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Impacts, procedural processes, and local context: Rethinking the social acceptance of wind energy projects in the Netherlands

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ABSTRACT

A lack of social acceptance obstructs the diffusion of wind energy and jeopardises the fight against global warming and climate change. Academic literature has identified the leading causes of social acceptance, but falls short in providing workable methodologies to consider this in the planning and decision-making process. This paper attends to this issue by providing a novel holistic conceptualisation of community acceptance as an interplay between project impacts, the procedural process, and local context. This conceptualisation can help project developers, decision-makers and researchers to better understand the different dimensions of acceptance and identify potential blind spots in their current methods and approaches. Based on this conceptualisation, we construct and apply a planning tool based on geographical information systems and multi-criteria decision analysis. Using this method on a national scale, we estimate wind energy potential in the Netherlands from a social acceptance point of view. We find that a third of the theoretically available land can be exploited, and that roughly 26.5GW worth of wind energy can be installed. The case demonstrates that the approach can effectively raise acceptance by reducing impacts, facilitating participation, and improving transparency in the siting process.

1. Introduction

Wind energy enjoys public support as an alternative energy source [1–3] but often lacks social acceptance on the local scale [4–8]. While more prominent in densely-populated areas [9,10], this acceptance deficit can be observed around the globe [11,12]. As a consequence, capacity growth figures of wind energy are inadequate to achieve a global, 2050 net-zero scenario [13], jeopardising the fight against global warming and climate change.

There exists a large body of literature on wind energy acceptance [14] and the concerns that inspire local opposition have been well-investigated [15–18]. Commonly, these include landscape impacts, environmental concerns, socio-economic factors, and the procedural process [17,19]. Yet, these scientific insights have not changed the methods of planners, developers and other stakeholders [4], arguably holding back successful adoption of the technology. For them, the primary focus remains on costs [20,21], behaviour often reinforced by existing subsidy schemes. What certainly contributes to this theory/practice-divide is the difficulty to operationalise scientific insights on social acceptance. Research often remains theoretical and ambiguous, making it hard for project developers and decision-makers to integrate findings into their practices. As Zaunbrecher points out: "many factors that influence social acceptance … are already known. However, a conceptual framework … that integrates these factors as well as the method of assessing them is still missing" [20], p. 312. As empirical case studies (such as those from the WinWind project [22,23]) have revealed best practices, the next step is to operationalise them in a workable process for project developers and decision-makers.

The present study attends to this objective in two ways. First, we present a holistic framework on community acceptance that builds on existing social acceptance studies. The novelty of this framework resides in its capacity to show the interplay between wind project impacts, the procedural process and local context. It provides a useful perspective for project developers and decision-makers that can help them identify the strengths and blind-spots in their methods. Second, we explore the potential of Multi Criteria Decision Analysis (MCDA) as a practical approach to yielding community acceptance by (1) limiting the wind projects' impacts and (2) facilitating (local) stakeholder participation. Through modelling, concepts and processes are made explicit and accordingly make the issue tangible and debatable. Because of its transparency, the approach becomes inherently useful for participatory processes [24]. Using a Geographical Information System (GIS) together with the Analytic Hierarchy Process (AHP), we operationalise social acceptance as design criterion for wind turbine site selection. To illustrate the potential of our approach, we examined all potential

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wind sites in the Netherlands, using expert inputs to deduct a social acceptability metric. The case study's results demonstrate the feasibility of spatial planning and reveal the differences between the space theoretically available and the area meeting minimum social impact requirements. We conclude by evaluating the strengths and weaknesses of the approach, using our framework as guiding principle.

We conclude by revisiting our theoretical framework with the proposed methodology, and assess the latter's potential and limitations for attaining social acceptance.

2. Theory

Based on the literature on social acceptance, we first provide a clear definition of the concept. Next we take a closer look at social acceptance and specifically community acceptance. We will use these findings to develop a framework whose utility we test against a use-case for participatory spatial planning, presented in Section 4.

2.1. Unpacking social acceptance

Even though local opposition to wind energy projects has become an increasingly relevant issue for the technology's diffusion in the energy system, it is by no means a new topic in the social science's field [25]. When the technology saw its first commercial implementation, the term 'social acceptance,' in the more general view of renewable energy technologies, was already on researchers' radars given its perceived impact on the projects' rates of success [18,26,27]. Initially investigated by Carlman [28] in the 1990's, the topic has been unpacked since [18,29]. However, despite its academic acknowledgement and wide-spread use in policy literature [18], a consensus on what exactly *is* social acceptance often remains unresolved [30]. As Dermont et al. [31] rightfully point out, these various interpretations of acceptance make seemingly analogous findings in empirical literature on what constitutes acceptance paradoxically incomparable. Borrowing from Upham et al. [32] and the dictionary example by Batel et al. [29], we define social acceptance in this study as:

> The positive response to, or tolerance of a technical or socio-technical transition project by members of a given social unit.

for which 'tolerance' is interpreted according to the definition provided by the Stanford Encyclopedia of Philosophy [33]: "the conditional acceptance of or non-interference with beliefs, actions or practices that one considers to be wrong but still 'tolerable,' such that they should not be prohibited or constrained". As such, satisfaction of all stakeholders with the given transition is no prerequisite. But, where these stakeholders perceive the process as 'fair,' tolerance, and consequently acceptance *can* still emerge [4].

Wüstenhagen et al. [18] describe social acceptance by discerning a socio-political, a market and a community dimension (see Fig. 1). Socio-political acceptance is the most general dimension and comprises the acceptance of technologies and policies by the public, regulators, key stakeholders and policy makers, and resonates through public support of the technology [18,34,35]. Conversely, market acceptance embodies the acceptance by those that engage with the technology's manufacturing and use, e.g., investors, energy suppliers, energy consumers and project developers [27,34]. Lastly, community acceptance is the most specific dimension of social acceptance [34]. Community acceptance covers the gravity and extent to which people and businesses are affected (in their local community context) by the technology's implementation and use. It concerns itself with issues of procedural and distributional justice; how opinions are considered, benefits shared and how policy-making is conducted [27,34,35].

The high general socio-political acceptance and the economic viability of the technology [36], suggest that community acceptance is the most relevant dimension for understanding local opposition against wind energy projects today [10,22]. By identifying the drivers that influence the level of community acceptance, impediments to it can be more practically anticipated and prevented by design.

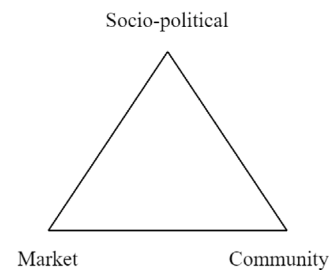

Fig. 1. Social acceptance conceptualisation. *Source:* Adapted from Wüstenhagen et al. [18].

2.2. Community acceptance: a conceptual framework

There is a broad literature on empirical research investigating the determinants of community acceptance, see e.g. [8,21,22,37,38]. From key findings in this research, we conceptualise community acceptance as the consequence of an interplay between an (adverse) impact, process and context dimension. To acquire social acceptance, no dimension can be neglected as disregard of endeavours in either dimension tempers the effect from those made anywhere else.

First, the impact dimension constitutes everything concerned with the turbine's physical presence in its environment. Second, the context dimension entails the social characteristics of the environment wherein the turbine is placed. Lastly, the process dimension acts as intermediary between the former dimensions; it is the process through which the project impacts are managed and perceived by the local community. In each dimension (discussed further below), some additional differentiation between community acceptance indicators can be made.

Impact dimension. We identified four steps in dealing with the adverse impacts of wind projects: prevention, mitigation, compensation (through community benefits), and tolerance. First, factors that can be leveraged to *prevent* impacts include visual disturbance, landscape mismatch, wildlife disturbance, high construction costs[1], noise nuisance and physical danger due to ice throw. Second, impact *mitigation* measures reduce a project's intrusiveness in its environment by either making changes to the project or to its surroundings. This includes (re-)painting the turbines in landscape colours, creating a turbine pattern that follows a river bed rather than placing them in a straight line, etc. Third, the *compensation* of impacts with community benefits does not affect the project per se, but can be leveraged to make the net impact of the entire development more acceptable. Examples include investment in local infrastructure & public facilities, the option of local ownership, tax benefits and financial compensation (specifically, see van Wijk et al. [41]). Finally, impacts that were or could not be prevented, mitigated or compensated would have to be *tolerated* by the local community. This could happen when community members that do not support the project still accept it due to its necessity for fighting climate change, or for reasons of (future) energy security.

Note that while presently, many efforts by developers and municipalities focus on tolerance through community participation and impact compensation through financial participation [22], the prevention of impacts is the most effective way to acquire acceptance; compensated impacts do not need to be tolerated, mitigated impacts do not need to be compensated and prevented impacts do not need to be mitigated. More specifically, as many of the wind project's adverse impacts are

[1] This indicator is also (and perhaps more) part of Wüstenhagen et al.'s [18] market acceptance dimension. However, in the framework's context it refers specifically to how the local community perceives the project's costs (and benefits) [27,34,39,40].

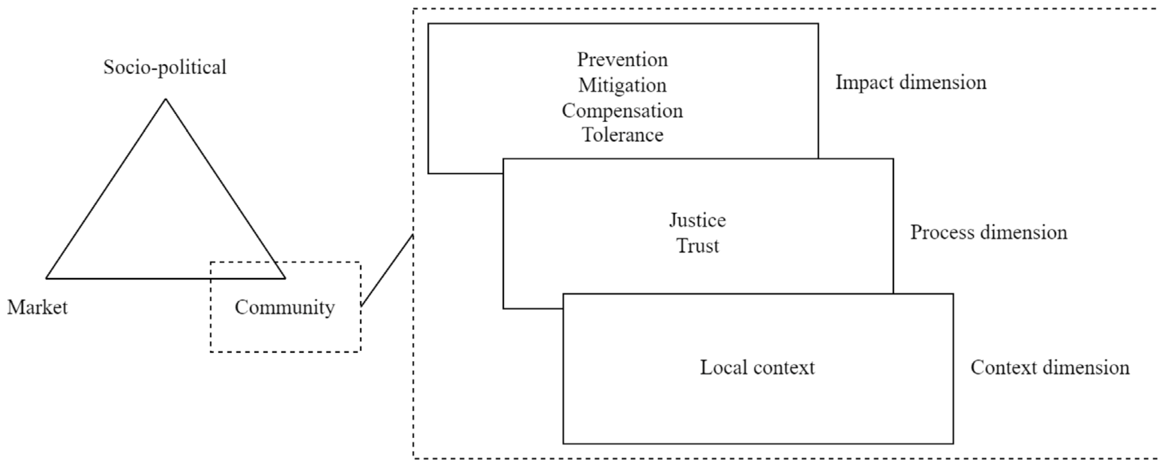

Fig. 2. Community acceptance framework in the context of social acceptance.

geographically determined, spatial planning is considered one of, if not the most effective strategy to prevent impacts and raise community acceptance [4,9].

Process dimension. The process dimension suggests that effective attempts in the procedural process increase the perceived justice and generate trust among local stakeholders [22]. Examples include the involvement of local communities in project site selection, general participation, engagement of local authorities, process transparency and the quality of communication.

Local context dimension. The local context maintains all the relevant characteristics that affect how the local community, through the development process, responds to the (mis-)management of project impacts. In this context, place attachment and place identity play an important role [42–44], as do people's conceptions about wind energy and climate change [45–47]. While the relevance of the dimension is clear, it is difficult to capture in specific mechanisms or indicators. For example, an above-median education level can be a strong community resource to mobilise opposition, but also support [6,48]. In a similar sense, community cohesion and social networks can have either a positive or negative impact on a project's chance of success.

To conclude, community acceptance is the most important aspect of social acceptance holding back the implementation of wind energy projects. Community acceptance is influenced by the (perceived) project impacts, the procedural process, and the context wherein the socio-technical transition takes place. Focusing on the first dimension, project developers benefit from impact prevention to escape the need for compensation & mitigation measures, or the need of excess tolerance of the local community. The importance of the decision process as intermediary between the handling of impacts and the consideration of the local context is emphasised in the literature [4,30,49], and the notion that the acceptance dimensions should not be considered in isolation was recently emphasised by Vuichard et al. [50]. We now demonstrate how transparency in the process dimension and prevention of impacts in the impacts dimension can actualise acceptance-by-design through spatial planning.

3. Case: the Netherlands

The Netherlands is a country of about 17.7 million inhabitants [51] located in the North-Western part of Europe, neighbouring Belgium on the South and Germany on the East as well as the North Sea along its North-Western shoreline. With a surface area of 41,526km^2, it is the most densely populated country in the European Union (2022).

In terms of land use, the Netherlands is intensely cultivated (54% agricultural land), has large water reserves (19%), and roughly equal shares of natural land and built environment (15% and 13% respectively). With a national high of 322 metres above sea level and a national low of 7 metres below, the Netherlands mainly consists of coastal lowland and reclaimed land (polders) with a few hills in the middle and South-East [52]. The even landscape and close proximity to the North Sea yield very favourable conditions for wind energy generation [53–55].

Nevertheless, when it comes to attaining renewable energy targets, the country ranks amongst the lowest of the International Energy Agency (IEA) member states [56]. The chief reason for this impeded implementation is caused by local opposition during the planning stage of local projects [57], despite the prevailing support for renewables amongst the population [58]. A recent national assessment underlines how this issue remains an important and prevalent obstacle for the Dutch energy transition today [59].

Ambitions in the Regional Energy Strategies (RES) concentrate largely on solar energy [60], presumably as a consequence of opposition to wind [61]. However, this development will only further exacerbate the present grid congestion issue [62]; while a 2:1 capacity ratio of wind-to-solar is desirable [63], the balance is already favouring solar in the existing energy mix (1:1.7) [64]. Hence, exploring the use of a practical acceptance-by-design approach is particularly imperative in the Dutch national context.

4. Methodology

This section describes how we use the factors that influence the impact of wind energy projects, and thereby community acceptance, for spatial planning. To this end, we divide the Netherlands into 25 × 25 m squares and use GIS data and stakeholder-based input to evaluate the suitability of each location. While using GIS for optimal site selection is not an uncommon method [65,66], we further refine the approach by individually considering social concerns (shadow flicker, sound nuisance and visual impact) and using more sophisticated calculation functions. Also, we move beyond social *constraints* (i.e. a location is either suitable or unsuitable, see e.g. [67]) and consider the site suitability characteristics as *criteria* instead (i.e. a site has a *measure* of suitability).

The methodology entails three consecutive steps (see Fig. 3) [68]. For every impact criterion, we first map the suitability of every location using suitability scores. Second, we use stakeholder inputs (in this case expert inputs) to evaluate the relative importance of each of the criteria using the AHP. Finally, the suitability scores are integrated into a single map, and all prohibited sites (too close to power lines for example) are excluded. This yields the final suitability map. Below, each of the steps is described in more detail.

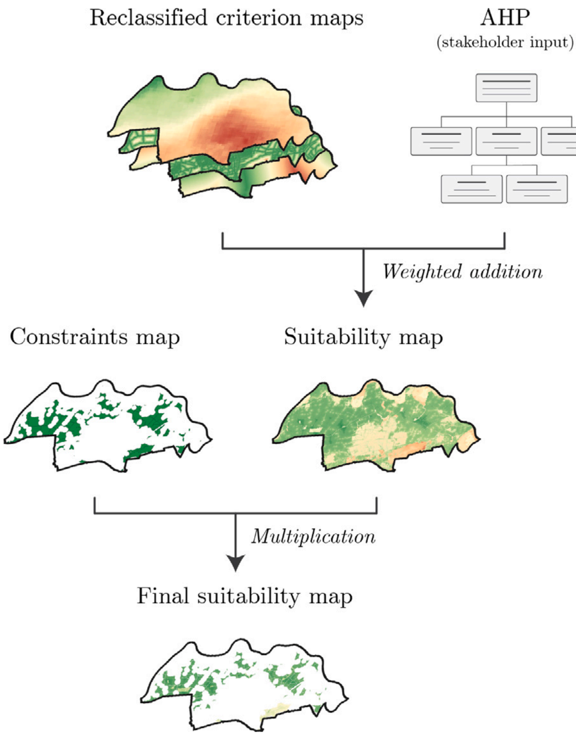

Fig. 3. Schematic overview of the methodology.

Table 1
Data sets used to perform spatial analysis.

Data set	Link
Municipal borders 2019	link
Dutch provinces	link
National road archive	link
Waterway section archive	link
National energy atlas	link
High-voltage lines	link
Topography Basic Registration (TOPNL)	link
Water framework directive	link
CBS population centres 2011	link
National archive primary flood defences	link
Low fly zones & airport space	link
Addresses Database	link
Global Wind Atlas	link
Protected areas - Provinces	link
Digital Cadastral Map	link
CBS land use archive	link

4.1. Step 1: criteria

A review of the literature on the spatial planning of wind energy yielded eight criteria covering economic (road & power line distance), social (shadow flicker, visual impact and sound nuisance), ecological (land use and protected natural land) and technical (wind power) decision aspects. Below we present the site-specific suitability score calculations for each of the criteria. Where necessary, calculations are based on a Vestas V150 reference turbine, akin to prior spatial studies conducted for the Netherlands [69]. The turbine has a hub height of 166m, a rotor diameter of 150m and rated power of 5.6MW. The sound power is bound at 104.9dB(A) (though noise reduction solutions are available) and the model has a cut-in and out wind speed of 3 and 25m/s respectively [70]. Spatial datasets used for the calculations are enclosed in Table 1, a full description of the sets and their use is provided in Appendix A.

Road & power line proximity. To limit construction & maintenance costs, a close proximity to the existing road network is desirable [71–75]. Similarly, staying near transmission lines helps to reduce transmission network costs and power losses [74–79]. In addition to the economic feasibility component of community acceptance [40], this criterion also contributes to the market acceptance dimension in Wüstenhagen et al.'s [18] original classification. Hence raising social acceptance in multiple ways.

For the suitability calculation, areas further from roads or power lines are assigned a lower suitability score. To perform this calculation, we first generate a map where each location is given a value equal to the distance from the nearest road or power line. We then use linear reclassification to convert these distance values into a dimensionless suitability score between zero and one. Practically this entails dividing each location's distance value by the highest value found on the map and subtracting the residual from one. For roads and (high-voltage) power lines, the highest distance value corresponds to 5,701 m and 41,192 m respectively.[2] The suitability maps for the road and power line proximity criteria are shown in Figs. 10(d) and 10(b) respectively.

Shadow flicker. The periodic interruption of sunlight due to turbine blade rotation can be a notable cause of distress [9,80,81]. In the Netherlands, strict rules are set for this specific criterion. According to the RVO [82], turbines need to be turned off when shadow flicker has occurred for more than 20 min during at least 17 days a year (or about 6 h annually [82]).

Areas where there is a risk of meeting this threshold are assigned the lowest suitability score (0) whereas other areas were given a value of one. To identify the shape and size of these 'risky locations,' we used the *Wind Turbine Shadow Calculator*[3] developed by the Danish Wind Industry Organisation, considering a worst-case scenario. A recent study by Haac et al. [83] performing a more detailed analysis shows that such a worst-case scenario is likely an overestimation of the actual effect. The suitability map for shadow flicker is shown in Fig. 10(c).

Sound nuisance. Noise produced by wind turbines can have a negative impact on the well-being of people living nearby [84] and some studies suggest that turbine noise may be an indirect cause for adverse health effects [85–87]. Though the latter claim is not universally supported (e.g. by [88]), it is a concern that ought to be recognised in the decision process [9,81,89,90].

We use a logarithmic noise propagation function to estimate the sound impact based on the distance from residences. Actual sound impacts are hard to predict as their magnitude depends on a variety of factors, such as wind speed, wind direction, distance from the observer, number of turbines and background noise [91,92]. Moreover, a purely technical view on the issue is unlikely to cover all its aspects, as a recent and elaborate study by Dallenbach and Wüstenhagen [93] has shown. Most studies consider a linear distance-based function, which, as Peri and Tal [94] point out is an insufficient proxy for the actual impact. In our case, we use the geometric dispersion of energy to estimate the sound pressure relative to the distance from a point source (inverse square law), and a logarithmic scale to convert the sound pressure level to one of a perceivable Decibel scale (dB) [95–97]. Taking the Dutch threshold value of 47 dB [69] as suitability bound (any sound levels lower are considered to be equally suitable), and taking the inverse of our composite equation (further is better), we find the impact/distance-function, shown in Fig. 4. The ensuing suitability map is shown in Fig. 10(f).

[2] To find the maximum value, large water bodies and small remote islands were excluded.

[3] The calculation tool can be found at the organisation's website: Windpower.org.

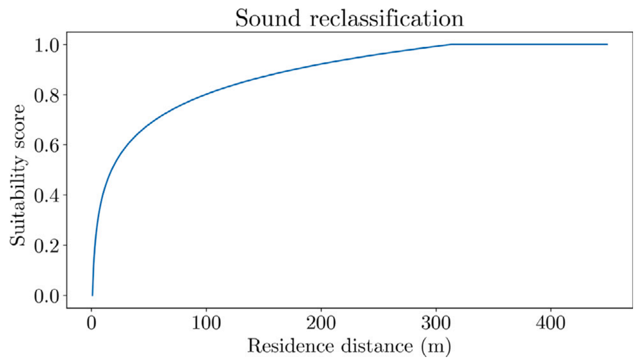

Fig. 4. Noise propagation function for the reference turbine.

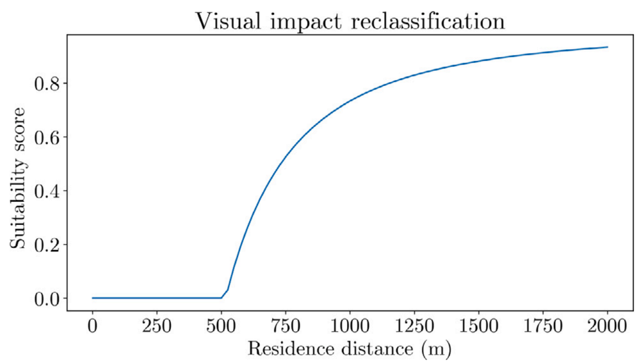

Fig. 5. Visual impact function for the reference turbine.

Visual impact. Visual impact is often considered the most significant indicator of social acceptance [27,98–100]. However, like sound, the visual impact is often considered to behave linearly with respect to the observer distance, again a clear oversimplification of reality [101].

We combine visual field theory for impact magnitude (how visually intrusive the turbines are) and a linear-logit model[4] by Shang and Bishop [103] for impact probability (how likely it is that the turbine will be observed) to approximate an impact/distance-relation for the wind turbine's visual presence. Visual field theory suggests that the relative share a turbine occupies in an observer's visual field decreases squarely with the distance from the object. This is consistent with empirical observations by Bishop [104] and Sullivan et al. [105], who observe a $1/distance^2$-like relationship in their data. The inverse, aggregate impact/distance-relation is illustrated in Fig. 5, the subsequent suitability map is presented in Fig. 10(h).

Wind power. Wind speed is by many considered the chief technical indicator for the performance of wind energy projects [106–109], and consequently a relevant indicator for community (through a project's economic feasibility) and market acceptance. Though the wind speed is most commonly used for spatial analysis, others deploy the wind power density to generate their suitability maps [110–112]. As the turbine power output (P) is given through [112]:

$$P = \frac{1}{2} C_p \rho A_{rotor} w \tag{1}$$

where the maximum power coefficient (C_p) and rotor surface area (A_{rotor}) are constant turbine properties, the wind speed (w) and air density (ρ) are the only variables left. Consequently, capturing these two variables in a single indicator (i.e. wind power density, $w \times \rho$) yields the best proxy for our suitability calculation. We subtract the lowest measured average wind power density from each location's value, and then divide the result by the now-highest wind power density to compute the suitability indicator for the turbine's technical performance (linear, min–max reclassification). Fig. 10(e) shows the corresponding suitability map for the wind power density.

[4] "A logit model, is used to model dichotomous outcome variables. In the logit model the log odds of the outcome is modelled as a linear combination of the predictor variables" [102].

Land use. Land use reflects the present natural character and ecological value of a designated area [113]. Using the land use data set by the Dutch Bureau of Statistics (CBS), we discern three land use classes, namely water bodies (19.03%), natural land (14.51%) and agricultural terrain (53.54%). Naturally, the built environment (12.92%) is excluded from the analysis.

Suitability scores for different land use classes were assigned based on stakeholder input, according to the following procedure: First, stakeholders are asked to indicate how important they think each land use class is with respect to the others using the AHP (explained in step 2), yielding a weight (between one and zero) for each type of area. Next, the values are subtracted from one to give the highest-rated land use class the lowest suitability score. Third, the suitability scores are divided by the highest score in the series. This ensures that the most suitable (lowest-rated) land use class is given a suitability score of one, while the relative importance between the alternatives is maintained. Lastly, all areas in the study area are given the suitability score corresponding to the land use class they belong to. Based on expert input, the result of this procedure is shown in the suitability map from Fig. 10(a).

Protected natural area. In addition to the land use classes, certain areas are also subject to natural protection laws. Each natural category has its own specific ecological characteristics and value, hence making it relevant for mutual comparison and weighting. For the Netherlands, we identify the following categories:

- Natura 2000 parks & Nature Protection Act (Dutch: Natuurbeschermingswet) (NBW)-zones: inhabited by endangered plant and animal species [114,115].
- Silence areas: only sounds naturally inherent to the location are permitted here [116].
- Dutch Nature Network (Dutch: Natuurnetwerk Nederland) (NNN)-zones: small segmented nature reserves [117].
- National landscapes comprising the 21 large Dutch natural parks [118].
- Geoheritage sites: landscapes illustrative of their natural formation process [119].

Weight calculation of the different protected areas follows a similar approach to that of the land use types and uses weighting inputs from the same group of experts. However, unlike the previous criterion, protection classes are not mutually exclusive and one site can be subject to multiple protection laws. This area overlap is handled in a reinforcing manner, meaning that when a location has multiple protection classifications, the weights are multiplied, yielding a proportionally lower suitability score. The ensuing suitability map is shown in Fig. 10(g).

4.2. Step 2: The relative importance of the criteria

The relative importance of the different criteria is estimated using MCDA, facilitating a systematic assessment of the economic, social, technical and ecological dimensions. What makes MCDA particularly useful here is its ability for stakeholder involvement [120–123]. Stakeholder involvement, as our framework has shown, can positively contribute to the process-dimension of community acceptance. Indeed, GIS-based MCDA are considered the most suitable [124,125] and most commonly applied [126] solutions to multi-criterion spatial planning problems, outperforming customary cost–benefit analyses in terms of

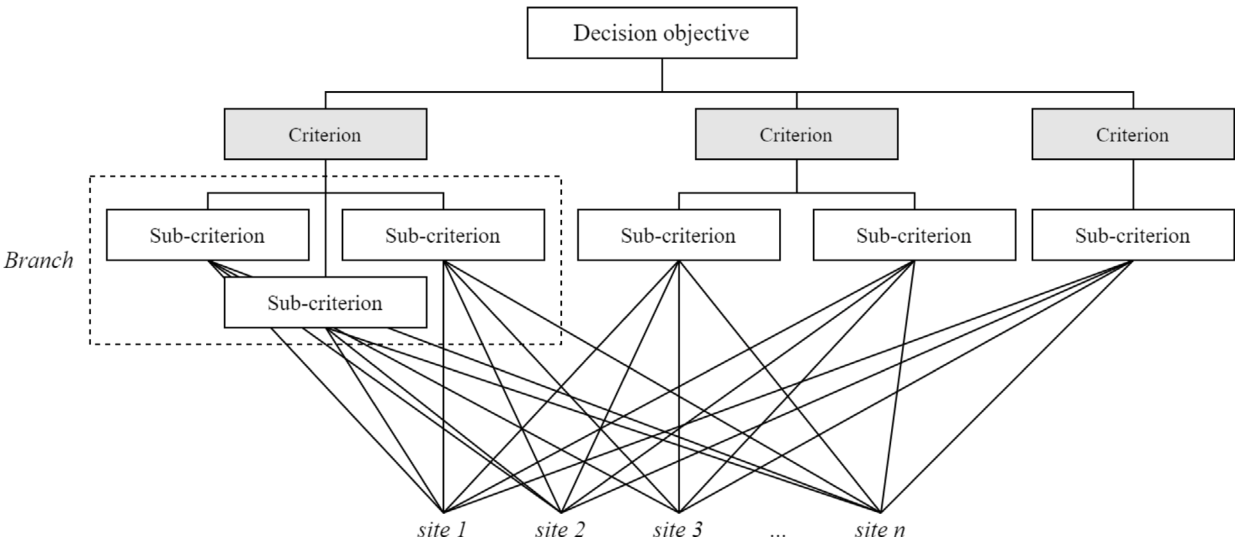

Fig. 6. Conceptual example of a decision hierarchy.

transparency [123]. In this study, we use Qgis[5] to perform the spatial analysis and the AHP as MCDA approach.

As MCDA method, the AHP is commonly applied in spatial contexts [127,128]. It was originally developed and introduced by Saaty [129] in the 1980's [130,131] and has been used in a variety of contexts since [132]. In its simplest form, the procedure involves three steps or phases: (1) forming the decision hierarchy from the relevant criteria, (2) obtaining the relative importance of each of the criteria, and (3) computing the criterion's weights [81,133–136]. These steps are further clarified below.

1. Forming the decision hierarchy. The first step is to formalise the impact of the criteria on the objective by positioning them in a decision hierarchy. The objective (site suitability) is placed at the top, and the criteria and alternatives (all 25 × 25 m areas) on the second and third rank respectively [130]. Each criterion will have to be compared to the others, so when more than seven,[6] criteria are considered, they must first be clustered into groups or 'branches' according to similarities in their nature (e.g. economic, ecological, social or technical), see the conceptual example in Fig. 6.

2. Conducting pairwise comparisons. Once the decision hierarchy is established, the importance of every criterion is approximated by inputs from a stakeholder group. To do so, each stakeholder is asked to estimate how much more important one criterion is over another using Saaty's nine-point scale [138]. When the importance of one criterion (C_i) over another (C_j) is denoted as c_{ij}, a decision matrix (A) for n criteria is given through $A = [c_{ij}] \forall i, j = 1, 2..., n$ [130,138].

$$A = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ \vdots & \vdots & \ddots & \\ c_{n1} & c_{n2} & & c_{nn} \end{bmatrix} \tag{2}$$

Fundamentally, the importance of a criterion with respect to itself (c_{ii}) is always equal to one, and, following the reciprocal judgement, c_{ij} is always equal to $1/c_{ji}$ [129]. Thus, considering a (part of a) decision hierarchy with n criteria, a total of $n(n-1)/2$ comparisons are required to compute the decision matrix. For this study, inputs from 9 experts in the field of spatial renewable energy planning were used to calculate the criterion weights. More details on the experts and their involvement can be found in Appendix B.

3. Calculating the weights & decision consistency. To calculate the criteria weights, the relative importance of each criterion is extracted from the priority vector of the decision matrix. For a consistent matrix, the priority vector w is equal to the principal eigenvector (see Saaty [139] for proofs), and can be calculated using the eigenvalue method.

By comparing the decision matrix's Consistency Index (CI) with the average CI of a sizable sample of similar eigenvalue problems, it can be judged whether a series of comparisons is'sufficiently consistent.' Finding the Consistency Ratio (CR) entails dividing the matrix's CI by the Random Consistency Index (RI), which is a function of the number of criteria considered [129]. According to Saaty [130], the decision matrix is consistent enough when its CR is smaller than 0.1.

After the decision matrices for all branches have been computed, the weight of each individual criterion can be calculated by multiplying its weight with the weight of its branch.

The weights estimated by the different experts were averaged and used to construct a composite suitability map. In this composite suitability map, the score (s) of each location is found by multiplying, for each criterion ($i = 1...n$), its weight ($0 \leq w \leq 1$) with the score in the corresponding criterion's map ($0 \leq k \leq 1$):

$$s = \sum_{i=1}^{n} w_i k_i \tag{3}$$

To then acquire the *final* suitability map, prohibited locations should be excluded. This final step is described below.

4.3. Step 3: Constraints

To acquire the final suitability map, prohibited locations, enclosed in a constraint map, need to be excluded from the previous result. This constraint map holds a binary value for each location, where a location is either prohibited (a value of zero), or permissible (a value of one). Constraints are often excluded due to safety or social reasons, or simply because the site has already been reserved for another use. The constraints here are considered unequivocal, even though constraints

[5] a free and open-source GIS

[6] Indeed, following the 1960's theory by Miller [137] experts can only handle seven (± two) facts at a time, a number beyond which the information becomes incomprehensible.

Table 2
Study constraints.

Constraint	Buffer distance (m)	Source
Roads	$^1/2d_{rotor}$	[141]
Power lines	$^1/2d_{rotor} + h_{mast}$	[141]
Railways	$^1/2d_{rotor} + 11$	[142]
Waterways	50	[142]
Primary weirs	50	[140]
Low-fly-zones	$^1/2d_{rotor}$	[141]
Airport airspace	$^1/2d_{rotor}$	[141]
Scattered houses	300	[69]
Urban centres	500	[69]
Existing turbines	$4d_{rotor}$ from blade tip	[69]
Large water bodies	–	[69]
Built area	–	–

Table 3
Prohibited area statistics for constraints.

Constraint	Constrained (%)
Roads	11.11
Power grid	4.21
Railways	1.52
Water & waterways	20.54
Primary weir dikes	0.82
Restricted airspace	10.81
Disseminated settlements	59.84
Urban centers	24.23
Existing turbines	4.1
Built area	11.36
Combined	83.79

Table 4
Expert panel criterion weights (average).

Criterion	w	Sub-criterion	w	w_i
Economic	0.241	Power line proximity	0.817	0.197
		Road proximity	0.183	0.044
Social	0.281	Visual impact	0.310	0.087
		Shadow flicker	0.206	0.058
		Noise	0.484	0.136
Technical	0.166	Wind power density	1.000	0.166
Ecological	0.312	Protected land	0.740	0.231
		Land use	0.260	0.081

may be lifted or abated based on further situation-specific impact or risk analysis [140]. An overview of the constraints considered in this study (following the Dutch Programme of the Regional Energy Strategies [69]) is presented in Table 2. Where applicable, a buffer zone is created in addition to the initial area, and both are assigned a zero-value.

To compute the final suitability map, the aggregate suitability score for every location (equation (3)) is multiplied with it's constraint score, yielding the final suitability equation (4) [124,143,144]:

$$s = \sum_{i=1}^{n} w_i k_i \prod_{q=1}^{r} b_q \tag{4}$$

5. Results

The reclassified criterion maps for all eight criteria of the siting analysis are shown in Fig. 10(a) through 10(h) in Appendix C, where dark areas indicate a low adverse impact or high suitability for the corresponding criterion. The aggregate constraint map can be found in Fig. 10(i), where grey areas indicate prohibited locations. The contribution of every constraint (considered individually) to the total excluded area (84% of the national landscape) is presented in Table 3.

The average weights computed from the expert panel inputs are shown in Table 4. Experts ranked the ecological criteria most relevant (0.312), followed by those of social (0.281), economic (0.241) and technical (0.166) concern.

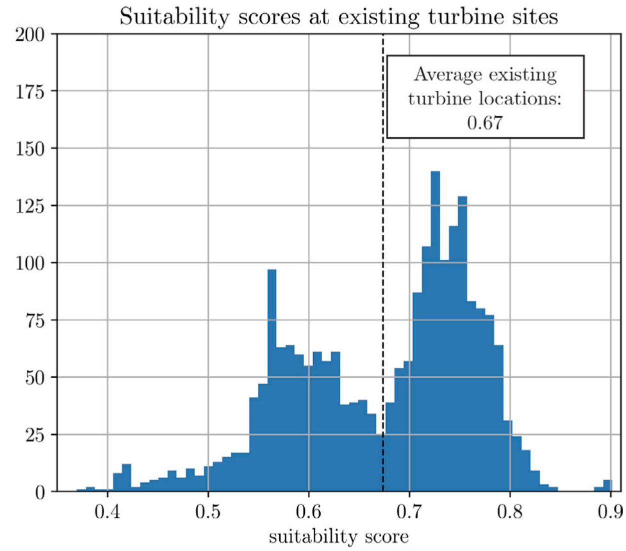

Fig. 7. Histogram of site suitability scores coinciding with existing wind turbines.

Aggregating the criterion maps using their corresponding weights and subtracting the prohibited areas using the constraint map, the *final* suitability map is shown on the left in Fig. 8 (for a high-resolution gradient map, see Fig. 11 in Appendix D).

In order to identify sufficiently suitable sites, we established a threshold value by looking at the scores of already existing turbine sites (see histogram in Fig. 7). These turbines appear to be placed at locations with an average suitability score of 0.67, 0.06 higher than the average of all unrestricted locations. Deploying this average suitability score as a minimum requirement, we find that there are still many unused areas left to explore. To illustrate their spatial distribution, a map with sufficiently suitable sites is presented on the right-side of Fig. 8. The most suitable locations reside primarily in the northern part of the country.

Populating the sufficiently suitable locations with 5.6MW reference turbines, a rough estimate of the total wind energy potential in the Netherlands can be projected. This yielded a total potential wind energy capacity of 26.5GW. Together with existing onshore turbines (accounting for 3.3GW of installed capacity), the total potential for onshore wind energy in the Netherlands, considering a social acceptance threshold, is 29.8GW.

6. Conclusion and discussion

Although public support for wind energy is high, opposition to local projects is threatening renewable energy objectives globally. Local opposition is the consequence of a lack of social, and especially community acceptance. In this study, we use insights from the empirical literature on the determinants of community acceptance to develop a framework. The framework (Fig. 2) provides a holistic conceptual representation of community acceptance as the result of an interplay between project impacts, process and context. It can serve as a benchmark for project developers and decision-makers to identify blind-spots in their current methods and processes, and better understand (the lack of) social acceptance.

We found that community acceptance emerges from the extent to which the project impacts are prevented, mitigated, compensated and tolerated (impact dimension), and the degree to which the local context is taken into account (context dimension). Furthermore, we have found

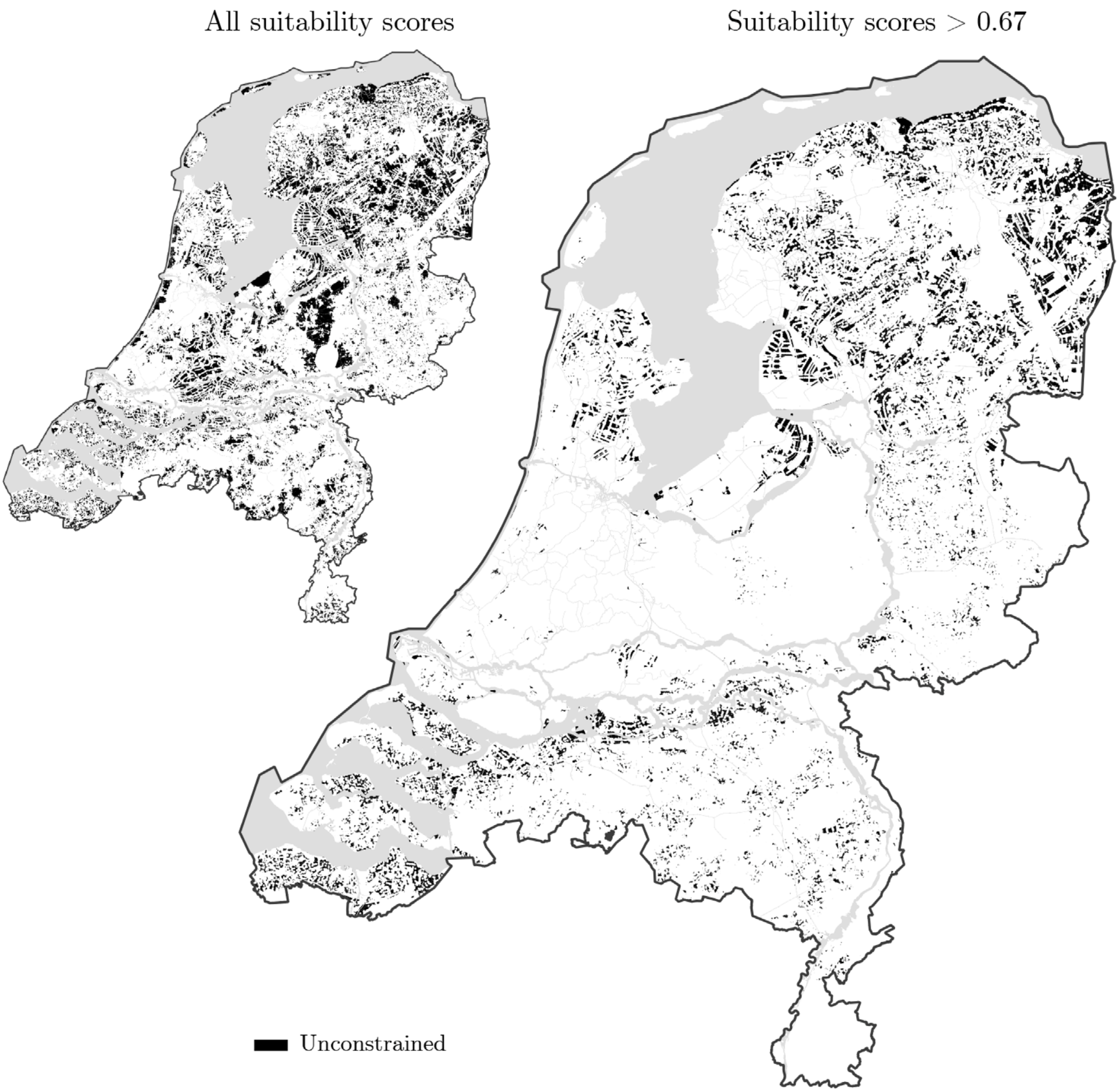

Fig. 8. Unconstrained locations with any suitability score (left) or with suitability scores higher than 0.67 only (right).

that trust and fairness are universal determinants in the project's development process, which as the third dimension intermediates between the former two.

Taking the framework as guiding principle, we performed a MCDA on possible wind turbine sites in the Netherlands. Using GIS software and expert input, we demonstrate how each site can be rated on various criteria (economic, social, environmental and technical) to identify least-impact locations, and that depending on how important each criterion is considered, the most suitable location (25 × 25 m) can be found. In doing so, we demonstrate the feasibility and potential of integrating an 'acceptance by design'-mentality in the planning process of wind energy projects.

For the Netherlands, experts assess the ecological criteria as most relevant, and specifically value natural areas that are protected by law. Excluding prohibited areas, around 6,734 km^2 (16%) of the Dutch national area remains available for facilitating onshore wind. Using existing wind turbine locations as social acceptance suitability threshold, we have found that 2,531 km^2 (37% of the available area, 6% of the national total) scores as good as, or better than the sites presently used. Populating this residual area with 5.6MW reference turbines, we concluded that the total potential for onshore wind energy in the Netherlands amounts to 29.8GW. Though this exceeds all Dutch future energy scenarios [145–148], its distribution amongst the provinces is rather uneven, with excess turbines located in the North. This might cause congestion issues and trigger discussions on the distribution of costs and benefits as the lion's share of demand comes from the south [56].

Spatial planning using GIS and MCDA shows to offer a tangible, transparent and traceable approach. Due to its potential for improving transparency and trust, it could very well facilitate the now-limited

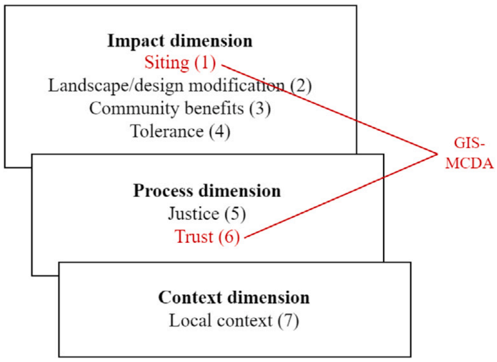

Fig. 9. GIS and MCDA in the community acceptance framework.

stakeholder involvement and participation [149]. Using local preferences (as opposed to expert input) on criterion selection and importance weighting, regional sentiment can be captured through this universal technique. Because the relationship between project impact and site suitability is made explicit, site selection becomes transparent and can be apprehensibly discussed. Our framework clearly illustrates why this particular approach is so valuable for social acceptance; apart from its potential to prevent turbine impacts, it also contributes to improving trust in the process dimension[7] (see Fig. 9). With the emergency regulation proposed by the European Commission under REPowerEU to speed up the permitting process of renewable energy projects [151], methods like these that can effectively address the societal bottleneck can be very helpful.

As said, our framework also helps decision-makers to understand the limitations of their methods. Blind spots of the GIS-MCDA-approach reside in its inability to consider the reduction of impacts through design modifications and applying compensation schemes. Moreover, for safeguarding justice and the proper consideration of local contexts, supplementary methods will be required. These findings are in line with spatial planning studies and research that recognises the importance of procedural and contextual factors. While the proposed methodology facilitates stakeholder involvement, improves transparency in the planning process, and can consequently help raising trust, we should emphasise that by itself, it cannot guarantee a favourable outcome. Decision-makers must recognise that participatory planning can only be part of a democratic decision making process, never a substitute to enforce implementation.

Limitations in the modelling process should also be addressed [152,153]. Firstly, while modelling real-world impacts from a social, environmental, economic and technical point of view allows us to consider multiple impacts simultaneously, it also demands a certain degree of abstraction [24]. Though we identified an important benefit of GIS-MCDA-modeling (making social acceptance explicit), some aspects of the real world are lost [154]. Two recommendations would therefor be to (1) develop creative ways to (more accurately) capture perceivably intangible acceptance criteria such as place attachment (e.g. [155]) and ecological value (e.g. [156]), and (2) to quantify the importance of missing data. In our study, we have taken a first step in considering social criteria individually and in a more precise manner than through a simple distance-function. Criteria that could not be considered in this study due to data unavailability included land costs, grid congestion risk and landowner data. By including these missing criteria in the MCDA (even though they cannot be used for the modelling objective), their relative importance could have been used to estimate the siting analysis' (in)completeness. For example, if grid congestion was given a weight of 0.1 (10%), this would mean that the siting analysis only accounts for 90% of the relevant criteria, which has valuable implications for how the results should be interpreted and used.

Another disadvantage of GIS-based MCDA, is that it impairs the consideration and heterogeneity of local contexts. Where concerns and perspectives can be shared conveniently through narrative-based approaches, modelling involves a certain disciplinary 'lock-in' that leaves these areas unexplored. Pluralist 'bridging strategies' and constructive conflict between model-based and dialogue approaches should, to this end, be further explored [153].

Finally, the importance of the other acceptance components of both community and social acceptance cannot be overstated. Though spatial planning can be a valuable instrument for incorporating community acceptance in wind energy projects, planning alone will not be enough. Since no site in the study area attained a zero-impact score (suitability score of 1), there will always be impacts to compensate, mitigate and tolerate. A recent study suggests that the gap between the expected (modelled) and actual (real-world) outcomes can be explained by these other factors, particularly justice [93]. The quality of the development process, and the consideration of the context wherein it takes place thus become the now-important determinants influencing wind projects' acceptance and success.

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CRediT authorship contribution statement

C.W. Klok: Conceptualization, Methodology, Formal analysis, Investigation, Writing. **A.F. Kirkels:** Writing – revision. **F. Alkemade:** Writing – revision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Links to the data used is provided in the article.

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[7] The importance of which was recently emphasised by Prados et al. [43] and Gölz et al. [150].

Appendix A. Data-sets

See Table 5.

Table 5
Available data sets used to perform analysis.

Object	Data set	Source(s)	Version	Link
Borders municipalities	Gemeentegrenzen 2019	Esri Nederland	apr-20	link
Borders provinces	Provinciegrenzen van Nederland	Provincie Overijssel & Kadaster	jan-19	link
Primary roads	Nationaal Wegenbestand	Rijkswaterstaat	okt-19	link
Secondary roads	Nationaal Wegenbestand	Rijkswaterstaat	okt-19	link
Other roads	Nationaal Wegenbestand	Rijkswaterstaat	okt-19	link
Waterways	NWB vaarwegen: Vaarwegvakken (RWS)	Rijkswaterstaat	aug-21	link
Existing turbines	Nationale energieatlas	RIVM, Rijkswaterstaat & Windstats.nl	nov-20	link
Gridlines	Bovengrondse hoogspanningslijnen met indicatieve magneetveldzone	RIVM	aug-21	link
Railways	Dataset: Basisregistratie Topografie (BRT) TOPNL	Kadaster	jun-21	link
Surface water bodies	Kaderrichtlijn Water	Rijkswaterstaat	aug-21	link
Urban centres	CBS Bevolkingskernen 2011	CBS	mei-14	link
Primary weir dikes	Dataset Nationale Basisbestanden Primaire Waterkeringen	Informatiehuis Water	mrt-17	link
Low fly zones & airport space	Rijksdienst voor Ondernemend Nederland	ILT, LVNL, Defensie, RVB, IenW & RWS	apr-21	link
Non-nature areas	Basisregistratie Adressen & Gebouwen (BAG)	Kadaster	feb-21	link
Wind power density	Global Wind Atlas	Global Wind Atlas	aug-21	link
Area protection status	Beschermde gebieden - Provincies	Kadaster	n.d.	link
Disseminated settlements	Digitale Kadastrale Kaart	Kadaster	apr-18	link
Other built areas	Basisregistratie Topografie (BRT) TOPNL	Kadaster	sep-21	link
Land use	CBS Bestand Bodemgebruik	CBS	jan-19	link

Appendix B. Details stakeholder involvement

The experts (Table 6) were approached individually and asked to indicate their perceived importance of each of the acceptance criteria in an excel sheet. The sheet explained how the criteria weights were calculated and also calculated the consistency of their decision matrices. By giving immediate feedback on the experts' inputs, they were able to adjust their preferences dynamically—eliminating the need for any long-term iterations.

Table 6
Expert panel for criterion weights (anonimised).

Function	Organisation type
Renewable Energy Expert	Renewable energy & climate policy advisory firm
Spatial Development and Energy Consultant	Renewable energy & climate policy advisory firm
Renewable Energy Consultant	Renewable energy & climate policy advisory firm
Policy Officer Energy Transition & Circular Economy	Regional environmental association
Project Manager Renewable Energy and Agriculture	Engineering consultancy
Senior Advisor Sustainable Energy and Spatial Planning	Renewable energy & climate policy advisory firm
Manager Project Development Wind and Solar	Renewable energy supplier
Project Engineer Wind Energy and High-Voltage Grid	Construction engineering company
Project Engineer Wind and Solar Energy	Construction engineering company

Appendix C. Criteria and constraint maps

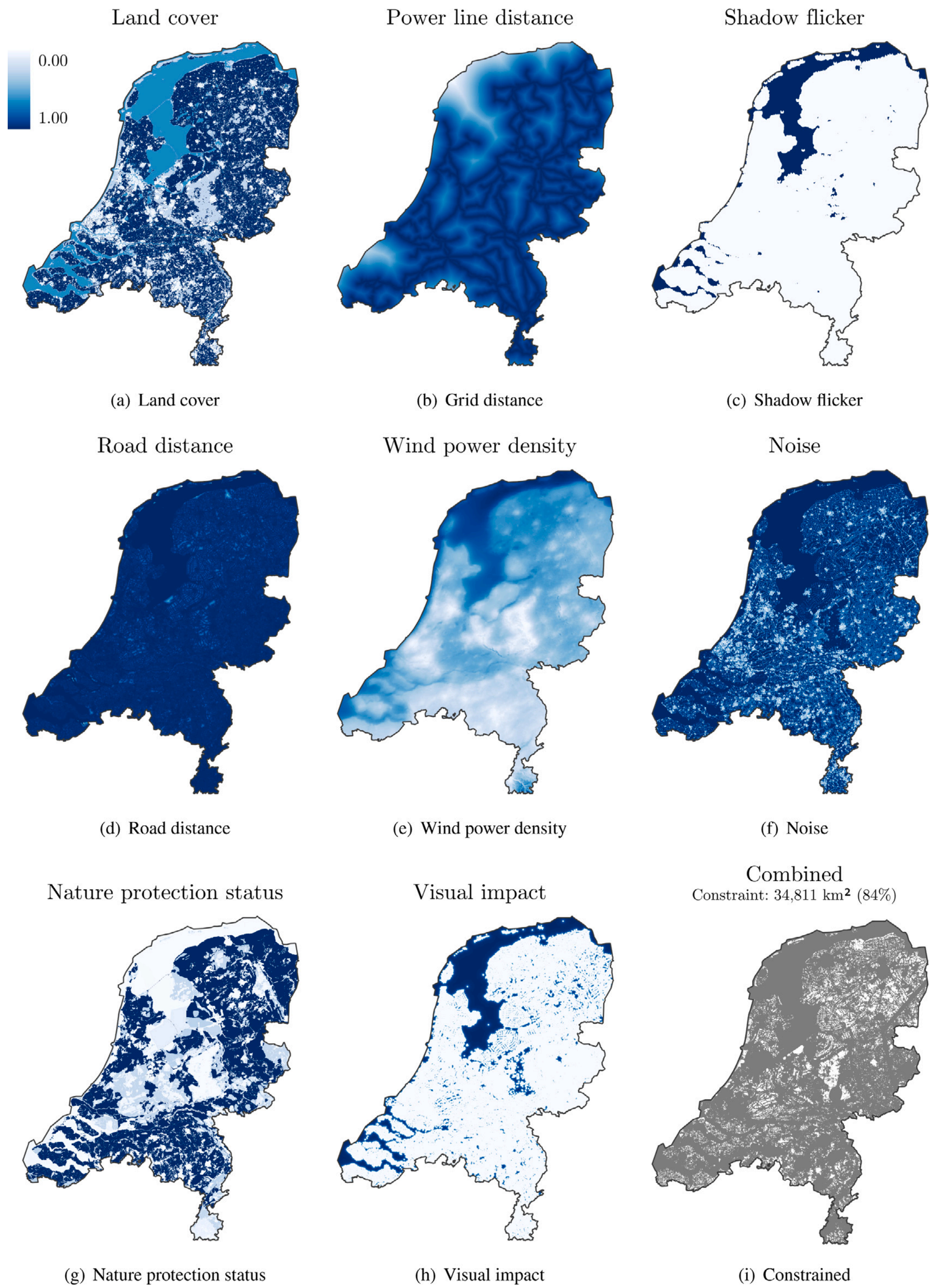

Fig. 10. Reclassified evaluation criterion and total constraint maps for wind energy project siting in the Netherlands.

Appendix D. High-res suitability map

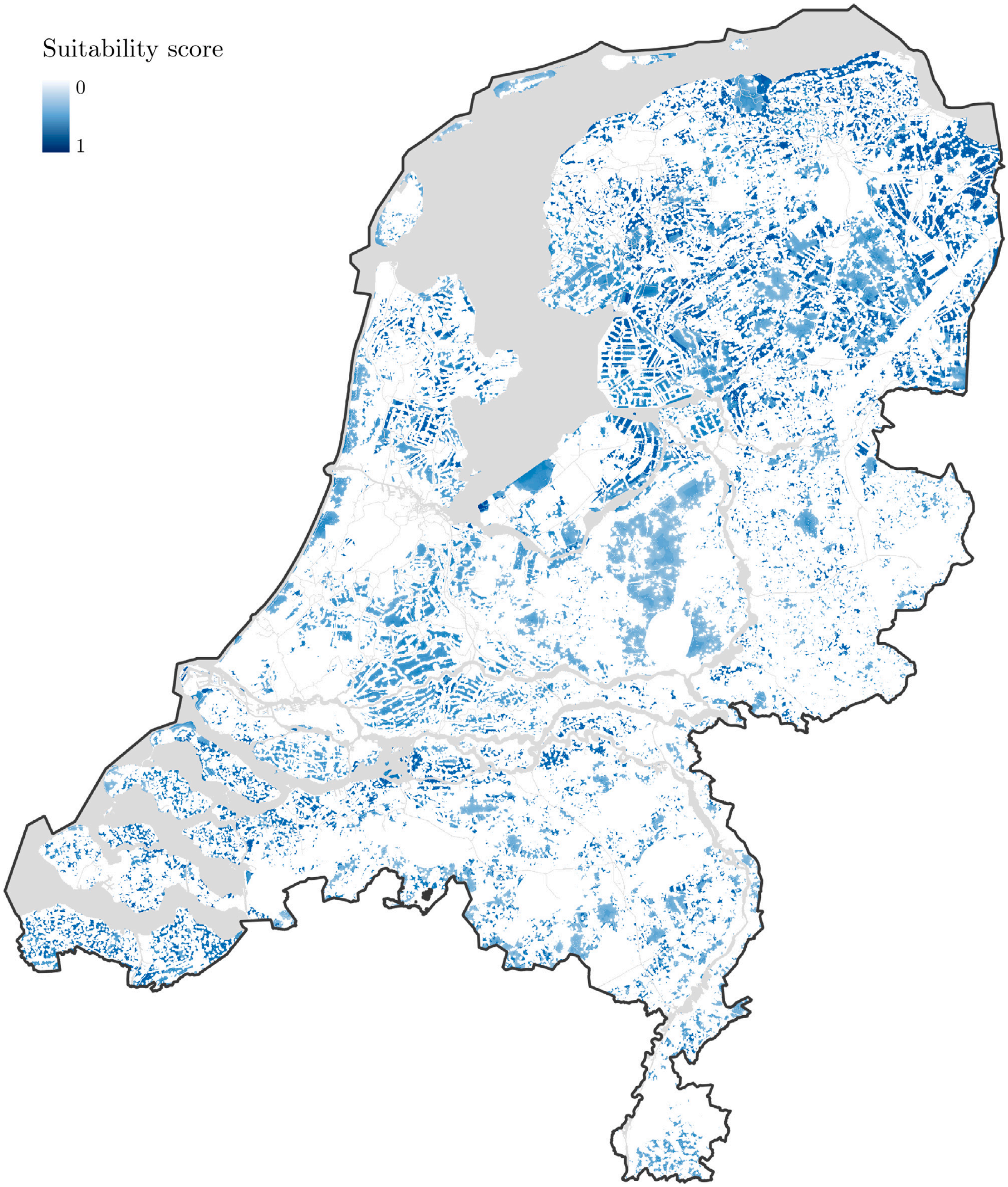

Fig. 11. Final suitability map.

References

[1] P. Devine-Wright, Beyond NIMBYism: Towards an integrated framework for understanding public perceptions of wind energy, Wind Energy 8 (2) (2005) 125–139, http://dx.doi.org/10.1002/we.124.

[2] M. Johansson, T. Laike, Intention to respond to local wind turbines: The role of attitudes and visual perception, Wind Energy 10 (5) (2007) 435–451, http://dx.doi.org/10.1002/we.232.

[3] T. Bolsen, F.L. Cook, The polls - trends: Public opinion on energy policy: 1974–2006, Public Opin. Q. 72 (2) (2008) 364–388, http://dx.doi.org/10.1093/poq/nfn019.

[4] J. Rand, B. Hoen, Thirty years of North American wind energy acceptance research: What have we learned?, Energy Res. Soc. Sci. 29 (February) (2017) 135–148, http://dx.doi.org/10.1016/j.erss.2017.05.019.
[5] J. Meyerhoff, C. Ohl, V. Hartje, Landscape externalities from onshore wind power, Energy Policy 38 (1) (2010) 82–92, http://dx.doi.org/10.1016/j.enpol.2009.08.055.
[6] L.S. Giordono, H.S. Boudet, A. Karmazina, C.L. Taylor, B.S. Steel, Opposition overblown? Community response to wind energy siting in the Western United States, Energy Res. Soc. Sci. 43 (June) (2018) 119–131, http://dx.doi.org/10.1016/j.erss.2018.05.016.
[7] S. Gross, Renewables, land use, and local opposition in the United States executive summary (January), 2020, pp. 1–24.
[8] P. Enevoldsen, B.K. Sovacool, Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France, Renew. Sustain. Energy Rev. 53 (2016) 178–184, http://dx.doi.org/10.1016/j.rser.2015.08.041.
[9] E. Peri, N. Becker, A. Tal, What really undermines public acceptance of wind turbines? A choice experiment analysis in Israel, Land Use Policy 99 (April) (2020) 105113, http://dx.doi.org/10.1016/j.landusepol.2020.105113.
[10] G. Ellis, G. Ferraro, The Social Acceptance of Wind Energy, Tech. Rep., 2016, http://dx.doi.org/10.2789/696070.
[11] M.J. Pasqualetti, Opposing wind energy landscapes: A search for common cause, Ann. Assoc. Am. Geogr. 101 (4) (2011) 907–917, http://dx.doi.org/10.1080/00045608.2011.568879.
[12] J.R.F. Diógenes, J. Claro, J.C. Rodrigues, M.V. Loureiro, Barriers to onshore wind energy implementation: A systematic review, Energy Res. Soc. Sci. 60 (2019) (2020) 101337, http://dx.doi.org/10.1016/j.erss.2019.101337.
[13] IRENA, Global Renewables Outlook 2020: Summary, Tech. Rep., International Renewable Energy Agency, 2020, URL www.irena.org.
[14] D. Bessette, J. Crawford, All's fair in love and WAR: The conduct of wind acceptance research (WAR) in the United States and Canada, Energy Res. Soc. Sci. 88 (2021) (2022) 102514, http://dx.doi.org/10.1016/j.erss.2022.102514.
[15] A. Jobert, P. Laborgne, S. Mimler, Local acceptance of wind energy: Factors of success identified in French and German case studies, Energy Policy 35 (5) (2007) 2751–2760, http://dx.doi.org/10.1016/j.enpol.2006.12.005.
[16] M. Karydis, Public attitudes and environmental impacts of wind farms: A review, Glob. Nest J. 15 (4) (2013) 585–604, http://dx.doi.org/10.30955/gnj.000932.
[17] M.A. Petrova, NIMBYism revisited: Public acceptance of wind energy in the United States, Wiley Interdiscip. Rev. Clim. Change 4 (6) (2013) 575–601, http://dx.doi.org/10.1002/wcc.250.
[18] R. Wüstenhagen, M. Wolsink, M.J. Bürer, Social acceptance of renewable energy innovation: An introduction to the concept, Energy Policy 35 (5) (2007) 2683–2691, http://dx.doi.org/10.1016/j.enpol.2006.12.001.
[19] M.A. Petrova, From NIMBY to acceptance: toward a novel framework - VESPA - for organizing and interpreting community concerns, Renew. Energy 86 (2016) 1280–1294, http://dx.doi.org/10.1016/j.renene.2015.09.047.
[20] B.S. Zaunbrecher, M. Ziefle, Integrating acceptance-relevant factors into wind power planning: A discussion, Sustainable Cities Soc. 27 (2016) 307–314, http://dx.doi.org/10.1016/j.scs.2016.08.018.
[21] M. Segreto, L. Principe, A. Desormeaux, M. Torre, L. Tomassetti, P. Tratzi, V. Paolini, F. Petracchini, Trends in social acceptance of renewable energy across Europe—A literature review, Int. J. Environ. Res. Public Health 17 (24) (2020) 1–19, http://dx.doi.org/10.3390/ijerph17249161.
[22] P. Maleki-Dizaji, N. del Bufalo, M.R. Di Nucci, M. Krug, Overcoming barriers to the community acceptance of wind energy: Lessons learnt from a comparative analysis of best practice cases across Europe, Sustainability (Switzerland) 12 (9) (2020) http://dx.doi.org/10.3390/SU12093562.
[23] E. De Luca, C. Nardi, L.G. Giuffrida, M. Krug, M.R. Di Nucci, Explaining factors leading to community acceptance of wind energy. Results of an expert assessment, Energies 13 (8) (2020) 1–23, http://dx.doi.org/10.3390/en13082119.
[24] G. Holtz, F. Alkemade, F. De Haan, J. Köhler, E. Trutnevyte, T. Luthe, J. Halbe, G. Papachristos, E. Chappin, J. Kwakkel, S. Ruutu, Prospects of modelling societal transitions: Position paper of an emerging community, Environ. Innov. Soc. Transit. 17 (2015) 41–58, http://dx.doi.org/10.1016/j.eist.2015.05.006.
[25] Y. Fournis, M.J. Fortin, From social 'acceptance' to social 'acceptability' of wind energy projects: Towards a territorial perspective, J. Environ. Plan. Manag. 60 (1) (2017) 1–21, http://dx.doi.org/10.1080/09640568.2015.1133406.
[26] S. Bolwig, T.F. Bolkesjø, A. Klitkou, P.D. Lund, C. Bergaentzlé, K. Borch, O.J. Olsen, J.G. Kirkerud, Y. k. Chen, P.A. Gunkel, K. Skytte, Climate-friendly but socially rejected energy-transition pathways: The integration of techno-economic and socio-technical approaches in the nordic-baltic region, Energy Res. Soc. Sci. 67 (September 2019) (2020) 101559, http://dx.doi.org/10.1016/j.erss.2020.101559.
[27] M. Westerlund, Social acceptance of wind energy in urban landscapes, Technol. Innov. Manag. Rev. 10 (9) (2020) 49–62, http://dx.doi.org/10.22215/TIMREVIEW/1389.
[28] I. Carlman, The views of politicians and decision-makers on planning for the use of wind power in Sweden, in: European Wind Energy Conference, 1984, pp. 22–36.
[29] S. Batel, P. Devine-Wright, T. Tangeland, Social acceptance of low carbon energy and associated infrastructures: A critical discussion, Energy Policy 58 (2013) 1–5, http://dx.doi.org/10.1016/j.enpol.2013.03.018.
[30] J.J. Cohen, J. Reichl, M. Schmidthaler, Re-focussing research efforts on the public acceptance of energy infrastructure: A critical review, Energy 76 (2014) 4–9, http://dx.doi.org/10.1016/j.energy.2013.12.056.
[31] C. Dermont, K. Ingold, L. Kammermann, I. Stadelmann-Steffen, Bringing the policy making perspective in: A political science approach to social acceptance, Energy Policy 108 (May) (2017) 359–368, http://dx.doi.org/10.1016/j.enpol.2017.05.062.
[32] P. Upham, C. Oltra, Á. Boso, Towards a cross-paradigmatic framework of the social acceptance of energy systems, Energy Res. Soc. Sci. 8 (2015) 100–112, http://dx.doi.org/10.1016/j.erss.2015.05.003.
[33] Toleration, 2017, URL https://plato.stanford.edu/entries/toleration/.
[34] B.K. Sovacool, P. Lakshmi Ratan, Conceptualizing the acceptance of wind and solar electricity, Renew. Sustain. Energy Rev. 16 (7) (2012) 5268–5279, http://dx.doi.org/10.1016/j.rser.2012.04.048.
[35] D. Bidwell, The role of values in public beliefs and attitudes towards commercial wind energy, Energy Policy 58 (2013) 189–199, http://dx.doi.org/10.1016/j.enpol.2013.03.010.
[36] M. Wolsink, Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support, Renew. Energy 21 (1) (2000) 49–64, http://dx.doi.org/10.1016/S0960-1481(99)00130-5.
[37] M. Enserink, R. Van Etteger, A. Van den Brink, S. Stremke, To support or oppose renewable energy projects? A systematic literature review on the factors influencing landscape design and social acceptance, Energy Res. Soc. Sci. 91 (July) (2022) 102740, http://dx.doi.org/10.1016/j.erss.2022.102740.
[38] M.D. Leiren, S. Aakre, K. Linnerud, T.E. Julsrud, M.R. Di Nucci, M. Krug, Community acceptance of wind energy developments: Experience from wind energy scarce regions in Europe, Sustainability (Switzerland) 12 (5) (2020) 18–20, http://dx.doi.org/10.3390/su12051754.
[39] J. Zoellner, P. Schweizer-Ries, C. Wemheuer, Public acceptance of renewable energies: Results from case studies in Germany, Energy Policy 36 (11) (2008) 4136–4141, http://dx.doi.org/10.1016/j.enpol.2008.06.026.
[40] C. Brannstrom, N.S. Leite, A. Lavoie, A. Gorayeb, What explains the community acceptance of wind energy? Exploring benefits, consultation, and livelihoods in coastal Brazil, Energy Res. Soc. Sci. 83 (2022) 102344, http://dx.doi.org/10.1016/j.erss.2021.102344.
[41] J. van Wijk, I. Fischhendler, G. Rosen, L. Herman, Penny wise or pound foolish? Compensation schemes and the attainment of community acceptance in renewable energy, Energy Res. Soc. Sci. 81 (August) (2021) 102260, http://dx.doi.org/10.1016/j.erss.2021.102260.
[42] A. Gorayeb, C. Brannstrom, A.J. de Andrade Meireles, J. de Sousa Mendes, Wind power gone bad: Critiquing wind power planning processes in northeastern Brazil, Energy Res. Soc. Sci. 40 (December 2017) (2018) 82–88, http://dx.doi.org/10.1016/j.erss.2017.11.027.
[43] M.J. Prados, R. Iglesias-Pascual, Á. Barral, Energy transition and community participation in Portugal, Greece and Israel: Regional differences from a multi-level perspective, Energy Res. Soc. Sci. 87 (December 2021) (2022) http://dx.doi.org/10.1016/j.erss.2021.102467.
[44] B.J. Kalkbrenner, J. Roosen, Citizens' willingness to participate in local renewable energy projects: The role of community and trust in Germany, Energy Res. Soc. Sci. 13 (2016) (2016) 60–70, http://dx.doi.org/10.1016/j.erss.2015.12.006.
[45] U. Liebe, G.M. Dobers, Decomposing public support for energy policy: What drives acceptance of and intentions to protest against renewable energy expansion in Germany?, Energy Res. Soc. Sci. 47 (August 2018) (2019) 247–260, http://dx.doi.org/10.1016/j.erss.2018.09.004.
[46] V. Westerberg, J.B. Jacobsen, R. Lifran, Offshore wind farms in Southern Europe - determining tourist preference and social acceptance, Energy Res. Soc. Sci. 10 (2015) 165–179, http://dx.doi.org/10.1016/j.erss.2015.07.005.
[47] A. Delicado, E. Figueiredo, L. Silva, Community perceptions of renewable energies in Portugal: Impacts on environment, landscape and local development, Energy Res. Soc. Sci. 13 (2016) 84–93, http://dx.doi.org/10.1016/j.erss.2015.12.007.
[48] D.L. Bessette, S.B. Mills, Farmers vs. lakers: Agriculture, amenity, and community in predicting opposition to United States wind energy development, Energy Res. Soc. Sci. 72 (June 2020) (2021) 101873, http://dx.doi.org/10.1016/j.erss.2020.101873.
[49] J. Firestone, W. Kempton, M.B. Lilley, K. Samoteskul, Public acceptance of offshore wind power: Does perceived fairness of process matter? J. Environ. Plan. Manag. 55 (10) (2012) 1387–1402, http://dx.doi.org/10.1080/09640568.2012.688658.
[50] P. Vuichard, A. Broughel, R. Wüstenhagen, A. Tabi, J. Knauf, Keep it local and bird-friendly: Exploring the social acceptance of wind energy in Switzerland, Estonia, and Ukraine, Energy Res. Soc. Sci. 88 (December 2021) (2022) 102508, http://dx.doi.org/10.1016/j.erss.2022.102508.
[51] CBS, Bevolkingsteller, 2022, URL https://www.cbs.nl/nl-nl/visualisaties/dashboard-bevolking/bevolkingsteller.
[52] CIA, CIA world factbook, 2021.

[53] P. Enevoldsen, F.H. Permien, I. Bakhtaoui, A.K. v. Krauland, M.Z. Jacobson, G. Xydis, B.K. Sovacool, S.V. Valentine, D. Luecht, G. Oxley, How much wind power potential does Europe have? Examining European wind power potential with an enhanced socio-technical atlas, Energy Policy 132 (April) (2019) 1092–1100, http://dx.doi.org/10.1016/j.enpol.2019.06.064.
[54] K. Eurek, P. Sullivan, M. Gleason, D. Hettinger, D. Heimiller, A. Lopez, An improved global wind resource estimate for integrated assessment models, Energy Econ. 64 (2017) 552–567, http://dx.doi.org/10.1016/j.eneco.2016.11.015.
[55] J. Bosch, I. Staffell, A.D. Hawkes, Temporally-explicit and spatially-resolved global onshore wind energy potentials, Energy 131 (2017) 207–217, http://dx.doi.org/10.1016/j.energy.2017.05.052.
[56] IEA, The Netherlands 2020 Energy Policy Review, Tech. Rep., International Energy Agency, 2020, URL https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/The_Netherlands_2020_Energy_Policy_Review.pdf.
[57] S. Agterbosch, W. Vermeulen, P. Glasbergen, Implementation of wind energy in the Netherlands: The importance of the social-institutional setting, Energy Policy 32 (18) (2004) 2049–2066, http://dx.doi.org/10.1016/S0301-4215(03)00180-0.
[58] Y.D. Kluizenaar, C. Carabain, A. Steenbekkers, Klimaatbeleid En de Samenleving - Een Korte Samenvatting Van Inzichten Uit Het Scp-Onderzoek Op Het Vlak Van Duurzame Samenleving, Tech. Rep., 2020.
[59] PBL, Wind-Op-Land: Lessen En Ervaringen, Tech. Rep., Planbureau voor de leefomgeving, 2019, URL https://www.pbl.nl/sites/default/files/downloads/pbl-2019-wind-op-land-lessen-en-ervaringen-3379.pdf.
[60] NVDE, Analyse Concept Regionale Energiestrategieën, Tech. Rep., 2020.
[61] D. Iseger, Focus op zon in de R.E.S. geeft lastige uitdagingen, 2020, URL https://overmorgen.nl/blog/focus-op-zon-in-de-res-geeft-lastige-uitdagingen/.
[62] M.J. van Blijswijk, L.J. de Vries, Evaluating congestion management in the Dutch electricity transmission grid, Energy Policy 51 (September 2010) (2012) 916–926, http://dx.doi.org/10.1016/j.enpol.2012.09.051.
[63] P. Li, G. Fan, W. Wang, Y. Huang, Z. Lin, Proportion optimization of wind and solar power capacity for regional power network, in: Asia-Pacific Power and Energy Engineering Conference, APPEEC 2016-Decem, 2016, pp. 2424–2428, http://dx.doi.org/10.1109/APPEEC.2016.7779920.
[64] S. Mertens, Design of wind and solar energy supply, to match energy demand, Clean. Eng. Technol. 6 (2022) 100402, http://dx.doi.org/10.1016/j.clet.2022.100402.
[65] J.L. Peters, T. Remmers, A.J. Wheeler, J. Murphy, V. Cummins, A systematic review and meta-analysis of GIS use to reveal trends in offshore wind energy research and offer insights on best practices, Renew. Sustain. Energy Rev. 128 (2019) (2020) 109916, http://dx.doi.org/10.1016/j.rser.2020.109916.
[66] T. Christidis, J. Law, Review: The use of geographic information systems in wind turbine and wind energy research, J. Renew. Sustain. Energy 4 (1) (2012) http://dx.doi.org/10.1063/1.3673565.
[67] F.H. Permien, P. Enevoldsen, Socio-technical constraints in German wind power planning: An example of the failed interdisciplinary challenge for academia, Energy Res. Soc. Sci. 55 (April) (2019) 122–133, http://dx.doi.org/10.1016/j.erss.2019.04.021.
[68] J. Malczewski, GIS and multicriteria decision analysis, vol. 1, 1999.
[69] T. Kuijers, B. Hocks, J. Witte, J. Schilling, M. Meyer, F. v. d. Poll, T. Scholten, E. Tol, R. v. Veen, N. Voulis, Analysekaarten NP RES: Verantwoording Bronnen En Methoden, Tech. Rep., 2020.
[70] Vestas, The Foundation for the Future of Wind, Tech. Rep., 2020.
[71] D. Latinopoulos, K. Kechagia, A gis-based multi-criteria evaluation for wind farm site selection. A regional scale application in Greece, Renew. Energy 78 (2015) 550–560, http://dx.doi.org/10.1016/j.renene.2015.01.041.
[72] R.v. Haaren, V. Fthenakis, GIS-based wind farm site selection using spatial multi-criteria analysis (SMCA): Evaluating the case for New York State, Renew. Sustain. Energy Rev. 15 (7) (2011) 3332–3340, http://dx.doi.org/10.1016/j.rser.2011.04.010.
[73] S.M. Baban, T. Parry, Developing and applying a GIS-assisted approach to locating wind farms in the UK, Renew. Energy 24 (1) (2001) 59–71, http://dx.doi.org/10.1016/S0960-1481(00)00169-5.
[74] J.R. Janke, Multicriteria GIS modeling of wind and solar farms in Colorado, Renew. Energy 35 (10) (2010) 2228–2234, http://dx.doi.org/10.1016/j.renene.2010.03.014.
[75] L.I. Tegou, H. Polatidis, D.A. Haralambopoulos, Environmental management framework for wind farm siting: Methodology and case study, J. Environ. Manag. 91 (11) (2010) 2134–2147, http://dx.doi.org/10.1016/j.jenvman.2010.05.010.
[76] S. Janjai, I. Masiri, W. Promsen, S. Pattarapanitchai, P. Pankaew, J. Laksanaboonsong, I. Bischoff-Gauss, N. Kalthoff, Evaluation of wind energy potential over Thailand by using an atmospheric mesoscale model and a GIS approach, J. Wind Eng. Ind. Aerodyn. 129 (2014) 1–10, http://dx.doi.org/10.1016/j.jweia.2014.03.010.
[77] M.A. Baseer, S. Rehman, J.P. Meyer, M.M. Alam, GIS-based site suitability analysis for wind farm development in Saudi Arabia, Energy 141 (2017) 1166–1176, http://dx.doi.org/10.1016/j.energy.2017.10.016.
[78] M. Uyan, GIS-based solar farms site selection using analytic hierarchy process (AHP) in Karapinar region Konya/Turkey, Renew. Sustain. Energy Rev. 28 (2013) 11–17, http://dx.doi.org/10.1016/j.rser.2013.07.042.
[79] Y. Noorollahi, H. Yousefi, M. Mohammadi, Multi-criteria decision support system for wind farm site selection using GIS, Sustain. Energy Technol. Assess. 13 (2016) 38–50, http://dx.doi.org/10.1016/j.seta.2015.11.007.
[80] J.J. Watson, M.D. Hudson, Regional scale wind farm and solar farm suitability assessment using GIS-assisted multi-criteria evaluation, Landsc. Urban Plan. 138 (2015) 20–31, http://dx.doi.org/10.1016/j.landurbplan.2015.02.001.
[81] T. Höfer, Y. Sunak, H. Siddique, R. Madlener, Wind farm siting using a spatial analytic hierarchy process approach: A case study of the Städteregion Aachen, Appl. Energy 163 (2016) 222–243, http://dx.doi.org/10.1016/j.apenergy.2015.10.138.
[82] RVO, Slagschaduw En Windturbines, Tech. Rep., Rijksdienst Voor Ondernemend Nederland, 2019, http://dx.doi.org/10.1007/978-3-642-50788-5{_}11.
[83] R. Haac, R. Darlow, K. Kaliski, J. Rand, B. Hoen, In the shadow of wind energy: Predicting community exposure and annoyance to wind turbine shadow flicker in the United States, Energy Res. Soc. Sci. 87 (2021) (2022) 102471, http://dx.doi.org/10.1016/j.erss.2021.102471.
[84] S.A. Janssen, H. Vos, A.R. Eisses, E. Pedersen, A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources, J. Acoust. Soc. Am. 130 (6) (2011) 3746–3753, http://dx.doi.org/10.1121/1.3653984.
[85] R.H. Bakker, E. Pedersen, G.P. van den Berg, R.E. Stewart, W. Lok, J. Bouma, Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress, Sci. Total Environ. 425 (2012) 42–51, http://dx.doi.org/10.1016/j.scitotenv.2012.03.005.
[86] L.D. Knopper, C.A. Ollson, Health effects and wind turbines: A review of the literature, Environ. Health: Glob. Access Sci. Source 10 (1) (2011) 1–10, http://dx.doi.org/10.1186/1476-069X-10-78.
[87] L.D. Knopper, C.A. Ollson, L.C. McCallum, M.L. Aslund, R.G. Berger, K. Souweine, M. McDaniel, Wind turbines and human health, Front. Public Health 2 (JUN) (2014) 1–20, http://dx.doi.org/10.3389/fpubh.2014.00063.
[88] D.S. Michaud, K. Feder, S.E. Keith, S.A. Voicescu, L. Marro, J. Than, M. Guay, A. Denning, D. McGuire, T. Bower, E. Lavigne, B.J. Murray, S.K. Weiss, F. van den Berg, Exposure to wind turbine noise: Perceptual responses and reported health effects, J. Acoust. Soc. Am. 139 (3) (2016) 1443–1454, http://dx.doi.org/10.1121/1.4942391.
[89] S. Reid, Wind and wind energy, vol. 13, 2005.
[90] K. Langer, T. Decker, J. Roosen, K. Menrad, Factors influencing citizens' acceptance and non-acceptance of wind energy in Germany, J. Clean. Prod. 175 (2018) 133–144, http://dx.doi.org/10.1016/j.jclepro.2017.11.221.
[91] K. Dai, A. Bergot, C. Liang, W.N. Xiang, Z. Huang, Environmental issues associated with wind energy - A review, Renew. Energy 75 (2015) 911–921, http://dx.doi.org/10.1016/j.renene.2014.10.074.
[92] A.H. Poulsen, O. Raaschou-Nielsen, A. Peña, A.N. Hahmann, R.B. Nordsborg, M. Ketzel, J. Brandt, M. Sørensen, Impact of long-term exposure to wind turbine noise on redemption of sleep medication and antidepressants: A nationwide cohort study, Environ. Health Perspect. 127 (3) (2019) 1–9, http://dx.doi.org/10.1289/EHP3909.
[93] N. Dällenbach, R. Wüstenhagen, How far do noise concerns travel? Exploring how familiarity and justice shape noise expectations and social acceptance of planned wind energy projects, Energy Research and Social Science 87 (September 2021) (2022) http://dx.doi.org/10.1016/j.erss.2021.102300.
[94] E. Peri, A. Tal, A sustainable way forward for wind power: Assessing turbines' environmental impacts using a holistic GIS analysis, Appl. Energy 279 (June) (2020) 115829, http://dx.doi.org/10.1016/j.apenergy.2020.115829.
[95] P. Morris, R. Therivel, Methods of environmental impact assessment, 2009.
[96] Y. Anjaneyulu, V. Manickam, Environmental impact assessment: Effective methodologies, 2007.
[97] M. Talbot-Smith, Sound, speech and hearing, in: Telecommunications Engineer's Reference Book, Butterworth-Heinemann, 1993, http://dx.doi.org/10.1016/B978-0-7506-1162-6.50014-9, 8-1, 8-3-8-16.
[98] M. Harper, B. Anderson, P. James, A. Bahaj, 30th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, ECOS 2017, (1998), 2017.
[99] M. Wolsink, Attitudes and expectancies about wind turbines and wind farms, Wind Eng. 13 (4) (1989) 196–206.
[100] E. Strazzera, M. Mura, D. Contu, Combining choice experiments with psychometric scales to assess the social acceptability of wind energy projects: A latent class approach, Energy Policy 48 (2012) 334–347, http://dx.doi.org/10.1016/j.enpol.2012.05.037.
[101] J.F. Palmer, Deconstructing viewshed analysis makes it possible to construct a useful visual impact map for wind projects, Landsc. Urban Plan. 225 (April) (2022) 104423, http://dx.doi.org/10.1016/j.landurbplan.2022.104423.
[102] UCLA, Logit regreion: R data analysis examples, 2021, URL https://stats.idre.ucla.edu/r/dae/logit-regression/.
[103] H. Shang, I.D. Bishop, Visual thresholds for detection, rrcognition and visual impact in landscape settings, J. Environ. Psychol. 20 (2) (2000) 125–140, http://dx.doi.org/10.1006/jevp.1999.0153.
[104] I.D. Bishop, D.R. Miller, Visual assessment of off-shore wind turbines: The influence of distance, contrast, movement and social variables, Renew. Energy 32 (5) (2007) 814–831, http://dx.doi.org/10.1016/j.renene.2006.03.009.
[105] R.G. Sullivan, L.B. Kirchler, T. Lahti, S. Roche, K. Beckman, B. Cantwell, P. Richmond, Wind Turbine Visibility and Visual Impact Threshold Distances in Western Landscapes, Argonne National Laboratory (May 2012), 2012, pp. 1–47, URL http://medcontent.metapress.com/index/A65RM03P4874243N.pdf%5Cnhttp://visualimpact.anl.gov/windvitd/docs/WindVITD.pdf.

[106] L.C. Rodman, R.K. Meentemeyer, A geographic analysis of wind turbine placement in Northern California, Energy Policy 34 (15) (2006) 2137–2149, http://dx.doi.org/10.1016/j.enpol.2005.03.004.
[107] S.H. Siyal, U. Mörtberg, D. Mentis, M. Welsch, I. Babelon, M. Howells, Wind energy assessment considering geographic and environmental restrictions in Sweden: A GIS-based approach, Energy 83 (2015) (2015) 447–461, http://dx.doi.org/10.1016/j.energy.2015.02.044.
[108] K.Q. Nguyen, Wind energy in Vietnam: Resource assessment, development status and future implications, Energy Policy 35 (2) (2007) 1405–1413, http://dx.doi.org/10.1016/j.enpol.2006.04.011.
[109] B. Sliz-Szkliniarz, J. Vogt, GIS-based approach for the evaluation of wind energy potential: A case study for the Kujawsko-Pomorskie voivodeship, Renew. Sustain. Energy Rev. 15 (3) (2011) 1696–1707, http://dx.doi.org/10.1016/j.rser.2010.11.045.
[110] S. Al-Yahyai, Y. Charabi, A. Gastli, A. Al-Badi, Wind farm land suitability indexing using multi-criteria analysis, Renew. Energy 44 (2012) 80–87, http://dx.doi.org/10.1016/j.renene.2012.01.004.
[111] A.G. Amarasinghe, E.N. Perera, Modeling predictive suitability to determine potential areas for establishing wind power plants in Sri Lanka, Model. Earth Syst. Environ. 7 (1) (2020) 443–454, http://dx.doi.org/10.1007/s40808-020-00868-w.
[112] I. Potić, T. Joksimović, U. Milinčić, D. Kićović, M. Milinčić, Wind energy potential for the electricity production - Knjaževac municipality case study (Serbia), Energy Strategy Rev. 33 (2021) http://dx.doi.org/10.1016/j.esr.2020.100589.
[113] P. Díaz-Cuevas, J. Domínguez-Bravo, A. Prieto-Campos, Integrating MCDM and GIS for renewable energy spatial models: Assessing the individual and combined potential for wind, solar and biomass energy in Southern Spain, Clean Technol. Environ. Policy 21 (9) (2019) 1855–1869, http://dx.doi.org/10.1007/s10098-019-01754-5.
[114] RVO, Wet natuurbescherming, 2021, URL https://www.rvo.nl/onderwerpen/agrarisch-ondernemen/beschermde-planten-dieren-en-natuur/wet-natuurbescherming.
[115] Rijksoverheid, Natura 2000, 2021, URL https://www.rijksoverheid.nl/onderwerpen/natuur-en-biodiversiteit/natura-2000.
[116] Atlas Leefomgeving, Stiltegebieden, 2021, URL https://www.atlasleefomgeving.nl/stiltegebieden.
[117] Rijksoverheid, Natuurnetwerk Nederland, 2021, URL https://www.rijksoverheid.nl/onderwerpen/natuur-en-biodiversiteit/natuurnetwerk-nederland.
[118] Atlas Leefomgeving, Nationale Landschappen, 2021, URL https://www.atlasleefomgeving.nl/nationale-landschappen.
[119] Bodemrichtlijn, Aardkundige waarden, 2021, URL https://www.bodemrichtlijn.nl/Bibliotheek/bodembescherming/aardkundige-waarden/a-ontstaan/aardkundige-waarden-in-nederland-algemeen.
[120] B. Uhde, A. Hahn, V.C. Griess, T. Knoke, Hybrid MCDA methods to integrate multiple ecosystem services in forest management planning: A critical review, Environ. Manag. 56 (2) (2015) 373–388, http://dx.doi.org/10.1007/s00267-015-0503-3.
[121] G. Higgs, R. Berry, D. Kidner, M. Langford, Using IT approaches to promote public participation in renewable energy planning: Prospects and challenges, Land Use Policy 25 (4) (2008) 596–607, http://dx.doi.org/10.1016/j.landusepol.2007.12.001.
[122] R.A. Estévez, V. Espinoza, R.D. Ponce Oliva, F. Vásquez-Lavín, S. Gelcich, Multi-criteria decision analysis for renewable energies: Research trends, gaps and the challenge of improving participation, Sustainability (Switzerland) 13 (6) (2021) http://dx.doi.org/10.3390/su13063515.
[123] L. Elghali, R. Clift, P. Sinclair, C. Panoutsou, A. Bauen, Developing a sustainability framework for the assessment of bioenergy systems, Energy Policy 35 (12) (2007) 6075–6083, http://dx.doi.org/10.1016/j.enpol.2007.08.036.
[124] L. Gigović, D. Pamučar, D. Božanić, S. Ljubojević, Application of the GIS-DANP-MABAC multi-criteria model for selecting the location of wind farms: A case study of Vojvodina, Serbia, Renew. Energy 103 (2017) (2017) 501–521, http://dx.doi.org/10.1016/j.renene.2016.11.057.
[125] G. Villacreses, G. Gaona, J. Martínez-Gómez, D.J. Jijón, Wind farms suitability location using geographical information system (GIS), based on multi-criteria decision making (MCDM) methods: The case of continental Ecuador, Renew. Energy 109 (2017) 275–286, http://dx.doi.org/10.1016/j.renene.2017.03.041.
[126] J.J. Wang, Y.Y. Jing, C.F. Zhang, J.H. Zhao, Review on multi-criteria decision analysis aid in sustainable energy decision-making, Renew. Sustain. Energy Rev. 13 (9) (2009) 2263–2278, http://dx.doi.org/10.1016/j.rser.2009.06.021.
[127] M. Habib, A. Matouk, Integrating AHP and GIS as a decision-making tool for the optimal allocation of wind farm: A case study of Syria, IOP Conf. Ser.: Mater. Sci. Eng. 800 (1) (2020) http://dx.doi.org/10.1088/1757-899X/800/1/012019.
[128] S.D. Pohekar, M. Ramachandran, Application of multi-criteria decision making to sustainable energy planning -A review, Renew. Sustain. Energy Rev. 8 (4) (2004) 365–381, http://dx.doi.org/10.1016/j.rser.2003.12.007.
[129] T.L. Saaty, A scaling method for priorities in hierarchical structures, J. Math. Psych. 15 (3) (1977) 234–281, http://dx.doi.org/10.1016/0022-2496(77)90033-5.
[130] R.W. Saaty, The analytic hierarchy process-what it is and how it is used, Math. Modell. 9 (3–5) (1987) 161–176, http://dx.doi.org/10.1016/0270-0255(87)90473-8.
[131] T.L. Saaty, L.G. Vargas, Decision Making with the Analytic Network Process: Economic, Political, Social and Technological Applications with Benefits, Opportunities, Costs and Risks, Vol. 195, 2013, http://dx.doi.org/10.1007/978-1-4614-7279-7{_}15.
[132] O.S. Vaidya, S. Kumar, Analytic hierarchy process: An overview of applications, European J. Oper. Res. 169 (1) (2006) 1–29, http://dx.doi.org/10.1016/j.ejor.2004.04.028.
[133] A. Aly, S.S. Jensen, A.B. Pedersen, Solar power potential of Tanzania: Identifying CSP and PV hot spots through a GIS multicriteria decision making analysis, Renew. Energy 113 (2017) 159–175, http://dx.doi.org/10.1016/j.renene.2017.05.077.
[134] J. Jangid, A.K. Bera, M. Joseph, V. Singh, T.P. Singh, B.K. Pradhan, S. Das, Potential zones identification for harvesting wind energy resources in desert region of India – A multi criteria evaluation approach using remote sensing and GIS, Renew. Sustain. Energy Rev. 65 (2016) 1–10, http://dx.doi.org/10.1016/j.rser.2016.06.078.
[135] H. Aras, Ş. Erdoğmuş, E. Koç, Multi-criteria selection for a wind observation station location using analytic hierarchy process, Renew. Energy 29 (8) (2004) 1383–1392, http://dx.doi.org/10.1016/j.renene.2003.12.020.
[136] S. Ali, J. Taweekun, K. Techato, J. Waewsak, S. Gyawali, GIS based site suitability assessment for wind and solar farms in Songkhla, Thailand, Renew. Energy 132 (2019) 1360–1372, http://dx.doi.org/10.1016/j.renene.2018.09.035.
[137] G.A. Miller, The magical number seven plus or minus two: Some limits on our capacity for processing information, Psychol. Rev. TA - TT - 63 (2) (1956) 81–97.
[138] T.L. Saaty, How to make a decision: The analytic hierarchy process, European J. Oper. Res. 48 (1) (1990) 9–26, http://dx.doi.org/10.1016/0377-2217(90)90057-I.
[139] T.L. Saaty, Decision-making with the AHP: Why is the principal eigenvector necessary, European J. Oper. Res. 145 (1) (2003) 85–91, http://dx.doi.org/10.1016/S0377-2217(02)00227-8.
[140] C. Faasen, P. Franck, A. Taris, Handboek Risicozonering Windturbines - Eindversie, Tech. Rep. September, 2014.
[141] RVO, Veiligheid En Windturbines, Tech. Rep., Rijksdienst voor Ondernemend Nederland, 2020, URL https://www.rvo.nl/sites/default/files/2016/05/FactsheetVeiligheid.PDF.
[142] Rijkswaterstaat, Handreiking Risicozonering Windturbines (HRW2020), Tech. Rep., Rijkswaterstaat Water, Verkeer & Leefomgeving, 2020.
[143] M. Szurek, J. Blachowski, A. Nowacka, GIS-based method for wind farm location multi-criteria analysis, Min. Sci. 21 (2014) 65–81, http://dx.doi.org/10.5277/ms142106.
[144] H.A. Effat, Spatial modeling of optimum zones for wind farms using remote sensing and geographic information system, application in the Red Sea, Egypt, J. Geogr. Inf. Syst. 06 (04) (2014) 358–374, http://dx.doi.org/10.4236/jgis.2014.64032.
[145] PBL, ECN, Verkenning van routes naar een schone economie in 2050. Hoe Nederland klimaatneutraal kan worden, 2011.
[146] Urgenda, Nederland 100 Procent Duurzame Energie in 2030: Het Kan Als Je Het Wilt! Tech. Rep., 2020.
[147] B. d. Ouden, J. Kerkhoven, J. Warnaars, R. Terwel, M. Coenen, T. Verboon, T. Tiihonen, A. Koot, Klimaatneutrale Energiescenario's 2050, Tech. Rep., april (2020, URL https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2020/03/31/klimaatneutrale-energiescenarios-2050/Rapport-Klimaatneutrale-energiescenarios-2050.PDF.
[148] Rijksoverheid, Klimaatakkoord, Tech. Rep., 2019, URL https://www.klimaatakkoord.nl/binaries/klimaatakkoord/documenten/publicaties/2019/06/28/klimaatakkoord/klimaatakkoord.pdf.
[149] S. Elmallah, J. Rand, After the leases are signed, it's a done deal: Exploring procedural injustices for utility-scale wind energy planning in the United States, Energy Res. Soc. Sci. 89 (February 2021) (2022) http://dx.doi.org/10.1016/j.erss.2022.102549.
[150] S. Gölz, O. Wedderhoff, Explaining regional acceptance of the German energy transition by including trust in stakeholders and perception of fairness as socio-institutional factors, Energy Res. Soc. Sci. 43 (January 2018) 96–108, http://dx.doi.org/10.1016/j.erss.2018.05.026.
[151] European Commission, REPowerEU: Commission steps up green transition away from Russian gas by accelerating renewables permitting, 2022, URL https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6657.
[152] J. Goodman, J.P. Marshall, Problems of methodology and method in climate and energy research: Socialising climate change?, Energy Res. Soc. Sci. 45 (August) (2018) 1–11, http://dx.doi.org/10.1016/j.erss.2018.08.010.
[153] W. McDowall, F.W. Geels, Ten challenges for computer models in transitions research: Commentary on Holtz, et al., Environ. Innov. Soc. Transit. 22 (2017) 41–49, http://dx.doi.org/10.1016/j.eist.2016.07.001.
[154] N.E. Matthews, L. Stamford, P. Shapira, Aligning sustainability assessment with responsible research and innovation: Towards a framework for constructive sustainability assessment, Sustain. Prod. Consump. 20 (2019) 58–73, http://dx.doi.org/10.1016/j.spc.2019.05.002.

[155] S. Gottwald, J. Brenner, C. Albert, R. Janssen, Integrating sense of place into participatory landscape planning: Merging mapping surveys and geodesign workshops, Landscape Res. 46 (8) (2021) 1041–1056, http://dx.doi.org/10.1080/01426397.2021.1939288.

[156] B.S. Zaunbrecher, B. Daniels, M. Roß-Nickoll, M. Ziefle, The social and ecological footprint of renewable power generation plants, balancing social requirements and ecological impacts in an integrated approach, Energy Res. Soc. Sci. 45 (2017) (2018) 91–106, http://dx.doi.org/10.1016/j.erss.2018.07.015.