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Theoretical Framework for Integrated Neigbourhood Development to Ensure Ecological, Social and Climatic Performance

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1 ABSTRACT

Urban development is traditionally a planning task in which many individual aspects, strategies and measures have to be considered and coordinated. Socio-economic, socio-demographic and socio-cultural change, fast growing cities, densification, supply of green infrastructure, resource management to name a few, are all urgent issues of our time that require an intensive examination of the challenges for urban development, as well as the development of coping strategies. Last but not least, the needs of climate protection, the consequences of climate change and the global loss of biodiversity are (emerging) pressing challenges for urban planning which have to be considered within all processes. At the same time, more and more data and tools are available, which - properly processed, used, examined and evaluated - support the cities in the design and implementation of their urban planning and urban development strategies. These tools are also increasingly used to automate and simplify these processes and analyses.

Due to the complexity of challenges the common approach in urban planning is a sectoral approach (Ovink & Boeijenga 2018, Juschten et al. 2021) where individual experts analyse their field of action and based on these develop sectoral solutions and measures. There are numerous sectoral strategies in and for cities, some of which contain contradictory planning requirements with respect to other sectors and therefore depict the need of intersectoral and comprehensive planning strategies. The second approach necessary for integrated neighbourhood development is to consider the different planning and policy levels. Planning decisions at higher levels influence local decision-making possibilities and vice versa.

The aim of this contribution is to present the development of a theoretical and methodical concept for integrated and participatory neighbourhood development processes. The article is based on a research project in the market town of Lustenau with around 25,000 inhabitants in the Austrian state of Vorarlberg. The market town of Lustenau is taking a large-volume educational building project in the quarter Rotkreuz to address integrated, inter- and transdisciplinary development of an existing neighbourhood. The research question is: “How can integrated neighbourhood development be implemented taking into account climate protection, climate change adaptation, ecosystem services of urban nature, biodiversity and social concerns?”. This contribution describes how these fields can be characterised, analysed and incorporated in master planning processes and how digital tools support the analysis and balancing of these different requirements.

Keywords: urban planning, social justice, biodiversity, climate resilience, digital tools

2 INTRODUCTION – INTEGRATED PLANNING AS AN ANSWER TO THE SOCIETAL CHALLENGES CHALLENGES

With the large-scale educational building project in the neighbourhood Rotkreuz, the municipality of Lustenau wants to address the integrated development of an existing urban quarter. This includes existing non-profit housing estates from the 1940s and 1980s, school and kindergarten buildings, communal catering, a planned new "Assisted Living" project, as well as new public open spaces serving the diverse community and connecting the area ("Rotkreuz Generations Park"). These plans and changes affect the entire neighbourhood.

The main role of urban planning is to coordinate different demands on limited space. Urban planning is therefore an inter- and transdisciplinary field (Despres et al 2011). Grand environmental challenges like climate change, global resource scarcity or societal challenges pose new challenges for urban development

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which have to be taken into account (see chapter 3 for details). Due to the large number of people and sectors and their diverse interests and issues involved, planning processes and construction projects are becoming increasingly complex. This complexity leads to lengthy and expensive planning processes, which is challenging especially for smaller communities and cities. On the other hand, there are more and more data and digital tools that can support analysis and planning itself on different planning levels.

Using the example of the market town of Lustenau, this article shows which challenges currently have to be taken into account in planning and how these requirements can be supported by using various analysis and simulation tools. The aim of this contribution is to present the development of a theoretical and methodical concept for integrated and participatory neighbourhood development processes. The research question is: "How can integrated neighbourhood development be implemented taking into account climate protection, climate change adaptation, ecosystem services of urban nature, biodiversity and social concerns?". Starting with a description of the actual societal challenges urban planning has to face, five fields of action for an integrated neighbourhood development are described and digital tools presented, that support integrated neighbourhood development.

3 CHALLENGES IN URBAN DEVELOPMENT AND INTEGRATED NEIGBORHOOD DEVELOPMENT

The EU has identified 7 priority societal challenges[1] that also affect urban planning or where planning is expected to come up with solutions (Cohen-Shacham et al. 2016). For the urban development processes in Lustenau the following aspects are central (for the selection of challenges see also Section 4.1):

3.1 Climate change and loss of biodiversity

Due to climate change, meteorological patterns are occurring with altered frequency and intensity (IPCC 2022a, APCC 2014). Over the past years, extreme precipitation events, prolonged droughts resulting in wildfires, and yearly summer heat records occurred. Further changes in climate signals and an increase in extreme events are expected in the future according to different simulations. Extreme events can impact settlement areas through multiple aspects: endangering the health of the population, damaging crucial infrastructure for e.g. mobility or energy and thereby altering the energy supply and demand, as well as other sectors (ÖROK 2021). In particular, changes in temperature and precipitation have an impact on spatial development. Above all, rising temperatures, heavy rain events, but also longer periods of drought are a challenge for settlements with densely populated areas being particularly affected due to sealing and overbuilding. The construction and overbuilding and the associated sealing of natural surfaces, as well as the increase in process energies are the main factors responsible for the development of urban heat islands. The urban heat island effect and disturbed local water cycles exacerbate the effects of climate change (Kuttler 2011, Pauleit & Breuste 2011). Further, the sealed surfaces allow no infiltration of rainwater, therefore str also lacking the cooling effects of evapotranspiration. At the same time, the water absorption capacity of available green spaces, such as unsealed soils and vegetation is often impaired because of too compact characteristics – consequences of the permanent vibrations due to traffic, leading to a change in the water regime. Overall evapotranspiration, groundwater recharge and purification capacities of the soil are reduced, while surface runoff and pollution levels of water bodies as well as the dryness of the air increase.

Since 2013, the potential of climate-effective green structures in settlements has been promoted by the EU Green Infrastructure Strategy (GI) (European Commission 2013). The Green Deal and the EU Biodiversity Strategy 2030 (European Commission 2020) refer to the necessary interlinkages between these structures and strengthening biodiversity. However, the potential for biodiversity in cities and settlements is still widely neglected, both by urban planners and by nature and species conservationists. The appeal for a “Doppelte Innenentwicklung” [To use space reserves in the building land in a structurally sensible way, but at the same time to develop urban greenery] as a response to population growth, land consumption and climate protection means that conserving urban biodiversity, which has received little attention to date, is even more

[1] 1. Health, demographic change and wellbeing, 2. Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy, 3. Secure, clean and efficient energy, 4. Smart, green and integrated transport, 5. Climate action, environment, resource efficiency and raw materials, 6. Europe in a changing world - inclusive, innovative and reflective societies, 7. Secure societies - protecting freedom and security of Europe and its citizens.

necessary (Kühnau et al. 2017). This calls for nature-inclusive planning that understands the value of built urban nature. In this context, nature-inclusive means offering plants and animals opportunities for living and settling in their own dynamics and no longer seeing nature and settlement as opposites (Fassbinder 2002; Hauck & Weisser 2015).

3.2 Demographic changes and social justice

More than half of the world's population currently lives in cities and this proportion will continue to rise (United Nations 2019). Certain groups have always been more exposed to the risks of social exclusion and marginalisation because of their age, their gender identity, their physical abilities, their socio-economic status and their ethnicity, religion or origin. This exposure phenomenon has come to the fore of understanding cities and developing policies for them (Andersen & Van Kempen 2003, Atkinson 2000, Madanipour 2004, Woodward & Kohli 2001).

Climate change combined with poor planning is leading to a climate crisis for people. Climate impacts and consequences of climate policy measures are more severe in socio-economically disadvantaged groups. Key vulnerability characteristics are low income, age above 65 years, health impairments, migration background or low education level. A total of 56 % of the Austrian population over the age of 15 exhibit at least one of these characteristics and can therefore be considered particularly vulnerable to the consequences of climate change (BMSGPK 2021). Also, infants and children below the age of 5 years and women are more vulnerable to climate change. When certain impact processes, e.g. heat or immission load, meet vulnerability characteristics the result is material or health deprivation (BMSGPK 2021).

3.3 Energy and mobility

77.01 % of the greenhouse gas emissions of all member states of the European Union can be attributed to the energy sector (Europäisches Parlament 2019). Around a third of this is due to transport. In the energy sector, there is potential for climate protection both in the area of using the energy potential of sustainable forms of energy and in the area of increasing efficiency, e.g. of heating and cooling requirements.

While in the building sector energy consumption could be reduced between 2011 and 2020 there was a further increase in energy consumption in the mobility sector in the whole of Austria and in Vorarlberg. Despite efforts and investments to facilitate public transport, cycling and walking, the overall greenhouse gas emissions in Austria increased alarmingly by 74.4 % in the mobility sector between 1990 and 2019 (BMK 2021). Transport – with over 40 % as the largest cause of climate-damaging emissions – must make a significant contribution to the reduction of CO2 emissions in the future. To achieve the national target according to the federal government's integrated climate and energy strategy, emissions from the mobility sector in Austria are to be reduced by 31 % compared to 2005 (BMNT/BMVIT 2018). Given the limited successes to date and even more foreseeable gains in the mobility sector while at the same time the Austrian federal government wants to achieve climate neutrality by 2040, this is a particular challenge. Therefore, changes in the modal split are predominantly relevant for the reduction of greenhouse gases from mobility.

3.4 Settlement structure and infrastructure

The settlement structure has a central influence on the challenges described above. The share of the building sector alone accounts for around 10 % of Austrian greenhouse gas emissions in 2019 (UBA 2021). In addition, the settlement structure determines the use of land, the use of resources for development or, via the degree of sealing, the degree of greening. A denser and more compact urban structure is the prerequisite for short distances and dense public transport as well as walking and cycling networks, and are the basis for optimising the energy system and using land sparingly. Single-family houses have the highest proportion of energy demand compared to denser building types, both during construction and operation with their development infrastructure and road construction requirements being energy intensive (alpS GmbH 2019).

With clever planning, the energy transition is supported by measures that promote energy-efficient spatial and settlement structures in a way that supports structural energy savings, mobility and grid-based energy supply (Stöglehner 2021).

The settlement structure, the development structure and the density also determine the possibilities for building and maintaining everyday life infrastructure. In combination with good accessibility and a high quality of everyday life infrastructure facilities, overall distances are shorter, chains of paths are supported,

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the autonomy of the residents is promoted and in turn the energy consumption for mobility is reduced (Sturm et al. 2018).

3.5 The interplay of challenges - integrated urban planning is necessary

All of these challenges have in common that they mutually influence or condition each other. In the context of energy planning, denser overall development and compact buildings are a prerequisite for short distances and a dense public transport, footpath and cycle path network. At the same time, they are the basis for the optimisation of the energy system and the economical use of land and soil (alpS GmbH 2019). However, denser development leads to a loss of green spaces and thus biodiversity. This means that their ecosystem services, such as temperature regulation are lost and the local water cycles are disrupted by the high degree of sealing. Changes in demographics also have an impact on the use of buildings. The population density tends to decrease in neighbourhoods that are affected by an ageing population (alpS GmbH 2019). This means that the infrastructure is less utilised or new infrastructure facilities are necessary - e.g. assisted living instead of children's playgrounds. All these connections and interactions make an integrated neighbourhood development necessary.

There is a need for comprehensive and inclusive approaches to overcome these challenges (Ovink & Boeijengap 2018). Integrated urban planning aims at overcoming sectoral or silo approaches to foster the collaboration of different sectors and disciplines. Collaboration instead of competition or compromising is necessary. Only with an integrated approach the value for all stakeholders can increase. In other cases only an average result (compromise) or a one-sided optimization (competition) is achieved (Wertheim 2002).

Current challenges manifest themselves on different policy and planning levels (Kok & Veldkamp 2011). In addition to horizontal intersectoral coordination, integrative neighbourhood development thus also requires vertical coordination at the various planning and policy levels as well as fields of action in urban planning. (Geerlings and Stead 2003). Measures to reduce CO2 emissions from transport need for example have to be considered on a large scale (e.g. modal split) but also on the local level (qualities of road open spaces). The same applies e.g. to biodiversity, where a small biotope can make a local contribution, but at the same time the large-scale distribution has to be considered.

As urban planning sets the preconditions that determine long-term influences the build environment and thus also social structure, green spaces or energy consumption, a horizontal integration of different planning fields but also a vertical integration of planning and policy levels is necessary for integrated neighbourhood development. This is where the IQ_Lustenau research project comes in.

4 MATERIALS AND METHODS

4.1 Inter- and transdisciplinary, integrated research process set in a real laboratory

In order to meet the challenges of sustainable urban development, Wolfram et al. (2016) point to research that should capture the spatial-institutional complexity of urban transformation processes and move to multi-systemic approaches. In an interdisciplinary and transdisciplinary, collaborative approach, the research team is developing a novel toolset tailored to the different integrative planning processes that demonstrate its feasibility in a proof of concept.

The research approach and methods follow the real laboratory approach (see also Chapter 5.1), which enables the research team to test new technologies (tools) in the existing project location without having to be anchored in the legal framework (BMWi, 2019). The aim is to couple the development of the toolset with a regulatory learning process in order to ultimately implement it in day-to-day planning (Wolfram et al., 2016; BMWi, 2019).

4.2 Desktop research, policy analysis and participation

In order to provide a framework for programming the process of integrated neighbourhood development, basic research was carried out on urban planning processes (e.g. master planning processes) and on the requirements of an integrated planning process. The aim was to define planning instruments and procedures for programming, which should enable high-quality preparation and process control. In order to record the needs of the community and to develop measures in a co-creative manner, a comprehensive policy analysis of the spatial and social development target system of the community was carried out on the one hand and a

participation process was initiated with the various departments of the community on the other hand. The policy analysis was conducted to identify different strategies for urban development on federal state and city level following the method of qualitative content analysis (Mayring 2021, Kuckartz 2016).

An integrated neighbourhood development requires the inclusion of different perspectives. Interviews with planning experts of the market town were conducted and workshops implemented to identify the sectoral challenges and objectives. Based on these results, five fields of action for integrated neighbourhood development could be identified (see chapter 5).

4.3 Data, tools and instruments to support resilient, integrated neighbourhood development

In recent years, the progressive application of computational design tools to urban systems in urban design practices has enabled exploration of physical space. In comparison to conventional forms a new type of digital modelling is revolutionising the planning process and the way we can design resilient urban environments (Koenig et al. 2020). A parametric model is able to generate many iterations of design that can be modified, examined and evaluated. The use of digital tools should support the planner in generating more resilient designs by providing a fact-based decision-making basis. There are different tools and processes at the scale levels (e.g. GIS, Rhino, CAD, Building information modelling) of planning – the interfaces and interrelationships stand out as particularly important. In order to design a resilient and integrated neighbourhood, coordinated processes and procedures are needed in the exchange of data and the performance indicators.

In addition, there is more and more (social-space-related) data available nowadays that - properly processed - supports urban planning and urban development in seeking coping strategies for the emerging problems of our time (see section 2). Increasingly, digital planning instruments and planning tools are being used to automate and simplify this processing (Speranza 2016). For this reason, computational urban planning methods and digital tools are particularly effective in simulating measures and the effects of planning decisions in a transdisciplinary approach. This includes micro-climate, biodiversity, energy, mobility and other planning aspects. New capabilities of digital collaboration (online, virtual/mixed reality) allow experts from different disciplines to be involved in co-creation processes. This enables a high degree of transparency and time-saving planning processes and use-oriented results in scenarios can also be developed.

5 RESULTS – FIVE FIELDS OF ACTION AND DIGITAL TOOLS THAT SUPPORT INTEGRATED NEIGHBOURHOOD DEVELOPMENT

Due to the project's spatial scale as well as its social and political importance, the following challenges were identified within stakeholder workshops and discussions with the municipality for the development of the neighbourhood Rotkreuz: (1) Consideration of different social groups and their demands on settlement, infrastructure and green space; (2) Lack of awareness and analysis of climate change and loss of biodiversity, as well as the need to provide space for the development of ecologically resilient urban districts; (3) Integration of measures for climate protection, for climate change adaptation, ecosystem services of urban nature and social issues in everyday municipal planning for district development.

Figure 1: Overview of the neighbourhood Rotkreuz. The area outlined in red includes the school and kindergarten conversion, a new park, assisted living and the redesign of street open spaces that influence the whole neighbourhood.

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5.1 Objectives and guiding principles for urban development of the market town Lustenau

To embed the integrated development process of the neighbourhood Rotkreuz in present policies, several pre-existing guiding principles were identified in policies at local, regional and federal state level. These guidelines for spatial development frame the integrated process for Lustenau as described above:

- Targeting cross-divisional cooperation (Eichberger 2006; Amt der Vorarlberger Landesregierung 2019a) and "taking collaborative action" involving various stakeholders (alpS GmbH 2019)
- Long-term protection of the functional capacity of ecosystems and their biological diversity through the preservation and creation of biotope network areas and stepping stones (Amt der Vorarlberger Landesregierung 2020)
- Preserving existing biotopes and natural elements – i.e. trees, shrubs, meadows, dry stone walls, water bodies, etc. – to ensure a high level of biodiversity (Lenz et al. 2022; Amt der Vorarlberger Landesregierung 2019a)
- Preserving, developing and connecting open spaces and green infrastructure as a key driver of quality of life (Eichberger 2006)
- Frugal and responsible use of land should be enforced by active land policy and by actively addressing climate change adaptation (Eichberger 2006; alpS GmbH 2019)
- Polycentrism should promote urban quarters with site-specific qualities (Eichberger et al. 2016)
- Moderate densification, neighbourliness and short distances shape the community (Eichberger 2006)
- Promoting environmentally friendly mobility – i.e. cycling, walking, public transport – with a primary design focus on re-establishing social relations, high quality of stay and overall safety for inner-city streetscape (Amt der Vorarlberger Landesregierung 2011; AG Lustenau mobil 2012)
- Understanding immigration and pluralism as a strength and opportunity and strengthening social cohesion by participatory processes (Amt der Vorarlberger Landesregierung 2019b)

Accordingly, these thematic guidelines aim at polycentric, compact urban structure with small-scale, mixed-use urban quarters that offer living, working, educational and recreational opportunities for high quality of life for all while preserving natural resources.

5.2 The five fields of action of an integrated neighbourhood development

Based on the challenges and guiding principles described above, the requirements for an integrated neighbourhood development and the goals of the market town of Lustenau in the area of spatial development, five fields of action were identified, which are analysed and processed in the project and supported by digital tools (see Figure 1 below): (1) climate smart; (2) biodiversity, (3) social justice, (4) sustainable mobility, and (5) accessibility. The following sections describe which topics and content must be considered in order to be able to support integrated neighbourhood development. Based on this, it is shown which tools can support them. Tools were identified for these fields of action that enable qualification or quantification, support the weighing of the interactions of measures and thus enable integrated planning processes (see section 4.3).

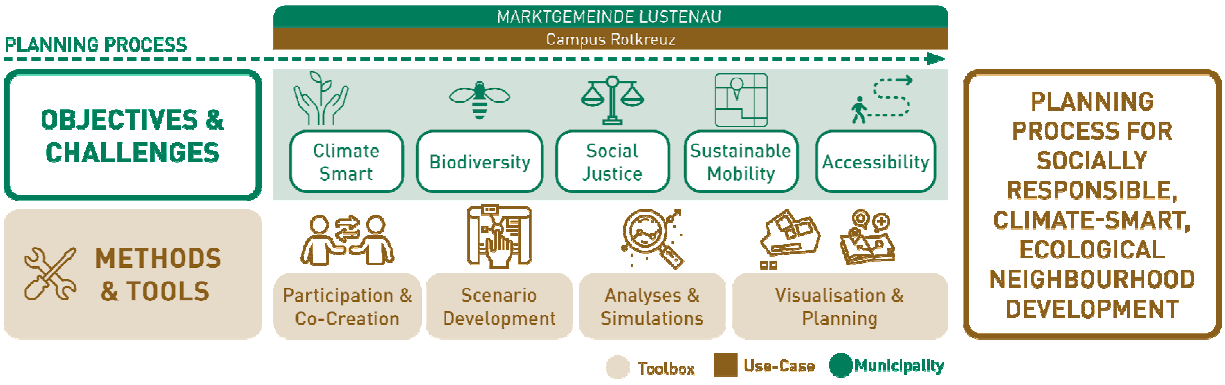

Figure 2: Use of the various tools to achieve the necessary goals for the implementation of socially just, climate-resilient and ecological neighbourhoods in the various phases of an integrated planning and implementation process.

5.2.1 Climate smart

This field covers both: climate change mitigation and climate change adaptation. Measures in this area have both synergies and conflicting goals and must therefore be considered together from the outset. In the face of current climate trends of rising temperatures, increasing heavy rain events but also droughts municipalities are required to implement climate smart strategies to keep their districts both liveable and enjoyable for their inhabitants and reduce energy consumption. Especially in cities with dense urban environments, locally strengthened effects of climate change such as the Urban Heat Island Effect (UHI) demand even greater efforts. Climate resilience in general refers to the capacity to cope with hazardous events and trends, while also maintaining the capacity for transformation (IPCC 2022b).

The federal state of Vorarlberg and thus the municipality of Lustenau are also confronted with those developments. According to the ÖKS15 (2016) scenario in the state of Vorarlberg, the mean air temperature will increase by 1.2 °C (RCP4.5 climate protection scenario) to 1.4 °C (RCP8.5 - business-as-usual scenario) by 2050 and up to 4 °C by 2100 (RCP8.5). Due to the proximity to the river Rhine and the generally high groundwater level in the region, there is a high risk of flooding despite flood protection measures. In this case, too, climate-conscious planning must minimis e the impact of flooding in the region. Therefore, it is important to incorporate relevant climate forecasts (e.g. EURO-CORDEX, or derived climate indicators) into planning practice in order to show the precipitation amounts that are likely to occur in the whole region.

More than two thirds of the total energy consumption of households in Lustenau is used for room heating (alpS GmbH 2019). 40 % of the single-family houses are heated with oil. In multi-apartment buildings, gas dominates as an energy source. In comparison, biomass plays a minor role in Lustenau (alpS GmbH 2019). The average energy consumption per person for the provision of room heating, hot water and electricity is largest in single-family houses with 11,645 kWh per year and smallest in the multi-apartment buildings with 4,769 kWh per year (alpS GmbH 2019). Overall, the mix of energy of the market town of Lustenau is determined by the fossil energy carriers oil and gas. For households, the share of renewable energy is about 30 % (alpS GmbH 2019).

The A/V ratio (the quotient of the heat-exchanging outer surface A, which gives off the heat to the environment, and the heated building volume V) is an indicator for the compactness (built-up area and number of floors) and the energy demand of a building. The smaller the A/V ratio, the more compact and thus energy efficient the building. Average A/V ratio for the market town of Lustenau is 0.74. For comparison, the Hannes Grabherr housing estate in Negrellistraße - one of the densest residential areas in Lustenau - has an A/V ratio of 0.47 (alpS GmbH 2019).

5.2.2 Biodiversity

Biodiversity loss and climate change are interlinked in many ways, since nature-based solutions in the field of green infrastructure - as one of the most effective adaptation strategies - require functioning ecosystems. The loss of biodiversity therefore reduces the ability to adapt to climate change. At the same time, climate change itself is one of the main reasons for the loss of biodiversity and, therefore, requires a strong, committed climate policy. Achieving climate change adaptation goals will not be possible without intact, vital, resilient and diverse nature. However, despite efforts in nature and species conservation and some successes in individual areas, further losses of biodiversity could not be stopped. In 2019 in Austria 44 % of the habitat types and 34 % of the species assessments show an unfavourable to poor conservation status (BMK 2020 – based on the EU Habitats Directive). These, in turn, are a prerequisite for high biodiversity. The main strategy for the settlement areas is to preserve and to expand public green spaces as well as private and semi-public gardens. Existing natural structures must also be preserved, corridors developed and particularly sensitive areas protected.

The settlement area of the market town of Lustenau comprises 780 ha, of which 8.3 % are road areas, 16 % are building areas and 1.2 % are water areas. 87.5 % are designated as building land, of which 13 % are building land reserves (alpS GmbH 2019, 8). An infrared evaluation indicated a share of sealed area in the municipality of already 48 % in 2015 (alpS GmbH 2019, 26) with the trend rising. A part of yet undeveloped building plots are important biodiversity refuges and serve as stepping stones for the biotope network (Pulswerk 2022). Simultaneously, they can act as a source of cooling and cold air conduits. This must be

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considered with regard to the necessary (re)densification of inner-city areas in order to reduce overall land consumption and to use synergies with this already existing green infrastructure.

Instead, a gradual de-densification of residential quarters – a development contrary to redensification efforts – was found in the averagely low occupancy rate of buildings (three inhabitants per building) in Lustenau with every second single-family house hosting only up to two persons (Eichberger et al. 2016).

In conclusion, in Lustenau there is a high proportion of undeveloped, greened areas, some of which are still ecologically valuable remnants (e.g. typical orchard meadows), but most of these remaining biotopes are on the fringe of their existence due to being designated as building land. The difficult legal framework conditions call for strategic protection of these orchards as well as deliberate densification concepts with alternative implementation strategies (Eichberger 2006; Eichberger et al. 2016).

5.2.3 Social Justice

A central approach to deal with social change processes and the related (urban) spatial and planning challenges, as well as in the implementation of target group-oriented urban planning, is to focus on social space. The concept of social space includes the mutual addressing and consideration of the interactions between the built environment and different social groups. Henri Lefebvre (1991) describes (social) space as (socially) produced and effective in everyday life. The socio-geographic approach was adopted in urban and spatial sociology and leads to a relational understanding of space, as arrangements of living beings and social goods in places (Löw 2001). Understanding these relational social constructs means to better understand interrelations between places and people which is key for being able to foster social justice in urban planning. Structural principles such as gender and classcross all levels of socio-spatial constitution, in which societal privileges or disadvantages are embedded. The relational perspective can be applied to (de)construct such social constructs in order to address inequalities and discrimination and acknowledge that all these social concepts are always a product of interconnected, social processes (Crenshaw 2015, Damyanovic & Horelli 2019, Knapp 2005, Thiel 2020).

To aim at socially just (public open) spaces means to involve a complex web of multiple spatial, social and economic factors to provide all residents with the same opportunities to access, use and enjoy the city as well as to fully participate in the production of urban space (Harvey 2012; The World Bank, 2020). Dale and Newman (2009) pointed out the need to link liveability with social equity, or else risk gentrification at the cost of accessibility and social inclusion. The guiding principle for action in that regard is a gender-equitable city of short distances that is suitable for everyday life, with barrier-free urban spaces and open spaces that can be used in a variety of ways.

In the last 15 years, the number of people living in Vorarlberg has increased by 40,000 to over 390,000 with immigration having a key role in this. Compared to the population development of the whole of Austria, this growth is above average. The population growth is and will be mainly taking place in the urban areas in the Rhine Valley, especially in the district of Dornbirn, where Lustenau is located (Amt der Vorarlberger Landesregierung 2019b). According to the "Regional Population Forecast" („Regionale Bevölkerungsprognose“) from the federal state of Vorarlberg an increase of about 12 % compared to the reference year 2020 is expected for the market town of Lustenau by the year 2050 (Amt der Vorarlberger Landesregierung Landesstelle für Statistik 2022). In the district of Dornbirn the proportion of the population of particularly vulnerable groups - such as those over 85 years of age for example - will increase from 2,000 today to over 5,700 by 2050 according to the small-scale population forecast of ÖROK (2021). To achieve social justice, planning has to employ a site- and group-specific approach that creates more equitable processes, access to resources, and systems for all groups.

5.2.4 Sustainable mobility

According to urban planning at human scale, walking must be the measure of urban planning and urban development (Kohr 2002). On this basis, the size of settlements is compatible with nature and humans, resulting in a corresponding structural diversity within which people can move over distances that are appropriate for pedestrians. Consequently, there is no excessive need for private motorised mobility, since the essentials of daily life are organised locally (see also next section). In this context, the development of the city and urban living spaces via sustainable and future-proof forms of mobility such as walking and cycling as well as public transport is essential (Zopf 2012).

The modal split of Lustenau clearly highlights Vorarlberg's efforts to promote cycling – the share of ways done by bike gained more than five per cent between 2013 (17 %) and 2017 (22 %). However, it also shows the missing investments in public transport (it's modal split share dropped from 13 % in 2013 to 7 % in 2017) and walking (dropped from 19 % in 2013 to 12 % in 2017), while still more than every second trip is done by car (alpS GmbH 2019). To shift short and medium car trips to cycling and walking requires infrastructure enhancement, ongoing public outreach, rules and laws promoting bicycling and walking, and land-use planning measures (Amt der Vorarlberger Landesregierung 2019a).

5.2.5 Accessibility

One of the goals of integrated city planning is to provide the population with goods and facilities for daily/weekly needs that are close to home and suitable for everyday use. A full range of everyday life infrastructure facilities in the neighbourhood makes it easier for people with care and support obligations (for children or care-dependent adults) to reconcile family work, gainful employment and leisure time (Damyanovic & Horelli 2019, Damyanovic et al. 2021). In combination with good accessibility and a high quality of the everyday life infrastructure facilities, a complete infrastructure offer supports chains of routes (combination of tasks) and promotes the autonomy and independence of the residents.

A transformation of cities towards human scale is what the "15-Minute City" concept proposes: A neighbourhood-oriented approach in which people can reach all facilities necessary to meet their daily needs within fifteen minutes on foot or by bicycle (Blaschke 2022; Moreno et al. 2021). Thus, promoting social dimensions, urban proximity, and diversity via increasing use of technologies (Allam et al. 2020). A neighbourhood suitable for everyday life must include a gender-equitable approach which means designing barrier-free urban spaces and open spaces that can be used in a variety of ways. The provision of adequate everyday life infrastructure amenities in the neighbourhood facilitates the reconciliation of (unpaid) care work, employment and leisure time and promotes the autonomy and independence of all residents.

In planning this objective is supported by a polycentric urban structure. The area around the planned education campus in Lustenau is to take on this central function for the entire quarter. The range and location of infrastructure facilities - technical, social and green infrastructure - and their expansion are therefore one of the fields of action for an integrated neighbourhood development.

5.3 Digital tools to support integrated neighbourhood development

In the framework of the research project 'IQ Lustenau' tools and methods were selected to support a holistic assessment (active mobility, biodiversity, microclimate, social justice) of sustainable and integrated neighbourhood development. Cross-scale (GIS, 3D building models) approaches were selected and the interfaces to the simulation programmes were defined. These will be explained in more detail below and will further be used in the project for the analysis of spaces and the evaluation of different planning scenarios.

5.3.1 Rhinoceros 3D / Grasshopper

In recent years, the use of parametric planning methods for cities has increased rapidly. This is due to the possibility of evaluating the performance of many scenarios (Fink 2018). The software environment Rhinoceros 3D and the parametric native plug-in Grashopper have numerous interfaces for connection to GIS programs, CAD and BIM. Therefore, there is a wide range of possible applications and the coupling to simulation environments, as well as the possibility of analyses within Grasshopper. Numerous libraries are available to perform environmental, planning, mobility and other performance evaluations. For the integrated neighbourhood development in the example of IQ Lustenau, the graph-based analysis of accessibility (walkability) as well as parametric modelling of densification scenarios are suitable. The use of Ladybug tools enables the analysis of solar radiation, shading, sunshine hours and other microclimatic indicators. Another toolbox from DeCoding Spaces supports graph-based analysis to evaluate the accessibility of everyday life infrastructure.

11.1.1 SMTG+ Rapid Assessment Tools

As part of the Smart through gender+ research project, a rapid assessment tool was developed at city and district level. The district level tool is based on GIS data and manually mapped data and was developed using Grasshopper. It contains an interface for simplified operation and analysis of important planning topics (e.g.

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analysis of supply with everyday life infrastructure). It is structured in static visualisation (e.g. visualisation of manually mapped data), dynamic visualisation (crosswise evaluation of statistical data) and dynamic simulation (accessibility, real walking distances). The tool on city level was developed using R-Shiny and can import and assess GIS data to create needs and potential maps for different user groups. Furthermore, analyses of demand, based on demographic data and supply, can be carried out using the available PoIs (Points of Interest). These result in demand and potential maps which are created individually for individual user groups and can be visualised interactively.

5.3.2 PALM-4U

As stated above, the assessment of climate resilience emphasises on higher temperatures in future climate scenarios. Evaluations of this field of action (climate smart) requires a state-of-the-art high-resolution urban model with the ability to simulate biometeorological quantities to distinguish between the impacts and effects of the developed scenarios on the comfort of people. The model of choice to fulfil the high requirements is PALM-4U, an integrated component of the PALM (formerly an abbreviation for Parallelized Large-eddy Simulation Model) model framework. It can be initialised using regional climate model data, thus incorporating the available climate projections of the representative radiative concentration pathways. In addition to the entire PALM modelling environment, PALM-4U features a separate energy balance solver for building and paved surfaces, fully interactive land surface and radiation schemes, including shadowing effects and reflections between urban structures, a heat transfer model between atmosphere and buildings and direct output of biometeorological quantities. It is designed for application of climate research in urban contexts and practical city planning related to urban microclimate (Maronga et al. 2021, PALM-4U 2022). PALM-4U simulates urban areas with spatial resolutions up to under 10 m.

5.3.3 SUMO: Simulation of Urban Mobility

SUMO is an open source, microscopic, multi-modal traffic simulation (see Lopez et al 2018). It allows to simulate how a given traffic demand which consists of single vehicles (cars, bicycles, public transport buses and trains) and pedestrians moves through a given transport network. The simulation allows to address a large set of traffic management topics on a microscopic level: each vehicle and each person is modelled explicitly, has an own route, and moves individually through the network (SUMO 2022). The network is based on the OSM graph of the considered region. SUMO is used for traffic safety and risk analysis, for the calculations of emissions (noise and pollutants) and to provide traffic forecasts for city authorities. In the use case of IQ Lustenau, SUMO can be used to evaluate the different scenarios of the integrated neighbourhood development with respect to their mobility impacts and to their greenhouse gas emissions.

6 DISCUSSION - REQUIREMENTS FOR AN INTEGRATED NEIGHBOURHOOD DEVELOPMENT

When addressing complex sustainability challenges (as mentioned in section 3) cities are embracing experiments to respond to particular societal, economic and environmental issues in a given urban place (Bulkeley et al. 2016). A real laboratory approach frames integrated (i.e. cooperative, dialogue-oriented and trans-sectoral) neighbourhood development processes where consideration of synergies and trade-offs of various sectoral requirements is necessary. The success of integrated neighbourhood development depends on the formation of appropriate foundations for the subsequent planning and implementation steps.

6.1 Experimental spaces

Instead of following a policy of incremental steps due to its insufficiency in addressing complex (urban) sustainability challenges (Wilson et al. 2020) cities around the world are embracing experiments to “design, test and learn from innovation in real time in order to respond to particular societal, economic and environmental issues in a given urban place” (Bulkeley et al. 2016). Various stakeholders collaborate in these (real-life) laboratories, testbeds, or platforms which combine technological innovations, nature-based solutions, and community activities in terms of comprehensive structural and cultural change (Grin et al. 2010; Eneqvist & Karvonen 2021; Suitner, 2021). Such experimental spaces have been successful in urban climate change governance with social innovations emerging as essential components (Schartinger 2018, Fazey et al. 2018). Social innovations are new ways of working together for the purpose of addressing societal needs or goals by establishing, renewing, or changing social practices and interactions more

effectively than previous social configurations have done (Moulaert et al. 2013). Such a perspective allows to view urban experiments as innovative processes of ideas and implementation in a specific structural and socio-political context (Bulkeley et al. 2016; Suitner, 2021).

6.2 Dialogue-oriented and cooperative trans-sectoral process

Likewise, neighbourhood development requires dialogue-oriented and cooperative, trans-sectoral processes that can only be realised with continuous information flows and feedback (Reinwald et al. 2021). Increased communication and coordination efforts result from the necessity to develop an inter- and transdisciplinary planning approach and implementation process in order to make the differing goals (trade-offs) visible as well as to consider the various sectoral requirements. Therefore, having an interdisciplinary planning team from the fields of architecture, spatial planning, landscape planning, mobility planning, energy planning, (micro-)climatology, climate resilience, urban ecology, social planning, participatory planning, etc. in combination with representatives of the municipality, property owners, developers, external experts and specialist planners, residents, citizen representatives, etc. at an early stage is crucial for neighbourhood development projects. Due to this wide range of stakeholders, interests and issues, dedicated (temporary) organisational structures are created for integrated urban development projects (see SIR 2021 or Scheuvens et al. 2010). Various stakeholders collaborate in such experimental spaces to aim at comprehensive structural and cultural change in urban climate change governance with social innovations emerging as essential components (Suitner 2021).

6.3 Integrated view on planning and policy levels

As with any planning task, dealing with a specific place begins with an analysis of its qualities and development possibilities (Scheuvens et al. 2010). A comprehensive basic analysis from different perspectives and on different scales is more and more state of the art (Reinwald et al. 2021). An analysis of the fields of action described above creates the basis for this. The central challenge is that more and more spatial research is being carried out, more and more data is available, but the effort and the necessary prerequisites to be able to carry out such analysis are also increasing. At the same time, there are also more and more strategies at different planning and policy levels in different sectors. It is becoming increasingly difficult to provide the necessary integration performance to be able to analyse and develop a space in a truly integrative manner. Being able to assess the many interactions, dependencies, conflicts of aims or synergies is difficult even for interdisciplinary teams.

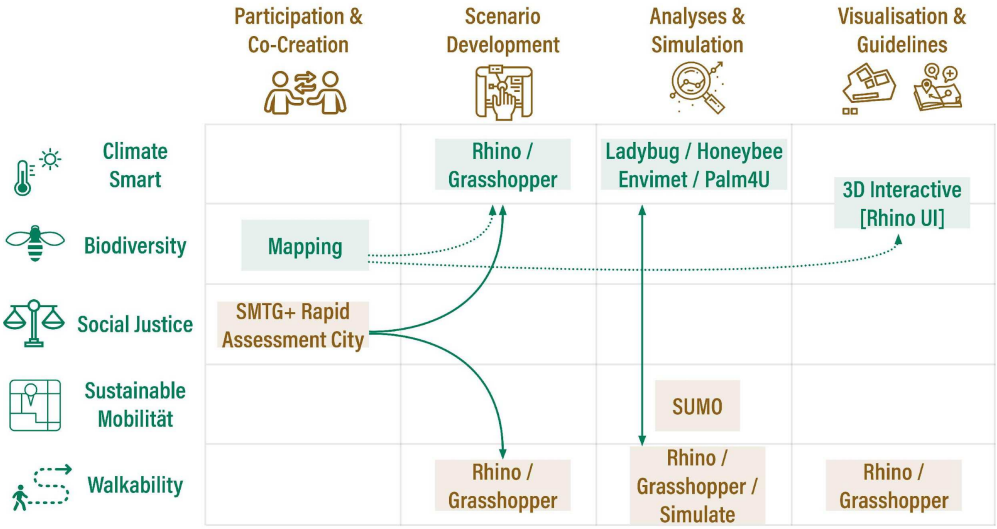

Figure 3: Matrix as overview of the IQ Lustenau phases and their designated tools.

6.4 Tools that support the assessment of the five fields of action

To support this holistic assessment for a sustainable neighbourhood planning, digital planning instruments and planning tools are being used by automating and simplifying these processes (Speranza 2016).

The use of the selected tools was transferred to the planning phases and analysis of the fields of action. Here, the potentials for the use of GIS for mapping and data collection through the overall city explorer (online) in

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participatory processes already become apparent. This data complements urban and statistical data, which serve as the basis of further analyses. For the development of the planning scenarios, Rhinoceros 3D was chosen because of the native plug-in Grasshopper, which enables parametric modelling and the import of GIS data. Furthermore, microclimatic simulations can be performed using the Ladybug and Honeybee libraries within the same software environment. For further microclimatic considerations, the 3D scenarios can be exported and simulated in Palm4U or Envimet and used for visualisation in Rhino 3D. The sustainable mobility analyses in SUMO can also be linked to the parametric planning models using a common database for traffic demand generation. In the visualisation phase, the results can be interactively visualised and evaluated at the overall city level as well as at the small-scale for the area.

6.5 Including biodiversity as a grand challenge of integrated neighbourhood planning

The conservation of biotopes and stepping stones as connecting elements is challenging the dynamic development of settlements. As in many municipalities, there is a lack of data bases for inner-city biodiversity and its ecosystem services. Therefore, these aspects are hardly considered in the practice of settlement developments. In particular, the existing, mature elements, such as naturally grown soil, old trees and meadows, geomorphological irregularities, etc. must be located and integrated into initial planning processes. They are non-recreatable within a one or two generations time period and are important parts of nature-based solutions for climate change adaptation and health care. Nature-inclusive planning requires a transdisciplinary planning process that considers the expertise of development, implementation and maintenance (Löning et al. 2020). Processing biodiversity-related data and information and integrating them into digital tools in order to support the (integrated) planning and decision-making process in the best possible way is a particular challenge. A challenge for integrated neighbourhood development is that all fields of action are equally consciously included in the consideration process. In some fields of action, the data situation is much better, which can also lead to these fields being given an overweight. To prevent a bias here, the project will test a simplified assessment system that takes biodiversity equally into account.

7 CONCLUSION

The urban challenges of densification and transformation have become even more complex by the global impact of climate change and loss of biodiversity. Neighbourhood planning must perform well in many different areas and scales (quality of life, microclimate, mobility, social justice). However, there is no solution that offers a perfect performance for all challenges. Therefore, intelligent methods and planning processes are needed that support a discourse for decision-making and provide fact-based considerations for decision-making. It is necessary to make the effects of planning decisions on the different planning and policy levels transparent and clear in order to enable sustainable neighbourhood development. Furthermore, the effects on future developments (mobility transition, transport transition, demographic developments, climate change) must be considered as well to ensure sustainable and integrated planning. In order to integrate the challenges of decision-makers in cities and municipalities into planning tools, a discourse on the content of the requirements for planning and methodology is needed. Furthermore, urban data collection and management must go hand in hand with planning processes to enable the basis for analyses at the city and district level as a foundation for qualified decision making.

A successful integrated planning - taking into account actual challenges urban development is facing - is defined by the following requirements: (1) space and time for experiments and thinking outside of the usual work context, (2) a planning process that actively involves multiple stakeholders and experts in different fields throughout the whole process, (3) an integrated view of a neighbourhood to analyse different fields of actions and scales and (4) support through digital tools that help prepare the extensive existing data material for decision-making on the different planning levels.

The contribution shows that considering the five fields of action - (1) climate smart; (2) biodiversity, (3) social justice, (4) sustainable mobility, and (5) accessibility – is a necessary prerequisite for implementing an integrated neighbourhood development. It is also shown that the many sectoral fields of action and planning levels must be considered together in order to make conflicting goals visible and to use synergies. By using digital tools, the effects in the different fields of action and scales can be analysed and presented. The next step is to develop a consistent toolset and tailor it to the needs of the municipalities.

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