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Original research article

Fields for food or electricity: revisiting spatial analysis to evaluate land-use priorities for solar siting in Swedish agricultural landscapes

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ABSTRACT

Ground-mounted photovoltaics (GMPV) expansion on agricultural land in Sweden is frequently contested, with several cases settled in court. Analysis of recent rulings and permit applications shows that authorities are determining how to prioritize vital societal interests in food production and renewable-energy deployment while a coherent legal framework remains under development. Developers, meanwhile, concentrate proposals on agricultural land near grid infrastructure, neglecting concerns about food security as well as values and identities embedded in existing landscapes. The landscape-governance lens reveals how landscapes emerge from socio-cultural processes and how conflicts around GMPV are signs of misalignments between socio-technical development and locally anchored land-use preferences. To explore alternatives aligning with social priorities in southern Sweden, we assess the potential for agrivoltaics and GMPV on rewetted agricultural peatlands through a scenario-based GIS approach. By translating the divergent reference frames of developers and regional authorities into parallel land-constraint scenarios, we show that these frames result in sharply different solar capacities (0–172 GW) and consequences for land use. Further, evaluating distance to grid against socio-economic factors shows its unsuitability as a siting criterion. Combining our spatial assessment approach with participatory iterative engagement could empirically capture land-use expectations and landscape values.

1. Introduction

Solar power is expected to drive the expanding role of renewable energy technologies in future energy systems [1]. In this context, developers of large ground-mounted photovoltaics (GMPV) have identified agricultural land as attractive for project development [2,3]. Land policy developments in the US have led to a land rush, sparking controversies over environmental and land-use impacts [4] and over “solar panel monocultures” [5]. Similar policy developments that favour solar energy in cases of land-use competition [6] are causing tensions in Europe, where GMPV developers are associated with the concept of *green grabbing* [7], i.e., the control and capture of land and natural resources “in the name of environmentalism or sustainable development” [8]. The East German “solar rush”, in which agricultural land was viewed as a “mere economic resource”, led to public rejection of GMPV [9] and illustrates how these tensions can complicate the transition to a renewable-based energy system.

In a 2024 study, Spangler et al. [10] draw critical attention to the uncertain yet widely disseminated narrative that GMPV on agricultural

land could function as a “30-year cover crop”, with farmers returning to traditional agriculture production once the lease expires. That narrative warrants investigation because the current understanding of the environmental impacts of solar power on land remains limited, context-biased, and methodologically inconsistent, underscoring the need for standardized long-term monitoring and adaptive management to ensure a safe energy transition [11]. By hampering incoming light, GMPV alter micro-climates [12] and physically impact land during construction making soil less stable, lowering its overall quality [13]. Further, there are concerns over cumulative socio-ecological and justice effects tied to PV supply chains [14]. These concerns add to various existing challenges in the agricultural sector, such as the transition to sustainable agriculture [15], soil degradation [16] and food security [17]. Related to this, multifunctional use of space has been proposed as a win-win option, combining, for example, energy and food supply in the concept of Agrivoltaics (AV) [18,19], energy supply and carbon-emission reduction from peatlands in photovoltaics on agricultural peatlands [20], and multiple energy outputs in hybrid power plants [21,22], aligning with European policy frameworks aimed at accelerating the deployment of

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renewable energy sources in designated acceleration areas [23].

The interplay between electricity generation and land use has been the main focus in criteria-based and social [25] energy-siting assessments. Criteria-based siting typically involves operationalising various criteria such as land cover, electric infrastructure, or protected areas as parameters in Geographic Information System (GIS) frameworks [3] to support analyses of different societal impacts [26,27]. Such analyses may also be expanded to include scenario development, to capture different land-use priorities among societal stakeholders [28]. In order to assess land suitability, GIS analyses are combined with frameworks such as multi-criteria decision analysis (GIS-MCDA) [20,24,29,30]. Studies that apply high technical detail for assessing GMPV [29] and AV [20] significantly enhance suitability assessments, but risk being incompatible with environmental-justice considerations. Due to their emphasis on techno-economic aspects and top-down approach, instead of focusing on people and places, land gets treated as an abstract asset rather than the setting of cultural activity [30].

This study explores the development of GMPV on agricultural land using as a case two Swedish counties, Skåne and Halland. Here, 30% of the nation's food production takes place on 4% of the country's land area, and associated land-use conflicts are increasingly being resolved at the highest judicial level. This makes the region an important setting in which to examine how solar power development intersects with agricultural land use. So far, AV's technical potential and contributions to electrification targets have been in focus [31], and, to the best of our knowledge, socio-ecological land-use impacts and drivers of conflict in agricultural contexts have not been analysed. To address this gap, we aim to provide an overview of the development of GMPV, as well as analyse the interplay between solar power and land use to identify and assess the drivers of land-use conflicts in the case region. The aim results in three objectives: (I) map trends in land use and evaluate conditions for establishment of GMPV; (II) assess the role of electrical infrastructure as a siting criterion by exploring the economic impact of increasing the length of power lines to increase available land-use options; and (III) assess other feasible options including combinations of agriculture and PV, that could reduce land-use conflicts. Extending GIS-based solar siting research by developing a framework that replaces MCDA weighting with stakeholder-informed scenario development rather than collapsing diverse social and technical priorities into fixed weights, our approach represents the distinct reference frames that different actors bring to the siting process. This allows us to trace how siting criteria vary across actors, how these differences shape estimates of regional solar potentials, and how planners can more transparently navigate the trade-offs involved in GMPV development.

We start by explaining the background and supporting our choice of framework, see Chapter 2. In Chapter 3, we describe our methodological choices. Chapter 4 presents the results for the three research objectives. In Chapter 5, we discuss estimates of the potential land area and the relevance of the analytical framework, before presenting concluding remarks in Chapter 6.

2. Background

2.1. Case overview

The study focuses on the counties of Halland and Skåne, which together constitute Sweden's south-west coastal region (see Fig. 1). The region has a mild, maritime climate with relatively warm summers (average around 18 °C), cool but not severe winters (0 °C), and frequent coastal winds. Rainfall is higher in Halland (700–1300 mm per year) than in Skåne and fairly evenly spread through the year [32,33]. Owing to favourable soil conditions and high annual solar irradiation along the west coast and in southern Skåne [34], the region has long been one of Sweden's main agriculture regions. The region's high contribution to domestic food supply, particularly for key cereal crops, underscores its importance for national food security. In addition, the region is densely

populated with a dense electrical grid and is a net importer of electricity, further reinforcing its relevance at the intersection of land use, food security, and energy system planning.

Initially, rooftop PV installations dominated solar PV development in Sweden [35], but with the drop in unit prices, new applications have proven cost effective, and interest in projects connecting GMPV sites to the Swedish national grid is sky-rocketing [36]. So far, Swedish GMPV developers have mainly focused on customers [37], while environmental and land-use aspects have received less consideration [38]. Sweden does not apply feed-in tariffs, meaning that GMPV sites operate mainly under merchant business models exposed to spot-market price fluctuations (supplemented by tradable green certificates), with some developers making use of corporate bilateral power purchasing agreements [39].

As of 2025, interest in GMPV has grown rapidly, the authorities have been processing applications from developers, while legislation to deal with the new land claims is still at the formative stage. There is also limited support in the form of pre-existing spatial planning identifying suitable areas for establishing GMPV projects. The siting process is therefore based on techno-economic considerations, where the cost and accessibility of a site and its proximity to existing electrical infrastructure are key parameters [38]. The willingness to pay for access to land varies widely according to geographical location and potential alternative uses, from levels reflecting current agricultural use to several-fold higher [39].

2.2. Renewable electricity or food security

To understand the legal conditions for GMPV development in the case region, three kinds of input (voices) in the discourse on the legal situation were documented and interpreted, namely (i) applications for GMPV permit approval ($n = 23$), including a city hearing; (ii) regional authorities' guidelines for developers ($n = 2$); and (iii) cases brought to and ruled on by the Land and Environment Court of Appeal (LECA) ($n = 5$). The three kinds of input are described further in appendix A. Understanding the discourses that connect and shape the process of establishing the legal praxis for the development of GMPV on agricultural land is crucial, as the expansion of GMPV often proceeds rapidly once permits are secured, with few barriers to widespread implementation [41]. As of 2025, there is no legal praxis for when it can be allowed to establish any solar power on arable land. Fig. 2 provides an overview of the evaluated stakeholders and their respective goals for the formation of legal praxis.

In the absence of legal praxis and guidance from authorities concerning GMPV siting in the case region,¹ developers have identified suitable sites themselves and contacted landowners (or vice versa) without knowing the legal permissibility of a site. If the identified suitable site is agricultural land, the permissibility decision starts with the legal decision on whether agricultural land is permanently occupied when the GMPV is established; initially, there was no consensus on whether siting GMPV on agricultural land would indeed “permanently” occupy it. The key issue is whether an installation is of substantial duration. Until LECA ruled that such land would in fact be occupied in the relevant sense by a GMPV project (M 1026–22 & M 15064–21), the County Administrative Boards² (CAB) approved several GMPV sites on agricultural land without the need for a permitting process. Following the two LECA court rulings (ibid.), agricultural land is considered protected for food security (the LECA considers both food production and

¹ The CAB of Skåne issued its first guidelines in 2024 following M 13461–22. One region outside the case region (Västra Götaland) had already published guidelines as of 2024, but those were revised following the same ruling.

² In Sweden, there are 21 County administrative boards tasked with ensuring that national goals and targets are implemented with consideration of regional conditions.

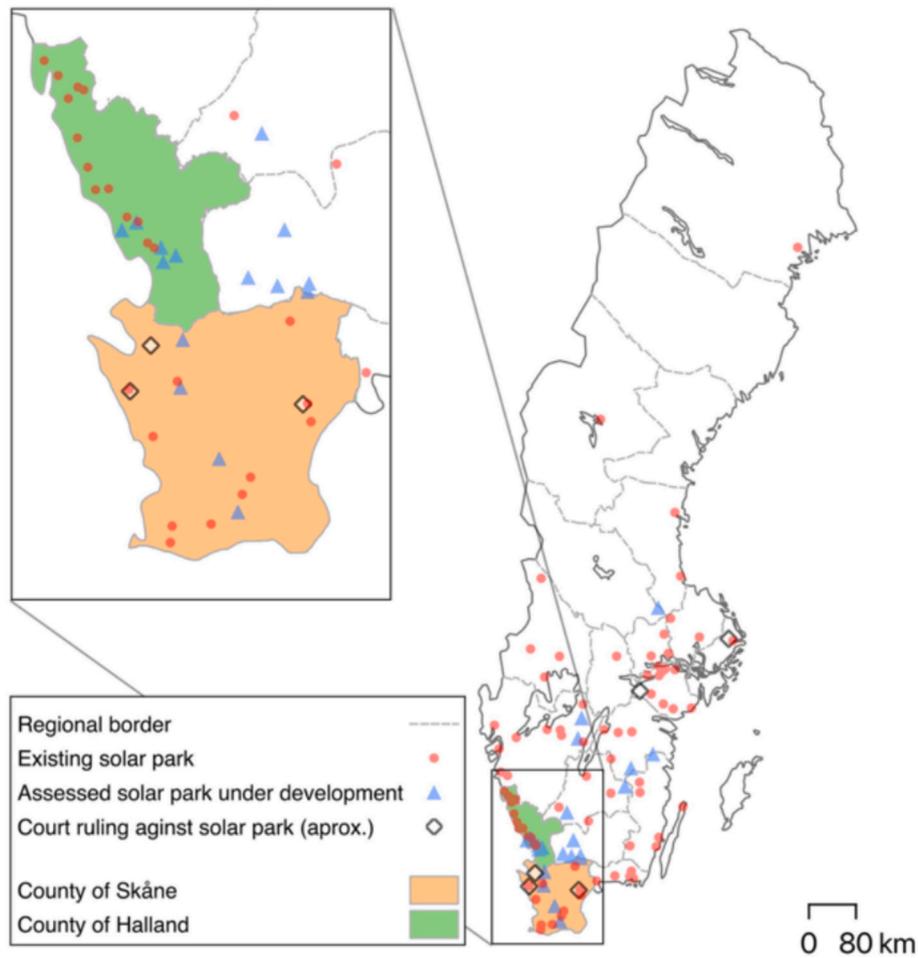


Fig. 1. Case region map, Halland in green and Skåne in orange. Red dots show ground-mounted photovoltaic (>0.5 MW) sites [40], blue triangles sites under development assessed in this study (our own compilation), and white diamonds site of rulings issued by the Land and Environment Court of Appeal (our compilation). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

supply) relative to the relevant development under the Environmental Code, meaning that energy developers must go through a permitting process with the CABs. The latter are now tasked with evaluating the

legal permissibility following the ruling in LECA. Confronted by the fortified legal standing of agricultural land, the GMPV developers employed an alternative interpretation of the Environmental Code to

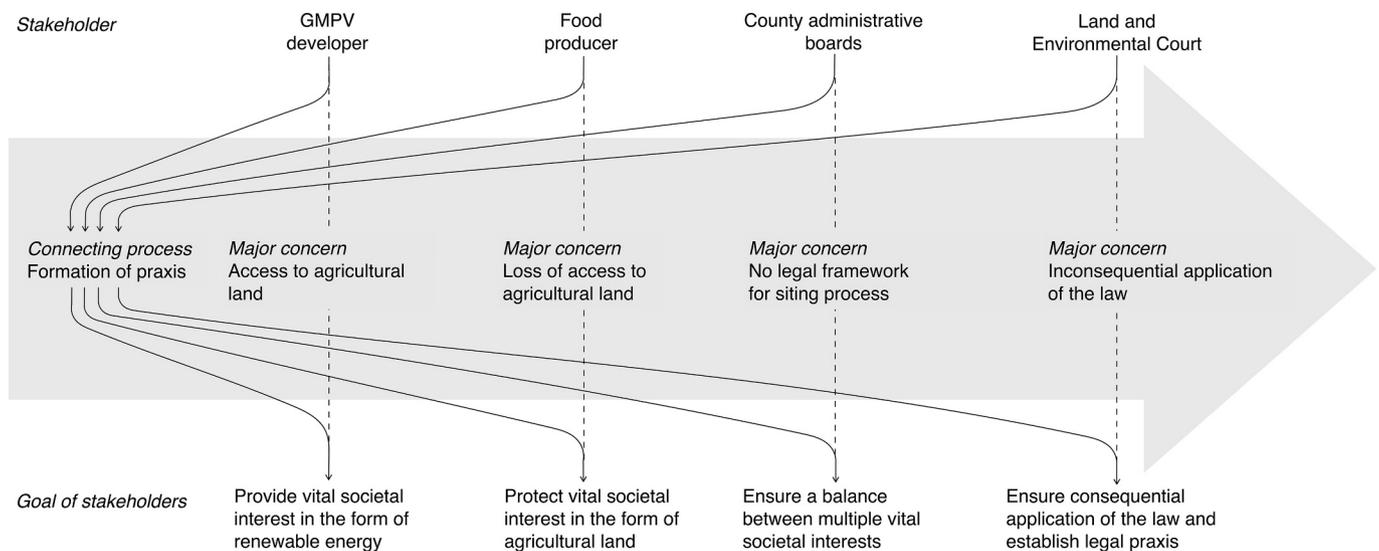


Fig. 2. The four stakeholders and their respective concerns and goals in the legal battle over land-use interpretations in the site-permitting process. The process starts with a developer of ground-mounted photovoltaic (GMPV) applying for a permit to establish at a specific site. Based on all GMPV cases ($n = 5$) in the Land and Environment Court of Appeal as of December 2024. Figure inspired by [42] and adapted to the current study's context.

circumvent the necessity for a permitting process with the CABs. They argued that land should not be considered permanently occupied by the GMPV project if the land is continuously used for agricultural activities, e.g., sheep grazing (under the panels) or cultivation of permanent grasslands of high biodiversity value. Ultimately, the LECA ruled that some degree of continued cultivation was insufficient to challenge the legal fact that at least some of the land was permanently occupied and therefore covered by the Environmental Code, i.e., the need for the permitting process remains (M-8658-23).

The next step of the permitting process considers whether the agricultural land is productive (CAB of Skåne considers almost all agricultural land to be productive, see appendix A, table A.2), and whether renewable electricity from GMPV is a vital societal interest (ruled so in M 13461–22). The CAB then requires developers to carry out an Environmental Impact Assessment (EIA) to create a shared knowledge base among stakeholders and support an informed decision by the authority. The assessment goes beyond physical impacts such as habitat loss and land-use change to include the experience of the agricultural landscape, with considerations such as visual appearance, living environment, and recreation and leisure opportunities. This is usually the first time the public is informed about the project, as the EIA process includes public hearings to gather relevant input. Further, to justify lifting the Environmental Code's legal protection of agricultural land, developers must demonstrate that electricity generation from GMPV is not only a vital societal interest, but one that takes precedence over food production, which the LECA regards as the primary societal interest. (M 13461–22).

To demonstrate that electricity generation takes precedence over food security (the rulings include both food supply and food production) in a particular case, developers need to show that there is no technically viable electricity generation alternative to GMPV sited on agricultural land. Initially vague (M-1026-22), the required assessment was gradually refined to include, in 2021 multiple sites (M 15064–21), 2022 other renewable energy sources (M 13461–22) and in 2023 alternative grid connections (M-6624-23). If the CAB decides that there are no alternative sites, that the project serves a vital societal interest, and is the most appropriate use of the land, permission will be granted to establish GMPV on the site. To ensure uniform application of the law, the permit can be appealed in two instances – in the relevant Land and Environmental Court and finally in the LECA. In its rulings, LECA stresses the role of the CAB as the societal planner with a unique regional perspective, basically suggesting that it is the CAB evaluation that determines whether it is food security or renewable electricity generation that is the primary societal interest (M 13461–22).

2.3. Spatial analysis revisited

Section 2.2 illustrates one example of social implications of land-use change in the wake of the Swedish energy transition. Drawing from a study in the rural New York area, Stedman and Nilson [43] suggest that energy transitions transform socio-ecological system by regrouping governance systems, markets, social relations, landscapes and communities. Participants in the New York area study “*emphasised that the project developers were an out-of-state energy conglomerate, an explicitly non-local entity*”. Similarly, in a town hearing in Halland, the international funding of a large-scale GMPV project was similarly contested (see table A.1 in appendix A).

Changes in governance system, social relations and landscapes are interpreted and given meaning in the context of the existing landscape [43]. However, a landscape can be many things and exist at many scales. On landscape governance, here defined as the political and interdisciplinary process of shaping and managing landscapes [44,45], Arts et al. [44] draw from the work of Görg [46] to argue that central in the governance question is the notion that landscapes are not ontologically fixed, but rather constantly shaped and re-shaped by socio-cultural practices and natural conditions. By transforming existing land-use practices that shape the landscape, the very same landscape is

reshaped, leading to conflict with cultural identities (social relations, landscapes and communities) and values attached to the existing landscape – a mechanism confirmed empirically in discrete choice experiments [47–49].

Conflicts over land-use change indicate a misalignment between local expectations and socio-technical development. If solar power projects are contested, it is partly due to their incompatibility with norms and values that are legitimate in those locally existing governance structures [50], actively forming the landscape. Considering prudent land use, identified by Schram et al. [50] as a value relevant for assessing solar power [50], solar power that by technical design maintains landscape features (e.g. food production or grid distance) or climate change mitigation (e.g., rewetting of landscape) is more likely to align with social expectations, while still pursuing broader societal objectives of renewable energy growth.

Swards et al. [30] demonstrate how public acceptability can be woven into conventional GIS-MCDA by incorporating people- and place-based factors—such as socio-economic patterns, community perspectives, and environmental justice concerns—highlighting the substantial but necessary effort required to gather these social data. Public participation GIS initiatives map landscape values relying on “lay” knowledge to identify place value and (ideally) informing, rather than deciding, as MCDA does, land-planning processes [51]. Other scholars instead suggest adopting a relational perspective, suggesting that a chief limitation in the treatment of social acceptance within renewable energy technology research is “its focus on the individual as being the ‘source’ of opposition to renewable energy technology” (37). Such a bottom-up perspective contrasts with top-down approaches in techno-economic spatial analysis, and further work is needed to fully incorporate landscape values and social considerations into GIS modelling.

3. Method

3.1. Grid proximity

The characteristics of the electrical infrastructure in the vicinity of a proposed GMPV site are highlighted in all covered GMPV permit applications (see appendix A, table A.1 for included projects). Developers commonly emphasize three major factors: the distance to the nearest power line, the voltage level of that line, and the capacity to accommodate additional electricity at the grid connection point. GMPV developers argue that exceeding a specific threshold distance voids economic profitability. While this threshold may exist in practice, increasing the length of powerlines could create opportunities to avoid sites where GMPV deployment is likely to be opposed. A fundamental driver of land-use conflict is the historical development of agriculture and of electrical infrastructure, which often overlap geographically—both having emerged as essential resources alongside human settlements. Challenging the notion of a fixed threshold distance could widen the range of viable sites for solar projects, potentially alleviating concerns about proximity [30] and procedural justice [50].

3.2. Agrivoltaics

As illustrated in Section 2.2, legal support for claiming productive agricultural land for GMPV is not a given. However, combining food and electricity production, as initially suggested by Goetzberger and Zastrow [52], may offer a land-use practice that influences acceptance [53] of solar power in agricultural landscapes. Promising to enhance land-use efficiency [54], two dominant AV designs include vertical rows of PV modules with crops in between, and elevated structures with PV modules overhead. Data for the latter in a study by [19] suggest a theoretical electricity yield of 0.4 MW per hectare for an AV system in the case region, compared to GMPV projects that typically yield 0.5–0.6 MW per hectare [40]. Based on statistical analysis, the AV potential in the EU is estimated at 1 TW of PV capacity on 1% of utilised agricultural area

[55]. While the report does not state nation-level details, Elkadeem et al. [31] use a techno-economic GIS assessment to estimate that 1000 ha (corresponding to 400 MW) could be considered of high suitability (limiting suitable land use to pastures) for AV in the case region. The suitable land is significantly higher if considering all land use, 737,000 ha corresponding to 295 GW (see table 5 in 32). However, it should be noted that these prioritisations reflect subjective decisions by experts, given that, as shown in chapter 2.2, all agricultural land can be considered protected by the Environmental Code. Further, specific land use (e.g., pasture or arable land) typically changes from year to year with crop rotations.

Frameworks for AV regulation have been created in countries like Japan, Germany, France, and Italy. The frameworks are outlined in Table 1, based on Dupraz [54] including latest regulatory developments as of late 2024. Italy's reverse auction scheme allows coalitions—provided they include at least one stakeholder from the agricultural sector—to submit project bids. Successful applicants are eligible for subsidies covering up to 40% of investment costs, with a total allocation of €1 billion available under the scheme. Such arrangements may improve the legitimacy of AV projects by including relevant stakeholders, in turn promoting acceptance.

AV is in the early development stage with few commercially operating sites. Several challenges, including shading impacts and border effects [18,54], integration of multiple crops in an AV system [19,60], public acceptance [25], and the risk of rent-seeking behaviour [61], still need to be addressed. Shade-sensitive crops (e.g., cereals) may also be particularly impacted by limited available sunlight during autumn-spring in the case region, and empirical data are needed.

Early research on AV has primarily focused on single-crop or pasture [62,63] or limited-crop combinations [64,65], leaving crop-rotation implications understudied [60]. Some authors suggest focusing on AV applications with permanent crops [19], or in specific settings such as for pest control [66]. Understanding the impact on crop rotation, and potential implications of integrating with AV, is vital to ensure food security [60].

While AV could potentially mitigate land competition, there is concern that AV deployment as a “techno-fix” risks undermining agricultural landscapes and reducing farms to economic assets [15,25,67]. One such sign in the European context is the land rents paid by AV developers, which can be ten times higher than equivalent rents intended for agriculture [9,61]. Such land rents might reinforce rent-seeking behaviour where investors or developers prioritize profit-maximization on agricultural land, neglecting the broader goals of agricultural productivity or community well-being [61]. Furthermore, lower crop yields under AV systems (recognized as tolerable in EU policies, see Table 1) mean that AV expansion will lead to reduced crop output, which in turn may result in greenhouse gas (GHG) emissions and biodiversity impacts associated with indirect land-use change [11]. Thus, the deployment of AV systems must carefully balance electricity production with agricultural and broader socio-environmental impacts, including the monetization of agricultural land that undermines its agricultural value.

3.3. Photovoltaics on rewetted agricultural peatland

The second multifunctional land use focuses on agricultural land that is already targeted for land-use change due to environmental policies. Agricultural peatland accounts for roughly 7 % of total agricultural land in Sweden, but its use causes one third of agriculture's total GHG emissions [68]. A national policy aims to subsidise the rewetting of around 10,000 ha of such lands (NV-11039-22), to reduce agricultural GHG emissions [69].

To reduce GHG emissions from the soil, while simultaneously producing electricity, PV modules can be placed on rewetted agricultural peatlands (here, RWPV). While the concept has been brought up in the literature [20,70], empirical data are missing as of 2025, since no RWPV

project exists in the case region. We expect electricity output per hectare to be similar to the average for GMPV sites established in Sweden as of 2024, i.e., 0.54 MW per hectare [40].

The possibility of locating GMPV on agricultural peatlands allows agricultural land tenants eligible for the rewetting subsidy scheme to control which land is used within certain soil conditions. Local communities around peatlands are likely in many places unaware of the potential for RWPV, which may not necessarily align with their sense of place. However, by embedding solar power within local social structures [43], this approach could facilitate solar deployment while maintaining existing land-governance structures, thereby minimizing social impacts.

3.4. Increased technical detail of constraints

Current GIS methods, which primarily assess site suitability by measuring the distance to power lines [24,30], overlook economic incentives implied by selective targeting of low-rent land. The cost of extending powerlines may be offset by lower rents further from the grid; this alternative method³ integrates economic trade-offs that could open new possibilities for balancing the expansion of GMPV within existing governance structures.

The least-cost alternative to transmit the required current for 1 to 63 MW of peak capacity was found by modelling three aspects that influence the required cross section and thus the total price: local voltage level of the sub-transmissional (10 kV or 20 kV), maximum peak capacity of the GMPV site (63 MW, limited by grid characteristics) and cable cost (including the average installation cost for 2022 [71]).

The hypothesis is that GMPV developers' willingness-to-pay for access to agricultural land (land rent) is highest close to appropriate electrical infrastructure where large GMPV projects can be established. It decreases as the realizable project size decreases or the required power-line length increases. To examine the economic cost of increasing the length of power lines, we calculate and compare the net present value of the annual rent savings with the cost of the required additional power line for two voltage levels. According to Lindahl et al. [39], annual rents for Swedish GMPV projects range from €278 to 2473 per installed MW of capacity. Based on an average agricultural land rent of €400 per hectare [72], and an average land-energy density of 1.84 ha per MW_p [40], the minimum rent is set to €736 per MW_p. Below this price, landowners in the case region are assumed to decline bids from GMPV developers. From the same authors we obtain the estimates 14 MW_p to 3 MW_p for large and small sites associated with the land rents, respectively. There is a lack of empirical data on the rate by which willingness to pay decreases with increasing distance to the grid. We use the longest distance mentioned by GMPV developers in project applications, 5 km, as a benchmark, justified by the fact that both the mentioned distance and the willingness to pay are related to the GMPV developer.

The annual savings from moving to a site further from the grid is summarised as a net present value test using Eq. (1), where N is the expected lifetime (30 years), R_{IC} the size-dependent annual savings in land rent, t is the year, i interest rate, and C_{PL} the cost of new power lines.

$$NPV(V_L, IC, d, t) = \sum_{t=1}^N \frac{R_{IC}}{(1-i)^t} - C_{PL}(V_L, IC, d) \quad (1)$$

Once the net present value is established, each site size is compared with its associated investment in new power lines. The interest rate GMPV developers are subject to is 1.4%, according to [39], thus a discount rate of 1.4% was used for future yearly savings on land rent.

³ See supplementary material for further details.

Table 1

Agrivoltaic policies in selected European countries. CAP: Common Agricultural Policy, main EU agri-subsidy; GMPV: Ground-Mounted PhotoVoltaics; AV: Agri-voltaics, combined agricultural and photovoltaic activity.

	Policy framework	Land-use constraints	Inclusion of agricultural sector	Yield loss tolerances	Source
Sweden	None, 85–90% CAP payment	GMPV legal under specific circumstances, AV no exception	No	Not specified. Suggestion to allow 10–15% land area lost	[56]
France	Integrated legal framework, CAP maintained	GMPV forbidden except for in designated areas, AV authorised when providing increased agri-value	Partly, emphasised through criteria ensuring continued agricultural use	Maximum 10%	[57]
Italy	National auction scheme of €1B laid out in 2024, no CAP payment	GMPV forbidden	Yes, at least one actor in project	PV system not to cover more than 30% of land	[58]
Germany	Standard established, 85% of CAP payment	GMPV and AV allowed on farmland	No	15% land loss	[59]

3.5. Spatial assessment revisited

3.5.1. GIS analysis of land

A GIS model was constructed using QGIS 3.34 *Prizem* to investigate which land types have been used for GMPV in the case region. Geographic GMPV data are available from the CAB and were used in conjunction with the National Land Cover Data (NLCD) [73]. In the NLCD, agricultural land is classified as arable land. As NLCD data are based on 2018 as the baseline year, and only two parks existed in the case region prior to that time, it is possible to determine land use prior to GMPV. To cover the two sites that existed before 2018, we assessed historical photographs with a mapping software. We then extend the GIS analysis to classify the NLCD data in relation to the distance to the regional grid, with the aim of answering why certain land covers were used in establishing the GMPV.

3.5.2. GIS modelling of land potentials

The second part of the GIS analysis, illustrated in Fig. 3, builds on established GIS-MCDA approaches [30] but deliberately excludes the MCDA weighting step. Instead, we apply a scenario-based approach informed by stakeholder input (described below) to examine how different social and technical constraints influence the total installed capacity of solar power in the case region.

Our methodological contribution lies in offering a GIS framework explicitly designed to represent multiple *reference frames* that coexist within a region. Siting criteria such as the minimum distance to the nearest settlement vary substantially depending on which actor's perspective is adopted, with solar developers typically proposing shorter distances than residents consider acceptable.⁴ By incorporating these variations as distinct scenarios, we can evaluate parallel estimates of solar potential without categorising land into static classes such as “excellent” or “unsuited”.

Removing the MCDA component shifts the purpose of the analysis from producing a single, optimal suitability map toward clarifying how solar power potentials change under different social assumptions. This allows for a more transparent link between spatial data and the diverse interests of people living in the landscapes where solar development is being considered. The scenario approach also engages with legal ambiguity that can surround land-use decisions for energy and agriculture, where planning bodies must weigh competing societal objectives without clear guidance. By making these trade-offs visible in parallel scenarios, the resulting scenarios provide regional planners and policymakers with spatial information for balancing multiple societal objectives—including renewable-energy expansion and food security—while avoiding the implicit value judgments embedded in conventional MCDA weighting.

⁴ As suggested by the planning permit documents (listed in appendix 1) as well as during the GMPV project town hearing in Harplinge, Halland county, 2024.

We model three scenarios and two cases of technologies representing multifunctional land use, resulting in six estimates of land potentials and the respective total installed capacities. In the first technology case, AV projects are allowed on agricultural land. In the second technology case, PV projects are limited to agricultural peatlands, providing an opportunity to establish RWPV when combined with rewetting. The designation “available land” is based on all the agricultural plots receiving CAP payments for 2023 and classified as arable land. For RWPV, the parts of plots overlapping with peatland patches are selected for PV, while the remainder, i.e., mineral soils, are continuously cultivated.

To construct the three scenarios, we first screened applications for GMPV permit approval. Screening the documents ($n = 23$) yielded seven types of land criteria (constraints) and their associated datasets, see Table 2. We then used these constraints to define three sets of increasingly restrictive scenarios yielding estimates of available land. The maximum distance to the grid is 5 km in each scenario. Integrating further technical constraints, such as incoming sunlight and terrain slope could be beneficial to identify sites with the highest suitability. However, we argue that fitting preconditions for food production, i.e., access for heavy machinery and adequate incoming sunlight, also fulfil fundamental technical aspects for land potentially suitable for solar power. Given our focus on potential development, rather than ideal development, this limitation does not impact the results. Scenario 1 allows projects on agricultural land and on rewetted peatland, requires no buffer zone outside nature reserves or settled areas, and is allowed in nature conservation areas and biotope protection areas. In Scenarios 2 and 3, GMPV is not permitted in nature conservation areas or biotope protection areas, and there is a 1 km buffer zone around nature preserves. For Scenario 2, there is a 100 m buffer to settled areas; for Scenario 3, that buffer is 500 m, see Table 2. To get the potential installed capacity for each land potential, we used a conversion factor of 0.4 MW per ha for AV,⁵ and 0.54 MW per ha for RWPV.

4. Results

4.1. GIS analysis of land use and cover

By July 2024, the case region included 35% of the total number of GMPV sites in Sweden (representing 80.2 MWp, or 30% of the total national installed capacity of GMPV). Fig. 4 shows the distribution of GMPV sites (4a) and installed capacity (4b) across the three land covers utilised for GMPV in the case region (Arable land; Artificial surfaces; Other open land). Initially, GMPV development focused on open land, such as grasslands and roadside hard shoulders, but a shift to agricultural land began in 2018. In 2019, agricultural land accounted for 18% of total installed capacity, a figure that surged to 92% within three years. In 2024, 18 out of 24 sites were located on farmland. The difference

⁵ For a comprehensive review of available technological configurations of agrivoltaic systems the reader is referred to [74].

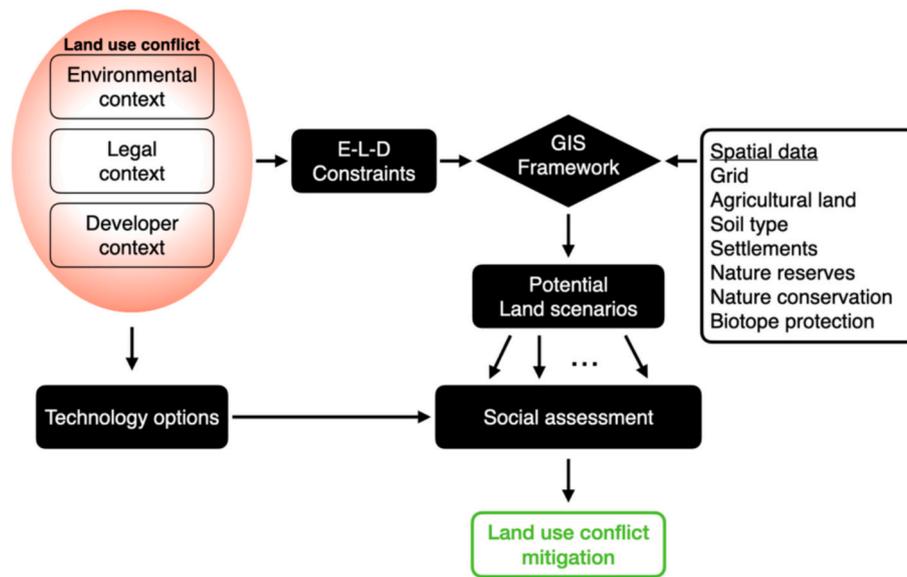


Fig. 3. The study's workflow. “E-L-D” refers to the environmental, legal and developer context. “Social assessment” refers to broad societal implications for individuals, landscape, the environment and climate policy.

Table 2

Scenario specifications: Land constraint, technologies (Agrivoltaics and rewetted peatland photovoltaics), type of constraint on land use, reason for consideration, scenario mapping, data sources.

Constraint	Technology	Type of constraint	Reason for consideration	Included in set of potential land area			Data source
				Scenario 1	Scenario 2	Scenario 3	
Agricultural land	Agrivoltaics	On	Main interest of GMPV developers	Yes	Yes	Yes	[73]
Organic soil	Rewetted photovoltaics	On	Peatland	Yes	Yes	Yes	[75]
Distance to grid (m)	Both	Distance	Key constraint	5000	5000	5000	[76,77]
Nature reserves	Both	Width of buffer zone (m)	Environmental impact	No constraint	1000	1000	[78]
Nature conservation areas	Both	Outside	Environmental impact	No constraint	Yes	Yes	[79]
Biotope protection areas	Both	Outside	Environmental impact	No constraint	Yes	Yes	[80]
Settlements.	Both	Width of buffer zone (m)	Public acceptance	No constraint	100	500	[81]

between the number of sites and the installed capacity highlights the larger size of GMPV sites on agricultural land. This land has become the primary target for GMPV developers who seek to minimize costs by focusing on land with maximum incoming solar light, minimal requirements on preparatory groundwork, and favourable distances to electrical infrastructure. Developers have focused on areas previously cleared for agriculture to benefit from previous use that has rendered the land suitable for siting GMPV. In 2020, there was development on artificial surfaces, including gravel fields and quarries. However, this only represents 0.6% of total GMPV capacity in the case region as of mid-2024.

GMPV sites are, on average, located 1800 m from the sub-transmission grid. Closest to the power lines, more than half of the area is classified as open land—including arable land, other open areas, and artificial surfaces, see Fig. 5. As the distance to power lines increases, forested land increases and agricultural land decreases. Regardless of the distance to power lines, approximately 5% of the area is classified as either waterbodies or wetlands.

The land cover distribution, together with findings from project planning documents from GMPV developers, provides valuable insights into the establishment of GMPV projects in the case region. Initially, small sites were utilised, often comprising abandoned industrial sites, quarries, and landfills. However, such land decreased in importance as GMPV developers minimized costs and complexity by engaging with single landowners that could provide access to larger areas. Achieving

economies of scale—where larger capacities result in increased profitability—further necessitated larger sites. Forested areas were typically excluded due to the high costs associated with preparatory groundwork, including the removal of harvest residues (e.g., stumps), and to unsuitable soil types.

4.2. Evaluation of techno-economic constraint

With the distance to electrical infrastructure as the key constraint, this section answers the question of whether access to less expensive land can justify the investment in longer powerlines. We first present the market cost of power lines in the case region and then the results from the net present value test showing potential trade-offs.

4.2.1. Cost for grid connection for different GMPV sizes

There is an initial sharp decline in grid connection costs as the GMPV site capacity increases, see Fig. 6. Costs fall sharply up to 5–10 MW and then level off to a relatively stable level at 20 MW and above. Since GMPV sites were initially small, with the first site greater than 5 MW built in 2021, early projects faced high per-km costs. This incentivized proximity to existing grid infrastructure, where, as seen in Fig. 5, agricultural land is the most common land cover.

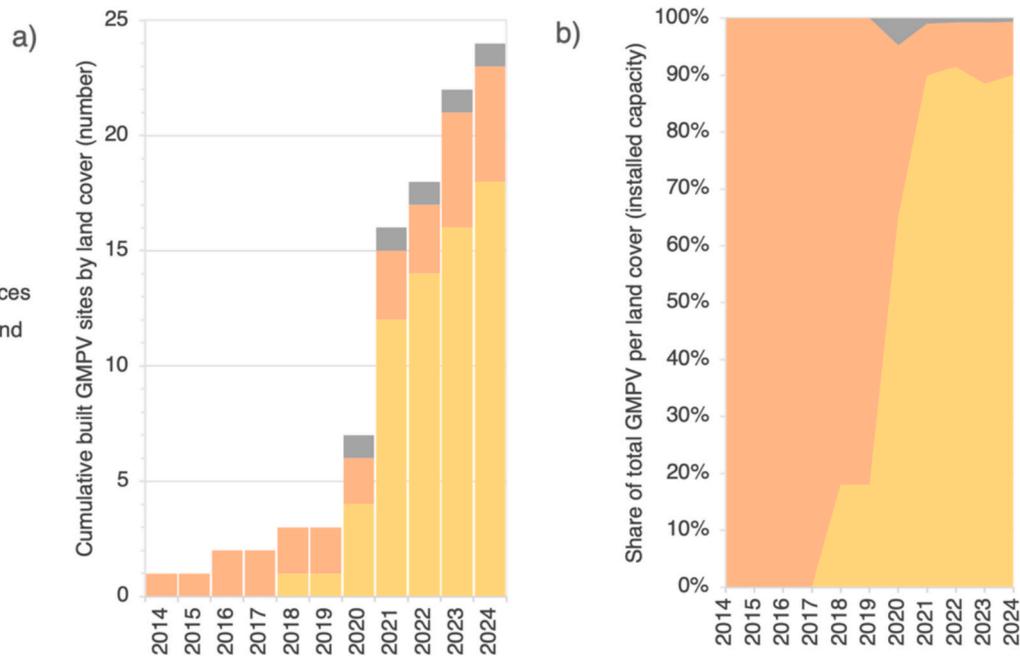


Fig. 4. Data for the case region. a) Cumulative number of built ground mounted photovoltaic (GMPV) sites over 0.5 MW of installed capacity per land cover. b) Cumulative GMPV sites (over 0.5 MW), expressed as share of total installed capacity per land cover. The relevant land cover is determined by the main land use prior to the GMPV project, at which point the land-use cover changed to energy production.

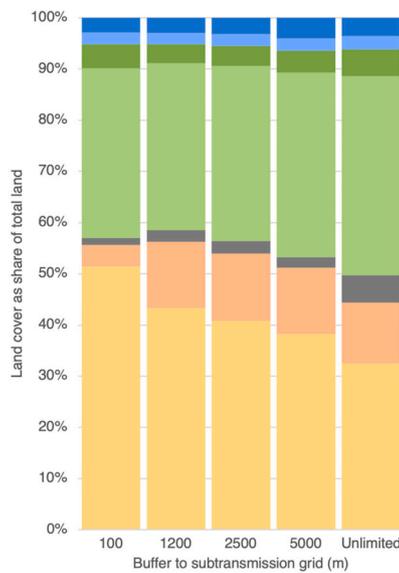


Fig. 5. Land cover within buffer of given distance to subtransmission grid, *unlimited* includes all land regardless of the distance to power lines. Land use based on [73].

4.2.2. Profitability for increased distances to grid through access to less expensive land

The economic feasibility of a strategy to establish GMPV sites further away from regional power lines, leveraging less expensive land, is shown in Fig. 7. While this strategy is viable in most cases, smaller sites—particularly those below 10 MW, and even more so those below 5 MW—are less compatible with the strategy. An equilibrium distance for 10 kV lines appears between 7 and 8 km. In the 20 kV case, variance is greater, and the equilibrium distance is in the range of 10–14 km. The data highlight a clear trend: higher voltage levels enable cost-effective greater distances between the existing grid and the GMPV site. However, the equilibrium distance is impacted by the rate of decrease in rent

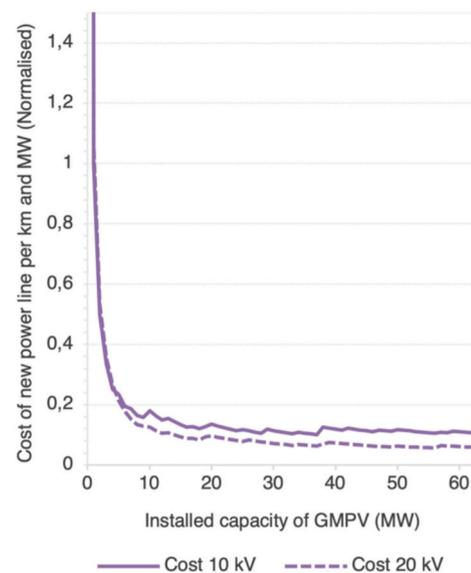


Fig. 6. Decreasing cost when increasing ground-mounted photovoltaic site size (installed capacity) illustrating economy of scale. Costs are normalised to the 1 MW, 20 kV case. The voltage levels correspond to levels present in the regional grid. Costs based on [71].

and the discount rate. While our choice of the latter is supported by empirical evidence, a changing world economic context with higher interest/discount rates could significantly reduce the equilibrium distance estimates.

4.3. GIS analysis of multi-functional land

The additional social constraints imposed in Scenarios 2 and 3 more severely limit land availability than the techno-economic factor of distance to grid, see Fig. 8. In Scenario 2 (100 m buffer zone to closest settlement, outside nature protection areas and 1 km distance from

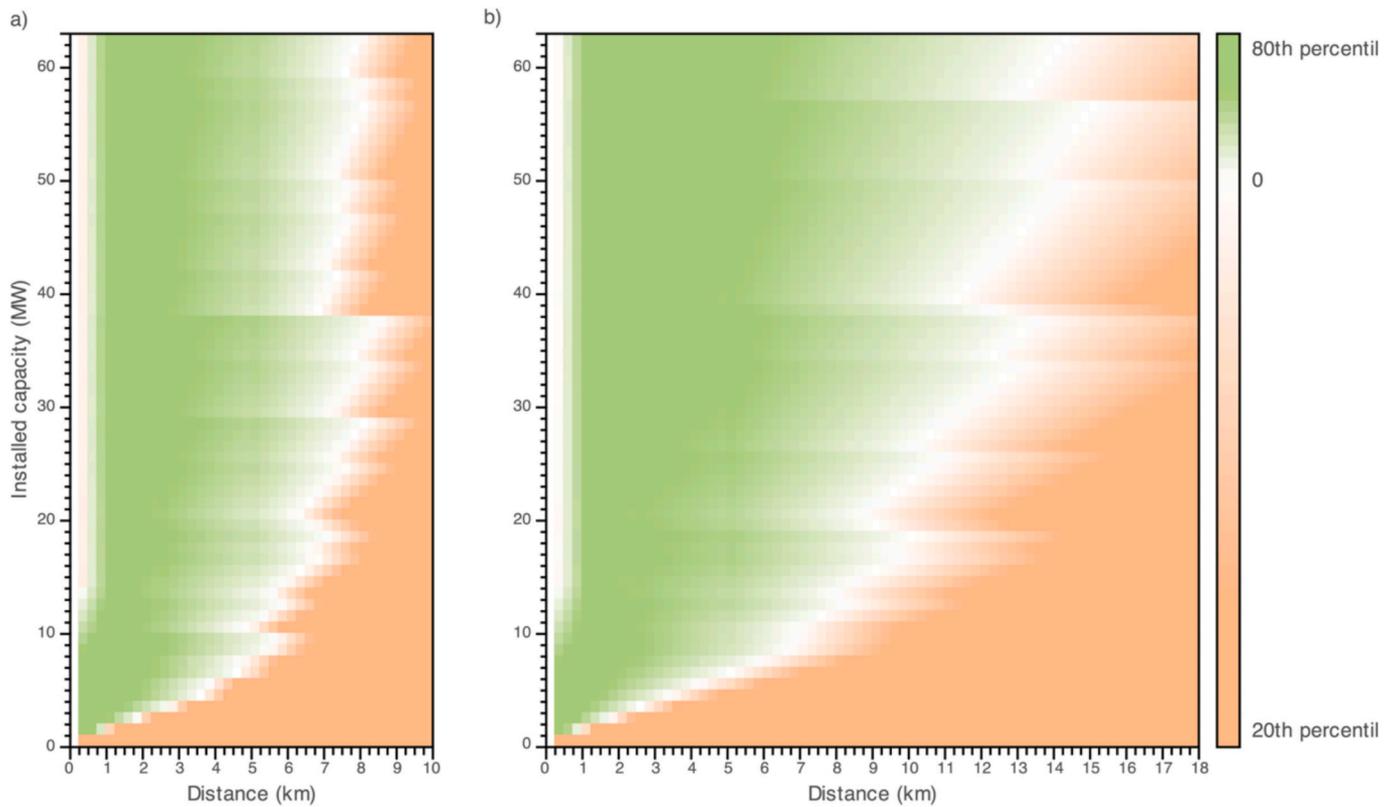


Fig. 7. Economic viability of a ground-mounted photovoltaic site for a given installed capacity and distance to the (a) 10 kV and (b) 20 kV sub-transmissional grid based on net present value cost. In green, savings outweigh cost (80th percentile); in red areas cost outweighs savings (20th percentile); the in-between results are shown in white. The net present value test assumes a discount rate of 1.4%; land-energy density is estimated at 1.84 ha per MW. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

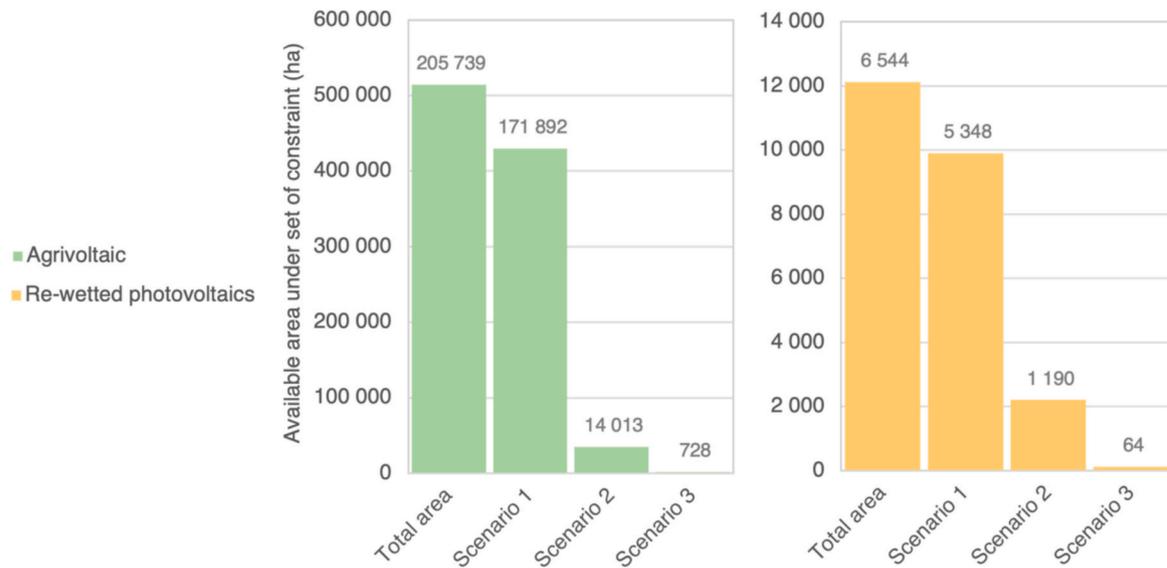


Fig. 8. Overview of the six estimates of land potential for solar power compared to total available land. Numbers above a bar show the energy potential in MW.

nature reserves), only 5 and 18% of respective land categories remain available, while increasing the buffer zone to 500 m (Scenario 3) reduces the available land to 0.2 and 1%.

Available land still holds a significant energy potential in the case region, as shown in Table 3, with AV capacity ranging from 171 GW down to 0.7 GW, while the potential for RWPV ranges from 5.4 GW down to 0.06 GW.

The overlap of existing GMPV sites with areas identified as suitable

indicates the extent to which the approach to identifying technoeconomically suitable sites is consistent with the historical siting processes in the case region, see Fig. 9. The fact that many existing GMPV sites are in locations that are not classified as available in any of the scenarios (see appendix B) indicates that the constraints considered do not fully reflect the siting process in the case region. Fig. 9a shows agricultural land and the existing GMPV sites as of 2024. Fig. 9b shows agricultural land together with the concentration of AV sites in Scenario

Table 3

Total installed capacities (MW) in each of the six estimates of land potential for solar power. Power density of Agrivoltaics is estimated to 0.4 MW per hectare, for Rewetted photovoltaics 0.54 MW per hectare.

	Scenario 1	Scenario 2	Scenario 3
Agrivoltaics	171892	14013	728
Rewetted photovoltaics	5348	1190	64

3, which are mainly located inland, away from the typically coast-concentrated settlements. Fig. 9c shows the RWPV sites in Scenario 3, on agricultural peatland, with a concentration in the northern part of the case region. Fig. 9d combines all information shown in subfigures a-c.

One specific constraint that does not seem to be considered is biotope protection areas, with 2 GMPV sites located within such areas (for a visualisation of all individual constraint please refer to appendix C). Clusters, i.e., a geographical area representing the most sites within 5 km, are scenario dependent, see the map in appendix D, which compares Scenarios 2 and 3 and visualizes the effect of buffer zone to settlements. While not all agricultural land is available for AV and RWPV, clusters can be considered areas where AV and RWPV expansion would less likely cause land-use conflict.

5. Discussion

This study aims to identify and assess land-use conflicts by examining the social setting of solar development. By examining applications for GMPV permit approval, legal documents, and historical land-use change patterns, we show that GMPV developers identified agricultural land close to the subtransmission grid as the ideal setting for deployment, before facing a major legal barrier. This legal barrier is due to concerns about food security and changes to agricultural landscapes and associated values held by regional authorities.

Implications of results suggest that the responsibility for determining whether solar projects may override the legal protection of agricultural land lies with the CAB. In practice, this assessment is operationalized through a three-stage evaluative framework. First, the boards establish whether renewable electricity supply constitutes a vital societal interest—a point that recent court rulings have affirmed. Second, they assess whether the site is needed for food production, a question that is almost invariably answered in the affirmative, as the Environmental Code provides unequivocal protection for agricultural land. Third, the boards consider whether the proposed installation could be located elsewhere. No standardized legal procedure exists for balancing competing societal interests, and decisions are instead made on a case-by-case basis. However, the CAB may (as illustrated by existing GMPV on agricultural land) make different interpretations at every stage depending on perceived local priorities and preconditions, resulting in interpretive uncertainty. Consequently, the precedence of food security or renewable electricity generation remains dependent on discretionary judgments rather than codified legal hierarchies, creating regulatory ambiguity for both developers and landowners. To provide guidance in this ambiguity, we translate the social setting into a set of criteria-based scenarios using a GIS framework to evaluate the potential of AV and RWPV. By using scenarios, instead of exclusive and decisive constraints as described in Sward et al. [30], we can explore parameter values to assess different preferences. Examples include preferred buffer zones to settlement [24], which may vary depending on the setting [53,82]. Our contribution lies in identifying cases of prudent land use (see Table 4) that could entail an alignment between food and electricity production, rather than evaluating the potential for solar power on agricultural land in the Swedish energy system. Fig. 3 shows the methodological steps that could be applied to evaluate other geographical regions. Further, we contribute to a method for evaluating criteria by increasing technical detail to uncover the criteria's relevance. Our results suggest that distance to the grid, generally considered particularly influential in GIS-MCDA analysis

[24,30] and by solar developers alike, is too narrow a criterion, as the threshold distance also depends on site size, alternative land rent, and voltage level. Comparing results with previous studies [31] confirms the relevance of our methodological framework, and points, albeit with different focus on land use, at a potential of 0.4 (pastures)-0.7 (agricultural) GW of agrivoltaics in the region. However, relying on expert-based ranking of decision criteria may help derive suitable sites but introduce bias [30]. Bias is problematic if the reference frames of the experts are not adequately portrayed. Results derived by anonymous experts as in Elkadeem et al. [31] may be relevant in the panel setting, but the lack of transparency is an issue if the results are intended for policymakers operating in a democratic setting. There are ways to portray experts transparently, see for example [83], that could be integrated in MCDA-based siting methodology. In its absence, we argue that scenario building, see also Katkar et al. [3], is a more transparent and socially legitimate method in social spatial settings. No national targets for solar power exist. Instead, an energy actor network estimates that current grid and market dynamics would void profitability of new installations in the county of Skåne once it reaches 2 GW of installed solar power (i.e., not only GMPV) [84]. Considering 2 GW as a limit of demand, it is unlikely that regional authorities would grant more permits for solar power after this point since they would not represent, as framed in court documents, “vital societal interests” nor the most “appropriate use of land” or prudent land use. From Table 3, we see that AV Scenario 1 and RWPV Scenario 2 could satisfy most of this demand, arguably resulting in cases of prudent land use by allowing energy generation while respecting social land-use constraints. Less restrictive scenarios would entail a similar expansion in terms of installed capacity, but with less regard for the identified social considerations and therefore with less potential to mitigate land-use conflicts.

However, understanding the impact on food yields from reductions in incoming solar light, currently limited to relatively small pilot plants [63], is particularly relevant to determining the impact of AV on food security. In the case region, a focus on permanent crops [19] would constrain the potential of AV to relatively low levels, as only a small share of the agricultural land is used for the cultivation of permanent crops. Our analysis of legal proceedings shows a strong advocacy for food security, with no special consideration for GMPV projects framed as AV by developers. Concerns for food security also have practical implications: The economic incentives of maintaining food production in a profit-maximising business model will be small compared to the income from electricity generation. If CAB were to allow for conditional land-use change of agricultural sites (i.e., promised continued agricultural production in combination with PV), a variety of European policies could serve as models to ensure the role of food production. However, follow-up of the implementation of conditional policies is likely both costly and complex over time [18]. Ensuring that agricultural activity remains substantive rather than nominal therefore requires institutional capacity and clear regulatory mandates (e.g., implementation of a maximum threshold of allowed ground covering). Eventually, AV in the case region is likely limited unless a legal definition of AV is established that addresses both the possibility to claim agricultural land and the preceding use of that land. It should be noted that omitting social considerations until after a technology has been legally specified typically introduces social-acceptance challenges and thus conflict [85]. On a broader societal level, while some argue that AV can be seen as a silver bullet for fulfilling multiple UN Sustainable Development Goals such as 7 (affordable and clean electricity) or 13 (Climate Action) [86,87], some also point at local negative consequences [88]. Our results also point toward this contextual dependency. Crop productivity may become less stable under AV, and electricity generation may not reliably meet local demand in winter months. These stability challenges, combined with uncertainties in scaling AV beyond pilot trials, suggest that its contribution to the goals is not straightforward. A nuanced, context-specific approach is therefore essential when evaluating AV as a sustainable land-use strategy. The second example, RWPV, is, we argue, a case of

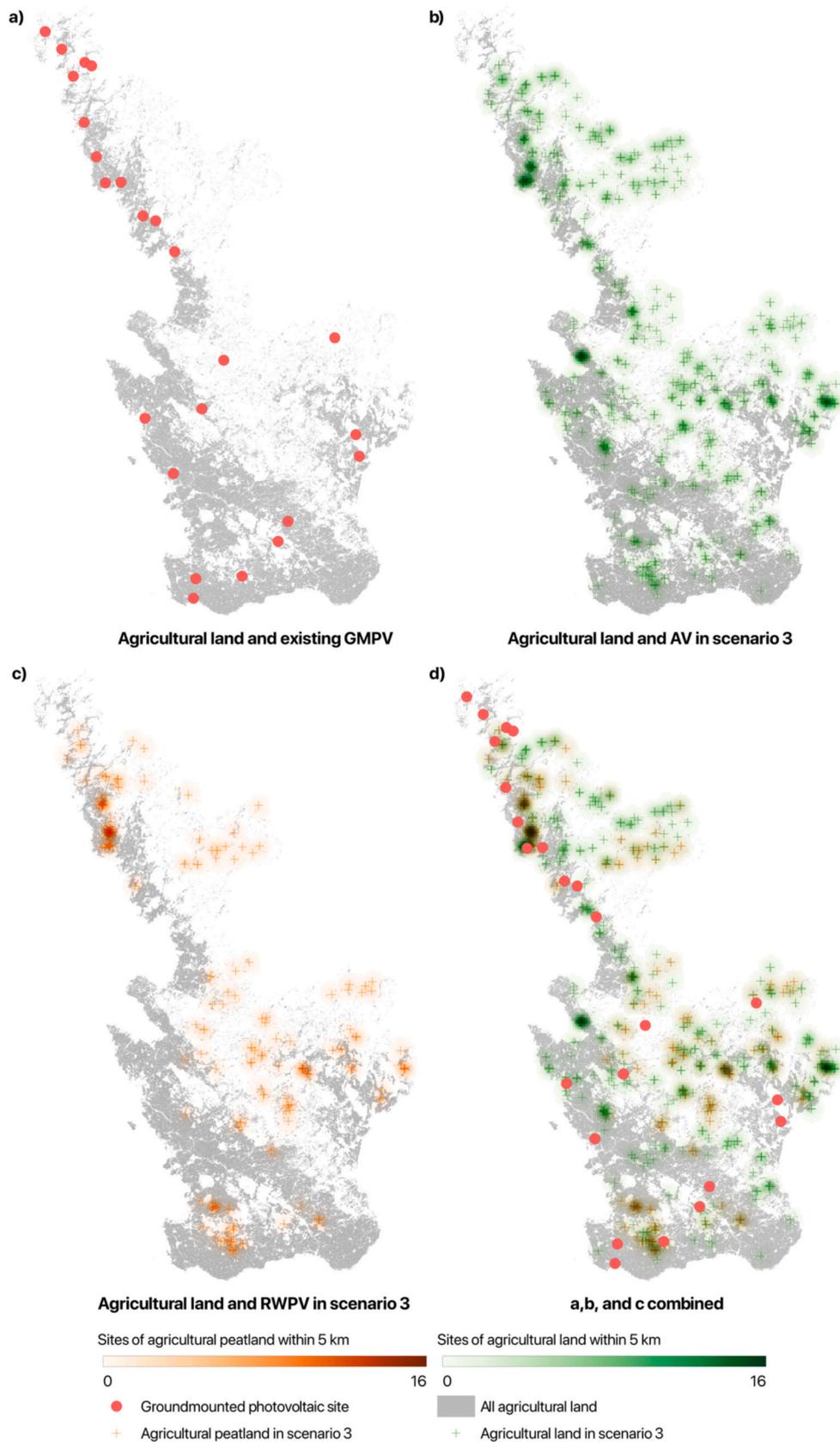


Fig. 9. Agricultural land shown in grey, with yellow dots indicating ground-mounted photovoltaic (GMPV) sites in the two studied counties. Gradients represent sites within 5 km under Scenario 3 (>500 m to closest settlement, outside nature protection measures and within 5 km to the grid) on agricultural land for agrivoltaic (in green hue, green plus signs indicate individual site) and on agricultural peatland for rewetted photovoltaic (shown in red hue, red plus sign indicate individual site). 1 × 1 km raster where the intensity (darker for increasing number) of each cell indicates the number of sites within 5 km. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 4

Summary of opportunities and main challenges for each scenario and technology representative of prudent land use.

	Scenario 1	Scenario 2	Scenario 3	Comments
Ground mounted photovoltaics	Possible rapid build out disregarding negative externalities	Very high potential but major legal barrier	Moderate potential, unclear legal situation	Unlikely part of major solution due to permanent claim of agricultural land. Some sites may be considered suitable.
Agrivoltaics	Possible rapid build out but unclear advantage	High potential but “techno-fix” with acceptance issues	Moderate potential dependent on farmer participation	High risk associated with food production, high reward in electricity potential. Dependent on interpretation of environmental law.
Rewetted photovoltaics	High potential, could lead to win-win scenario	Moderate potential, challenging economics	No significant potential	Moderate gain and low risk. Could leverage rewetting policy scheme under development.

prudent land use since it enables productive use of land subject to restrictions by environmental regulations. For RWPV, no case has been tried in court. However, when rewetting agricultural peatland, food production capacity is lost, so RWPV deployment does not require any legal assessment to evaluate if solar power takes precedence over food production. In theory there is thus no barrier in the Environmental Code to establishing RWPV. While the rewetting of argi-peatland implies lost food production, revenue from sold electricity, as well as potential GHG savings and existing policy support for rewetting, generates new value and reinforces the case for RWPV as prudent land use.

Another aspect that could significantly impact demand for agricultural land for establishing solar power is the available transmission capacity. However, grid operators consider the short-term potential for adding electricity generation to the grid strategic information, so it is not publicly available. The scope of our study does not include grid-side measures such as battery-based storage or grid expansion, since our perspective is on the limited resource that is land. From this perspective, such technological constraints are not fixed but vary over time and while requiring land, we see this demand as small given the high energy density.

As for methodological choices, the resolution of settlement data is one limitation impacting the accuracy of the results, as the buffer distances to settlements are underestimated because the actual location of settlements on the 100 × 100-m-resolution of the population raster is not known. For food production, adequate data on land productivity is lacking. If such data were available, given the case region's importance for the Swedish food market and the importance granted to this issue by the CAB in the permit process, this would likely decrease the amount of land where any solar power would be considered *appropriate* use of land. Local variation in agricultural rents depending on accessibility, specific soil types, available irrigation systems, and geographical features will also impact the economically viable distance to the grid. One suggested area of improvement for the framework is to refine the assessment of site size, as our results highlight its importance. In the real world, multiple sites may be connected and thereby imply the feasibility of sites far from grid, while multiple small sites may show as a high concentration albeit small in total area. Lastly, social acceptance of the multifunctional land uses needs to be evaluated empirically to validate assumptions used in this study as does the realistic potential of rewetting agricultural peatland, which could be as low as 3–28% [89]. Another limitation is the explicit consideration of impact on landscape values. Empirical evidence suggests that negative landscape impacts caused by solar power can result in restrictive land-use policies [90]. Such evidence supports the CAB emphasis on disruptions in the “agrarian” landscape as an argument against GMPV on agricultural land (M 13461–22), even given a societal ambition to expand renewable electricity generation. While arguably examples of prudent land use, the establishment of either AV or RWPV will result in a modification of the landscape, changing it and subjective values associated with it. The criteria of the modelling framework were not designed for assessing such impact on value, since as of 2025, this aspect has not gained any legal significance. So far, landscape consideration is limited to either a voluntary threshold distance to locals promoted by developers, or categorical arguments of technology as “disruptive elements” in the agrarian landscape by the CAB. However, to

some extent the increasingly restrictive scenarios reflect the implications for land availability of going from considering not-in-my-backyard (100-meter threshold) to not-in-my-landscape (500-m threshold). Basing landscape impact on threshold distance will miss aspects of place and people [30] and empirically grounding landscape impact constraints by qualitative methods, such as drawing on interviews with rural habitants to operationalise negative externalities would be an ideal starting point for forthcoming analyses.

Bearing in mind these limitations and uncertainties, the identified clusters nevertheless provide an opportunity to promote cost-efficient electricity generation and could serve as a starting point for initial experimentation and participatory spatial planning. However, clusters present both advantages and disadvantages. On the one hand, shared electrical equipment within clusters could reduce cable costs, and undertaking multiple projects in parallel implies lowered rewetting expenses. On the other hand, aggregated effects might disrupt wildlife movements and recreational values [11] or entail ecological degradation. As shown in appendix D, clusters are most relevant for Scenario 3; the potential land in Scenario 2 is more evenly spread out (although clusters also exist), and scenario comparisons show similarities to the ongoing debate on land sparing versus sharing. These two perspectives can also be used to frame the preference for AV or GMPV. Proponents of GMPV would argue that the option sets aside land for nature since less land in absolute terms would be impacted by electricity generation. Proponents of AV would instead argue that land sharing increases land-use efficiency and represents a more prudent use of land. However, this perspective is challenged by the different understandings among stakeholders of what AV is, where some see it as a “win-win” and some as masked GMPV [25,61,67,85].

Ultimately, quantitative assessments such as GIS-MCDA typically lead to a focus on techno-economic optima. While this approach may result in cost-efficient technology deployment, it can also lead to a lack of consideration for local values [30] and cost-shifting processes such as increased land costs for farmers [61]. In any centrally governed deployment of AV or RWPV, local societies will be exposed to such negative externalities to some extent. The landscape democracy literature includes suggestions that conflicts over renewable energy technologies relate to different fundamental understandings of what the landscape is [91]. Landscapes exist as both a *space*—a delimited area of objective, tangible resources—and a *place*—an environment encompassing subjective immaterial symbols. Conflicts over land use occur while individuals are unable to reconcile their differences and establish a shared perspective. As this study shows, top-down planning initiatives typically side with landscapes as a space. However, Arler et al. [91] point out: “*Conceived as a place... a landscape is a location for human lives, a setting with a particular atmosphere, a scenery, as well as a collection of remnants and relics of significant geological, evolutionary, and historical events. [...] it is the landscape they urge to protect*”. Unpacking how landscapes as places are reshaped by changing sociocultural practices [44]—as with renewable energy projects—should be targeted to further refine the presented framework's social considerations. This could be done by, for example, mapping land-grabbing practices such as centralised decision structures, concentrated decision power, or legal irregularities [92], to allow for a just energy transition [93].

6. Conclusions

This study provides policy-relevant evidence on how legal interpretation and solar permitting documents influence the deployment of ground-mounted solar power. Furthermore, it emphasises the potential application of the landscape governance perspective in the evaluation of less socially contested land uses, which may serve to mitigate conflict. By replacing MCDA weighting with stakeholder-informed scenario development, we offer a transparent and replicable framework that highlights how different regulatory and planning assumptions translate into materially different estimates of regional solar potential. The findings indicate that proximity to higher-voltage grid infrastructure and site size are decisive for economic viability. This entails that uniform distance-to-grid criteria are ineffective as planning instruments. The estimated technical potential varies widely—from zero to 172 GW—depending on how agricultural land is regulated, but our findings indicate that more permissive conversion of agricultural land to solar use would negate the relative advantages of less contested alternatives such as agrivoltaics and photovoltaics on rewetted agricultural peatland. Collectively, these insights facilitate more targeted energy planning by explicitly articulating the social and technical consequences of legal ambiguity. However, note that scenario-based assessments applied without empirical engagement with space and place expectations and values risk entrenching rather than resolving conflict. Consequently, future development of this approach should integrate participatory and iterative engagement to support energy transitions that align solar

expansion with locally legitimate land-use practices and historically shaped landscapes.

CRedit authorship contribution statement

Oskar Belzons Berthelemot: Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Conceptualization. **Jimmy Ehnberg:** Writing – review & editing, Validation, Supervision. **Göran Berndes:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization.

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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.

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Appendix A. Evaluated applications for GMPV permit approval, official guidelines and court documents

Table 1

a list of evaluated applications for GMPV permit approval.

Place	Material	Size (MW)	Date	Approximate coordinates SWEREF 99 TM
Skedala	Document of planning for application according to chapter 9 article 6b of environmental code	25	2022	N 6284993, E 377026
Persköp	Document of planning for application according to chapter 9 article 6b of environmental code	115	2022	N 6240001, E 387603
Älmhult	Document of planning for town hearing according to chapter 6 article 24 of environmental code	340	2022	N 6267351, E 449324
Älmhult	Document of planning for application according to chapter 9 article 6b of environmental code	80	2023	N 6263356, E 448584
Tonnersjö	Document of planning for application according to chapter 9 article 6b of environmental code	600	2023	N 6281059, E 384233
Bonnarp	Document of planning for town hearing according to chapter 6 article 24 of environmental code	75	2023	N 6216684, E 386501
Falerum	Document of planning for application according to chapter 9 article 6b of environmental code	400	2023	N 6439888, E 572390
Kogshult	Document of planning for application according to chapter 9 article 6b of environmental code	150	2023	N 6155951, E 414546
Brunskog-Stjärnarp	Document of planning for application according to chapter 9 article 6b of environmental code	100	2023	N 6277946, E 378078
Fröllinge	Document of planning for application according to chapter 9 article 6b of environmental code	50	2023	N 6297253, E 364979
Vårsås	Document of planning for town hearing according to chapter 6 article 24 of environmental code	127	2023	N 6466440, E 445011
Skintaby	Document of planning for town hearing according to chapter 6 article 24 of environmental code and <i>Including notes from town hearing in Harplinge, spring 2024</i>	100	2023	N 6293485, E 357892
Krutebo	Document of planning for town hearing according to chapter 6 article 24 of environmental code	90	2023	N 6415906, E 535113
Horshult	Document of planning for town hearing according to chapter 6 article 24 of environmental code	70	2023	N 6340641, E 426204
Horndal	Document of planning for town hearing according to chapter 6 article 24 of environmental code	80	2023	N 6688619, E 581345
Löberöd	Document of planning for application according to chapter 9 article 6b of environmental code	53	2023	N 6181926, E 405356
Ingatorp	Document of planning for application according to chapter 9 article 6b of environmental code	115	2024	N 6384874, E 524798
Moholm	Document of planning for town hearing according to chapter 6 article 24 of environmental code	174	2024	N 6501113, E 451246

Table 2

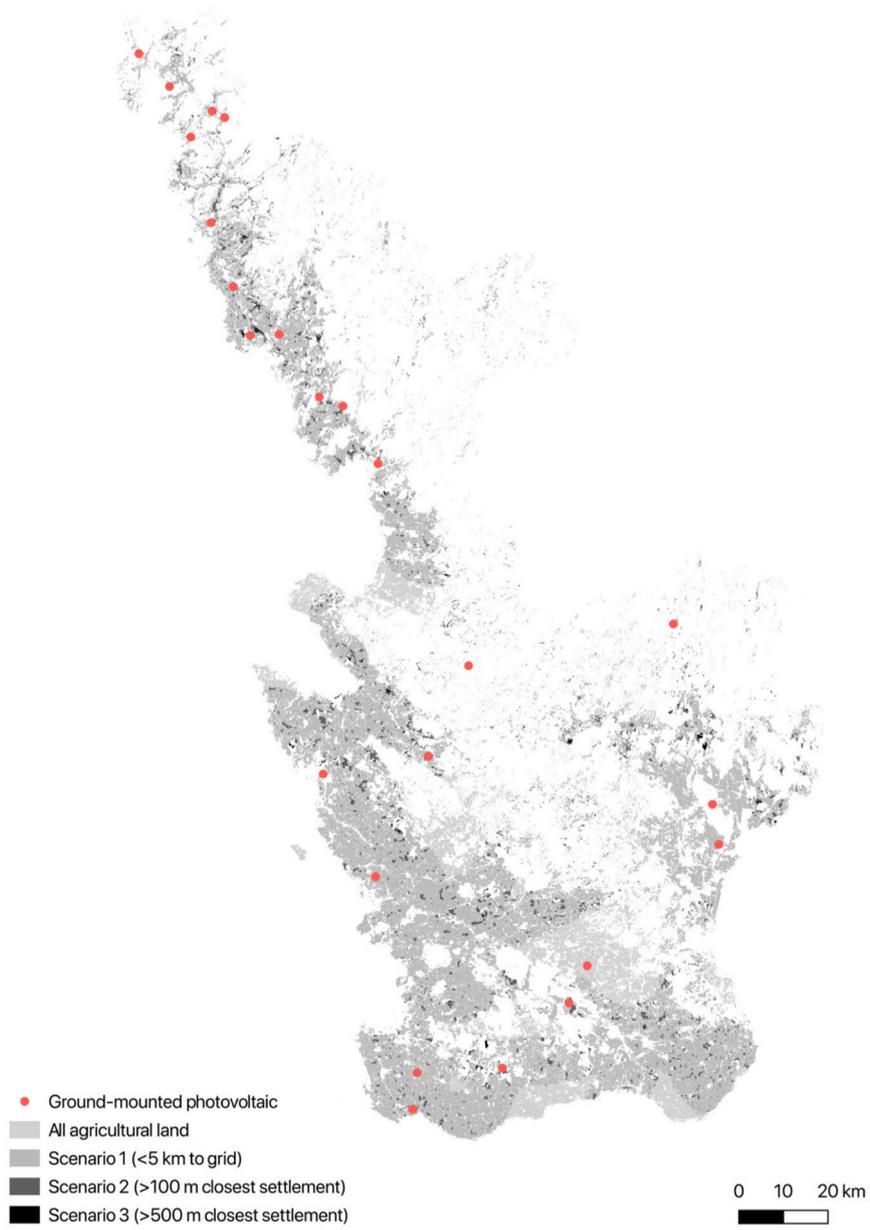
Overview of official guidelines.

Official actor	Name	Date	Significance
County administrative board of Västra Götaland	<i>Länsstyrelsens vägledning om solceller på jordbruksmark</i>	May 2024	Description of required geographical scope in assessment
County administrative board of Skåne	<i>Länsstyrelsen Skånes vägledning om solceller på jordbruksmark</i>	2024	Description of required technological scope in assessment All agricultural land considered productive and thus status of “vital societal interest”

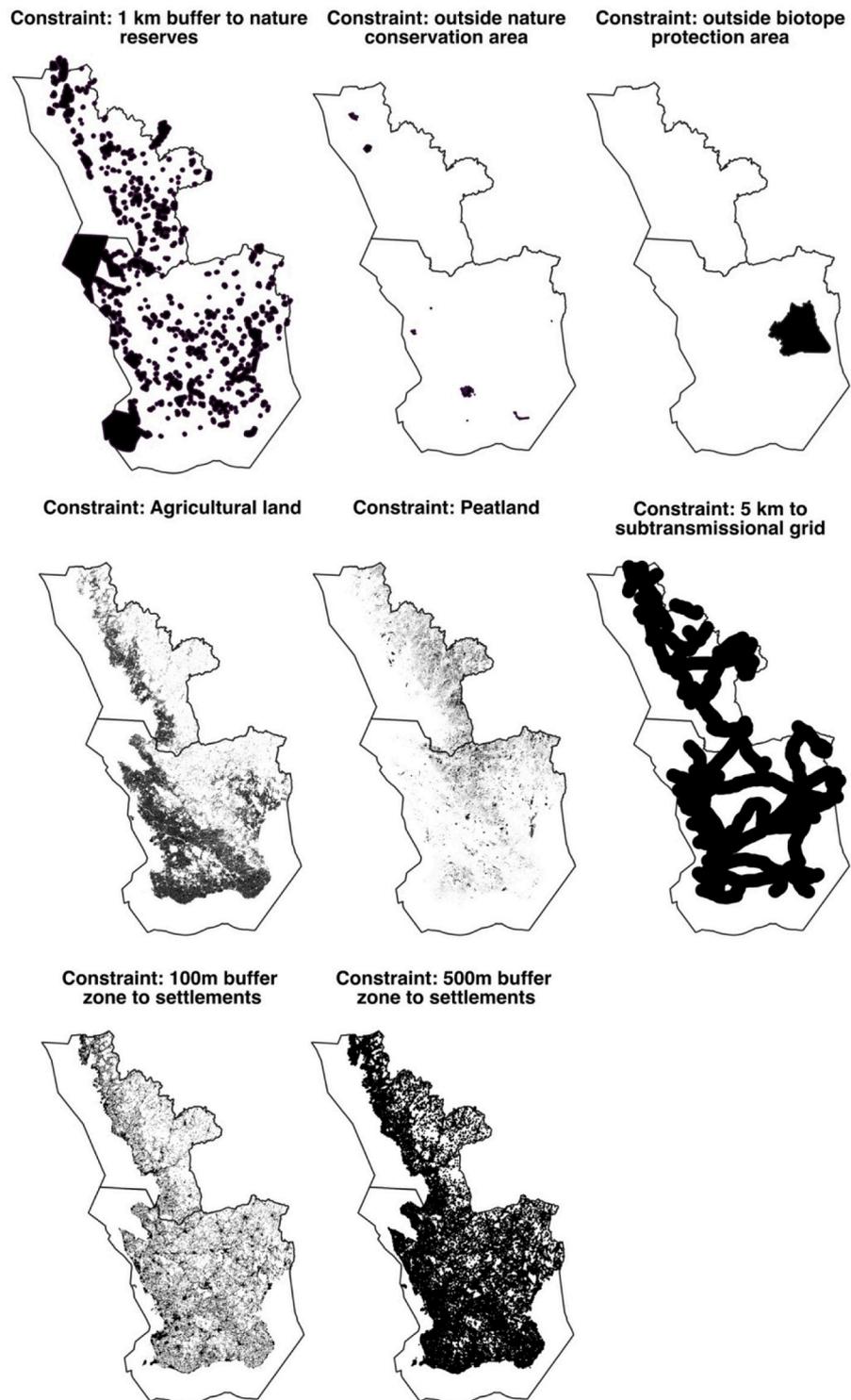
Table A.3
Overview of cases, stakeholders against, for and outcome in ruling.

Case	Against	For	Outcome	Major advancement of legal praxis	Major argument brough forward by Land and Environmental Court of Appeal
M 1026-22	County administrative board of Skåne	Individual solar power developer	Solar power on agricultural land banned	Agricultural land permanently claimed	Not sufficiently assessed if claim of agricultural land necessary
M 15064-21	County administrative board of Skåne	Solar power developer	Solar power on agricultural land banned	Vague mentioning of assessment of alternative sites Agricultural land permanently claimed	Not sufficiently assessed if claim of agricultural land necessary
M 13461-22	County administrative board of Skåne Nature's protection NGO	Solar power developer	Solar power on agricultural land banned	Assessment to include multiple sites Solar power on agricultural land vital societal interest Food production primary social interest	Not shown that GMPV have sufficient societal value
M 8658-23	County administrative board of Södermanland	Solar power developer	Solar power on agricultural land banned	Assessment to include multiple renewable power sources Some continued cultivation insufficient for upheaving permanent claim of agricultural land	Not assessed if electricity needs can be met without using farmland. Thus, food production takes precedence.
M 6624-23	Cultural heritage association	Solar power developer	Solar power on agricultural land banned	Assessment to include multiple connection points to grid	Vital societal interest to maintain land for food production takes precedence over energy production.

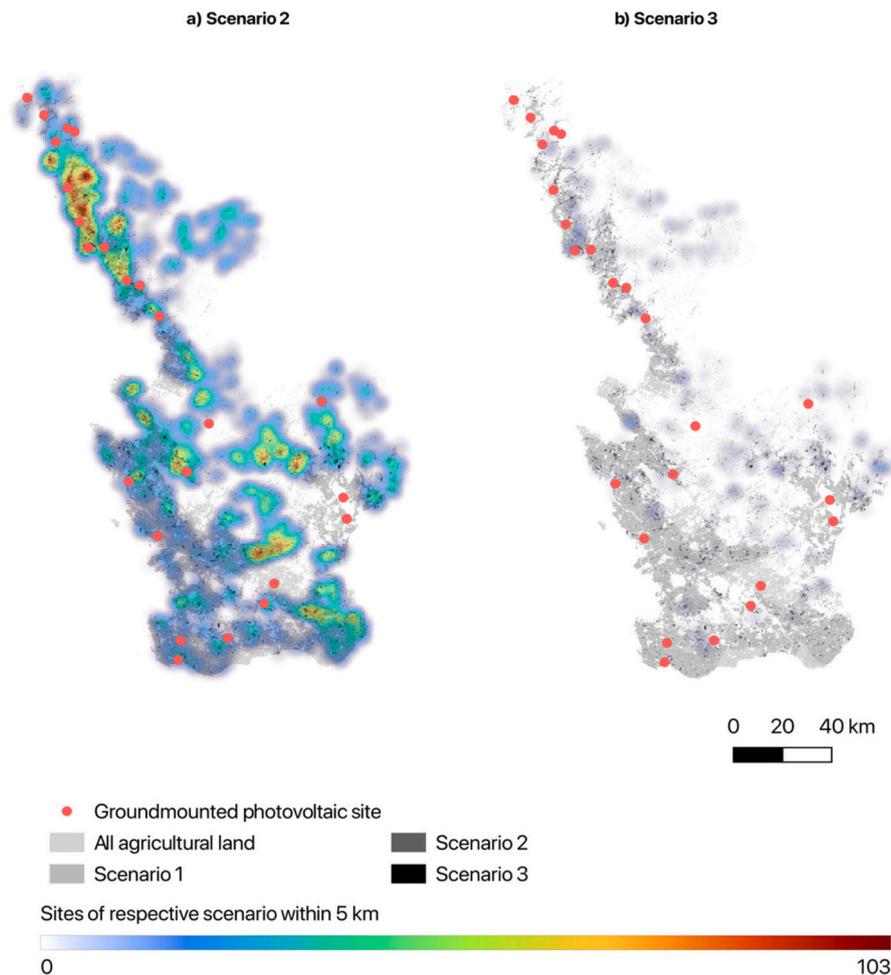
Appendix B. Visualisation of three scenarios



Appendix C. Individual overview of used constraints



Appendix D. Comparison of concentrations in scenario 2 and 3 material college



Appendix E. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.erss.2026.104611>.

Data availability

Data will be made available on request.

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