencies or causal relationships between different drivers to understand their impact on future developments. In the corporate context, contextual drivers are usually selected across the political, economic, socio-cultural, technological, legal, and environmental (PESTLE) framework (van der Heijden 2005). However, other themes, such as spatial and transport-related issues, can also be considered. The approach involves a contextual analysis – where planners and the community have no influence – to identify critical uncertainties or indeterminates that might influence the community's future (Avin 2007).

Scenario planning approaches, particularly exploratory scenario planning, have recently garnered attention in urban design and planning literature (Chakraborty and McMillan 2015; Avin and Goodspeed 2020; Knaap et al. 2020). A handful of urban planning and design articles and reports summarized different scenario planning processes (Khakee 1991; FHWA 2011; Caplice et al. 2013; Ange et al. 2017; Stapleton 2020). Most projects complemented exploratory methods with forecasting and normative techniques to select a desirable scenario or generate a reference scenario. Overall, the scenario planning process, discussed in these reports, consisted of several sequential steps and is divided across different participatory workshops that involve diverse stakeholders. Initially, the core project team sets the scenario agenda, including the timeframe, focal questions, and scope of analysis, and selects the stakeholders. During workshops, participants identify trends, driving forces, and uncertainties and later prioritize and rank drivers. The interdependencies and cause-effect relationships between different factors and drivers are analyzed and the drivers' root causes are traced. Participants later pair critical uncertainties and place them on a 2x2 matrix – a prevalent yet not necessarily a

preferred technique – where each axis represents the range of desirable and undesirable futures. Participants then explore each scenario's characteristics, provide a title for each future, and detail the narratives. Finally, participants explore the implications of each scenario through a set of indicators and develop contingent and robust plans, policies, and strategies that are refined into recommendations with timelines (Stapleton 2020; Abou Jaoude, Mumm, and Carlow 2022).

Increasing environmental, socioeconomic, or technological challenges are likely to produce uncertainties in the built environment and require scenario planning processes, given their nature and long-term implications. Thus, exploratory scenario planning is recommended when external uncertainties (structural uncertainty) are critical and imminent; conflicting values and views between stakeholders exist (value uncertainty); solutions require cooperation between different scales; or problems and issues are unknown (Abbott 2005; Avin 2007; Avin, Cambridge Systematica, and Patnode 2016; Goodspeed 2020). Exploratory scenario planning fosters systems thinking and seeks to broaden the range of possible futures. Indeed, this approach enables users to adequately account and adapt to uncertainties.

Exploratory approaches to scenario-based planning ideally result in robust and contingent plans and policies that help communities better adapt to the future. However, many scenario planning efforts fail to achieve this theoretical goal and instead yield only insights and recommendations or are often not followed up after presenting the narratives (Avin and Goodspeed 2020). Scenario-based planning projects may involve public participation and integrate quantitative and qualitative data (Goodspeed 2020). Various exercises may use models and sketch tools to generate, assess, and visualize scenarios and understand future development patterns and dynamics. Tools and models are particularly necessary when iterations are needed to refine and replicate results, or stakeholders are faced with difficult decisions that require the consideration of impacts and trade-offs between scenarios. While many scenario-based planning projects are essentially qualitative, it is often only regional-scale projects and large organizations and cities that undertake and can afford a quantitative level of analysis. Through various case studies, Stapleton (2020) demonstrated that effective exploratory scenario planning does not require the use of tools and models but rather a structured process and method that can, alone, yield insights and guide policy. Compared to traditional urban planning methods, scenario planning can be a complex, time-consuming, and costly exercise (Avin 2007). The cost and complexity of a scenario planning project is contingent upon the scale (regional, local, etc.), topics, and range of external forces considered; digital and analysis tools used; number of experts consulted; meetings held, etc.

3.3. Case Study: The METAPOLIS Project

Several workshops were undertaken as part of the METAPOLIS research project to formulate four qualitative scenarios for Lower Saxony. The research project was conducted at Technische Universität Braunschweig and Leibniz Universität Hannover in cooperation with several Lower Saxon municipalities. The workshops aimed to analyze physical, ecological, social, and information networks and identify

3.3 Public Participation
Citizens participating in the scenario process had the opportunity to discuss and select their preferred futures for the sustainable development of Lower Saxony.

synergies across the urban-rural gradient in Lower Saxony. Scenarios were then applied to the three sample communities of Eydelstedt, Detmerode, and Schöppenstedt. The expert meetings and workshops were held between 2018 and 2019. Prior to the scenario development process, an interdisciplinary team of architects, planners and geoecologists had devised a systematized process and considered the 13 identified TOPOI types (Figure 3.5; settlement types or units) and their characteristics, namely form, functions, and linkages (Carlow et al. 2022). In subsequent workshops under the METAPOLIS project, the participants represented more diverse disciplines including political scientists, data scientists, environmental scientists and traffic planners, to depict the future of settlement types and their relations.

An exploratory scenario planning approach and the scenario-axis technique were selected prior to the commencement of the project. Initially, experts, academics, and municipality representatives convened to discuss their aspirations and visions for different towns and villages in Lower Saxony (Figure 3.1). Apart from stakeholders' values and interests, three guiding principles were derived from this workshop, namely *green and blue networks*, *five-minute city*, and *livable communities*. Data and GIS-based maps were later collected and analyzed by the researchers to understand the current conditions in the selected study areas. Semi-structured interviews were carried out with academic experts to gather more insights and learn about the history, challenges and opportunities pertaining to each discipline. Drawing on the interviews, the project team collectively created an extensive list of drivers, including population, migration, age, disruptive technologies and energy consumption, and questions that were later illustrated on cards. Key drivers were also borrowed from the Sustainability Strategy for Lower Saxony report (MUEBK 2017). The indicator report of the German Environment Agency (2017) and the interviews conducted by Böttger, Carsten, and Engel (2016) on the future of Germany were consulted, too. These reports and the book were also crucial for framing questions that addressed diverse disciplinary perspectives. For example, questions regarding future urban development included: (1) will density increase in major urban centers in the two study areas or will there be more sprawl especially around big urban centers? (2) What are the common building types in the two study areas? (3) Which spatial configurations will help achieve higher densities? During a series of meetings, the identified drivers were presented and the purpose, scope, and timeframe of the scenario exercise were determined.

During a second workshop, twelve participants convened to formulate scenarios for the future of the two study areas (Figure 3.2). Along with a deck of cards describing previous studies, the questions were used to initiate discussions. Participants were divided into two groups and then encouraged to draw causal loop diagrams and cluster drivers. Cards and questions served as generative tools to prompt participants to think beyond their disciplinary perspectives and overcome presumed assumptions. An uncertainty and impact matrix, otherwise known as the Wilson matrix, was employed to help participants prioritize and narrow down their selection of critical drivers. Through the scenario-axis technique and plenary discussions among groups, 'lifestyles' and 'governance' were selected as critical drivers to formulate

four first-generation scenarios, namely: *Green Communities*, *Planned Happy Futures?*, *New Settlers*, and *Communities Repurposed!* (Figure 3.4). Each scenario narrative depicted diverse disciplinary perspectives and considered issues that emerged during the discussions. The scenarios reflected interests of stakeholders (municipal representatives, funding agents, and expert groups) and were formulated along the three main guiding principles. After the workshop, the project team drafted and refined the narratives, which were later shared and presented to the participants to solicit their feedback. The scenarios were then visualized and presented to the public during a public event at Technische Universität Braunschweig (Figure 3.3). In a survey consisting of a series of multiple-choice questions, visitors could select their preferences for the future of Lower Saxony. The combination of preferences was then supposed to lead to a specific scenario. This exercise was intended to raise awareness among lay audiences of the implications of their choices and decisions and to discuss the scenarios with the public.

3.4. Evaluation of the Scenario Building Workshop

Various unanticipated challenges emerged throughout the scenario building process. Although regarded as a well-established 'standard' technique in scenario planning, the workshop revealed the discrepancy between theory and implementation of the scenario-axis technique. The technique's prevalence and wide appeal are due to its clear, simple, and communicable structure (Ramirez and Wilkinson 2014). However, narrowing down the number of drivers to two critical driving forces required extensive discussions among participants a considerable amount of time. Moreover, reaching consensus among interdisciplinary experts was not easily achieved. Indeed, selecting the two most impactful and uncertain drivers required trade-offs between participants, who reflected on the interests of various stakeholders. This process has ultimately led to the loss of insights gained during discussions on causal relationships and drivers. Some participants noted that the critical driving forces – lifestyle and governance – did not closely relate to the project's focus or the two study areas. Throughout the workshop, contrasting perspectives were not perceived as impediments but rather as opportunities to consider a broader range of possibilities. A short questionnaire containing nine questions was handed out to participants at the end of the workshop. The questionnaire consisted of free-text and close-ended questions requiring participants to rank certain tools. Overall, participants were satisfied with the tools used in the workshop and the plenary discussions. However, they were critical of the scenario-axes technique and the short duration of the workshop, which lasted four hours. While the workshop employed an exploratory approach to develop possible future alternatives, some participants noted that the guiding principles where strongly embedded in the scenarios and thus reflected normative aspirations.

3.5. Four Scenarios for Lower Saxony

In this section, we elaborate on the four scenarios for Lower Saxony derived from the scenario building workshop:

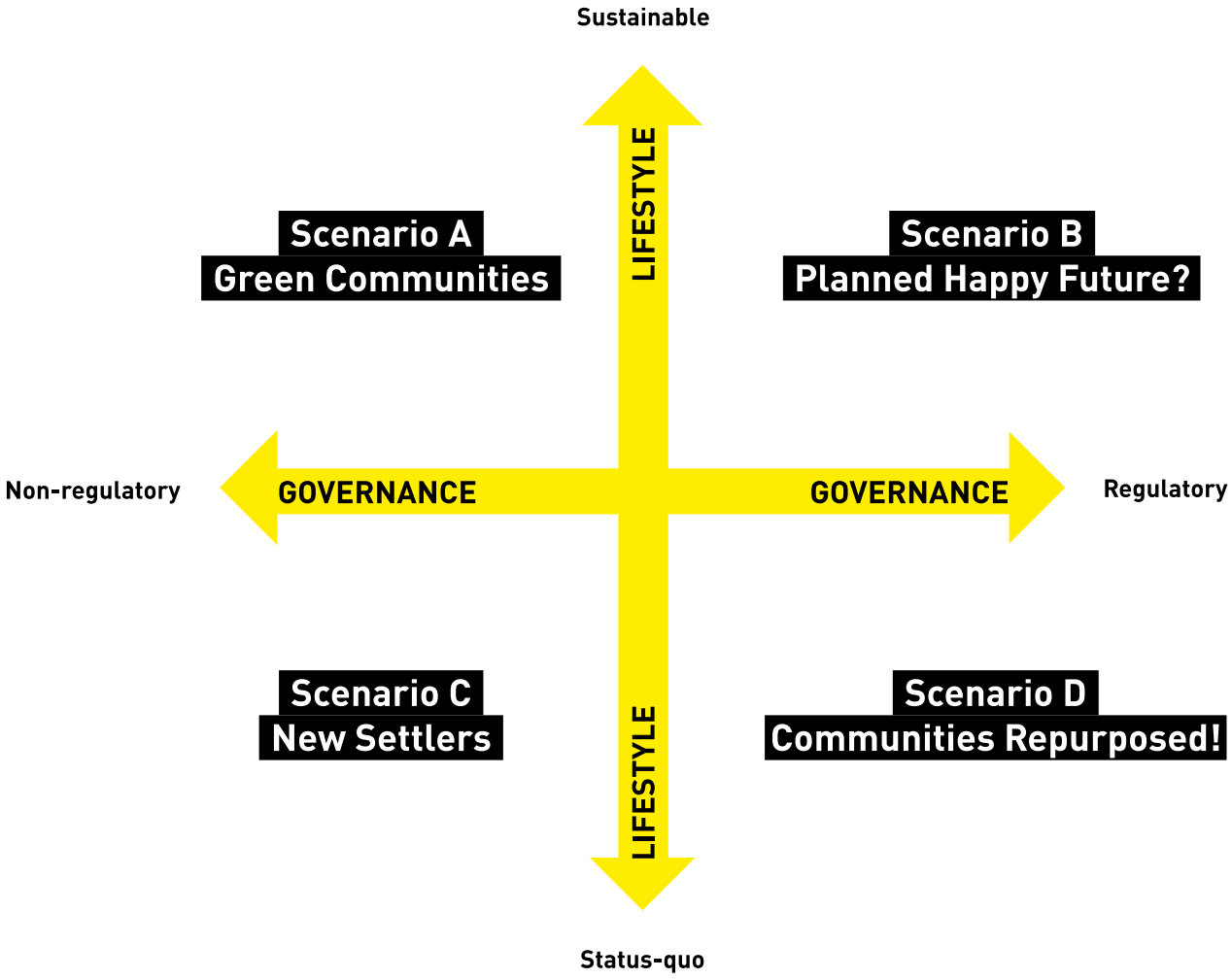
Green Communities

Green Communities is a scenario driven by bottom-up collaboration and relatively limited municipal regulation. By 2050, the number of households and household sizes have increased in the two study areas where people of different generations are living in close-knit communities. Most of the new rural population lives in compact settlements that form a network of nodes and are intrinsically motivated to reduce their resource consumption. Consequently, land consumption is also reduced. New developments in the Green Communities often exceed environmental targets benefiting collaborative and sustainable initiatives set by residents. The compact and mixed-use settlement structure results in shifts in individual ownership as sharing becomes a standard model. Decentralized, smart, and free public transport options are on the rise across the urban-rural gradient. New services such as car sharing and on-demand transport services are organized by the community. Clean vehicles prevail as energy is generated from renewable resources. To avoid losses and decentralize the system further, energy is consumed where it is produced, thereby blurring the conventional distinctions between producers and consumers. Compact settlements are surrounded by open landscapes that ameliorate the green and blue networks and improve ecological connectivity. Due to the growing environmental awareness and active engagement, communities call for and collaboratively contribute to the enhancement and resilience of green and blue infrastructures. Agriculture and industries occupy smaller areas and generate less pollution and emissions. Community-supported agriculture and organic farming are on the rise. Supported by digitization and technological advancements, sharing, recycling, and reusing products is popular. Energy consumption of enterprises is reduced, and green markets offer incentives for the regulation and control of sustainable development.

Planned Happy Future?

The population shrinkage in the two study areas has been counteracted by migration, resulting in a heterogeneous society in 2050. Improved governance of rural areas, economic incentives, and better access to infrastructure and services have created new employment opportunities and have attracted more investments to rural areas. Ongoing climate change, severe weather events, and pandemics have made rural areas an attractive place to live. Public investments in digital infrastructure have supported this trend, allowing people to move away from urban centers. Thus, the ongoing developments have succeeded in achieving population stability between rural and urban areas and in slowing down the rural exodus. Further land consumption is prevented through the effective use of space, renovation and conversion of the existing building stock into mixed-use developments, and equitable land allocation. As a result, per capita land consumption for new developments is considerably reduced. Stricter regulations promoting the use of sustainable building materials are introduced, improving the energy efficiency of new

3.4 Scenario Matrix
and the critical
drivers selected



and existing buildings. The refurbishment of the existing building stock and the efficient use of land have generally contributed to less energy consumption. Despite spatial controversies and local opposition, wind parks have been built allowing rural communities to harness renewable energy. Public transport is prioritized and subsidies are provided to encourage sustainable modes of transport. Water regulations and targets set prior to 2050 are attained. To improve biodiversity and support rural development, a green infrastructure strategy is devised to govern and guide compensation measures and agriculture schemes. New approaches and regulatory innovations are sought to respond to current and future environmental challenges. Flexible and dynamic regulations enable an effective implementation of adaptive management where cross-sectoral issues are considered and monitored, unintended consequences are addressed, and decisions are adjusted accordingly. Public goods such as water and land are also highly regulated and managed, and sustainable consumption is incentivized, where necessary via subsidies. While rural areas are attracting further investments, the provision of infrastructure is prioritized in some areas over others.

New Settlers

In 2050, growth beyond the TOPOS boundary is contained and settlements become increasingly compact and dense. New settlements have to meet stringent requirements regarding energy, building materials, and impervious surfaces. People with medium and high incomes opt to live in new settlements further away from dense urban areas. Despite the new and more compact building types, the ongoing settlement expansion contributes to resource consumption and the fragmentation of the landscape and green infrastructure. To counteract the ongoing dispersion, certain landscapes and green spaces are protected and maintained. Additionally, industrial agriculture – characterized by large-scale monoculture for biomass production – prevails due to subsidies and the proliferation of biogas facilities. Government incentives play a major role in advancing technological innovation and influencing social acceptance of new technologies. In this regard, wearable devices and climate-friendly technologies are increasingly adopted. Moreover, electronic waste is recycled into new products and hybrid materials for various applications. Significant technological shifts provide new transport opportunities and options for people with special needs. Rainwater drainage systems are decentralized and the reuse of rainwater in households is widespread.

Communities Repurposed!

Highly regulated frameworks prompt the transformation of obsolete areas and abandoned buildings into productive premises. New neighborhoods consist of modern detached houses that are dedicated either for residential or productive purposes. Technological shifts result in further advancements in autonomous driving with a wide variety of vehicles as well as charging and rental services. Previously set environmental and energy targets, such as restricting land use to less than 30 hectares per day and the 100% renewable energy plan for Lower Saxony, are not attained by 2050. Several actors prioritize their interests and prevent sustainable development plans, thereby disregarding environmental externalities.

In that regard, fossil fuels are not completely phased out by 2050 and continue to contribute to electricity supply and industrial production. Driven by globalization, monopolist modes of production prevail in some industries in the two study areas, exploiting technological advances to increase production and reduce labor. Mass production is still favored despite the growth of personal fabrication. Unsustainable practices in manufacturing account for most of the waste and greenhouse gas emissions. Technological advancements and innovations allow the study areas to maintain their competitive advantage in international markets. New stringent regulations prompt a complete restructuring of abandoned land and buildings into vertical modern greenhouses. These hybrid and productive buildings also provide working spaces and leisure facilities.

3.6. Conclusion

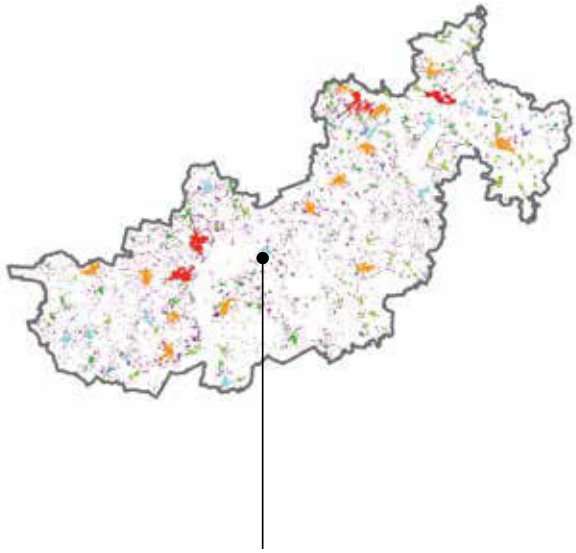
Engaging stakeholders and the public are key in scenario-based planning. Indeed, communities are often passively involved in workshops and presented with a number of predetermined scenarios to choose from. Actively engaging stakeholders and the public allows planners to learn from their practical and contextual experiences and may result in effective scenarios and efficient solutions that contribute to transformative change. By considering diverse and often contrasting viewpoints and interests, these workshops also raise awareness among participants, prompt them to establish a common ground, and may lead to shifts in perspectives and mental models.

While our case study did not aim to produce a regional plan that would guide future developments in Lower Saxony, it nevertheless provided us with an important learning opportunity, particularly in the context of Germany, where the implementation of scenario planning approaches is limited. The exercise was mostly expert-led; however, participants reflected on the conflicting interests of various partners and municipalities in the region. The findings of this case study can be used to inform practice and advance methods, techniques, and tools. Indeed, such exercises can form the basis for establishing a database of projects around the country, deriving lessons and knowledge for context-specific participatory workshops, and expanding the practice of scenario planning in Germany.

While the theoretical objective of an exploratory scenario exercise is to produce robust and contingent plans and policies, our exercise was concluded by presenting the outcomes of different scenario narratives to representatives of our partner communities. In that regard, the qualitative scenarios visualized in different photo renders were very useful during the discussions with partner municipalities, stakeholders, professional and non-professional participants. The visualizations provided a common language to engage participants and allowed the project team to solicit feedback. The scenarios depicted a range of desirable, business-as-usual, and undesirable events that can potentially take place in the future. The first scenario *Green Communities* was driven by bottom-up, collaborative approaches and yielded sustainable outcomes. In contrast, *Planned Happy Future?* represented a highly regulated top-down approach that resulted in sustainable localities

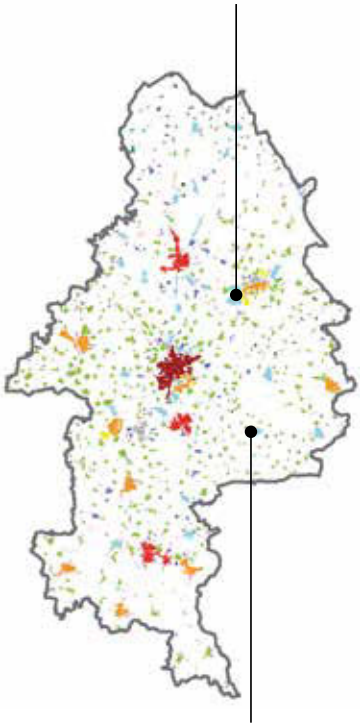
yet lacked the engagement of the public. *New Settlers* and *Communities Repurposed!* depicted business-as-usual futures yet reflected on different sustainable practices and technological trends. Additionally, *Communities Repurposed!* was the only scenario that explicitly focused on industrial production – a prominent sector in the region. Overall, the case study emphasized the potential of scenario planning, particularly exploratory scenario planning, which remains underexplored in both literature and practice, especially in Germany. By focusing on uncertainties, the scenario exercise sought to understand the long-term implications of choices made and emphasized the need to make effective decisions today to avoid unpredictable and undesirable futures.

3.5 Three Villages and Small Towns were selected from the total of 6,301 settlement units to apply the developed scenarios. Each of these settlement units represents a prototype for one of the 13 identified TOPOI types; Source: Carlow et al. 2022; Data: Carlow et al. 2020.



EYDELSTEDT,
a Disseminated Hamlet

DETMERODE,
an Exo Satellite Town



SCHÖPPENSTEDT,
a Periurban Village

Legend

Node City		Small Exo Village		Study Region	
Node Town		Disseminated Village			
Periurban Town		Agri Village			
Exo Satellite Town		Disseminated Hamlet			
Periurban Village		Disseminated Living			
Small Periurban Village		Agri Hamlet			
Exo Village		Exo Industrial Zone			

25 km