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Evaluating municipal landscape plans and their influence on selected aspects of landscape development – An empirical study from Germany

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ABSTRACT

In this paper we examine the question of whether and how municipal landscape plans exert a positive influence on and/or correlate with selected aspects of the landscape. To this end, a representative sample of municipal landscape plans in Germany and a statistical-quantitative evaluation approach are used to uncover correlations between planning and landscape development. As a result, we can show that municipalities which draw up a landscape plan have a higher proportion of natural areas and a lower hemeroby index, i.e. a lower level of human influence. The model also reveals a significant relationship between the quality of the landscape plan as well as its duration of impact and the density of landscape structural elements. It is also determined that municipal landscape plans help protect grassland areas. The indicator-based method provides impulses for the international discussion on the evaluation of plans.

1. Introduction

Planners ordinarily assume that their plans will somehow be effective and have a positive impact on landscape development. Yet in only a few cases is there empirical evidence for such assumptions.

Bryson already (1991) sees "[a need for] empirical, large sample, quantitative support for the proposition that planning and planners make a positive difference in the world." In international discussions on the spatial sciences, critics have been highlighting for some years the lack of analyses and models of the effects of spatial planning instruments (see Laurian et al., 2010 on plans in general and Pedroli et al., 2006 on landscape policies). Until today the deficit highlighted by Bryson (1991) seems only to have been remedied to a limited extent. As Brody and Highfield commented in, 2005: "The lack of empirical studies measuring the efficacy of plans and degree of local plan implementation subsequent to adoption represents one of the greatest gaps in planning research." Further, the UN-Habitat II Report of 2009 confirms that the monitoring and evaluation of 'urban plans' are global trends which must be reflected by the planning sciences (UN-HABITAT, 2009). A study by Conrad et al. (2011, p. 2105) on the current state of research shows that European landscape scholars rarely address 'landscape policies' directly and thus also instruments for the implementation of landscape strategies such as landscape plans. Clearly, landscape ecological research should be more strongly linked to research on landscape policies, landscape ecological indicators and planning instruments (cf. Conrad et al., 2011, p. 2106). Regarding collaborative environmental planning in the USA, Mandarano (2008) writes: "In particular, several [researchers] claim there is a bias toward evaluating the process and its social outcomes, which has led to a gap in our knowledge of the impact of collaborative environmental planning and management on changing environmental conditions." And finally, Oliveira and Pinho (2010) and Grădinaru et al. (2017) as well as Hersperger et al. (2017) confirm the lack of a systematic research-based evaluation of spatial planning outcomes before going on to develop a framework for such an evaluation methodology.

1.1. Municipal landscape planning in Germany and beyond

The landscape plan, such as addressed by the European Landscape Convention Article 6 E (Council of Europe, 2000), is one of the most important nature conservation and landscape development instruments in Germany. The country's planning legislation demands the implementing of the general goals of the German Nature Conservation Law (§§ 1 & 2) as detailed spatial planning solutions by the relevant administrative bodies and with the help of municipal landscape plans (von Haaren, 2002; Federal Nature Conservation Agency, 2008; von Haaren et al., 2019). With regard to the Nature Conservation Law, landscape plans must be drawn up if a new urban or infrastructure

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development is being planned within a municipality. As this is the case in most German municipalities, landscape plans are mandatory. The majority of the federal states pursue an approach of setting up landscape plans first, which then have to be integrated into a municipal zoning and/or land use plan at a second stage. This is different to other countries which adopt a more voluntary approach to the creation of landscape plans or where these are directly integrated into strategic spatial plans. For example, the Czech Republic, Belgium, Finland, France, Italy, Poland, Sweden and the United Kingdom try to incorporate landscape issues into spatial strategic planning (see Hersperger et al., 2020). However, the European Landscape Convention forces the signatory countries and EU member states to set up more legally-binding landscape planning systems. In the US and China, landscape issues are also contextualized within local environmental plans and/or directly within municipal spatial and zoning plans (Wang et al., 2014). Currently, however, these two countries have no mandatory system for setting up landscape plans. In Germany there are four levels of such landscape planning: (A) the landscape programme for the entire area of a federal state (*Land*); (B) the landscape master plan for planning regions (covering several districts in a state); (C) the landscape plan at the municipal level; and (D) the open space structure plan for parts of a municipality. The information, objectives and detailed conservation or development measures formulated in the landscape plans must be integrated into the corresponding land use plans to become valid and to be implemented in practice.

This system, which was legally anchored in 1976, was part of a trend from simply preserving nature by designating certain areas as nature reserves towards a much more integrative approach involving landscape analysis and the design of comprehensive landscape development. The objective of municipal landscape plans is to enhance the state of natural features and landscapes beyond the boundaries of these nature reserves.

According to Müssner and Plachter (2002), landscape planning follows seven procedural steps:

1 Scoping and drawing up important guidelines,
2 Analysis and data sampling,
3 Analysis and data processing,
4 Nature conservation assessment,
5 Evaluation of conflicts and synergies,
6 Development of guiding models and visions for landscapes and environmental quality objectives,
7 Implementation measures.

Although this methodological standard is not legally mandated and is generally reflected by the federal states as informal guidelines, most of the landscape planning processes generally follow these seven steps. The steps of landscape planning also determine the quality of a plan. The more detailed the descriptions of these seven steps in a plan, the higher the plan quality (Kiemstedt et al., 1999). Within this planning process, and particularly in steps 2, 3 and 7, the focus is on both biotic and abiotic elements (Federal Nature Conservation Agency, 2008). Investigations are conducted on biotic elements, including the analysis of flora, fauna, biotope or habitat systems, and biodiversity. Certain landscape services (Termorshuizen and Opdam, 2009; Bastian et al., 2014) and/or ecosystem services (von Haaren and Albert, 2011; von Haaren et al., 2019) are addressed in landscape plans, such as biotic regulation and regeneration services (particularly habitat value with regard to biodiversity, species and habitats), groundwater recharge, yield and decontamination services, the resistance of soil to water and wind erosion (the productive and regenerative services of soil), air quality and microclimatic balancing services as well as recreation services including the aesthetic value of landscapes. Recreation and aesthetic values also contribute to human health issues (Heiland et al., 2019). Thus, landscape planning follows a systematic and strategic approach.

Within the meaning of §§ 1 & 2 of the *Bundesnaturschutzgesetz* (Federal Nature Conservation Act), landscape planning has the social obligation to steer landscape change towards more 'sustainable' forms of land use. Hitherto, however, there has been little research into the extent to which this requirement is met (Gruehn and Kenneweg, 1998; also Wende et al., 2009 and Wende et al., 2012).

Beyond the administrative and legal framework of planning, landscape planning should also be understood as a planning *process* in which the various actors communicate with one another and negotiate future land uses. These can be actors from the local administration, for example nature conservation agencies, who are responsible for drawing up the landscape plan and who communicate with local or regional stakeholders such as land owners, farmers, environmental and nature conservation groups as well as citizens in order to further develop the plans with these actors. As landscape governance and landscape communication are regarded as key to the success of planning, Krätzing et al. (2019) identify (also technical) tools with which this exchange can be improved in the planning process. In the future, interactive landscape plans and electronic governance will play a special role, enabling communication between stakeholders, citizens and the administration to take place in a two-way exchange via the Internet or even through social media (Krätzing et al., 2019). However, it is important that such electronic media only be used as a supplement: The Internet or social media should certainly not replace personal hearings with citizens.

Individual key actors play a special role in the implementation of measures within the landscape plan to protect, maintain and develop landscapes and the natural environment. Some initial empirical studies (albeit of a very small sample of plans) already indicate that more measures for the protection, maintenance and development of landscapes and the natural environment are realized particularly in those municipalities where there are prominent and intrinsically motivated individuals who feel responsible for the implementation of the landscape plan, (Wende et al., 2012, masked for blind review). This factor is doubtless one of the most important of the possible influencing factors. At the same time, it seems to be irrelevant which specific actor this is, whether the mayor, an active person from local nature conservation associations, someone from the administration or an individual citizen without a landscape-related professional background. For the successful implementation of measures specified by landscape plans, it is only necessary that *somebody* assumes the role of key actor. While this point opens up questions regarding the 'performance' of landscape planning (see below), this particular issue could not be investigated at depth in the study presented here as the research funding was granted with the aim of clarifying the question of plan conformance, i.e. the influence of the plan product as such on the landscape (the results of which are presented in this article). It is intended to conduct a further empirical study to look precisely at the extent to which actors involved in the planning process of a landscape plan exert influence on landscape development. Due to the limited budget, the authors were at present only able to examine the impact of the plan itself, while remaining fully aware that the planning process with its actors and influences is equally important.

Our study makes use of landscape indicators to analyse the actual impact of landscape plans (not the landscape planning process as mentioned above) on the status of the landscape and on landscape development. In contrast to other studies, we have tried to compare the physical changes which landscapes undergo as they are developed *with* or *without* a landscape plan. In this way, municipal landscape planning is subject to close investigation as part of our evaluation project, which has been funded by the *Deutsche Forschungsgemeinschaft* (German Research Foundation) (WE 3057/3-1 and WA 2131/2-1). The central research question is: What influence does the municipal landscape plan have on the actual features of the landscape and its structure? This is also our guiding research question for this manuscript. Our aim has been to develop a generally transferable indicator-based method to evaluate nationwide plans, specifically by examining how landscape plans influence various aspects of the landscape.

1.2. Methods

Talen (1996) and similarly UN-HABITAT (Part IV 2009, 172) divide research on the evaluation of spatial plans into four categories:

- evaluation prior to plan implementation (e.g. analysis of planning documentation),
- the evaluation of planning practice (e.g. studies on the planning behaviour of actors involved in the planning process),
- evaluation/analysis of strategy or policy implementation,
- evaluation of the plan implementation (non-quantitative/quantitative).

Here we can discern two research strands: First, analysis that considers the influence of the planning product, i.e. the contents of the plan itself. This is termed ‘conformance’-based evaluation, which means judging the success or failure of a plan and/or planning using only a few criteria, and measuring the degree of conformance between plan objectives and the final outcomes on the ground (Oliveira and Pinho, 2010; Shen et al., 2019). The second strand comprises an analysis of the influence of the planning process, such as the activation of actors. When evaluating the planning process and the interaction of actors, Faludi (2000); Mastop and Faludi (1997); Oliveira and Pinho (2010) as well as Mueller and Hersperger (2014) talk about assessing the ‘performance’ of plans (see also Fitzsimons et al., 2012).

A further categorisation of evaluation approaches can be made with regard to the timing of the evaluation (see Oliveira and Pinho, 2010). Ex-ante evaluations must be carried out at the very beginning of the planning process and serve to develop alternative pathways in the planning process. Ongoing evaluations are integrated into the planning process itself as well as the early implementation phase. Ex-post evaluations are more likely to be conducted during the final phase of plan implementation to assess the impact of the plan.

We can also distinguish between qualitative and quantitative evaluations. The former generally focus on individual case studies (e.g. Fürst et al., 2010). Yet to achieve a full and representative view of plan and planning success, a statistical-based quantitative approach is essential. Specifically, Talen (1996 and 1997) as well as Oliveira and Pinho (2010) see a need for action and quantitative research in regard to this evaluation category named above.

Against the background, our evaluation method presented below can be described as a conformance-based, ex-post-oriented and quantitative approach to planning. What makes this method particularly interesting, however, is the fact that it uses high-resolution geodata and landscape data and indicators for an entire country to measure planning success. Using these indicators, it is possible for the first time to compare the planning success of municipal plans at the national level.

As a first step, a representative sample of 600 German municipalities was randomly selected and the status of their municipal landscape planning determined, namely whether or not a landscape plan exists (see Fig. 1). The landscape plan directory of the Federal Agency for Nature Conservation (https://www.bfn.de/themen/planung/landschaftsplanung/aktivitaeten/landschaftsplan-verzeichnis.html) was scrutinized to determine the existence of a landscape plan as well as all available directories of the federal states and regions. This data was supplemented and validated by an online survey of the selected municipalities. In addition, all municipalities for which no landscape plan could be located were contacted by telephone in order to confirm this finding. Here the aim was to generate the most accurate and up-to-date picture possible of the present state of landscape planning. Fig. 1 shows the locations of the randomly selected municipalities along with an indication of whether a municipal landscape plan exists or not for the analysis year 2013. The sample of 600 municipalities constitutes 5 % of all German municipalities, representing about 5 % of the national territory. Additionally, the age of the plans was investigated (see Fig. 2 for an overview: note the peak years 1997 and 1998, in which 33 landscape plans were established, respectively).

1.3. Indicators

To assess various aspects of the effectiveness of landscape planning, landscape indicators were selected on the basis of nationally available geodata. To conduct a nationwide analysis, the underlying data must be collected using identical methods and according to the same criteria. To this end, we made use of data provided by public land survey agencies, which collect data according to uniform and documented standards in all federal states.

The most important data was land use as specified by the official topographic information system (ATKIS) and the land cover model of Germany (LBM-DE) of the country’s surveying authorities. These data sources are utilized by the IOER monitor (www.ioer-monitor.de/en) to offer freely available statistical evaluations of Germany’s administrative units. For the calculation of indicators, see the sections below and additionally Wende and Walz (2017) as well as Stein (2018). Furthermore, own indicators were calculated using this base data (e.g. to measure the attractiveness of the landscape; see below).

Data for Germany’s official Topographical-Cartographic Information System (ATKIS Basis-DLM) is collected and updated by the Federal Agency for Cartography and Geodesy (2016). All areas are updated at least every five years while individual object types such as traffic routes are subject to a peak update of less than one year. By providing nationwide data on a regular basis, with updating secured by government order, clearly ATKIS Basis-DLM is currently the most suitable information system on land use in Germany.

The Digital Land Cover Model for Germany (LBM-DE) offers a vector dataset according to the uniform European CORINE nomenclature (Federal Agency for Cartography and Geodesy, 2018). In particular, the LBM-DE supplies up-to-date information on open space, since additional sources of information such as digital orthophotos or satellite imagery are exploited.

Furthermore, we used the digital elevation model with a cell width of 10 m (DGM10), prepared by the Federal Agency for Cartography and Geodesy.

The selection of indicators reflected the goals of nature conservation specified in § 9 Para 3 No. 4 of the *Bundesnaturschutzgesetz* as well as the wider nature conservation discussion in Germany, which is currently oriented towards the preservation and development of attractive landscapes (Hermes et al., 2018). This wider discussion on nature conservation also focuses on avoiding measures that reduce the level of hemeroby (Kowarik, 2006), on the preservation and development of green infrastructure as landscape structure elements (Albert and von Haaren, 2017), on the avoidance and reduction of land consumption for settlement and transportation infrastructure (Kretschmer et al., 2015) as well as the preservation of grassland (Conrad and Tischew, 2011). The selected landscape indicators (See Table 1; cf. Hersperger et al., 2017 on the necessity of such indicators for evaluation purposes) were used to determine the likely impact of municipal landscape planning on land use, landscape status and structure as well as changes to these in an initial time series. This was done to determine the state for 2010. In addition, data from the IOER monitor for the time periods 2000, 2006 and 2014 was considered to illustrate the most recent trends in land use. Retrospective data allowed us to investigate trends in land use for several indicators, such as ‘Density of forest margins, tree rows, hedges and coppices‘, ‘Ratio of settlement and transport area to municipal area’, ‘Ratio of built-up settlement area to municipal area’, ‘Ratio of grassland to agricultural land’ and others. The aim was also to investigate the temporal impact of municipal landscape planning on landscape change. All indicators were calculated for the area of every municipality in Germany.

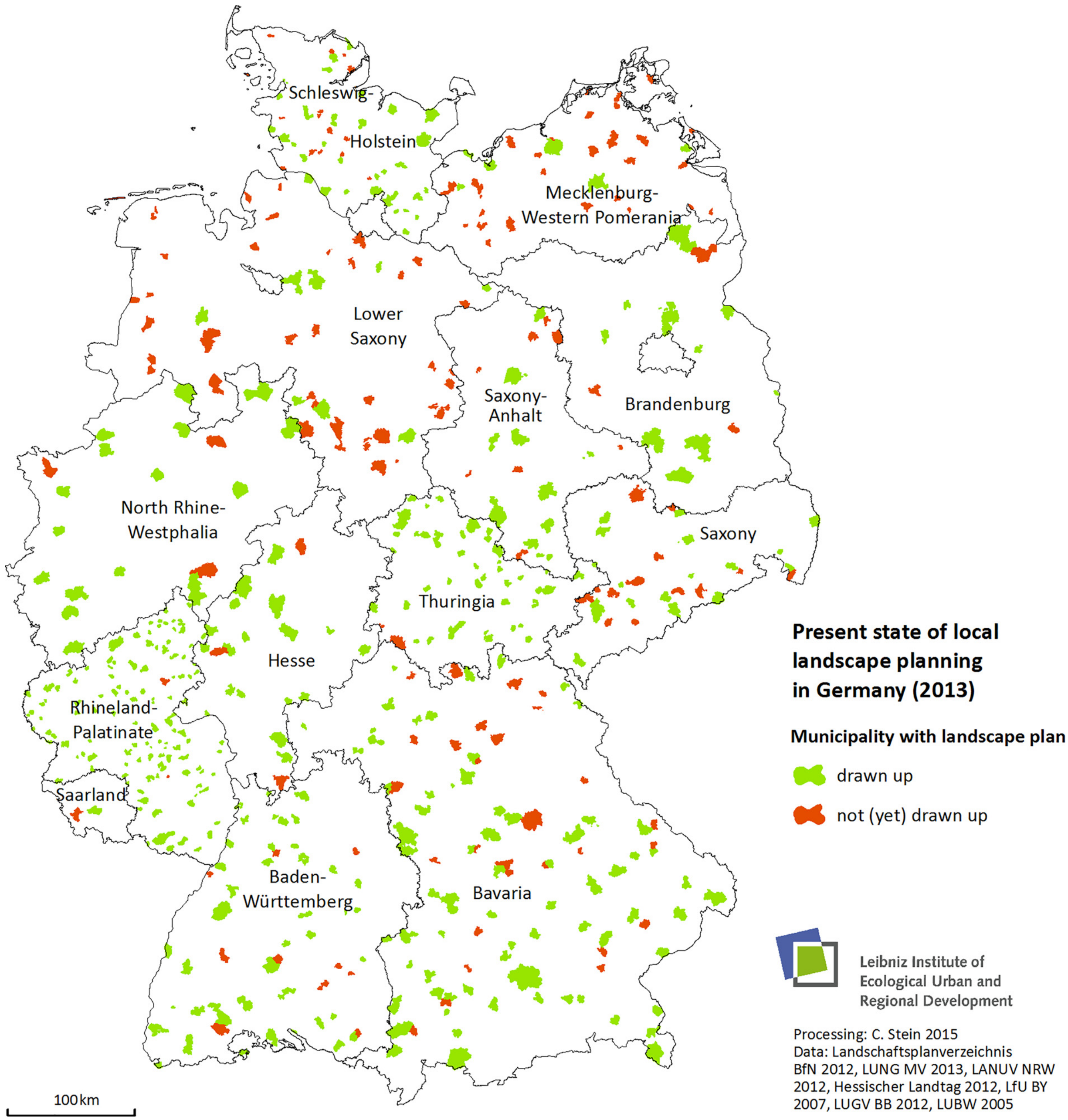

Fig. 1. State of municipal landscape planning in August 2013 with locations of the representative sample of individual municipalities (N = 600).

The indicator (1) *hemeroby* describes the degree of cultural influence of humans on a target area (Sukopp, 1972; Kowarik, 2006; Walz and Stein, 2014). On the basis of the Digital Land Cover Model (LBM-DE) and the ATKIS Basis-DLM, hemeroby levels were assigned to the individual land use categories (see Walz and Stein, 2014) ranging from 1 (ahemerobic, almost no human impacts) to 7 (metahemerobic, – excessively strong human impacts, biocoenosis destroyed). Additional information on potential natural vegetation was used to help determine whether forests and vegetation-free areas are appropriate to the location. For each municipality, we subsequently calculated the area-weighted mean value of the degrees of hemeroby. This index is particularly interesting because it shows the cumulative state of the landscape while taking into consideration other changes in land use. If, in addition to growing settlement and transport areas, there are changes in agricultural usage, for example due to the conversion of meadows into arable land, both of these factors are reflected in the indicator. For the purposes of nature conservation, however, nature-accentuated areas with a degree of hemeroby of 1–3 (ahemerobic to mesohemerobic) are of special interest, because these are subject to little or infrequent human intervention. Such areas include site-specific and non-native forests, woodlands and hedgerows, marshes and swamps. We calculated the proportion of these nature-accentuated areas to the reference area as a second indicator.

The extent of forest margins, hedgerows, tree rows, hedges and coppices mapped in the ATKIS Basis-DLM was used to calculate the indicator (2) *density of forest margins, tree rows, hedges and coppices* (expressed as length of the elements in km per area of municipality in km^2). Linear landscape structure elements, in particular, contribute to a diverse and structured landscape. This results in an attractive landscape for humans and provides important habitats for birds, mammals and insects.

The indicator (3) *ratio of settlement and transport area to municipal area* describes the proportion of settlement and transport space in a municipal area. It correlates positively with the degree of sealing and

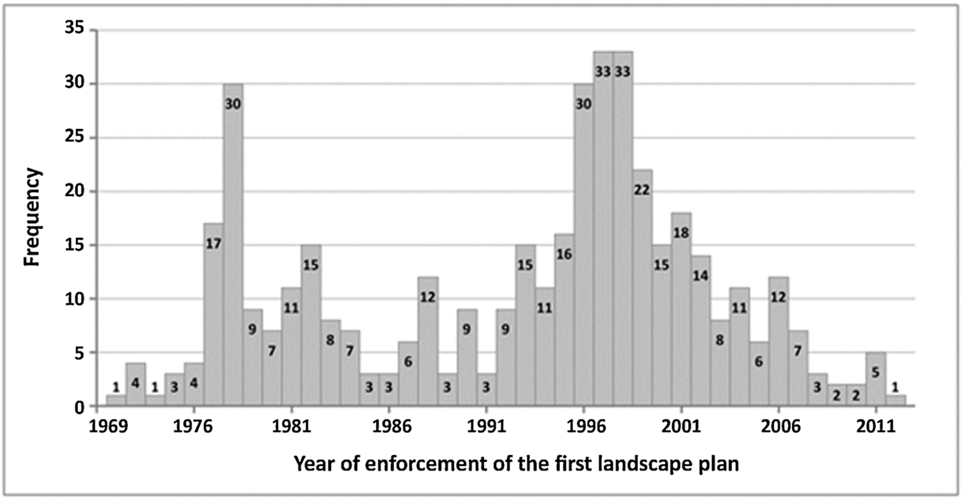

Fig. 2. Number of landscape plans newly created by the sampled municipalities in the years 1969-2011 (n = 429).

negatively with the proportion of open space.

The indicator (4) *ratio of built-up settlement area to municipal area* describes the proportion of residential, mixed use and special functional areas as well as industrial and commercial areas in a municipality.

The indicator (5) *ratio of grassland to agricultural land* describes the proportion of mown or grazed grassland as well as patches of grass in the agricultural area of a municipality. The higher the proportion, the less intensive the agricultural usage, since the soil is permanently covered and is not broken up by ploughing or similar activities. This means that soil erosion, for example, is lower.

Calculation of the indicator (6) *attractiveness of the landscape* is based on an approach which correlates attractiveness with the existence of natural features (see Fig. 3 and Walz and Stein, 2018). The perceived attractiveness of a landscape increases in line with its diversity, a high proportion of near-natural areas and a low level/number of disturbances (e.g. traffic noise) (see Roth et al., 2018 and Hermes et al., 2018). Therefore, the indicator combines sub-parameters on topographic diversity (6a), the proportion of open space (6b), the hemeroby index (6c; see indicator (1) above), the densities of forest margins, tree rows, hedges, coppices (6d; see indicator (2) above) and water margins (6e) as well as coastlines (6f) and the proportion of unfragmented open spaces > 50 km^2 (6 g). All seven sub-parameters of landscape attractiveness were initially calculated on the basis of a 5-km grid (standardized in accordance with INSPIRE) and then normalized between 0 and 1 to ensure an equal weighting (unity-based normalization: $X = \frac{X - Xmin}{Xmax - Xmin}$). For every grid cell, all values of the sub-parameters were summed to give an overall value and subsequently the mean value of all affected grid cells was taken for each municipality.

For the sub-parameter *topographic diversity* (6a) of this indicator, we calculated the ratio of the 2D-area and the 3D-area of the true surface based on a national digital elevation model (cell width 10 m), as this not only reflects the maximum altitude difference (relief energy) but also the cumulative altitude differences. Of course, this parameter cannot be influenced by the landscape plan. However, this indicator was developed for the purpose of measuring landscape attractiveness in general, and not particularly for the evaluation of local landscape plans. Although landscape planning cannot influence the topographic diversity, it is still an important factor for the overall measurement of landscape attractiveness in Germany, and thus should be reflected in this indicator.

The *density of water margins* (6d) was calculated by summing the length of water courses and the shore length of lakes. This parameter reflects the density (km/km^2) of all riparian areas. As coasts are an important factor for attractiveness and recreation, we included the indicator *presence of coasts* (6e) as “1” (coastal parts present) or “0” (no coastal parts present). The *proportion of unfragmented open space > 50 km^2* (6f) within a municipality considers the degree of fragmentation caused by the transport network (value range: 0–100). High fragmentation also implies high levels of noise and technical barriers that disrupt the landscape and pose obstacles to nature-related recreation (e.g. hiking).

1.4. Hypotheses

Corresponding hypotheses were drawn up as part of the investigation in order to answer the main research question: “How does the

Table 1
Tasks of landscape planning and associated selected features and indicators. Source: Stein, 2018.

Tasks of landscape planning according to Germany’s Federal Nature Conservation Law §§ 1 and 2	Landscape Feature	Selected Indicators
Avoidance, reduction or removal of impairments to nature and landscapes	Hemeroby	(1) Hemeroby index (measuring the degree of human influence on a particular site, in 7 levels)
Preservation and development of diversity, the unique qualities as well as the beauty of nature and landscapes	Structural diversity of landscapes	(2) Density of forest margins, tree rows, hedges and coppices (extent of hedges and coppices in km per km^2)
Avoidance, reduction or removal of impairments to nature and landscapes	Settlement and transport areas	(3) Ratio of settlement and transport area to municipal area (km^2/km^2) (4) Ratio of built-up settlement area to municipal area (km^2/km^2)
Avoidance, reduction or removal of impairments to nature and landscapes	Agricultural land use	(5) Ratio of grassland to agricultural land (ratio of grassland to the total agricultural area within a municipality; km^2/km^2)
Preservation and development of diversity, the unique qualities as well as the beauty of nature and landscapes	Beauty	(6) Attractiveness of the landscape (measured by the topographic diversity, the ratio of open space, the hemeroby index, forest ecotones, the density of water-body/course boundaries as well as the presence of coasts and the ratio of unfragmented open spaces > 50 km^2); values between 0 and 1

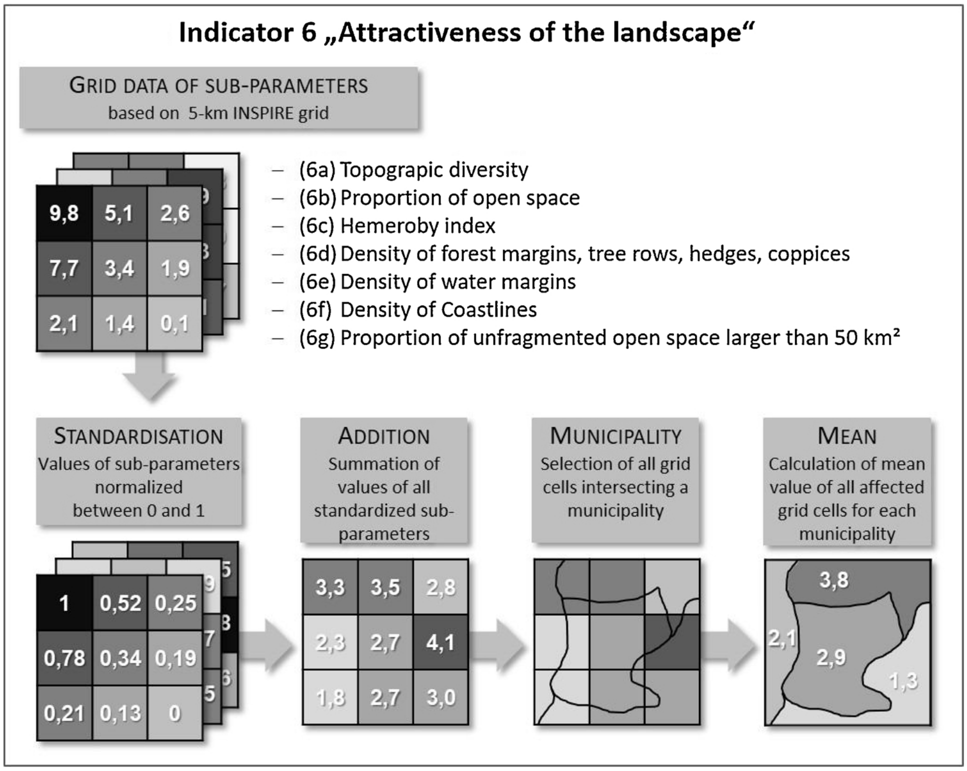

Fig. 3. Steps to calculate landscape attractiveness (source adapted from Walz and Stein, 2018).

municipal landscape plan influence specific features of the landscape and its structure?” (cf. also Stein, 2018, 14ff and Walz and Stein, 2017, Wende and Walz, 2017):

- We investigated whether a municipality with a landscape plan subsequently has a higher proportion of natural areas in the municipal area than one with no landscape plan (i.e. hemeroby, reflected by indicator (1)).
- We analysed the quality of a landscape plan and its influence on the density of forest margins, tree rows, hedges and coppices in the municipality (reflected by indicator (2)).
- We examined the duration of impact of a landscape plan and its correlation with the density of forest margins, tree rows, hedges and coppices in the municipality (reflected by indicator (2)).
- We considered whether a municipality with a landscape plan subsequently has a lower rate of land consumption (ratio of settlement and transport area as well as ratio of built up area over time; reflected by indicators (3) and (4)).
- We investigated whether a municipality with a landscape plan subsequently has a higher proportion of grassland in the agricultural area than a municipality with no landscape plan (reflected by indicator (5)).
- We analysed the quality of a landscape plan and its influence on the landscape attractiveness (reflected by indicator (6)).

These aspects were operationalized using information from the landscape plans as well as the selected indicators 1 – 6. The quality of a landscape plan was evaluated with the help of a checklist developed by the German Federal Agency for Nature Conservation (Kiemstedt et al., 1999), which, for example, collects information on how comprehensively and precisely a landscape plan describes and assesses the abiotic and biotic protected resources of soil, water, air, plants and animals (named in an inventory of natural resources) or examines whether proposals for measures to protect and develop the landscape are sufficiently developed. This checklist to analyze and assess the quality of landscape plans has been carefully developed and tested by state authorities and officially legitimized by the Federal Agency for Nature Conservation as a suitable checklist for evaluation purposes. Therefore, we do not intend here to provide any further explanation of this comprehensive quality checklist as a more detailed discussion would considerably expand the scope of the current article. However, Table 2 provides an excerpt from this quality checklist (Kiemstedt et al., 1999),

Table 2
Excerpt from the checklist to determine the quality of landscape plans of the Federal Agency for Nature Conservation (translated after Kiemstedt et al., 1999, p. 119).

Contents	is present			Remarks
	in full	in part	missing	
2.2 Protected resource: species and biocoenoses - identification and evaluation -		x		Biotopes not addressed.
	yes		no	
2.2.1. Protected areas and objects (e.g. nature reserves, landscape reserves, protected landscape elements, § 20c Federal Nature Conservation Act habitats)	x			
2.2.2. Biotopes and biotope complexes, presentation of vegetation and flora			x	
2.2.3. Selected wildlife species and groups	x			
2.2.4. Endangered plants and animals	x			
…	…		…	

thereby giving some idea of the basic procedure for determining the quality of a plan. Such plan quality also refers to the seven planning steps illustrated in Section 1.1. The more detailed the descriptions of these seven steps, the higher the plan quality. See also Berke and Godschalk (2009) for a discussion of ways to measure the quality of plans.

Hypothesis tests were carried out by means of bivariate and multivariate statistical methods depending on the scale of the variables.

2. Results

2.1. Which municipalities are most likely to draw up a landscape plan?

Of the 600 municipalities in our sample, 435 (72.5 %) had already drawn up a landscape plan (see Fig. 1). Preliminary investigations of the sample showed that the federal state (*Land*) in which a municipality is located has the strongest influence on the existence of a landscape plan due to legal anchoring or because of funding possibilities. Hence, whether or not a landscape plan exists depends first and foremost on the federal state. It is interesting to note that there are hardly any differences between east and west, i.e. between the old and the new federal states of Germany. In an additional finding, farming municipalities with lower population density and located in the periphery tend to draw up a landscape plan less frequently than more densely populated, centrally located, urban municipalities (see Fig. 4 and Stein et al., 2014). These findings on factors favouring landscape planning are all statistically significant. However, this does not necessarily mean that the level of landscape transformation will automatically be lower in small cities than in large cities, regardless of plan provisions.

Our results regarding landscape transformation as such (without considering the existence or non-existence of a landscape plan) do not show significant correlations with the size of the municipalities (very small villages, small towns, medium and large cities operationalized in km^2 per municipality). The following landscape transformation indicators show no significant correlation with the size of the municipalities:

- Ratio of agricultural land to municipal area (from year 2000 – 2014 in.% of 2000; $n = 593$, $p = 0.132$, $r = 0.062$ Pearson),
- ratio of arable land use area to municipal area (2000 – 2014; $n = 589$, $p = 0.486$, $r = -0.029$ Pearson),
- ratio of grassland to agricultural land (2000 – 2014; $n = 600$, $p = 0.286$, $r = -0.044$ Pearson),
- ratio of grassland to municipal area (2000 – 2014; $n = 592$, $p = 0.320$, $r = -0.041$ Pearson),
- ratio of woodland to municipal area (2000 – 2014; $n = 591$, $p = 0.148$, $r = -0.060$ Pearson),

Table 3
Indicators showing trends in landscape development for municipalities with and without landscape plans.

Development in 2000 – 2014 (%)	r_{bis}
Ratio of open space to municipal area	−0.099*
Ratio of agricultural land to municipal area	−0.112**
Ratio of arable land use area to municipal area	−0.195***
Ratio of grassland to agricultural land	0.132**
Ratio of grassland to municipal area	0.189***
Ratio of woodland to municipal area	0.017
Ratio of water area to municipal area	−0.065
Ratio of urban green space to settlement area	0.007
Ratio of settlement and transport area to municipal area	0.113**
Ratio of built-up settlement area to municipal area	0.158***

N = 600.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

- ratio of water area to municipal area (2000 – 2014; $n = 593$, $p = 0.806$, $r = 0.010$ Pearson),
- ratio of urban green space to settlement area (2000 – 2014; $n = 535$, $p = 0.973$, $r = 0.001$, Pearson),
- ratio of settlement and transport area to municipal area (2000 – 2014; $n = 593$, $p = 0.612$, $r = -0.021$ Pearson),
- ratio of built-up settlement area to municipal area (2000 – 2014; $n = 593$, $p = 0.154$, $r = -0.059$ Pearson).

If we now find such differences in landscape transformation depending on the landscape plan in the following, these results are then more clearly attributable to the existence of a landscape plan and not to the size of the municipality (see Table 3).

The only aspect of landscape transformation that correlates significantly with the size of the municipality is the ratio of open space to municipal area (2000 – 2014; $n = 593$, $p < 0.05$, $r = -0.102$*). However, the correlation is only low. The proportion of open space to municipal area has therefore decreased more in larger municipalities over the years than in smaller municipalities (and this irrespective of whether a landscape plan existed or not).

2.2. Landscape indicators

We obtained values for all of the above-named indicators for each municipality in Germany. Using the presented statistical methods, the indicator values enabled us to derive correlations between the existence of a landscape plan and selected landscape aspects.

Fig. 5 provides an example of the nationwide indicator 'density of

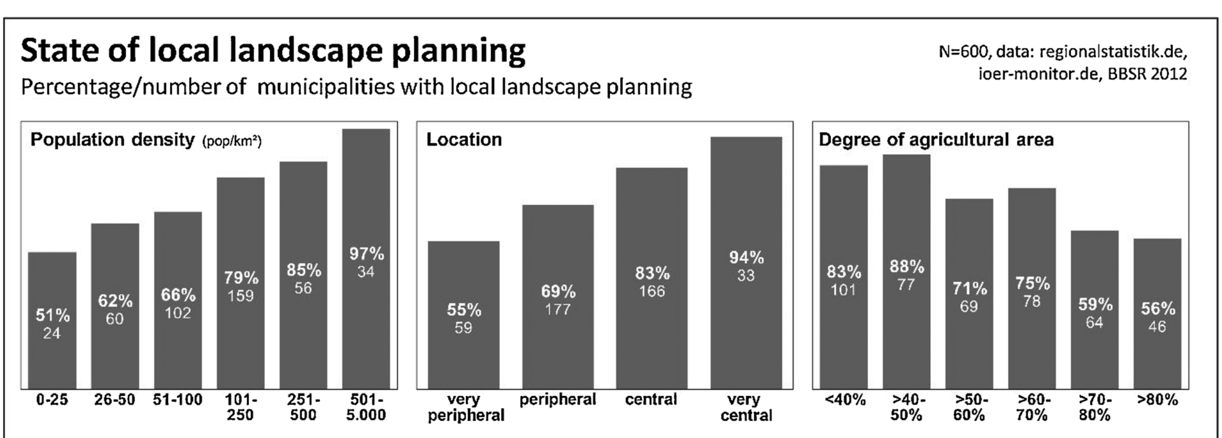

Fig. 4. Present state of municipal landscape planning according to municipal characteristics.

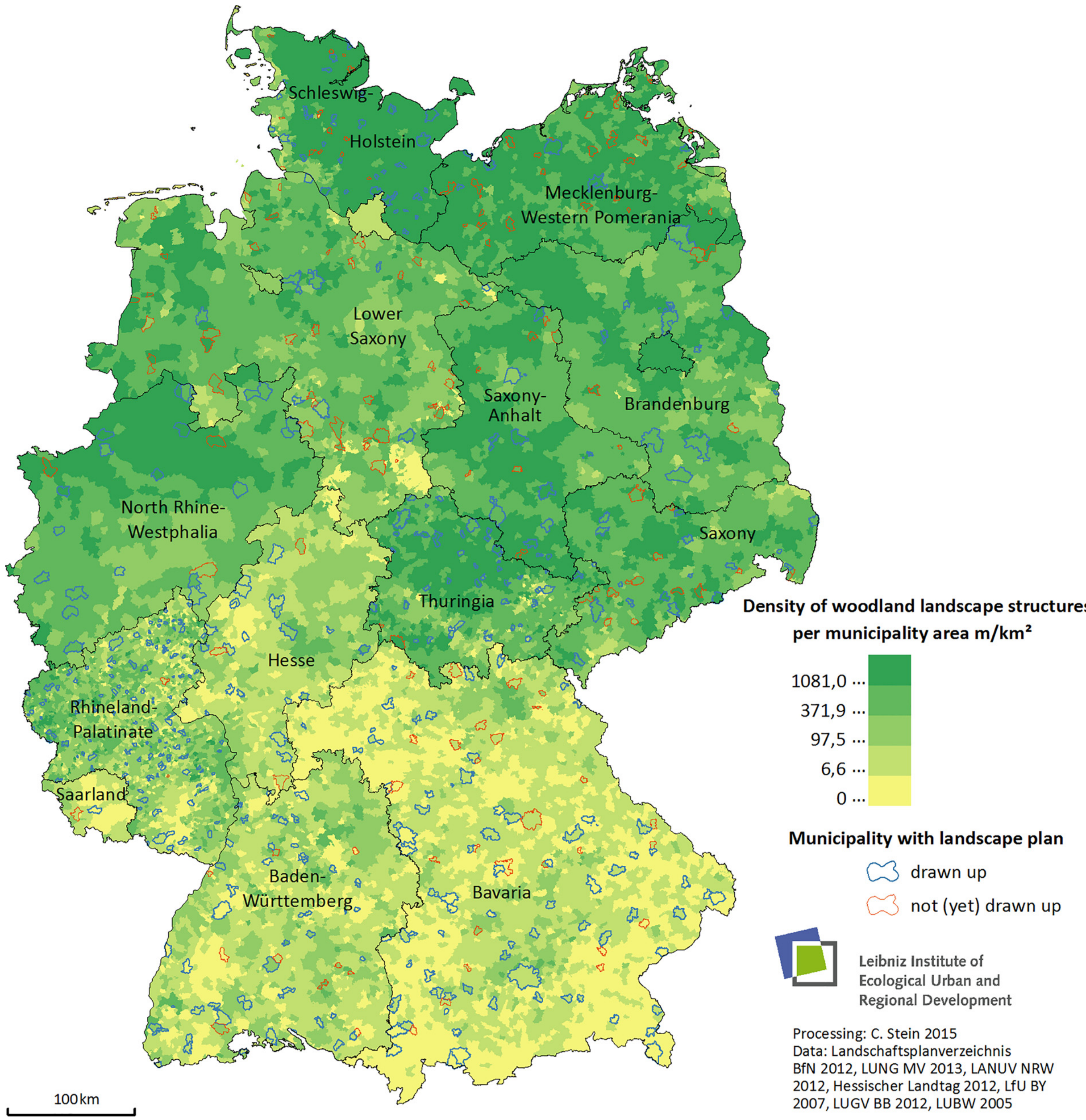

Fig. 5. Density of woodland landscape structures (hedges, coppices) in Germany (m/km^2).

forest margins, tree rows, hedges and coppices' (i.e. woodland landscape structures) to operationalize one aspect of the landscape structure diversity. While not all of the indicators mentioned above can be cartographically represented here, the map shows how such indicators may be spatially and cartographically visualized. Such mapping is a prerequisite for the use of indicators in evaluating a landscape plan.

2.3. Influence of landscape planning on selected landscape aspects

In the following we present selected analytical results of the hypothesis tests between landscape aspects and the presence / absence of a landscape plan. The main findings of our statistical analyses are:

- The **influence of landscape planning on hemeroby (or naturalness)** can be shown by the identified correlation with the indicator *ratio of nature-accentuated areas* (low hemeroby of degree 1–3). In individual municipalities or *Kreisen* (districts made up of several municipalities) with a landscape plan, the value is significantly higher (32.77 %) than in those without a landscape plan (25.91 %) using a biserial correlation testing method ($r_{pbis} = 0.148$; $p < 0.001$; $N = 594$).
- The **influence of landscape planning on landscape structure** is confirmed by the correlation of the indicator *density of forest margins, tree rows, hedges and coppices* with the quality of certain sections of a municipal landscape plan (in particular the quality of those dealing with the formulation and implementation of measures). Here it can be shown that the higher the quality of a landscape plan, the higher the density of such natural features as forest margins, tree rows, hedges and coppices (Spearman-Rho, $N = 56$; $p < 0.01$; $r = 0.406^{**}$). The correlation is of medium strength. The causal direction of the hypothesis seems to be more clearly identifiable, as the following hypothesis could also be confirmed: The longer the period in which a landscape plan has been in force (up to the year 2013), the higher the density of landscape structural elements ($N = 492$; $p < 0.01$; $r = 0.220^{**}$).
- We also found **an influence of landscape planning on steering**

the land consumption and on the proportion of grassland. Preliminary investigations with time series data show that municipal landscape planning does in fact have a steering effect on the structural development of a municipality or *Kreis* (county). A time series study conducted as part of our research underlines the role of the landscape plan as a factor for the successful management of landscape change. Over the period 2000 − 2014, the proportion of grassland within total agricultural land increased by 0.55 % for municipalities with a landscape plan. In municipalities without a landscape plan, the proportion of grassland decreased by 1.73 % over the same period (n with LP = 149; n without LP = 165; $p < 0.0049$*** using a Mann & Whitney U-test).
- The **quality and level of detail of a municipal landscape plan** is significantly correlated with the indicator *attractiveness of the landscape* (although only a low correlation of Spearman-Rho = 0.282; N = 56; $p < 0.05$).

Table 3 above shows all the indicators used to assess landscape development in the period 2000–2014. The analysis considers and distinguishes between municipalities *with* and *without* a landscape plan.

While the ratio of open space to municipal area in municipalities with landscape plans decreases significantly between 2000 and 2014, the correlation is extremely small ($r_{bis} = -0.099$*). However, this may also be primarily related to the size of the municipality (see Section 2.1 above). Similarly, the ratio of agricultural land in the municipalities with landscape plans shows a very significant drop; here too there is low correlation with the existence of a landscape plan ($r_{bis} = -0.112$**). The ratio of grassland to agricultural land as well as to total municipal area increases highly significantly or with the highest significance in municipalities with landscape plans (with low correlations: $r_{bis} = 0.132$ ** or $r_{bis} = 0.189$ ***).

There is no correlation between the development of the ratio of woodland, water area and urban green space with the existence of a landscape plan in a municipality.

At the same time, we note that the existence of a landscape plan has no influence on land consumption; municipalities with a landscape plan even show an increasing ratio of settlement and transport area to municipal area ($r_{bis} = 0.113$ **) together with an increasing ratio of built-up settlement area to municipal area ($r_{bis} = 0.158$***). Regardless of whether a landscape plan has been drawn up, total land consumption for settlement and transport development increases over time.

3. Discussion

An initial finding is that sparsely populated, peripherally located and largely agricultural municipalities tend to draw up a landscape plan less frequently than urban municipalities. In such rural municipalities, however, the type and form of agricultural activity greatly determine the sustainability of municipal development. This, in turn, can be positively influenced by municipal landscape planning (von Haaren et al., 2019), which is, however, rather lacking in these municipalities. On the other hand, our findings show that even after 40 years of formal landscape planning under the *Bundesnaturschutzgesetz* (Federal Nature Conservation Act), the principle of nationwide planning that covers every single municipality and *Kreis* (county) in the country has not yet been achieved. Specifically, around 25 % of Germany's municipalities have not yet drawn up a landscape plan (see also Pinto-Correia and Kristensen, 2013). Yet our study findings show that the steering of municipal urban development towards a more sustainable direction, for example by protecting grassland or preserving a higher proportion of natural areas, largely depends on the existence of a landscape plan. Currently, landscape plans are primarily set up in urban contexts. This is due to the Federal Nature Conservation Law, which requires a mandatory landscape plan only in cases of urban expansion. From this we can infer that urban expansion is somehow driving nature conservation and landscape development, an interesting paradox that should be further analysed and assessed. The question remains, however, whether this is actually an intended effect. If not, then all municipalities should be required by law to draw up landscape plans, regardless of whether they are urban settlements undergoing expansion or rural municipalities that are neither expanding nor experiencing settlement development. Further, the results indicate that modern agriculture, with its monotonous and highly intensive land use, is detrimental to the development of sustainable landscapes; and yet the absence of urban growth (but not landscape transformation) in these more agricultural-based municipalities is in fact an obstacle to setting up landscape plans, which might otherwise counteract the effects of intensive agricultural land use. If the future aim is to promote the creation of municipal landscape plans in order to achieve nationwide planning in Germany, special emphasis should be placed on rural municipalities located in peripheral locations.

In municipalities with landscape plans, the proportion of natural areas is higher (low hemeroby) than in municipalities without landscape plans. However, a reversal of the hypothesis cannot be ruled out: In municipalities with a higher proportion of natural areas (low hemeroby), a landscape plan may also have been drawn up precisely in order to preserve the landscape diversity (e.g. in popular holiday regions or health resorts).

The quality of the municipal landscape plan and the length of time it has been in effect are two key factors positively influencing the density of forest margins, tree rows, hedges and coppices in the municipality. It is interesting to note that the quality of the plan depends less on the section dealing with the current state of the landscape and its evaluation than – as suspected by the authors – the sections that consider in detail the development and possible implementation of measures to positively transform the landscape. In addition, the density of forest margins, tree rows, hedges and coppices is seen to increase over the implementation period of a landscape plan. There is much to suggest that this increase is due to the creation of a landscape plan, its quality and ultimately its duration, rather than vice versa. Here it was possible to demonstrate a medium-strength correlation.

In regard to land consumption and the development of the proportion of grassland in the municipalities, we can state the following: Although the landscape plan cannot prevent overall land consumption, it can serve the aim of nature conservation by ensuring that less significant (non-grassland) areas are selected for settlement development rather than grassland areas, which are better protected. This positive effect can be attributed to the landscape plan if we remember that the two sample populations (with and without landscape plan) were selected at random. Under such random sampling, all other conceivable influencing factors on the proportion of grassland have a relatively equal impact in both subsamples. Even the size of the municipality (in km^2) is not influencing here. The sole relevant factor is the existence of a landscape plan, regardless of whether the plan quality has been addressed or analysed. Clearly, the existence of a landscape plan can ensure that grassland is better protected against land consumption.

Additional analytical results reveal relationships between the quality of municipal landscape planning and the attractiveness of municipal landscapes, namely: the higher the quality of a landscape plan, the higher the landscape attractiveness. Here, however, the causal direction of our hypothesis remains unclear for the time being. It may be the case that the landscape plan actually contributes to the development of a more attractive landscape; alternatively, municipalities with many attractive landscape features may attach greater importance to a high-quality guiding model and development concept in the landscape plan. While the determination of cause and effect is unclear, this finding is interesting and should be examined in more detail in further empirical research. Yet uncertainty about the causal direction of this one indicator 'landscape attractiveness' does not mean that municipalities with a landscape plan have no sustainable landscape development. Other indicators which, in particular, refer to landscape structural and grassland indicators show the clear impact of a municipal landscape plan in terms of sustainable development (see the previous results).

The fact that between the years 2000 and 2014, the ratio of open space and the ratio of agricultural land to municipal area is seen to decrease in those municipalities with a landscape plan shows that the landscape plan cannot necessarily protect open space and agricultural land from construction and settlement development (but it protects grassland). Further, there is no correlation between the development of woodland, water area or urban green space and the existence of a landscape plan in a municipality. Thus, while we are able to identify some advantages of the municipal landscape plan as an instrument of spatial planning, these empirical investigations only confirm the impact of drawing up a plan as such. In accordance with the rather low correlation coefficients and also the scant explanation of the disparity in the plan impacts, additional as yet ignored influential variables must certainly be considered alongside the mere existence of a plan or the plan quality. After reviewing the relevant literature (cf. Brody, 2003 and Gailing and Leibenath, 2017), we assume that these are particularly the process-related factors of landscape planning, i.e. factors associated with the planning process itself such as the involvement of actors, questions of communication or general governance and performance-oriented influences. Future studies should examine these at greater depth. The methodology applied in this article is likely to be transferable to other countries and planning systems.

4. Conclusions

On the one hand, we have found that the landscape plan is particularly effective in the development of green infrastructure (Seiwert and Roessler, 2020), i.e. primarily in linear and punctuated measures. In order to achieve greater impact in the future over wider areas, such as in the large-scale transformation of intensively used arable land into less intensively used grassland areas, we make a number of recommendations.

The first of these is the provision of additional implementation assistance and programmes to accompany the landscape plan. However, it should be noted that the selected indicators in the current study are unable to record functional changes in use (e.g. reduced application of pesticides in fields, etc.). In this respect, only tentative conclusions can be drawn here on the functional rather than the structural impact of a landscape plan.

Our second recommendation is to change the Federal Nature Conservation Act, creating alternative incentives such as financial support to encourage also peripheral, rural municipalities to draw up landscape plans.

However, in order to ensure a positive landscape development, especially with regard to forest margins, tree rows, hedges and coppices, quality is more important than the mere existence of a landscape plan. The higher the quality of the plan, the higher the density of such landscape elements. Hence, in addition to achieving the goal of nationwide planning, we thirdly recommend placing greater efforts in coming years on ensuring quality assurance in municipal landscape planning. Local nature conservation agencies should intensify their quality assurance specifically for those sections of the landscape plan dealing with concrete measures and their implementation. However, this also means strengthening the capacity of such conservation agencies to meet the demands of monitoring and quality assurance. In addition, our fourth recommendation is to revise and update the quality checklist for landscape plans issued by the Federal Agency for Nature Conservation (Kiemstedt et al., 1999), and more strongly establish this checklist in practice as an instrument for quality control as well as to measure success. In this context, we also recommend tightening the legal requirements of the Federal Nature Conservation Act regarding the quality control of landscape plans.

Conclusions for the international discussion can be drawn regarding the spatial planning system as such. In Germany we can see the clear benefits of establishing a system of independent municipal landscape plans throughout the country and making this legally binding. The drawing up of independent landscape plans ensures, firstly, that strategic spatial and land use plans take better account of landscape-related content, and secondly, that greater consideration is given to landscape factors in the urban development of a municipality. For the wider discussion, it should also be emphasized that landscape plans are particularly important in an urban context.

Our fifth, more general recommendation, is to transform (voluntary) landscape planning systems into legally-binding landscape planning systems, i.e. to make municipal landscape planning strictly compulsory. This applies not just to Germany but also to other countries, thereby raising the effectiveness of landscape plans, although at the same time particular attention must be paid to quality assurance. This would raise the effectiveness of landscape plans in other countries, although at the same time particular attention must be paid to quality assurance. This applies not only to the countries that have signed and ratified the European Landscape Convention, i.e. in the European context, but also to countries in the wider international context such as the USA and China (Wang et al., 2014).

Overall, this research methodology is also suitable for the evaluation of municipal plans in other countries. An important prerequisite, however, is the availability of landscape indicators covering the entire national territory as dependent variables as well as an empirical representative approach in the study design. Individual case studies are inadequate in view of the lack of generalizable results. We agree with Bryson in seeing "[a need for] rigorous, empirical, large sample, quantitative support for the proposition that planning and planners make a positive difference in the world." (1991)

CRediT authorship contribution statement

Wolfgang Wende: Conceptualization, Validation, Investigation, Resources, Writing - original draft, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Ulrich Walz:** Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Visualization, Supervision, Project administration, Funding acquisition. **Christian Stein:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Writing - original draft, Visualization.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.landusepol.2020.104855.

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