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Do citizens' perspectives matter? A comparison of formal planning and local preferences for the deployment of renewable energies

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ABSTRACT

The aim of the study is to analyse the extent to which the spatial planning guidelines for renewable energies address the local people's perception of a sustainable energy transition. Using the example of the municipality of Tettmang in southern Germany, the study focuses on GIS-based visualisations to investigate the spatial intensity to which the overarching formal specifications on land use have been imprinted on the local contexts and what options for alternative spatial concepts are left for the local population to promote the expansion of wind turbines and photovoltaics. In a further step, the methods of participatory mapping and supplementary interviews are used to analyse which spatial perceptions of a spatially balanced energy transition prevail at the local level. The study sample indicates that the specifications of higher-level spatial planning for renewable energies are not so far away from the spatial ideas of the local population as theoretical concepts assume. Rather, a high degree of critical congruence was found between the interviewees informal and the overarching formal spatial concepts.

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Energy planning; renewable energies; participatory mapping; energy transition; energy landscapes

1. Introduction

Due to differences in the natural environment, planning laws, and political priorities, the expansion of renewable energies (RE) in Germany has so far been spatially uneven (Bruns et al., 2016, p. 130). This development implies that only a certain part of the population is affected by the landscape impacts of RE (Gailing, 2022, p. 31), which contradicts the aim of spatial planning enshrined in the German constitution (Article 72) to create equal living conditions in rural areas (Schöbel, 2012, p. 22). The spatial concentration of power plants leads to an uneven distribution of generation capacities, resulting in a surplus of electricity from RE in the north of Germany and a deficit in the south (IWD, 2022). A more even spatial distribution would therefore counteract the scenical burden on a few sub-regions and also make sense in terms of grid stability (von Seht, 2023, p. 192).

Based on the future deployment of RE, a more even distribution of installations could be aimed for. However, it is unclear to what extent the current planning law permits the expansion of RE and what 'scope for action' (Gailing & Röhring, 2015, p. 37) municipalities have to contribute to a more decentralised energy supply. For this reason, we want to take a closer look at the spatial options of RE at the local level. In doing so, we assume that protests against RE are, among other things, an expression of an unbalanced planning practice that omits important site factors (Bosch, 2021, p. 55). We refer to Trommsdorf et al. (2023, p. 56) who claim that local resistance suggests the impracticality of legal frameworks in ensuring the acceptance of close-by deployment of RE. Even more precisely: Opposition arises primarily when the perspectives of the local population are ignored (Cleland et al., 2016). Resistance to RE could thus be seen as the result of

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technocratic, top-down planning practices (Wolsink, 2007, p. 1250). For this reason, research approaches and tools that help to reconcile the overarching requirements for the expansion of RE with the perspectives of the local population are becoming increasingly important.

To address this research gap, our study focuses on sophisticated spatial analyses and corresponding tools. Our aim is to intersect technical, economic and ecological implications of local energy transitions with social factors that are so difficult to measure (Klok et al., 2023, p. 3). The importance of the social dimension has already been discussed in GIS-based approaches (McKenna et al., 2022, p. 677). GIS, which is the abbreviation for Geographic Information Systems, can be used to combine attribute tables (e.g. Excel spreadsheets) and geodata (e.g. vector data) in order to carry out complex spatial calculations and interpretations of all kinds of topics. However, it is methodologically difficult to capture and operationalise the diverse perspectives of the local people. Spatial analyses that tried to integrate the social dimension, tended to make simplified assumptions, e.g. increasing the spatial distances between energy plants and sensitive areas (Harper et al., 2019) or by generalising the categories of landscape aesthetics (Hermes et al., 2018; Weinand et al., 2022). These procedures do not address the complexity and heterogeneity of local contexts (Gailing & Leibenath, 2017; González et al., 2016). As a result, the spatial preferences of local people are insufficiently reflected in site decisions (Sward et al., 2021, p. 6).

Therefore, the focus of the study, which is based on (Schlenker, 2024), is to investigate the extent to which the lack of acceptability of close-by deployment of RE is the result of a mismatch between local preferences and the overarching RE planning guidelines. This leads to the following research questions:

- (1) To what extent is the energy transition at the local level dominated by top-down orientated RE planning guidelines?
- (2) What are the local population's spatial perceptions of an optimal RE expansion?
- (3) To what extent do the formal RE planning guidelines and informal local energy concepts diverge, what are the consequences of this, and how can potential planning conflicts be resolved?

Taking the southern German municipality of Tettang, we analyse the spatial intensity to which the RE planning guidelines have been imprinted on local energy transitions. In a further step, we identify what options are left for the local population to promote RE deployment according to their own ideas. In this, we analyse which ideas of a balanced expansion prevail at the local level, which factors are important and to what extent these perceptions differ from the formal guidelines. Therefore, the permissible spatial corridor regarding the expansion of wind turbines (WTs) and ground-mounted photovoltaic (PV) is analysed using official documents and GIS. The perspectives of the local population were collected using participatory mapping (PM), a method in which residents can map suitable and unsuitable sites for RE based on their own preferences. Furthermore, interviews were conducted to obtain additional information from the citizen group, such as the reasons for choosing certain site parameters. In a final step, the results of the individual mappings and the corresponding explanations are analysed and presented in textual and cartographic form. This allows to compare the formal RE planning practice with informal local concepts, to visualise opposing trends in land use preferences, and to identify spatial conflicts concerning local energy transitions.

Once the research questions and objectives have been clarified, the study addresses the theoretical reference point 'The production of space' (Chapter 2), which serves as the conceptual framework. Chapter 3 outlines the methodological approach in detail, focusing on GIS and PM in combination with map-based interviews. The cartographic results and collected spatial statements are presented in Chapter 4 and discussed in Chapter 5. The study closes with a brief conclusion (Chapter 6).

2. Theoretical background

The production of energy landscapes is the result of the prevailing social conditions or power asymmetries (Bosch & Kienmoser, 2022, p. 527). Control over how space is 'produced, organised and used' is exercised by those who control the way in which space is represented (Zieleniec, 2007, p. 74). According to Lefebvre

(1991), it is the powerful actors who organise space according to their own ideas and interests and seek to legitimise this order, the institutional framework of a society, through laws, jurisdiction, land use rights, maps and spatial planning (Bosch et al. 2020, p. 266; Karplus & Meir, 2013, p. 26). The spatial level at which this takes place is the conceived space, which according to Lefebvre (1991, p. 38f.) represents the dominant spatial framework of a society and is also referred to as the ‘abstract space of the experts’ (Lefebvre, 1991, p. 362), as it is conceptualised and constructed by experts, spatial planners and technocrats, as well as people with a bureaucratic or scientific background (Merrifield, 2006, p. 109). Applied to energy landscapes (Bosch & Schmidt, 2020, p. 238; Calvert, 2016, p. 112; Calvert et al., 2019a, p. 193), the conceived space is established by formal planning law aligned with the principles of technocratic planning. These legal regulations, which are the result of partial interests, restrict the given natural site potentials. Such spatial restrictions are highly persistent in time and cannot automatically keep pace with social change, which can lead to spatial conflicts.

Nevertheless, potential energy landscapes are discursively contested, especially regarding who they are intended for (Bridge et al., 2013, p. 333). Following Lefebvre’s theory (1991), two social counter-worlds emerge (Fuchs, 2019, p. 136): a world designed by dominant actors (conceived space) and a world shaped by less influential actors (lived space).

The latter refers to the space of everyday life, ‘the space of “inhabitants” and “users”’, experienced through the images and symbols associated with this spatial level (Lefebvre, 1991, p. 39). It includes both the meanings given to the space by its inhabitants, and the images, symbols, identities, memories, rituals, traditions, myths and dreams associated with the space (Fuchs, 2019, p. 137; Zieleniec, 2007, p. 75). Lived space can thus be understood as a kind of link between a society and its space (Karplus & Meir, 2013, p. 26). Lived space functions as a repository of informal local knowledge (Wolf & Mahaffey, 2016, p. 61). In contrast to abstractly conceptualised space, lived space embodies a concrete spatial dimension that is subjectively experienced by individuals (Lefebvre, 1991, p. 362).

The relations between these two spheres are often limited, but at times unfolding as social conflict. Lefebvre’s theory offers the possibility to interpret this spatial conflict as a relational interplay between different actors, bridging the mental, material and social dimensions (Delaisse et al., 2020, p. 4). This provides an opportunity not only to challenge dominant top-down planning procedures, but also to capture the perspectives of residents, who are directly confronted with the spatial implications of the energy transition (Calvert et al., 2019a, p. 193).

3. Method

To grasp the different spatial preferences in energy planning, our study follows a mixed-methods approach. It comprises the use of GIS, PM in combination with semi-structured interviews and desk research on policy documents and literature. In doing so, we analyse hypothetical spatial representations of conceived and lived spaces, not areas that have already been legally designated for RE expansion.

3.1. GIS-based analysis

A desk research on policy documents and literature is the basis for identifying the major natural site factors (techno-natural potential) and the restricting RE planning guidelines (conceived space). By linking geodata with attribute tables, which mainly contain technical data and data on planning law, the essential content can be digitised and visualised cartographically using GIS. By incorporating the prevailing formal planning criteria (as of October 2023), exclusion, restriction and potential areas for RE were identified. Table 1 shows the key exclusion and restriction criteria for the expansion of RE in the study area. In exclusion areas, RE cannot be permitted for technical or legal reasons or due to regional planning requirements. In restricted areas, RE are only permitted under certain conditions or must be balanced against specific land use requirements. This multi-criteria decision analysis (Shao et al., 2020), in which the available geodata are overlaid and intersected (overlay analyses), provides the opportunity to visualise the spatial relationships between different entities within multiple data layers (Lang & Blaschke, 2007, p. 59).

Table 1. Exclusion and restriction criteria used in the GIS analyses.

Geo data	Attributes	Data source
Land use	Settlement areas, agriculture, forests, water bodies, transport infrastructure	LGL BW (2022)
Natural site factors	Slope, shading distance, minimum wind speed	LGL BW (2022); LUBW (2023)
Distance regulations	Statutory distances from settlement areas and infrastructure	BAF (2023); BGR (2023); DWD (2018); LGL BW (2022); LGRB BW (2023); RVBO (1996b)
Monument Conservation	Cultural monuments with required assessment area	LAD BW (2023)
Nature and landscape conservation	Biosphere reserves, biotope network, focus areas of selected wind sensitive species, landscape conservation areas, legally protected biotopes, meadow orchards, Natura 2000 sites, natural monuments, nature conservation areas, national nature monuments, national parks, nature parks, regionally designated landscape areas of outstanding diversity, character and beauty, regional green corridors and green belts, regional priority areas for nature conservation and landscape management, protected landscape elements, wildlife corridors	BfN (2022); Geoportal RO BW (2023); LUBW (2023); RVBO (2021b)
Forest conservation	Forest reserves, regionally designated areas for forestry, regional priority areas for special forest functions	Geoportal RO BW (2023); FVA (2023); LUBW (2023); RVBO (2021b)
Water conservation	Flood plains, water bodies and water margins with legal setbacks, regional priority areas for water resource protection, regionally designated areas for water management, water protection areas zone I and II	Geoportal RO BW (2023); LGL BW (2022); LUBW (2023); RVBO (2021b)
Protection of agricultural land	Agricultural priority areas, regionally designated areas for agriculture, regionally designated areas of best agricultural land within the regional green belt	Geoportal RO BW (2023); LEL (2023a); RVBO (2021b)
Extraction and securing of raw materials	Regionally designated (priority) areas for extracting and securing near-surface resources	Geoportal RO BW (2023); RVBO (2021b)
Settlement development	Regional priority areas for housing construction, industry and commerce	RVBO (2021b)

Source: Own design.

One limitation in the use of geospatial information is the short half-life of geospatial data. Policy frameworks change very quickly and frequently in the context of energy transition, so the validity of GIS analysis is spatially and temporally contingent.

3.2. Participatory mapping and map-based interviews

To capture citizen's perspectives on local RE planning, a qualitative mapping study with accompanying semi-structured interviews was conducted. The methodological approach follows Jahns (2019). The interviews took place in spring 2023 with a total of 36 residents of the study area. Most participants ($n = 32$) were a selection of residents recruited as part of an on-street mapping approach (Cinderby, 2010) on different days of the week, at different times of the day and in different well-frequented locations. The only selection criterion for participation was that the respondents were citizens of the municipality of Tett nang or of the municipalities directly neighbouring Tett nang and thus had a clear local knowledge of the study area. As it was hardly possible to recruit residents from the eastern and southern parts of the study area, the sample was extended by gatekeepers to include additional residents ($n = 4$) from the corresponding municipal areas. During the mapping and interview activity, participants were asked to map suitable and unsuitable areas for WTs and PV-systems, and to explain the underlying influencing factors. Apart from topographical elements (e.g. terrain, streets, settlements), there was no additional information and no predefined sites for RE. The citizens were free to choose the sites and their dimensions. They drew them on the maps in the form of circles and hatching.

To analyse the spatial preferences of local people for RE development (lived spaces), PM is a promising methodological approach. It comprises a variety of methods (Cochrane & Corbett, 2018, p. 3), which have been developed to incorporate 'nuanced, nonexpert knowledge' (Denwood et al., 2022, p. 2324) into decision-making processes. This contrasts with technocratic approaches based on expert knowledge. PM is

understood as a tool that enables laypersons to articulate their personal knowledge, place-related concerns and imaginations about local developments and to spatially concretise these concepts (Müller et al., 2022). Individual mapping allows to capture both the material dimensions of the local environment and the lived experiences (Brown & Kyttä, 2018). PM can thus be seen as a tool for creating social acceptance in planning decisions, which provides planning authorities with important additional information on socio-spatial relationships (Huck et al., 2014).

However, this approach has also been described as ‘pseudo-participatory’ (Müller et al., 2022, p. 2), as it does not necessarily challenge existing power structures (Radil & Anderson, 2019, p. 198). Although citizens are involved for reasons of acceptance, their influence on the actual planning is kept to a minimum (Aitken, 2010). Due to the increasing complexity of planning processes, PM could even create a divide between planning experts and lay people, especially if actors with decision-making power ignore the results of PM and dismiss concerns of residents as NIMBY tendencies (Brown & Kyttä, 2018, p. 6). In some cases, however, conflict is even welcomed, to break up encrusted planning structures. In this regard, PM is seen as a form of counter-mapping (CM) (Peluso, 1995). In any case, it is a bottom-up approach that provides local people with the same tools (maps) as political-administrative decision-makers (Dalton & Stallmann, 2018, p. 93). The spatial data generated by PM is understood as a counter-narrative to the dominant spatial conceptions of appropriate land use (Brown & Kyttä, 2018, p. 2). Any dissent that emerges should hence be seen as an opportunity to disrupt hegemonic discourses and offer alternative spatial concepts (Ingalls et al., 2019, p. 634). This responds to the call for an in-depth examination of conflicts in the context of spatial planning (Hesse & Kühn, 2023a, p. 420).

The concrete input of residents can be obtained through a variety of different approaches (Brown & Kyttä, 2018, p. 5). They range from low-tech approaches (sketch maps) (Hamlin, 2022) to placing markers on paper maps (Calvert & Jahns, 2021) or web-based tools with digital input masks (Müller et al., 2022). The advantage of web-based participatory methods is that they offer a low-threshold opportunity to participate. However, digital tools exclude certain groups of people who do not have access to the necessary technology (Robinson et al., 2015). An alternative is the so-called on-street mapping, where participants are approached directly on the street (Cinderby, 2010). Thereby, it is possible to involve people who would not participate in official participation formats (Calvert et al., 2019b, p. 41). The present study uses this methodological approach. The disadvantage of this methodological approach is that the respondents do not automatically have the necessary expertise to make rational decisions for balanced spatial development.

To gain an even deeper insight into the local context, three additional map-based interviews were conducted with key local stakeholders. These have specific expertise and understanding of local social structures and challenges. A representative of the local agricultural sector, a representative of a local climate protection group and a representative of the local tourism industry agreed to participate. As these three people were explicitly identified as representing specific social groups, the information from these interviews was analysed separately. In addition, the mapping was not included in the evaluation and visualisation of the ‘normal’ residents’ cartographic visualisations.

The interviews were analysed using MAXQDA 2022 software, with the transcripts forming the basis of the qualitative analysis (Mayring, 2016, p. 121). Content coding was based on Petrova’s (2016) VESPA model, which categorises the important factors for local acceptance of RE into the visual/landscape (V), environmental (E), socio-economic (S) and procedural (PA) dimension (cf. Calvert & Jahns, 2021; Jahns, 2019).

3.3. Combination of empirical data

The spatial information collected through PM and the interviews was digitised and vectorised in ArcGIS for visualisation and analysis. As a result, four map layers were created for each participant, representing the suitable and unsuitable areas for WT and PV-systems. In a further step, the overlays of the individual maps were summed in relation to the categories *suitable* and *unsuitable*. The resulting vector data was transferred into a 50 m grid. This was used to produce heat maps showing areas of high and low suitability for WT and PV development. The numeric difference between the mapped land use preferences (for or against RE expansion) was used to determine the tendency of the locally preferred land use (tendency maps) within the sample (Brown &

Raymond, 2014, p. 200). This is done by subtracting the number of overlaps of areas mapped as unsuitable from the number of overlaps of areas mapped as suitable for RE. A positive value within a grid cell indicates a tendency for and a negative value a tendency against the expansion of RE.

A particular limitation of the empirical study, apart from the contradictions that sometimes occur between mapping and interview statements, is the selection and number of participants in the sample. The sample is not statistically representative and therefore the results cannot be generalised.

3.4. Study region

The municipality of Tettnang, which is part of the Lake Constance-Upper Swabia planning region, is located in the south-east of Baden-Wuerttemberg and home to 20,077 people (Stadt Tettnang, 2023a). Almost 60% of the municipal area is characterised by agriculture (60% grassland and 30% speciality crops such as fruit and hops). In addition to a large number of highly qualified jobs, the municipality offers a high quality of life (VVTN, 2011, p. 11). Furthermore, tourism plays a major role (Stadt Tettnang, 2023b). In 2022, Tettnang enacted an energy and climate policy concept (Stadt Tettnang, 2022). However, the municipality does not have any WTs or PV-systems. That is why the municipality was chosen: because there have not been any concrete planning efforts to expand RE so far and no planning areas have been designated. According to Müller et al. (2020, p. 9), this is an important prerequisite for an effective survey of local contexts as part of a participatory planning process.

4. Results

4.1. Technical-natural site potential

The technically suitable areas for the deployment of WTs are predominantly located on the eastern side of the municipality (Figure 1). This is primarily attributable to the prevailing natural wind conditions, which rarely exceed the value of 5 m/s wind speed required for the operation of WTs (Osterhage, 2019, p. 86). After deducting the technically unsuitable areas, 1,668 hectares remain for the installation of WTs, corresponding to 75 turbines. From a technical standpoint, 1,840 hectares are available for the construction of PV-systems (Figure 2).

4.2. Formal planning practice (conceived space)

The proportion of the technical site potential that can actually be utilised for energy generation is further constrained by the prevailing planning practice. This is embedded in an institutional framework of social rules determining both the type and extent of land use that can be attributed to energy planning. Ipsen et al. (2003, p. 13) refer to this as the 'social structuring' of landscape.

After deducting the exclusion areas, 14.9 hectares, distributed over three sites, remain for the construction of WTs (Figure 3). The site potential is mainly limited by the requirements for the protection of residents through the implementation of distance zones from residential areas and by nature and landscape conservation concerns. The remaining site potential, which is by no means unrestricted, is located in the northern half of the municipality. Theoretically, three individual turbines could be erected. However, various restrictions on these sites make the construction of WTs highly unlikely.

Considering the formal institutional framework for the construction of PV-systems, 690.4 hectares remain. Most of these areas are located in the north-eastern part of the municipality (Figure 4). The site potential for PV-systems is severely limited by the land requirements of nature and landscape conservation. Regional planning regulations in the form of regional green corridors, green belts and regionally designated areas for nature conservation and landscape management areas account for the largest share (RVBO, 1996a). About 86% of the technical site potential are also restricted by agricultural land use requirements. These include regional priority areas for agriculture and areas of best agricultural land (RVBO, 2021a, p. 23). Only 40.8 of the remaining 690.4

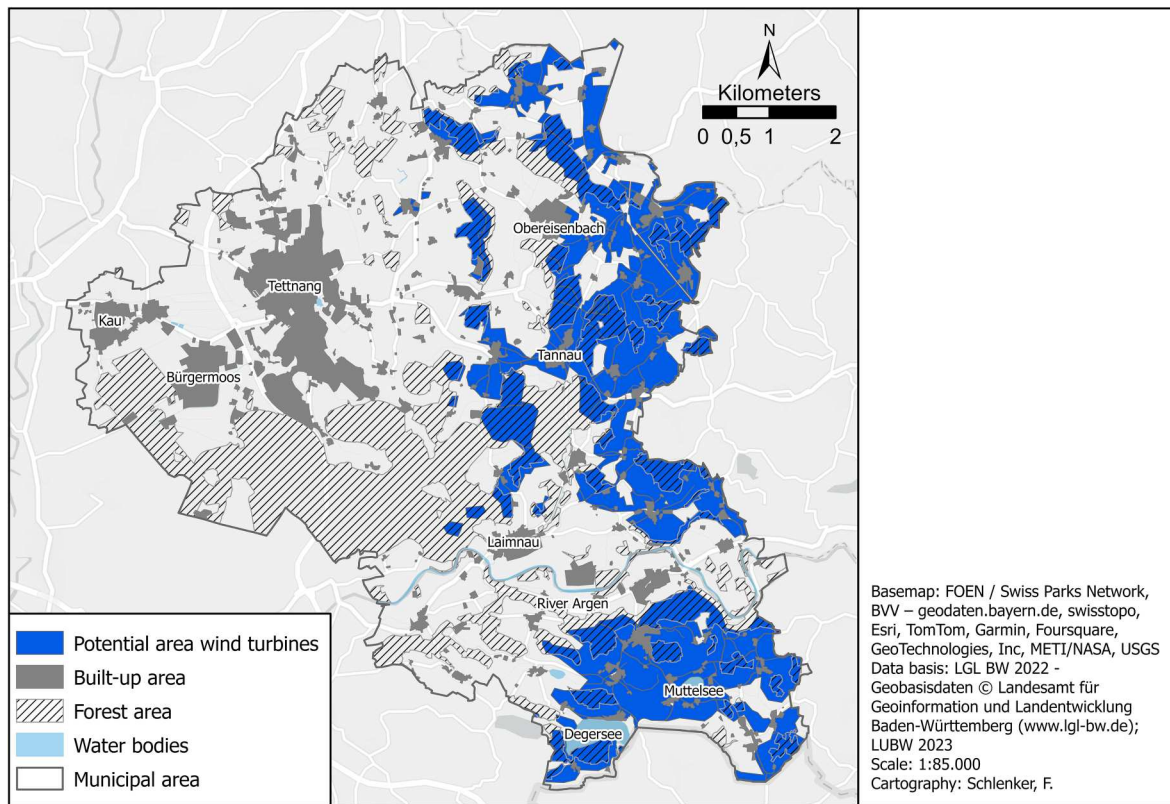


Figure 1. Technical-natural site potential of wind turbines. Source: Own design.

hectares are free of restrictions. Consequently, the RE planning guidelines severely limit the remaining space for local people to develop RE.

4.3. Site potentials in citizens' view (lived space)

A total of 96 areas were mapped by the residents as suitable and 78 as unsuitable for WTs, and 71 areas were mapped as suitable and 35 as unsuitable for PV-systems. Only one single resident and the tourism representative said that the entire municipality was unsuitable for WTs. Five of the residents did not map any areas that they considered unsuitable for WTs. Regarding the possible expansion of PV-systems, only one respondent described the municipal area as generally unsuitable. Three of the respondents said that they could imagine PV-systems anywhere. Ten residents didn't mention any unsuitable areas for solar energy.

In the map-based interviews, respondents mentioned a range of factors that influenced their spatial perception concerning an acceptable deployment of RE in their hometown. The most frequently mentioned factors relate to visual and socio-economic aspects of the technologies.

4.3.1. Visual/landscape factors

For 72% of the respondents, distance from populated areas is a key factor in selecting WT-sites. Almost half of the respondents consider densely populated areas or sites near settlements as unsuitable for WTs. Some identified noise from turbines as a major nuisance. The scenic impact of WTs is also an important aspect, particularly in terms of the visibility from residents' properties. One respondent articulated this sentiment, stating: 'Well, you know how it is, everyone wants it, and no one wants it 'round their own home' (resident 5).

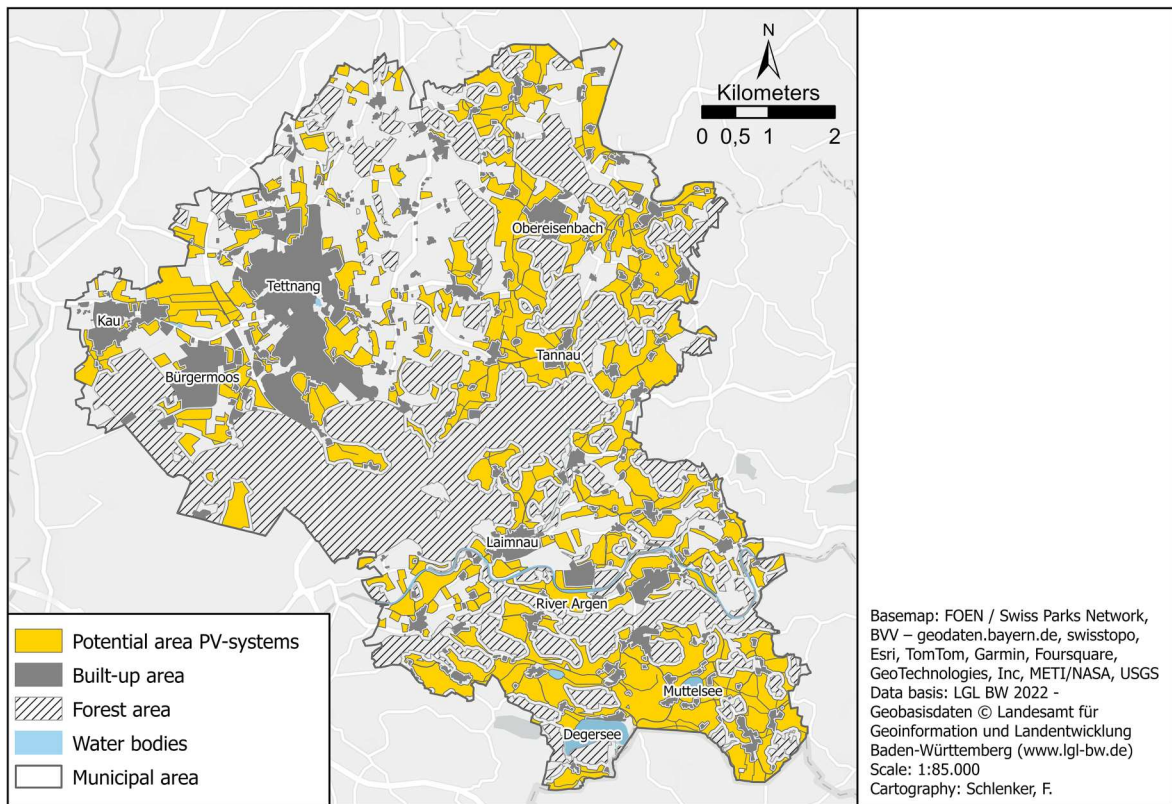


Figure 2. Technical-natural site potential of ground-mounted photovoltaic. Source: Own design.

The negative landscape impact of WT's was also emphasised with regard to the aesthetic and recreational value of certain areas, particularly the visual axes to Lake Constance and the Alps.

On the other hand, many respondents stated that landscapes already affected by infrastructure, are acceptable for the development of WT's. In this context, proximity to the main road is mentioned as a suitability category for WT's. One resident pointed out that elsewhere WT's are often located near main roads, therefore already being 'part of the picture' and that it is 'not nice anyway' (resident 14) along these roads. A similar assessment was made for the industrial areas around gravel pits within the municipality. Areas with radio masts or covered with hail nets were also deemed suitable, because they are already disfigured. Simultaneously, respondents indicate a discrepancy between their personal landscape aesthetics and the benefits of RE in facilitating a carbon-neutral energy supply: 'I mean, everyone would rather have these things far away from them. But I don't think it's that bad, because we really have to do something about energy' (resident 30).

For other respondents, WT's do not generally spoil the landscape. Some refer to WT's in the northern regions of Germany, where they are a 'highlight' (resident 15), or to countries such as the Netherlands, where people are even happy about windmills (resident 23). One resident even describes WT's as 'beautiful' (resident 18). It was also indicated that familiarisation with WT's could potentially influence their perception over time (tourism representative).

Due to their low height, PV-systems are generally perceived as less intrusive. However, some respondents argue that PV-systems disturb the landscape. According to them, areas used for local recreation should be excluded. In particular, the 'charm of the landscape' (resident 3) should be preserved, including the views of Lake Constance, the Alps and Tettang Castle. Furthermore, some respondents deemed PV-systems in residential areas or in their immediate vicinity as unacceptable. Conversely, however, PV is also described as a suitable 'gap filler' (resident 12) in populated areas.

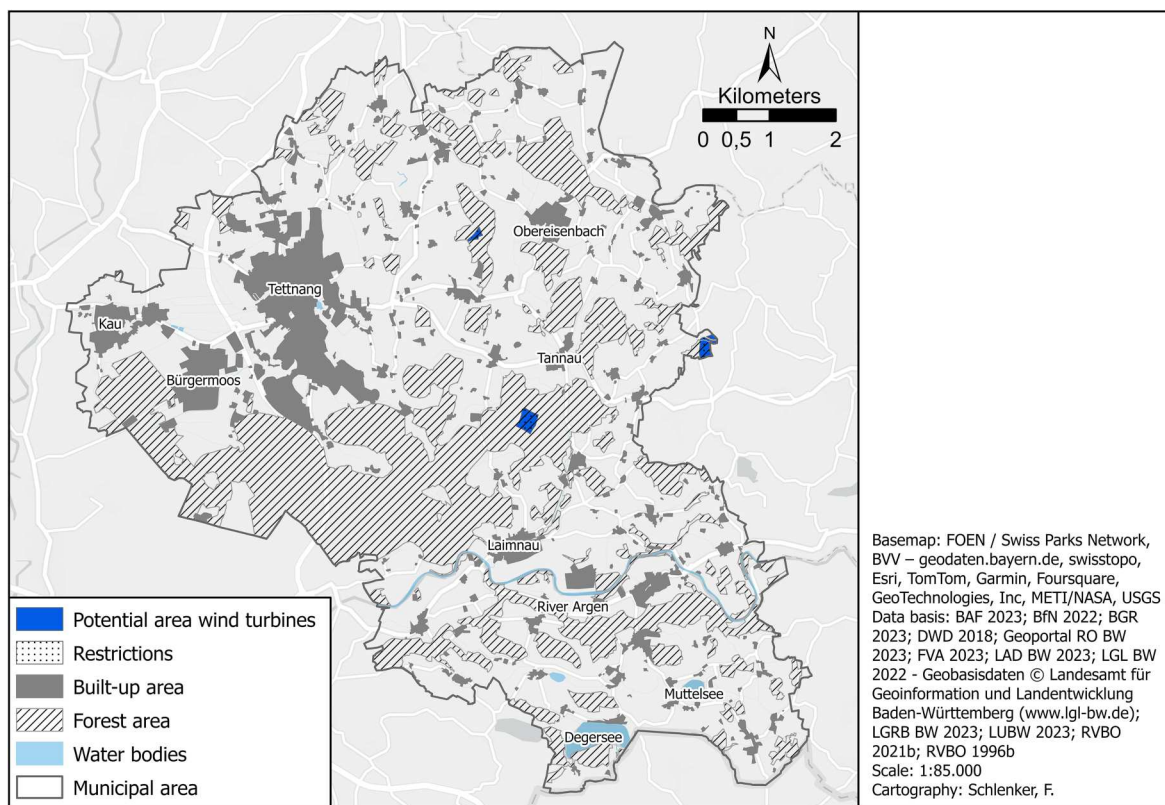


Figure 3. Formal planning potential (wind turbines). Source: Own design.

More than a third of respondents consider open spaces and agricultural land suitable for PV-systems. However, it was emphasised that due to the dense population, the intensive farming of fruit and hops, and the small amount of fallow land, open space is scarce. Roofs or sealed areas are therefore often mentioned as an alternative site for PV-installation. Synergy effects in terms of noise protection could be achieved if PV was installed along the main road (climate protection group representative). Additionally, pre-polluted areas are considered to be suitable, e.g. car parks, gravel pits, areas along major roads, industrial areas and areas with monocultures and hail protection nets. A quarter of respondents indicated that PV would be a preferable alternative to hail protection nets, citing the latter's considerable scenic impact on the local landscape. The tourism representative also emphasises that people are already accustomed to this impact on the landscape which could facilitate the integration of PV-systems in the municipal area more so than WTs. A prototype of an agricultural photovoltaic (Agri-PV) system installed on an orchard in a neighbouring municipality might play an important role in this positive assessment.

Furthermore, there are significant concerns regarding the density and scale of RE installations. The proliferation of PV could have an adverse impact on the landscape, whereas a more distributed approach involving multiple smaller systems may be more acceptable. In this context, the climate protection group and the tourism representative proposed setting a percentage for PV per municipality to regulate the expansion.

4.3.2. Environmental factors

Environmental factors that influence the attitudes towards RE encompass both the role of these technologies in averting the climate crisis, and their adverse effects on nature and species conservation. This ambivalence is reflected in the respondents' statements. For some, visual factors, which are typically

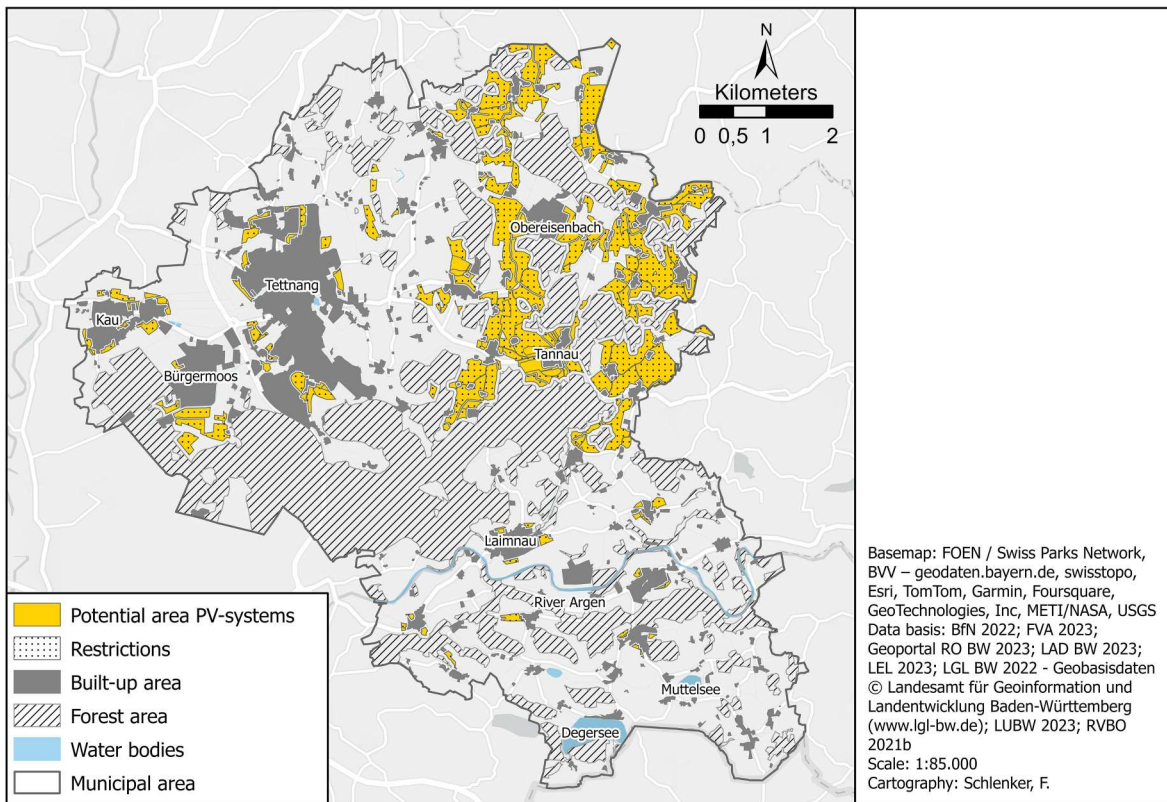


Figure 4. Formal planning potential (ground-mounted photovoltaics). Source: Own design.

regarded as very important, play a minor role in the context of the necessity for the energy transition. Personal interests would have to be ‘put aside’ (resident 17) and the ‘consequences’ (resident 27) for the landscape must be accepted. The representative of the local climate protection group emphasised that although he was disturbed by the visual impact of WT, their expansion was ‘socially relevant’ and a ‘solidarity contribution’.

Additionally, there is a pronounced emphasis on the necessity of developing RE in a manner that is in ‘harmony with nature’ (resident 30), the consideration of renaturation and compensation areas when construction energy facilities, and the protection of animals and bird migration routes. Some respondents stated that areas with a high diversity of animal and plant species are unsuitable for the construction of WT. Concerning PV-systems, meadows and clearings in forests were also mentioned as being important for wildlife and should therefore to be kept free of installations. However, the climate protection group representative emphasised that there are often misconceptions about PV-systems, as the areas underneath the modules are not in conflict with biodiversity. On the contrary, PV-systems could be well integrated into the biotope network, as biodiversity under PV-modules is often significantly higher than in agricultural landscapes.

Deforestation is one of the main environmental concerns associated with the expansion of RE. Almost a third of the residents consider the utilisation of WT on forest land and the associated deforestation as unacceptable. Some also stress the significance of forest conservation in the context of PV-expansion. This view is at odds with that of a subset of respondents who would specifically welcome WT on forest land. They argue that these sites are often located on ridge tops, which could offer not only greater efficiency but also greater distance from settlements. It is also pointed out that forests would reduce the visibility of turbines.

4.3.3. Socioeconomic factors

For more than half of the respondents, the efficiency of the WT plays an important role. 56% of respondents cited windy locations as an important decision criterion when choosing a site. Some respondents expressed scepticism about the availability of suitable windy sites within the municipality. Topography is also considered when selecting suitable PV-sites. In particular, south-facing slopes and areas devoid of shade are considered suitable. Furthermore, over one-third of respondents identified the intense competition for land between energy production, grassland, and special crops as a major challenge. In light of this, the utilisation of fallow agricultural land or the dual use of orchards and Agri-PV is recommended. However, as the agricultural representative emphasises, if AgriPV is to succeed, funding and economic viability need to be secured, planning requirements eased, and grid development accelerated.

4.3.4. Procedural factors

Only a few residents mentioned procedural factors. This may be because none of the considered RE have been installed or planned in the municipality yet, so respondents were not familiar with the procedural aspects of energy systems and the underlying opportunities for participation. Two of the interviewees indicated that they perceive the legal requirements and planning rules in place for developing WTs to be an obstacle. They feel that these 'go too far' (resident 7) and are an obstacle to contributing to climate protection (resident 12). Regarding the poorly developed Agri-PV-systems, the agricultural representative points to the inadequate procedural requirements. In addition, the interviewees stressed the importance of landowner consent as a prerequisite for acceptance. The agricultural representative also notes that financial participation of citizens (cf. distributional justice) could help to improve acceptance.

4.4. Synthesis of mapping and interview statements

To identify similarities and differences in the residents' spatial perceptions of a balanced energy transition and preferred land uses, further GIS analysis was carried out on the data collected. After digitising the suitable and unsuitable areas mapped by the residents, the respondents' statements on specific locations were also transferred into cartographic visualisations, as far as they could be spatially interpreted and corresponding geodata were available. There were some inconsistencies between the PM and the interview statements. In some cases, parts of the mapped suitable areas were described as unsuitable locations in the interview. This shows that inviting citizens to participate in the planning process is not necessarily conducive to acceptance, as they may later question their own decisions. This may be since mapping requires spatial imagination, cartographic knowledge and experience, which not all respondents necessarily have. These inconsistencies were not corrected, as this would contradict the purpose of PM, which is to tap into alternative sources of knowledge and place them on equal footing with expert knowledge.

4.4.1. Lived wind energy landscapes

The areas respondents identified as suitable for constructing WTs (Figure 5a) exhibit a broad spatial distribution across the municipality. With a few exceptions, suitable locations for WTs were mapped across the entire municipality. Concurrently, the map illustrates that the extent of overlap between the individually mapped suitable areas is relatively limited, with a maximum of 22% of respondents, even though all but one respondent mapped suitable areas. Firstly, the low degree of overlap is due to the large spatial dispersion of the suitable areas. Secondly, it can be explained by the fact that many respondents mapped small areas, which reduces the probability of an overlap. Nevertheless, there is an accumulation of areas identified as suitable in the north-eastern part of the municipality.

The areas identified as unsuitable for WTs (Figure 5b) show a significantly higher level of agreement between respondents' individual spatial perceptions. In particular, forests and residential areas and their immediate surroundings were considered to be unsuitable by many. The town area of Tett nang exhibits a particularly high level of RE rejection. The preferred land use within the sample (Figure 6) indicates a clear tendency against WT-development in the municipality. Only a limited number of small areas in the northeast exhibit potential for wind energy deployment or no clear tendency for or against WT deployment (white areas).

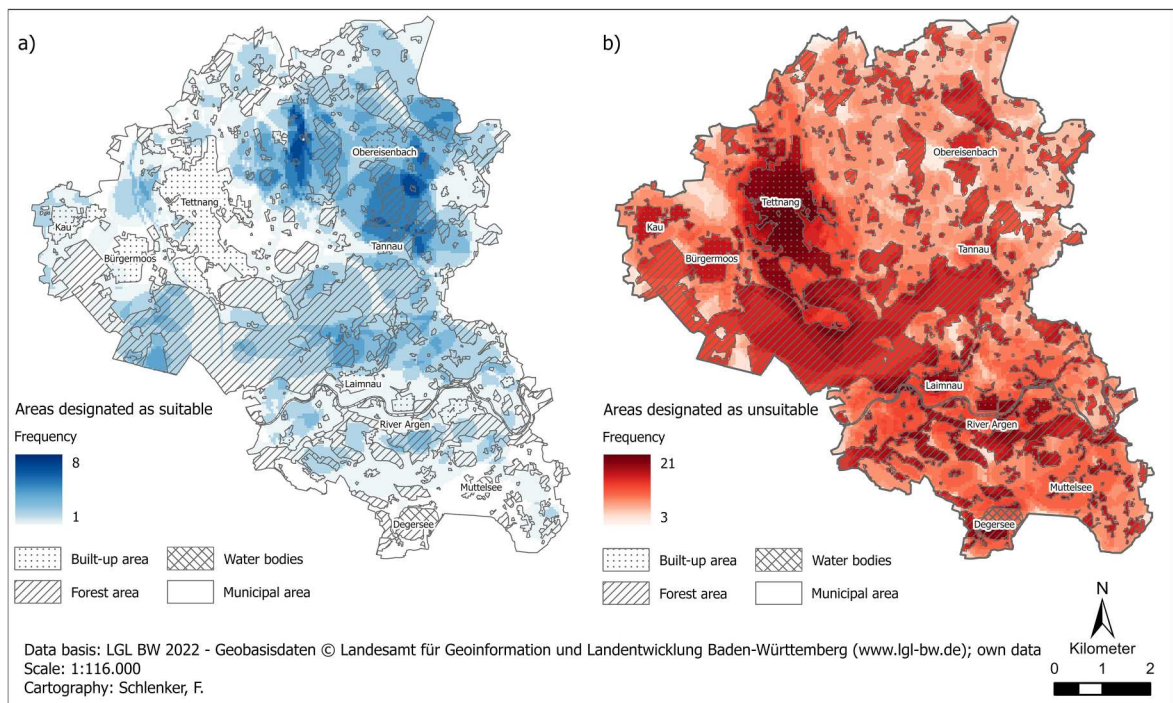


Figure 5. Heatmaps wind energy. (a) Suitable areas for the development of wind turbines (b) Unsuitable areas for the development of wind turbines. Source: Own design.

The heat maps (Figure 5a,b) not only reveal similarities in the individual spatial perceptions, but also illustrate a wide variety of sometimes even contradictory expansion concepts. There are only a few areas where the overall trend of the mapped energy landscape is in favour of WT expansion (Figure 6), although the majority of respondents could envisage WT installations within the municipal area. This illustrates how difficult and conflict-laden the identification of suitable sites for WTs can be.

4.4.2. Lived photovoltaic landscapes

The areas identified by respondents as suitable for the construction of PV-systems (Figure 7a) also demonstrate a wide spatial distribution. Nevertheless, there is a discernible concentration of areas designated as suitable on orchards. These are predominantly situated in the central northern part of the municipality and partially also in the north-west. Furthermore, the area along the main road west of Tettwang is considered to be highly suitable. Among the areas identified as unsuitable (Figure 7b), the Tettwang forest and the adjacent municipal area to the south were frequently mentioned. In general, both forests and settlement areas were described as unsuitable.

Figure 8 shows the high suitability of orchards for the deployment of PV. It is important to note, however, that the respondents described PV-systems *on* orchards as suitable, not the replacement of orchards. It can be concluded that the aforementioned areas are primarily related to the specific technological form of Agri-PV. Additionally, the areas along the main road are deemed suitable for PV expansion. In the southern part of the municipality, beyond the Tettwang forest, the deployment is viewed critically. Compared to WTs, there are considerably more (white) areas available, where there is no discernible tendency towards or against the expansion of PV-systems, and where opposing viewpoints are equally prevalent.

The suitable areas for PV expansion show a significantly higher number of overlaps compared to the suitable areas for WTs. This suggests a greater degree of agreement regarding the acceptability of PV-system expansion across different spatial perceptions. In contrast, the unsuitable areas for PV-systems and WTs exhibit a comparable degree of overlap. The situation is different regarding preferred land use. There are notably

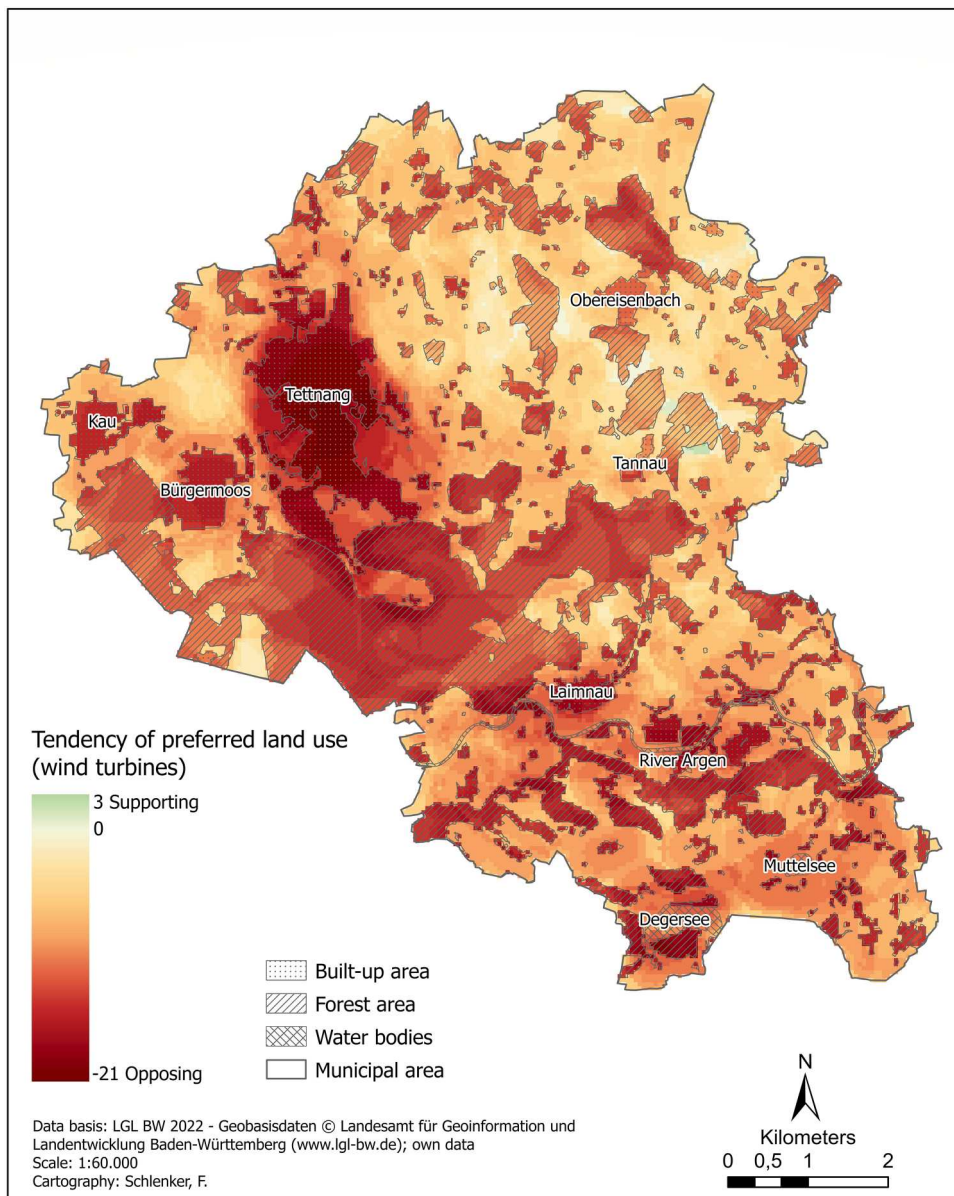


Figure 6. Tendency map wind energy. Source: Own design.

more areas with a tendency towards expanding PV- or Agri-PV-systems, which also have considerably higher approval ratings than the few areas with a tendency towards expanding WTs. Consequently, there is a markedly greater affinity for PV-systems within the study area.

4.5 Comparison of formal and informal area potentials

Finally, the informal planning ideas of the residents interviewed were compared with the site potentials derived from the RE planning guidelines (Figure 9). Both the spatial criteria and the specific locations derived from them were compared with each other.

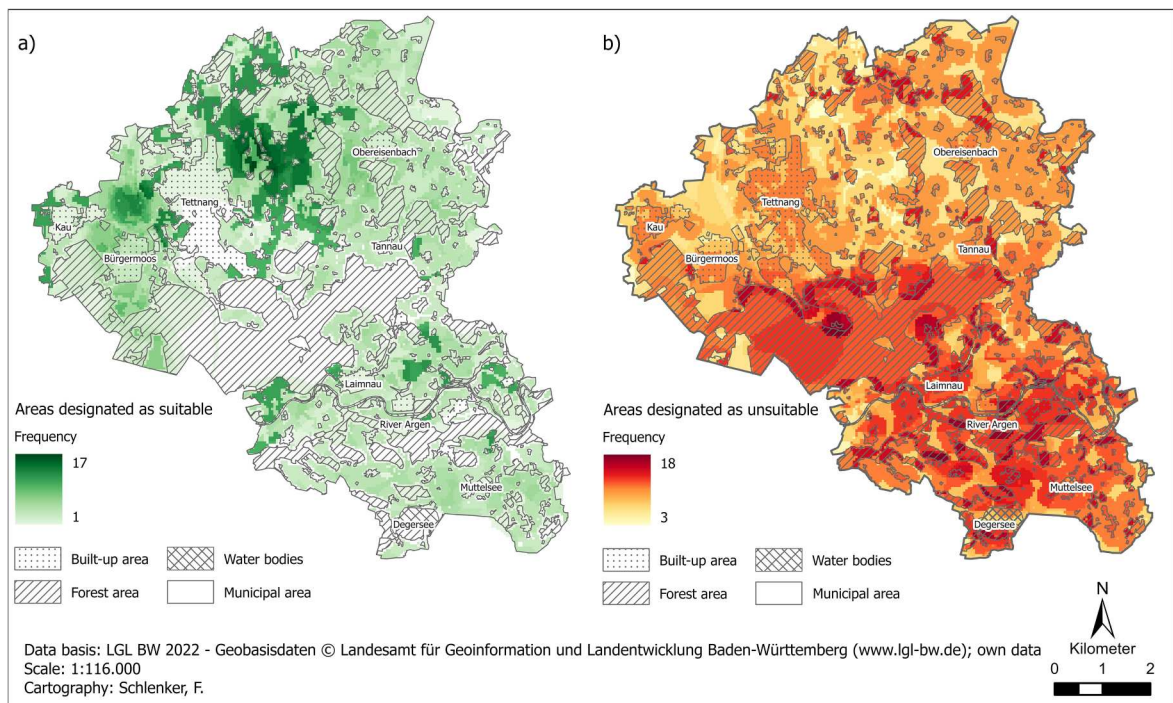


Figure 7. Heatmaps photovoltaics. (a) Suitable areas for the development of photovoltaic systems (b) Unsuitable areas for the development of photovoltaic systems. Source: Own design.

For most respondents, visual and landscape factors play a crucial role in the siting of RE. The distance between WTs and populated areas, demanded by many, is addressed in various legal regulations. These include the minimum distance from built-up areas required by the German Federal Immission Control Act (BImSchG), as well as the planning law (Section 35 (3) sentence 1 no. 3 of the Federal Building Code (BauGB) and Section 15 of the Federal Land Utilisation Ordinance (BauNVO)). Furthermore, recommendations for certain precautionary distances are given at state level (UM BW et al., 2012, p. 21). Consequently, it is primarily the minimum distances that must be maintained from residential areas that limit the developable potential for WTs. In contrast, there are no legal or planning requirements for the construction of PV-systems that define specific distances from residential areas. Instead, the unrestricted areas are all located in close proximity to settlements. The survey conducted does not allow for generalised statements about how large acceptable distances to different uses need to be. For one, the accuracy of people's abstract perception of distance compared to the objective measurement of visual or topographical distances beyond limited spaces has not been sufficiently clarified (Carlisle et al., 2016, p. 499). At the same time, Müller and Morton (2021, p. 65) emphasise that the degree of proximity of facilities that is considered acceptable by the population is subject to constant change and is part of a social negotiation process. The need to protect certain landscape and recreational areas is also considered in the formal institutional planning requirements, since the 'diversity, characteristic features and beauty of nature and landscape, as well as their recreational value' (Section 1 (1) no. 3 Federal Nature Conservation Act (BNatSchG)) are protected by law.

Additionally, the respondents identified pre-polluted areas as suitable for energy plants. While there are no analogous planning regulations for WTs, the requirement to give priority to the use of pre-polluted sites in the expansion of PV is enshrined in the Renewable Energy Source Act's (EEG) subsidy regime. The promotion of solar energy is primarily focused along transport routes, in conversion areas, and in agriculturally disadvantaged areas. However, in the study area, the utilisation of these sites is significantly constrained by the presence

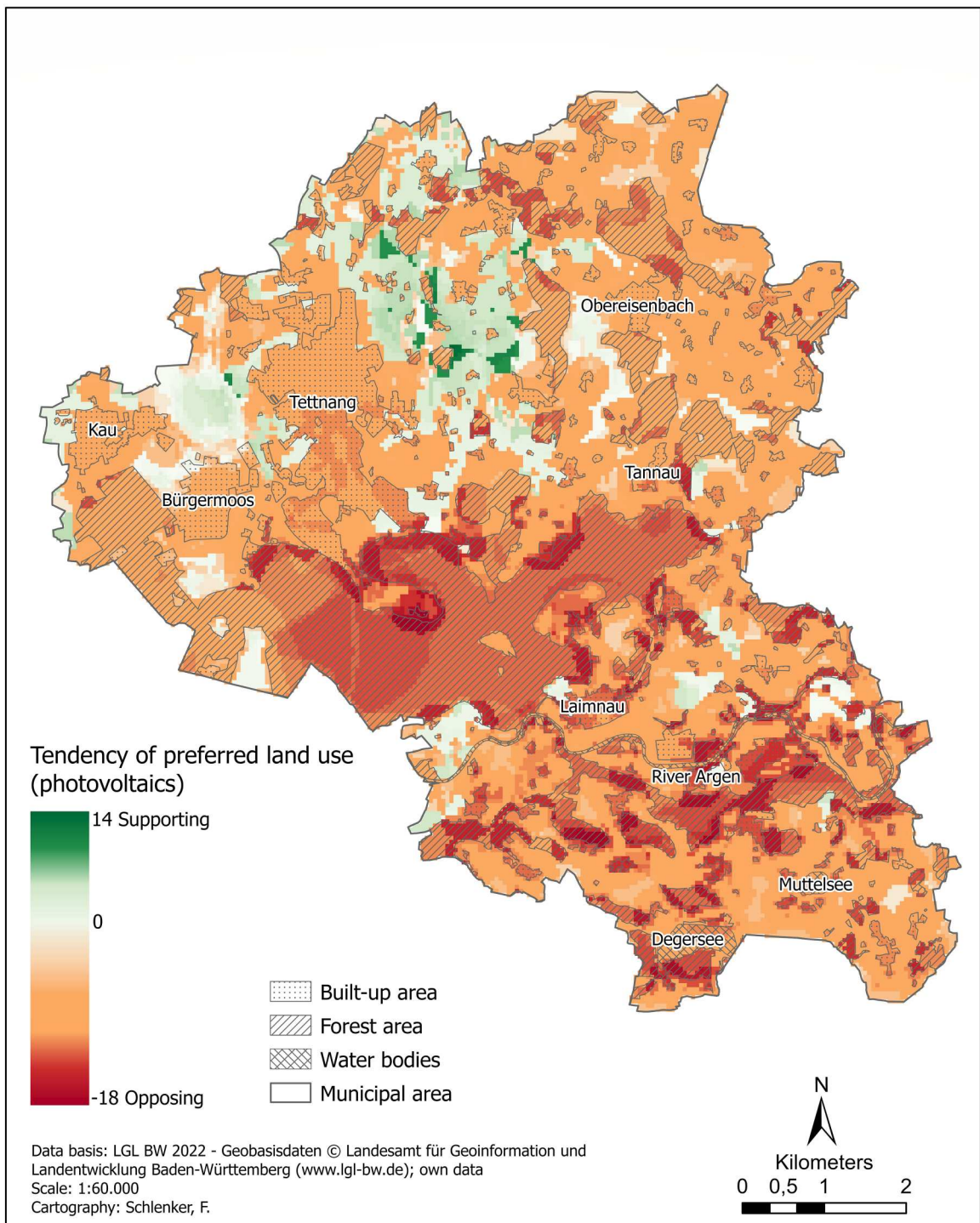


Figure 8. Tendency map photovoltaics. Source: Own design.

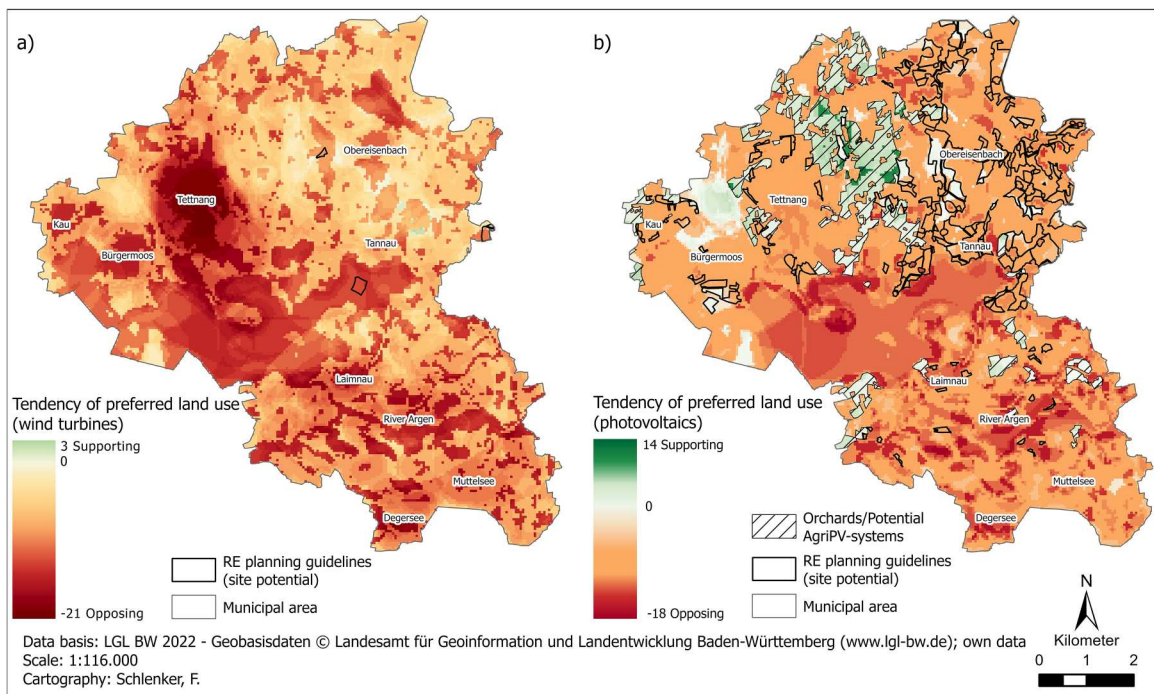


Figure 9. Similarities and differences in the planning concepts. (a) Wind energy (b) Photovoltaics. Source: Own design.

of other regional planning regulations. For instance, the majority of areas along the federal highway are located within regional green belts, where the construction of PV-systems and WTs is prohibited.

Regarding the environmental impacts of WTs and PV-systems, respondents highlighted both the benefits of these technologies for climate protection and to the potential negative impact on nature and species conservation. These considerations are also reflected in the overarching formal-institutional planning concepts for the expansion of RE. In the recent months, several barriers to RE expansion have been removed, and several laws and approval regulations have been amended to facilitate and accelerate the energy transition. In addition to the objective of reducing reliance on fossil fuel imports, efforts are being made to mitigate the effects of the climate crisis (GFG, 2023a, 2023b). This energy policy is consistent with the statements of the residents surveyed, who perceive the energy transition as a significant benefit in attenuating anthropogenic climate change.

Concerning the adverse impacts on nature and species conservation, respondents emphasised the significance of environmentally sustainable development and identified areas of high biodiversity as deserving protection. These demands are also reflected in formal institutional planning requirements, e.g. in the form of nature conservation areas or flora-fauna habitat areas, where biodiversity is given a high priority. Additionally, species conservation concerns must always be considered in planning approval procedures (Section 44 BNatschG). The most frequently cited ecological concern pertaining to the expansion of RE is the avoidance of deforestation. While clearing for the construction of PV-systems is an exception, forest areas are often cleared for the installation of WTs (GB, 2022, p. 5). The state government even actively promotes the expansion of wind energy on forest land (Quentin & Tucci, 2022, p. 22). Under current planning law, only specific forest functions (e.g. ecosystem services) need to be taken into account.

The demand of the interviewees to use (economically) efficient locations for the construction of RE is acknowledged to a certain extent by the formal institutional planning concepts. In accordance with Section 1 (3) BauGB land-use plans must be 'enforceable' (Spitz, 2016, p. 62). This is contingent upon the site in question being generally suitable for economic utilisation. Furthermore, the EEG subsidy scheme ensures the economic viability of energy plants. Nevertheless, WTs in less windy areas are incentivised with a higher subsidy

rate. This means that WTs can be subsidised across Germany, with expansion not being constrained to the most economically efficient locations. Consequently, formal institutional planning regulations ensure that expansion in economically inefficient location is hindered. Nevertheless, they cannot guarantee that only the most efficient sites are used.

Additionally, the legal framework is largely aligned with the requirement to consider agricultural interests. For example, areas deemed particularly suitable for agriculture are safeguarded from the expansion of WTs and PV-systems. An important factor in limiting PV-expansion is the delineation of agricultural priority areas. Concurrently, the benefits of Agri-PV-systems are acknowledged and their formal integration into spatial planning is facilitated. Agri-PV-systems are subsidised via the EEG, and since July 2023, privileged in the external area of municipalities (Section 35 (1) no. 9 BauGB). The state of Baden-Wuerttemberg is also promoting the technology in five pilot facilities on fruit and berry plantations (MLR BW, 2022). Moreover, it may be inferred that the spatial planning regulations for the protection of agricultural land do not impede the construction of Agri-PV-systems, as agricultural use is still feasible under the modules.

This does not mean, however, that the specific potential areas derived from the RE planning guidelines also represent suitable and conflict-free locations for RE expansion from the perspective of residents. Conversely, the spatial perceptions of the specifically suitable areas differ considerably (Figure 9), particularly regarding the potential construction of WTs. All three potential areas are forested, and thus not considered suitable for WTs by a significant proportion of the residents surveyed. Concurrently, the RE planning guidelines preclude the possibility of a locally adapted expansion of WTs outside the aforementioned areas, where the actual realisation of the project is questionable anyway due to existing restrictions. A more complex picture emerges regarding the spatial congruence of suitable areas for PV. This is because from the perspective of the residents surveyed, significantly wider range of areas shows a tendency towards the expansion for PV. Furthermore, the study area exhibits a considerably higher number of areas with legal development potential. Fruit-growing areas occupy a distinctive position. They were not included in the potential analyses, as their utilisation has not yet been part of the prevailing spatial practice. However, it is becoming evident that the deployment of Agri-PV in lieu of hail protection nets could represent a form of RE generation that could fulfil both planning objectives in criterial and concrete spatial terms.

5. Discussion

5.1. Criterial and spatial congruences and differences

Despite the expected differences between formal guidelines (conceived space) and local preferences (lived space), we find a congruence in the *criteria* identified as most valid for RE siting. Many of the concerns raised by local respondents are addressed within the overarching formal guidelines. As this congruence is particularly evident regarding the general exclusion and suitability factors for the expansion of REs, we call it *criterial congruence*. It is especially expressed 1. in the preferential use of sites that are far from settlements, pre-polluted and economically efficient, and 2. in the exclusion of areas that are close to settlements, as well as areas that are valuable in terms of landscape, nature, species and socio-economic aspects. Many of the parameters that characterise the spatial perceptions of the respondents coincide with the influencing factors that have also been identified in other spatial contexts. This is particularly the case for the importance of visual-landscape factors (Schweiger et al., 2018), with aesthetically unappealing areas being favoured for RE expansion (Betakova et al., 2015). This tendency can also be seen in our sample, where areas perceived as ‘beautiful’ (e.g. resident 13) were excluded and areas described as ‘not beautiful anyway’ (e.g. resident 14) were mapped as suitable areas for RE. This is in line with the planning rationale of concentrating expansion on pre-polluted sites (Bosch & Kienmoser, 2022, p. 527), which is viewed critically in the context of energy justice (Bickerstaff, 2017). At the same time, residents point to the cultural dimension concerning the perception of energy installations, described by Nadaï and van der Horst (2010, p. 149): e.g. the description of WTs in northern Germany as ‘a highlight’ (resident 15). The same applies to the discursive contextualisation of RE and the associated influence on the way in which installations are perceived (Müller et al., 2020, p. 7f.): People who consider

the expansion of RE to be important judge the spatial implications of the installations more positively, perceiving them as a sign of ‘progress’ (resident 20). These people do not experience a loss of landscape (Stemmer & Bruns, 2017, p. 285). The distances between WT and populated areas (Huck et al., 2014), the (low) number and density of turbines (Betakova et al., 2015), efficiency (Liebe & Dobers, 2019, p. 251) and the protection of agriculturally valuable land (Jahns, 2019, p. 57) for local acceptance of RE, which are the main factors influencing the perception of RE in Tettwang, have also been addressed in other case studies. This suggests that there are important site factors which are not explicitly tied to local contexts.

One explanation for the *criteria congruence* between conceived and lived space could be a learning effect in the siting of RE. This refers to the distances between WT and settlements (Glas & Sebald, 2022), the use of pre-polluted areas (Peter, 2023), or species and nature conservation concerns (Beck & Sebald, 2023), which are much discussed in the media and thus seem to have become common knowledge. In addition, various statements from residents suggest that certain areas are considered suitable because RE site patterns of other regions are unconsciously adopted, e.g. WT along major roads. In this way, locally acceptable areas could be anticipated at an early stage by transferring spatial concepts from one municipality to another. Simultaneously, the implementation of energy solutions would be made more difficult in the case of municipalities without similar spatial characteristics such as railway lines, major roads or pre-polluted areas.

Forests occupy an ambivalent position in relation to the study sample, being considered categorically unsuitable for RE development in some cases, and suitable in others. According to Liebal and Weber (2013, p. 233), this ambivalence can be attributed to different values: The majority of the population associates forests with ‘wilderness, beauty, recreation or ecology’ and forests symbolise ‘intact and untouched nature’ (Ludwig & Bosch, 2014, p. 297) which could be disturbed by RE. At the same time, there are several reasons, why the expansion of WT in forests makes sense. On the one hand, forests are distant to settlements, on the other hand their higher altitudes result in more wind speed and therefore in greater economic efficiency. However, as forests were significantly more often identified as unsuitable for WT, this broad consensus among respondents makes them less likely to be conflict-prone, as the local context precludes development in these areas. In any case, conflicts can never be ruled out, as studies have shown that powerful individuals may have the resources to mobilise siting decisions in their favour (Schwarz, 2020). It is therefore necessary to enable participation from the very beginning to be able to identify potential conflicts at an early stage.

The high *criteria congruence*, however, does not imply that the remaining developable sites, that are derived from RE planning guidelines, are suitable and free from conflicts with local citizens (Figure 9). Conversely, the results also show that the *spatial* conclusions derived from the various suitability and exclusion criteria exhibit a notable *spatial incongruence* – especially regarding a possible expansion of WT (see Figure 9). This is evident both within the cohort of respondents and when comparing respondents’ spatial perceptions with the formal planning concepts. The exact spatial reference points and locations of potential conflict thus appear to be highly context-dependent, underlining the importance and necessity of local negotiation processes.

In view of this, the assumption derived from the theory of Lefebvre that there is a large discrepancy between formal-institutional and informal spatial conceptions concerning a balanced energy transition cannot be clearly confirmed. Rather, the results suggest that the conceived and lived spaces are closely intertwined and, at least in part, converge through constant discursive exchange through education, social media and public debates on the pros and cons of RE siting. However, the results also show that social conflicts are always to be expected in the expansion of RE, because there is a high degree of heterogeneity even within the local population’s perceptions of a socially balanced energy transition.

5.2. Integrating citizens perspective into planning processes

The methodological approach used in our study proved to be well suited to identifying both the spatial obstacles and the spatial opportunities for an acceptable expansion of RE at the local level. It was possible to spatially concretise the subjective ideas about a balanced energy transition.

Nevertheless, it became clear that some of the interviewees lacked the necessary knowledge to provide meaningful planning decisions. The limitations do not stem from the tools provided, but from the people’s lack of

ability to evaluate complex geographical contexts. This was reflected in some of the interviewees' statements about the difficulties of mapping their spatial preferences, but also in the spatial contradictions that occasionally emerged between PM and the corresponding statements made in the interviews. This is due to the high complexity of spatial planning and therefore points to the importance of expert knowledge. Hence, we argue that preliminary research on local acceptance of RE should be considered as a complement to sophisticated technical and environmental analyses (Devine-Wright & Wiersma, 2020, p. 11). Lay knowledge should be given a permanent place alongside expert knowledge (Cadieux et al., 2013, p. 316). So far, the perceived discrepancy between expert and lay knowledge seems to have led primarily to a much greater emphasis on expert knowledge in planning processes (Aitken, 2009). As a result, actors with decision-making power may tend to ignore the results of PM (Brown & Kytä, 2018, p. 6). Approaches that aim to link the perceptions of the local population with expert knowledge appear to be much more sensitive to social contexts. In this way, a citizen expertise (Schöbel et al., 2022) could emerge, enabling the local population to make informed, legally compliant and meaningful planning decisions. However, the wide spatial distribution of suitable and unsuitable locations from the respondents' point of view reveals how far apart the subjective ideas of a spatially balanced energy transition are at the local level. Given the increasing polarisation of society (Hesse & Kühn, 2023a, p. 417) and growing populism (Reusswig et al., 2022), it is likely that planning conflicts will intensify in the future. The aim of energy planning should therefore not be to overcome conflicting ideas about land use (Müller et al., 2022, p. 15). Instead, the different perspectives should be integrated into the planning processes. This is problematic insofar as planning relies on a certain degree of consensus (Hesse & Kühn, 2023b, p. 432). However, in the context of RE planning, it is important to bear in mind that, due to the many competing interests, it is not always possible to use the optimal locations, but also those that are only conditionally acceptable. In this respect, our analyses provide a basis for discussion when balancing different spatial interests.

6. Conclusion

In view of the ambitious political promotion of the energy transition, the study makes an important contribution to the current debate on a socially balanced expansion of RE. The main interest of the study was to investigate the extent to which the RE planning guidelines address the local citizens' perception. The study sample indicates that the specifications of higher-level spatial planning and legislation for the expansion of RE are not so far away from the spatial ideas of the local population, as theoretical concepts assume. Rather, within the sample a high consistency between informal and formal planning concepts has been revealed. The interests of the local population are in many respects considered by the overarching planning requirements. This suggests that a lack of local acceptance concerning RE expansion is not generally due to highly divergent ideas about land use. Therefore, regarding the sample of Tettang, it can be argued that the formal guidelines are suitable for a spatially balanced development of RE. At the same time, however, it also became clear how far apart the individual ideas about siting can be, even within a small spatial sample. This suggests that spatial conflicts are always to be expected and therefore underlines the need to involve the local population at an early stage in the design of energy landscapes. Yet, it is not advisable to do this without expert knowledge, as the complexity of planning processes requires specialist expertise.

In this sense, the work shows that dialogue with local residents provides important information for locally adapted energy transitions. Citizens have already had the opportunity to comment on the expansion of RE. However, the existing formal participation processes have not been able to give local concerns sufficient influence. This is illustrated by the study's finding that some sites that were considered suitable by citizens were excluded from official planning. Therefore, more attention needs to be paid to establishing effective participation formats at the institutional level. It is essential to enable the population to make well-founded planning decisions that are considered in RE planning procedures. This is the only way to negotiate spatial conflicts, to counteract increasing populism and to find locally adapted solutions. In further studies it would be interesting to investigate the extent to which the issue of ownership of RE or suitable land influences local siting decisions and related conflicts. This would open up the possibility of delving more deeply into the power relations of the local energy transition.

Disclosure statement

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