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Land Use Conflicts and Synergies on Agricultural Land in Brandenburg, Germany

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Abstract: The growing and multiple interests in land as a resource has led to an increase in locally or regionally clashing land use interests on agricultural land which may result in conflicts or open up possibilities for synergies. Urbanization, food production, renewable energy production, environmental protection, and climate protection are known as key land use interests in many regions. The objective of our study is to identify and map land use conflicts, land use synergies, and areas with land use synergy potentials in the federal state of Brandenburg, Germany. We have combined different methods: an analysis of statistical data, an online survey with farmers, a primary document analysis (articles, court documents, policy documents, position papers), and a GIS-based spatial analysis. In our Brandenburg case study, we have identified the use of agricultural land for renewable energy production and environmental protection as the most relevant land use interests leading to conflict situations. We show that land use synergies can make a significant contribution to achieving environmental and climate protection goals, as well as sustainable development. Through the site-adapted and targeted establishment of agroforestry systems, agricultural areas with agri-photovoltaic systems and agricultural parcels with integrated nonproductive areas may lead to land use synergies. Our study contributes to a better understanding of the occurrence of land use conflicts and land use synergies. We highlight the potential for targeted and sustainable environmental and climate protection through the promotion of land use synergies as a result of establishing agroforestry systems and agricultural parcels with agri-photovoltaic systems and integrated nonproductive areas. Our results provide a basis for agricultural policy to promote land use systems that contribute to environmental and climate protection.

Keywords: land use interests; land use; land use conflicts; land use synergies; agriculture; sustainable development

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1. Introduction

For decades, the world population has been steadily increasing, and this is expected to continue in the coming decades [1], causing far-reaching problems [2]. The demand for land is reflected in different land use interests, which may lead to conflicts but potentially also to synergies in land use that manifest on a local scale. Urbanization, food production, renewable energy production, environmental protection, and climate protection are known as key land use interests in many regions. This is also the case in Brandenburg, where population numbers have increased by 34,000 from 2010 to 2021 [3], and increasing pressure from urbanization in the periphery of Germany's capital Berlin on environmental and climate protection policies and renewable energy production can be observed. Land use conflicts can be defined as a situation in which at least two different incompatible land use interests or land use objectives clash [4–8]. In contrast, land use synergies may be considered a unilateral or mutually positive influence of different land use objectives that are enacted on each other. The literature on land use conflicts has primarily aimed to highlight the causes and impacts of conflicts and present the methods for identifying and localizing these. To prevent the emergence of land use conflicts, to reduce their negative impacts, and to derive strategies for site-adapted, targeted, and low-conflict land use, extensive knowledge about land use synergies or the potential of such synergies is needed. Such knowledge and a better understanding of land use synergies may be the basis for better-informed policy decisions in the context of meeting climate change, environmental protection, and sustainable management of natural resources.

Many scientists have already addressed the different aspects of land use conflicts arising from the diverging objectives of land use: (a) the identification of land use conflict potentials [4,9–11] and land use conflict [12,13], (b) the investigation of the causes and impacts of land use conflicts [14–17], (c) the management of land use conflicts, including how to resolve them [18–20], and (d) mechanisms for spatial variation of land use conflicts [21]. The ongoing scientific debates of land sparing versus land sharing in the context of agricultural food production and biodiversity conservation illustrate this approach in how they focus either on separating land for different land use interests (land sparing) or on modifying the agricultural landscape so that, with extensive use and more habitat quality, biodiversity can be supported on the same land (land sharing) [22]. Recent studies have used participatory system dynamic approaches to investigate interrelationships between different stakeholder interests and cultural, social, climatic, or ecological variables [23,24]. In spatial decision-making and planning, one key objective is to reduce or prevent land use conflicts by means of suitable laws and regulations to reconcile agriculture with environmental protection and climate protection. In this case, exemplars are the EU regulations on the Common Agricultural Policy with Regulation (EU) No. 2021/2115 or the national regulations for environmental and climate protection. Planning instruments, such as landscape, regional, or land use planning, are also appropriate means to reduce or prevent land use conflicts through balanced land use. Based on site parameters and the balancing of different land use interests, it is possible to zone the landscape in suitable areas through a land use suitability analysis. These analyses have been applied numerous times. For example, Akıncı et al. [25], Amini et al. [26], and Charabi and Gastli [27] investigated which sites in a region are suitable for the production of renewable energy through the use of photovoltaic plants. Determining which area is suitable for which land use often requires balancing various land use interests.

Land use synergies, on the contrary, have only recently been addressed [28–30]. Earlier studies identified different land use systems with land use synergies on agricultural land when established in a targeted and site-adapted manner, particularly agroforestry systems, agricultural land with agri-photovoltaic systems, and agricultural areas that contain nonproductive areas such as fallow land or landscape features. An agroforestry system represents a land use system in which agricultural production (crop cultivation or animal husbandry) and the cultivation of woody plants (trees and hedges) occur simultaneously on the same agricultural parcel (field) [31]. Synergistic effects, which can result from the targeted establishment of an agroforestry system, include the stabilization of agricultural yields by a reduction in wind erosion and improvement in soil enrichment, on the one hand, and the cultivation of woody plants to produce valuable timber, on the other hand. Finally, agroforestry systems can lead to positive effects on the environment and the climate [32,33]. In agricultural land with agri-photovoltaic systems, agricultural production is combined with the use of solar radiation to generate renewable energy. Thus, this area generates income from different sources, including agricultural production and renewable energy generation. At the same time, the shading provided by agri-PV systems can lead to a reduction in the evaporation rate and, at the same time, to the mitigation of drought stress [34,35]. Land use systems in which nonproductive areas are integrated into agriculturally used land can lead to synergy effects, such as increased biodiversity, reduced plant protection and fertilizer inputs, or habitat provision and soil enrichment [36,37]. These land use systems are associated with several ecosystem services. They illustrate the multifunctionality of agricultural land (see Knickel et al. [38]). Although several studies have identified the general potential synergies of such land use systems, few have explored how to identify potential areas for these systems as a basis for spatial decision-making and planning.

The main objective of our study is to identify and map land use conflicts, land use synergies, and areas with land use synergy potentials. Hence, we address the following research questions.

(1) What are the key interests in agricultural land, and to what extent do they lead to land use conflicts or land use synergies?
(2) How and where can we identify and map land use conflict areas and land use synergy areas on agricultural land?
(3) What is the extent of land use synergy potentials on agricultural land in Brandenburg?

In the present study, we consider the case of the federal state of Brandenburg, Germany, which represents an excellent example for investigating land use conflicts and land use synergies. The study area has very heterogeneous environmental conditions and cultivation practices, along with large shares of landscape and nature conservation areas. In addition, Brandenburg surrounds the metropolitan region of Berlin. As a result of heterogeneity, there are a variety of possible land use interests that may clash and lead to conflicts, but also synergies. We assume that land use conflicts will increase, especially in and around the urban belt. Furthermore, we assume that the areas used for agriculture in Brandenburg have a large amount of potential for generating land use synergies. For the identification and localization of land use conflicts and synergies in the context of agricultural production and designation of agricultural areas with land use synergy potentials, we have combined different methods to address the research questions, including an analysis of statistical data, an online survey with farmers, a primary document analysis (articles, court documents, policy documents, position papers), and a GIS-based spatial analysis.

2. Materials and Methods

2.1. Study Area

Brandenburg is the fifth-largest federal state of Germany. It covers 29,654 km^2 and is located in the north German lowland in the northeast of Germany, with an east–west extension of 234 km and a north–south extension of 244 km [39]. The study area is divided into 14 counties, with 413 municipalities and 4 county-level cities [40]. Brandenburg surrounds Berlin, the capital city of Germany (Figure 1). Germany is located in a warm temperate climate zone and is subject to the maritime climate of Western Europe and the continental climate of Eastern Europe. The mean temperature and mean precipitation of the study area in the long-term average (1991–2020) are 9.5 °C [41] and 586 mm, respectively [42].

The area of Brandenburg is divided into 48.65% agricultural area, 34.8% forest, 6.87% settlement, 3.71% transportation, 3.36% water, and 2.61% other vegetation. More than 42% of the area of Brandenburg has a special protection status and is designated as either a landscape-protected area or a nature reserve [39]. Since 1992, the agricultural area—thus, the area available for primary agricultural production—has been decreasing by more than 800 hectares per year, that is, by almost 6% between 1992 and 2018.

Brandenburg's agriculture is dominated by large farms. The average farm size is 242 hectares, which is far above the national average of 63 hectares [43,44]. In Brandenburg, about 15% of all farms manage almost 70% of all farmland [43]. The agricultural area of 1,317,500 hectares is divided into about 77% arable land and 23% grassland. The main cultivated plants are wheat maize, rye, and barley [39]. The agricultural landscape is divided into six different types: peri-urban, high fragmentation, low fragmentation, high intensity, low intensity, and organic production [45].

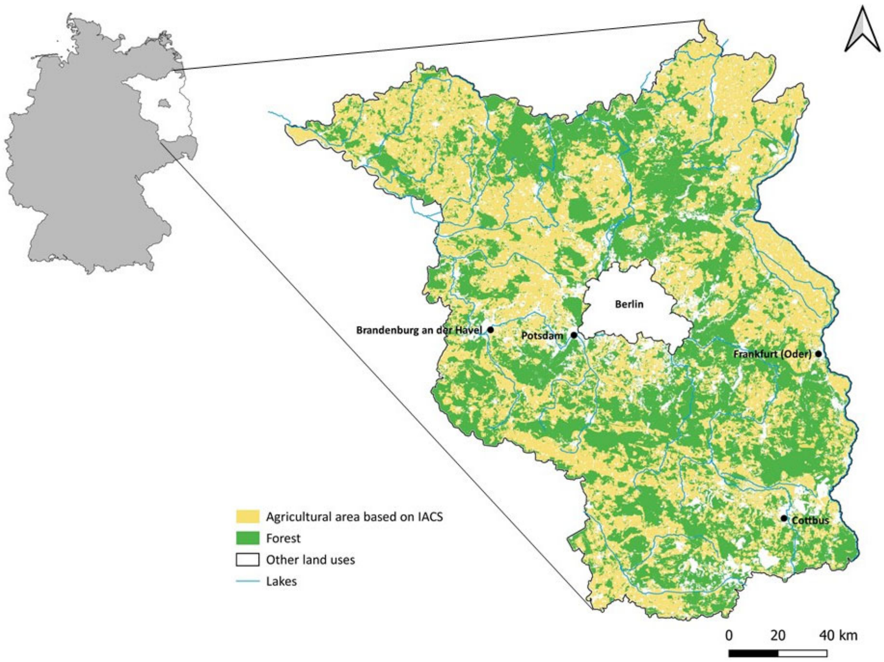

Figure 1. Agricultural and forestry land use in the study area of Brandenburg, Germany.

In the context of political efforts to protect the climate, the expansion of renewable energy production—especially through wind turbines and solar modules—has been pushed in recent years. In the meantime, around 3700 wind turbines, 35,000 photovoltaic systems, and more than 500 biogas plants in Brandenburg cover 66% of the electricity consumption from renewable energies [46].

2.2. Methodology

Our mixed methods approach, which consists of an analysis of statistical data, an online survey, a document analysis, and spatial data analysis, relies on primary and secondary data, as well as information from document analysis. We first compared different land use classification systems and developed our own simplified and harmonized land use classification approach to identify the relevant stakeholders and their potential specific land use interests together with a farmer survey and a document analysis.

To obtain an initial quantitative overview of the area where different land use interests clash, we evaluated the land use data from the statistical office Berlin-Brandenburg for the period from 1995 to 2020. These data represent the annual area of land use divided into six categories. Using these data, we derived the amount of annual land use change and potential land use conflicts that accompany the loss of agricultural area.

Within an online survey of farmers (conducted with LimeSurvey), we addressed the stakeholders confronted with land use conflicts and land use synergies in agricultural practice. The objectives of the survey were to identify (a) what land use conflicts farmers already faced and (b) what land use systems farmers are targeting to establish to generate land use synergies. A total of 178 farmers participated during the period from 20 March 2021 to 20 May 2021. For the evaluation of the survey data, the information from 118 farmers could be considered. For the analysis of the survey data, we applied a simple descriptive analysis and calculated the frequency distributions.

The survey data were supplemented with information from a document analysis. We considered articles in regional newspapers, administrative court decisions, and position papers of political parties and associations of interest for the time frame of 2000 to 2021 to identify and locate further land use conflicts and land use synergies in the study area. The search for relevant documents was based on the following keywords or keyword combinations: agriculture, agricultural use, arable land, biodiversity, climate protection, construction land, environmental protection, environmental protection association, farmers association, fertilizer regulation, forestation, insect protection, land use conflicts, loss of agricultural land, nature conservation, photovoltaic, road construction, and wind power plant.

In total, we identified 103 articles, seven court decisions, and 32 position papers that address conflicts between agricultural production and at least one other land use interest. We have listed the results of the search of the relevant documents by document type. The core attributes of the lists consist of the assignment of land use conflict/land use synergy and locality. Using these attributes, each individual conflict/synergy was mapped as a separate point using the GIS tool QGIS.

Finally, we conducted a spatial data analysis consisting of the localization of conflict areas and the designation of agricultural areas with land use synergy potentials. The data used for spatial analyses (with QGIS) are shown in Table 1.

Table 1. Overview of the data sources used for spatial analysis.

Data	Time/ Update Status	Spatial Resolution	Data Source	Availability (WMS = Web Map Service, WFS = Web Feature Service)
Area based on EU directive 92/43/EEC	02-06-2017	Polygon layer	State Office for Environment	Free download (shp)
Area based on EU directive 2009/147/EG	05-02-2010	Polygon layer	State Office for Environment	Free download (shp)
Nature reserves	12-31-2020	Polygon layer	State Office for Environment	Free download (shp) WFS
Protected landscape areas	12-31-2020	Polygon layer	State Office for Environment	Free download (shp) WFS
Biogas plants	11-24-2020	Point layer	Ministry of Economy, Labor, and Energy of Brandenburg	WMS
Combined heat and power plants	03-26-2020	Point layer	State Office for Environment	Free download (shp)
Digital map land value figures	09-03-2020	Plot-level data	BonaRes Data Center	Free download (shp)
Digital orthophotos	2018–2020	0.2 m grid	State Survey and Basic Geodata Brandenburg	WMS
Digital orthophotos	2009–2012	0.2 m grid		WMS
Digital orthophotos	2001–2009	0.4 m grid		WMS
Forestry map	10-26-2021	Plot-level data	Brandenburg State Forestry Office	Free download (gml), WMS
Ground-mounted photovoltaic systems	11-24-2020	Plot-level data	Ministry of Economy, Labor, and Energy of Brandenburg	WMS
Integrated Administration and Control System data	02-16-2021	Plot-level data	Ministry of Agriculture, Environment, and Climate Protection	Free download (shp)
Legally effective development plans	11-19-2020	Plot-level data	State Office for Construction and Transport	WFS
Municipality boundaries	07-05-2020	Plot-level data	State Survey and Basic Geodata Brandenburg	Free download
Soil types (VDLUFA)	07-29-2021	Plot-level data	Brandenburg State Office for Mining, Geology, and Raw Materials	WFS
Wind turbines	04-01-2021	Point layer	State Office for Environment	WMS

We focus on mapping the conflicts between agricultural production or food production and (a) production of renewable energy production, (b) environmental protection, and (c) forestry. We have chosen these three conflict situations because of their high political relevance in the context of environmental and climate protection. Based on the reference year 2020, we assumed that each area that was used for nonagricultural purposes in 2020 but that was originally agricultural land represents a conflict area. Areas that are to be used for the generation of regenerative energy in the future, according to planning data, are also categorized as conflict areas.

To localize the conflict area between agricultural production/food production and renewable energy production, we combined a visual interpretation of orthophotos with the spatial data of ground-mounted photovoltaic plants, wind turbines, and biogas plants that have already been built or are in the planning stage. We used aerial photos from 2018 to 2020 at a resolution of 1:5600. To assess whether the area used for renewable energy production by ground-mounted photovoltaic systems and wind turbines was originally used for agricultural production, we considered every potential conflict area retrospectively. This consideration would not be possible for the conflict between the production of food and biomass as a substrate for biogas plants because, in any case, agricultural use continues.

We have completely geometrically delineated the agricultural land that has been lost or will be lost because of the construction of ground-mounted photovoltaic systems, digitizing this as a conflict area. To determine the conflict area associated with the construction of wind turbines, including access roads, we geometrically delineated 10% of the area of the plants, including access roads, and extrapolated them subsequently. Both the plants that had already been built and those in the planning stage were considered. To determine the conflict area associated with the production of biogas, we used a different approach. Here, the focus was less on the area lost to the construction of biogas plants and more on the land used to produce biomass instead of food. Based on the orthophoto interpretation, we evaluated each captured biogas plant in terms of the main substrate used. For this purpose, we assumed that maize is mainly used as a biomass substrate in biogas plants. Biogas plants that did not have storage facilities for silo maize were excluded from the analysis because it can be assumed that they were fed with other substrates. For the remaining biogas plants, based on the data on the biogas plants and the combined heat and power plants under consideration of the national law for renewable energy, we determined the required area for energy maize production. This arose as a result of the total output of all biogas plants (KWH_T), multiplied by the permissible share of maize of 60% as biomass according to the German Renewable Energy Law and the average requirement of maize area per KWH of 0.7868 ha [47]. In addition, we assumed an additional maize requirement of 15% as a reserve to buffer any yield losses. Then, based on the study of Machl et al. [48] and Reckleben et al. [49], a mean distance between farm and field of 4.9 km was assumed. As energy maize areas—i.e., as conflict areas—we counted all areas that were cultivated with maize according to the 2020 IACS data and were within a radius of 4.9 km of biogas plants.

To locate the conflict area between agricultural production and environmental protection, we used the IACS data from 2020. All areas set aside under greening or agri-environmental and climate measures were selected. In this case, the areas not used for agricultural production in 2020 were also considered conflict areas. For the localization of the conflict area between agricultural production and forestry, we intersected the forest area from 2021 with the digital field block cadaster from 2010. The difference produced the conflict area.

For the identification and localization of agricultural parcels with land use systems that may lead to land use synergies, understood as a unilateral or mutually positive influence of different land use objectives, we also used a mixed methods approach. For this purpose and as part of the document analysis, we specifically used the keywords agroforestry system, agri-photovoltaic systems, and nonproductive land combined with agriculture and agricultural land. Based on the spatial analysis, we first determined the area total of agroforestry systems and then identified and located agricultural land with integrated nonproductive areas using IACS data.

In the process of designating agricultural land with land use synergy potential, we used a literature review to identify the general site requirements for the suitability analysis and the positive effects associated with establishing the already mentioned three types of land use.

Simultaneously, we highlighted the objectives related to environmental protection, climate protection, and sustainable development based on Regulation (EU) 2120/2115, the German GAP Strategic Plan, and the coalition agreement of the Brandenburg state government (Table 2, column 1).

Table 2. Parameters per land use system for zoning.

Objectives	Criteria	Parameters		
		AFS [(a)]	**APS** [(b)]	**N-PA** [(c)]
Reduction of wind erosion Reduction of water erosion Reduction of pesticide inputs Reduction of fertilizer inputs Reduction of greenhouse gas emissions Reduction of water transpiration Storage of carbon dioxide in biomass Maintenance/increase in biodiversity Increase in yield stability	Type of agricultural area	Arable land	Arable land	Arable land
	Size of agricultural parcel	Top 10%	≥10 ha	≥1 ha
	Soil type	Sandy soil	Sandy soil	Sandy soil
	Standard soil values	30–40 pt	20–30 pt	<25 pt
	Located in protected area	No	No	yes

[(a)] agroforestry system; [(b)] agri-photovoltaic systems; [(c)] nonproductive area.

Based on the literature review, we defined five location criteria for our analysis that may contribute to achieving the objectives, depending on the respective parameters (Table 2, column 2). For example, large, low-structure agricultural land with sandy soils and low ground cover may experience high wind speeds and promote erosion from wind [50]. In addition, the size of an area has an indirect effect on the evaporation rate. Large areas are usually characterized by only a few structural elements that could reduce the evaporation rate in the area through their shading [51]. To identify and designate agricultural land with land use synergy potential, we subsequently determined the analysis parameters for each land use system based on the objectives, as well as the identified site requirements and positive effects (Table 2, columns 3 to 5).

We chose the parameters per land use system so that there would be no overlap, even though any land use system could potentially be established on the same area. Because, in our view, a significant contribution to the achievement of environmental and climate protection goals can be made through the targeted and adapted management of arable land, we have considered only arable land. The determination of the area size was based on the objectives and the potential synergy effects of the respective land use system. Thus, agroforestry systems can significantly contribute to the structuring of the landscape, which contributes to lower wind speeds and a reduction of the risk of erosion. At the same time, the shade cast by woody plants can reduce the evaporation rate in the immediate vicinity of the woody plants [31,52]. Because Brandenburg has little fertile soil, we only considered sandy soils. The determination of the respective parameter values regarding soil fertility in the form of standard soil values was carried out by considering the respective site requirements. For agroforestry systems and areas with agri-photovoltaic systems, we chose "located out of protected area", and for nonproductive areas, we chose "located in protected area". The reason for this is that protected areas need a high level of protection, and habitats within these protected areas should be strengthened or restored. The establishment of nonproductive areas in an agricultural area can significantly contribute to achieving this objective. Finally, for each land use system, based on the defined parameters and using the IACS data, the data on soil types and standard land values, and the protected areas, we determined and identified the agricultural areas with land use synergy potentials.

3. Results

3.1. Stakeholders and Their Interests in Agricultural Land

Regarding the first research question and our own developed simplified land use classification approach (Table A1) and mixed methods approach, we identified 16 stakeholders with an interest in agricultural land (Figure 2). Some of these stakeholders are mentioned more frequently than others. From this, we could deduce that these stakeholders show an increased interest in agricultural land.

Stakeholders' interests in agricultural land may vary, but they may also overlap. For example, the interest of an energy producer may be to use an agricultural area to produce renewable energy using ground-mounted photovoltaic plants. In contrast, a farmer's interest may be to continue to use the land for agricultural purposes (different interests). However, the farmer's interest may also be that the land is used to produce renewable energy to profit financially from it (same interests). Based on our mixed methods approach, we identified the following key interests in agricultural land: food production, production of renewable materials, renewable energy production, environmental protection (including nature conservation and resource protection), climate protection, and the use of agricultural land as living space, industrial, or commercial space and transport routes.

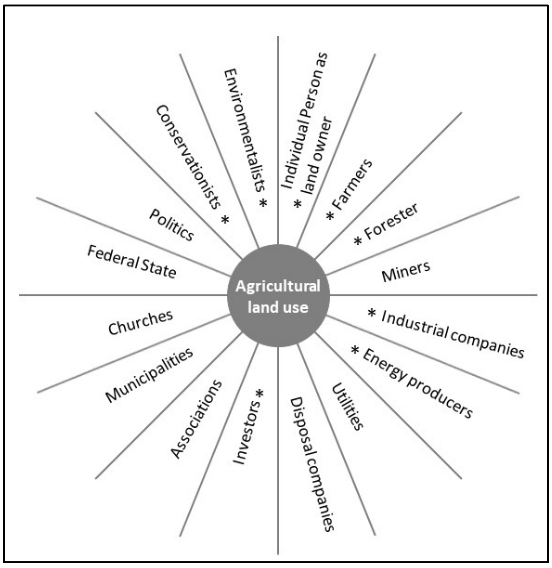

Figure 2. Important stakeholders with an interest in the use of agricultural land. (* stakeholders that are mentioned more frequently than others).

3.2. Land Use Conflicts—Differentiation and Spatial Distribution

The analysis of different land use interests revealed that a distinction of conflicts could be made between (a) conflicts with or without positive effects on agriculture and (b) between internal and external land use conflicts (Figure 3).

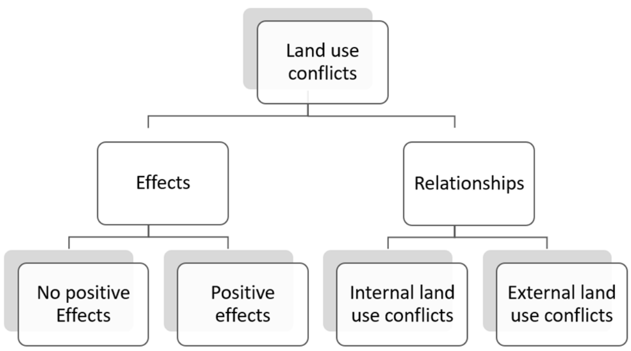

Figure 3. Classification of land use conflicts.

As described in Section 1, a land use conflict is a situation in which at least two different incompatible land use interests or land use objectives clash. If a conflict situation occurs on an agricultural parcel between agricultural use and nonagricultural use, two results can occur:

(a) Agricultural use remains on the agricultural parcel,
(b) Agricultural use is displaced by nonagricultural use, so agricultural land is lost.

In addition, conflict situations can arise in which several different agricultural use interests clash. An example of this is the conflict between the interest in food production and that in producing renewable raw materials such as energy maize.

Thus, as a result, we can summarize that the land use conflicts related to agricultural land can be divided into external and internal land use conflicts (Figure 4).

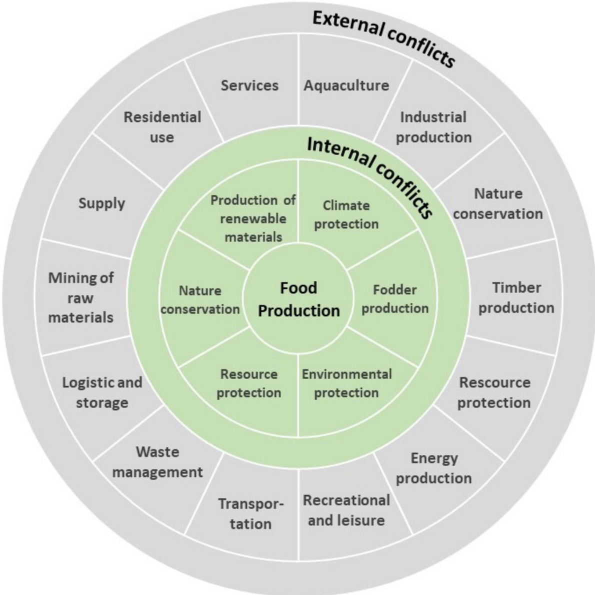

Figure 4. Schematic representation of the identified internal and external conflict relationships between land use objectives. External conflicts: no agricultural activity; internal conflicts: agricultural activity.

In our study, we identified existing conflict situations through document analysis, existing and already displaced conflict situations were identified through the farmer survey, and already displaced conflict situations were identified through statistical data analysis and spatial data analysis. An exception can be found in the court decisions that we used as part of the document analysis. Based on these documents, only completed conflict situations could be identified.

Based on the assumption that a land use change is the result of a conflict situation and regarding the evaluated statistical land use data, a total conflict area of 132,895 ha can be identified for the state of Brandenburg over the period from 1995 to 2020. This corresponds to an average annual conflict area of 5316 ha. The average annual conflict area regarding agricultural use amounted to 2476 ha. In total, this amounted to 61,903 ha over the period from 1995 to 2020. Of this, 49,569 hectares were at the expense of agricultural use, and 12,334 hectares were in favor of agricultural use.

Table 3 presents a summary of the development of all the statistical land use data collected by the state of Brandenburg over the period of 1995 to 2020. In this period, the agricultural area decreased by a total of 37,235 ha. Considering that the average size of a farm in Brandenburg was 242 hectares in 2021 [53], around 40 farms were deprived of their production during the period under review.

Table 3. Land use changes in Brandenburg.

	1995	2010		2020		Sum of Loss/Gain
Agricultural area	1,474,348 ha	1,455,972 ha	−18,376 ha	1,437,113 ha	−18,859 ha	−37,235 ha
Settlement area	158,962 ha	194,894 ha	+35,932 ha	206,578 ha	+11,684 ha	+47,616 ha
Transport	98,174 ha	106,956 ha	+8782 ha	109,666 ha	+2710 ha	+11,492 ha
Forest area	1,030,018 ha	1,045,122 ha	+15,104 ha	1,033,640 ha	−11,482 ha	+3622 ha
Water area	99,981 ha	100,775 ha	+794 ha	99,676 ha	−1099 ha	−305 ha
Further areas	86,385 ha	44,593 ha	−25,894 ha	78,762 ha	+21,588 ha	−4306 ha
Total	2,947,868 ha	2,948,312 ha	+444 ha	2,965,435 ha	+17,123 ha	+16,679 ha

In the online survey of Brandenburg farmers, 105 out of a total of 118 farmers stated that they had already been confronted with land use conflicts at least once (Figure 5). Most land use conflicts occurred between agricultural use and nature conservation as a part of environmental protection (58%), the production of renewable energy (52%), and the expansion of transport routes (49%).

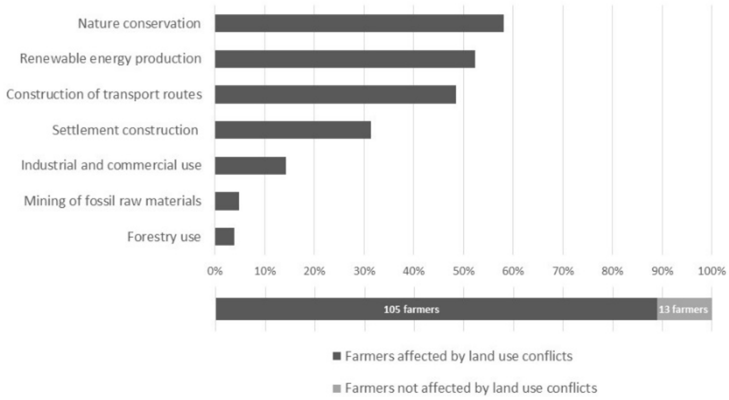

Figure 5. Reported land use conflicts by farmers.

Based on the document analysis, we were able to identify and locate a total number of 96 conflict situations between agricultural production and other land uses that still existed at the time of our investigations. Seven conflict situations were concluded, resulting from the evaluation of a court decision. Thus, based on the document analysis, we have identified and localized a total of 103 land use conflicts in a period of 20 years from 2000 to 2020 (Figure 6). The conflicts that occurred most frequently were between agricultural production and renewable energy production (49 conflicts), environmental protection (41 conflicts), and the use of agricultural land for construction projects such as settlement, transport routes, and industrial plants (13 conflicts).

In terms of identifying and locating land use conflicts through spatial data analysis, our focus was on conflicts between agricultural/food production, renewable energy production, conservation, and forestry. In the context of the use of agricultural land for generating renewable energy, we focused on the generation of energy by wind turbines, ground-mounted photovoltaic systems, and biogas plants. Based on the data source, as of March 2021, a total of 3888 wind turbines were installed, 279 were about to be installed, and 533 were in the approval process. Of the total number of wind turbines that have been commissioned, about to be commissioned, and in the approval process, 3926 were located on agricultural land. With a calculated average of 0.32 hectares per wind power station, this led to a total conflict area of about 1267 hectares in the agricultural area of Brandenburg. As Figure 7 shows, the distribution of the conflict area for wind turbines was heterogeneous. Especially in the north of Brandenburg, west of Berlin, and southwest of Brandenburg, there has been a high occurrence of conflict areas.

Conflict analysis by energy production through ground-mounted photovoltaic systems revealed a total of 183 installed ground-mounted photovoltaic systems and 104 additional ground-mounted photovoltaic systems in the approval process. These ground-mounted photovoltaic systems led to an overall conflicting area of about 5140 hectares of agricultural land. Here, Figure 7 shows a very inhomogeneous pattern, with a few clusters in the northwest to west, the south, and parts of the east of Brandenburg.

As a conflicting area connected with the production of regenerative energies by biogas plants, only maize cultivation area was considered within the scope of our investigation. Based on a determination of demand, this resulted in a conflict area of 111,042 hectares distributed over 8446 arable fields. The spatial pattern revealed a dominance in the north-east and northwest of Brandenburg. A summary figure (Figure 7, left) is given, with all three energy sources showing the carrying loss of land between 0.01 and 4185 hectares per municipality. The highest values were again in the northwest and east, while lower values dominated in the southern part.

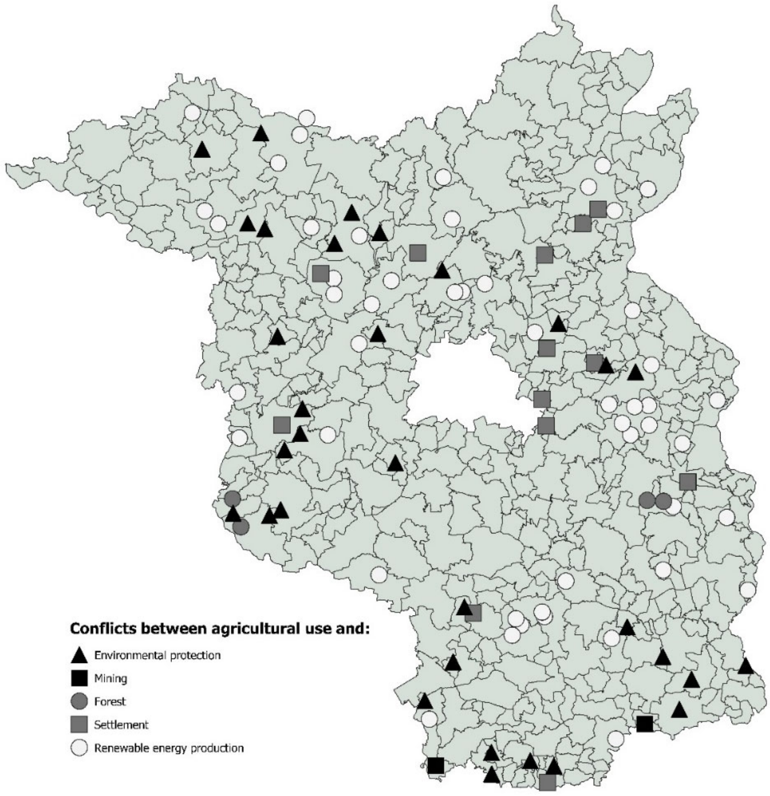

Figure 6. Agricultural land use conflicts by the Daily Regional Press and administrative courts decisions in the state of Brandenburg (2000–2020).

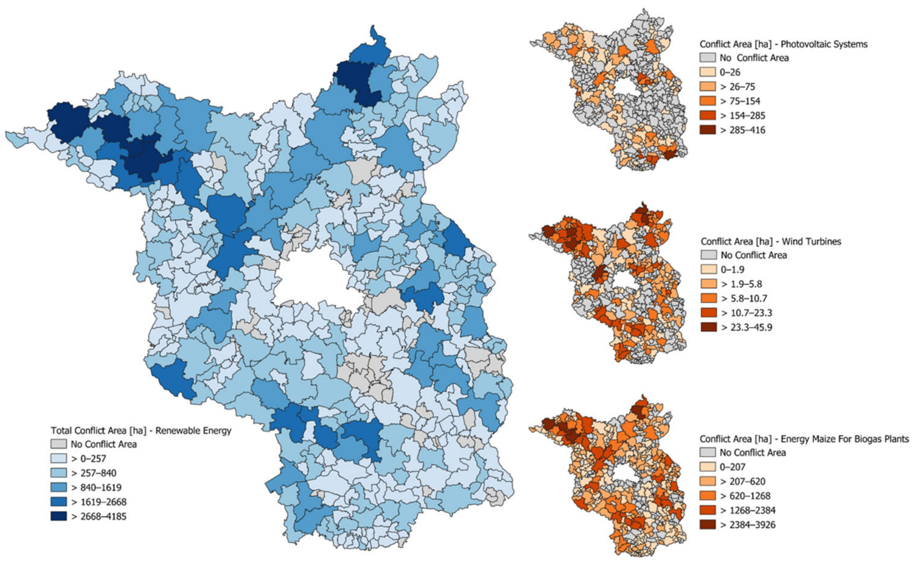

Figure 7. Distribution of the conflict areas between agricultural production and renewable energy production divided by the type of production.

The literature has shown that conflicts between agricultural use and the use of agricultural land occur much more frequently than conflicts between agricultural use and forestry (Figure 8). Although we identified 50,716 ha of agricultural land used for environmental protection, the conflict area related to forestry was 19,127 ha. Regarding the agricultural area used for environmental protection, the focus of the conflicts has been predominantly on the central to northern or western Brandenburg. The south or southeast have been less affected. Regarding the conflicts related to forestry, these occurred particularly in the north of Brandenburg, south of Berlin, and in the municipality of Schenkendöbern, which is on the border with Poland. The number of municipalities with no conflicts related to environmental protection or forestry was 12, or 2 out of 413 municipalities.

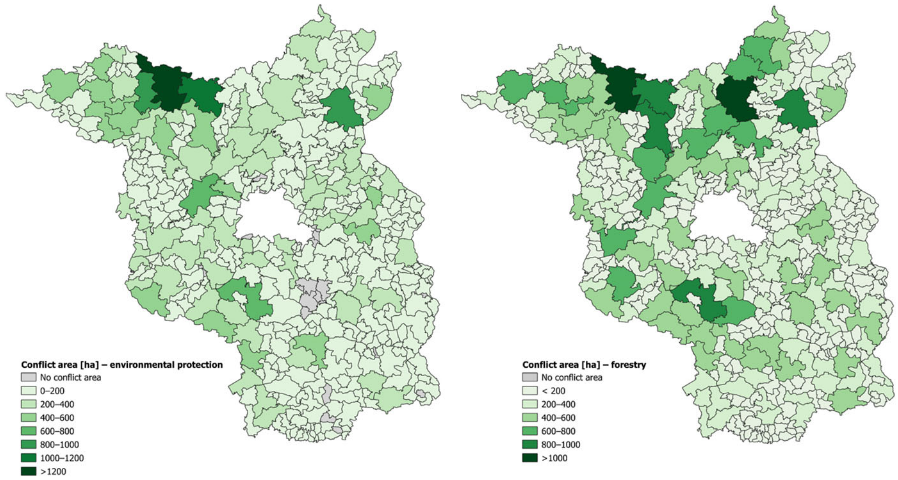

Figure 8. Distribution of the conflict areas between agricultural production and environmental protection, as well as forestry.

3.3. Land Use Synergies—Distribution of Potential Areas

Land use synergies may be identified in different ways. To identify agricultural areas with land use synergies, knowledge about land use systems that may lead to land use synergies in a targeted and site-adapted manner is needed. Based on this, we could see the possibility of establishing a spatial relationship with land use synergies. To identify and locate existing land use systems that could lead to synergies, document analysis, as well as a survey of land users on this topic, was an appropriate tool. Spatial data analysis can also be considered a suitable option, depending on the availability and quality of the data and information. Assuming that little or no data and information are available on these existing land use systems, a potential analysis can be conducted. Regarding the site requirements of such land use systems and the different land use objectives of policy and the public, potential synergy areas can be designated.

Comparatively few areas were identified and located where the land use systems (agroforestry system, agricultural area with agri-photovoltaic system, agricultural area with integrated nonproductive land) were established. We identified and localized 219 ha of land where the agroforestry systems were established, 0 ha of agricultural land with agri-photovoltaic plants, and 1282 ha of land with an integrated nonproductive area (small fallow land, fallow strips, flowering strips) (Figure 9). The results show that, especially in the north of Brandenburg, nonproductive land was increasingly integrated into agricultural land. The analysis has shown that, especially in the north of Brandenburg, nonproductive areas were increasingly planted on agricultural land. However, it is striking that, southwest of Berlin, hardly any strips of unproductive land have been established on arable land. In the case of agroforestry systems, no clear concentration can be identified regarding location.

Figure 10 shows the distribution of areas, here depending on the established land use system on which synergy effects can be expected if such a system were to be established in a site-adapted manner. The summarized map on the left side of Figure 10 shows a broad distribution of areas on which land use synergies are expected. Some key regions had a higher synergy potential than the rest of the state, and these were located in the northwest, northeast, and east of Brandenburg.

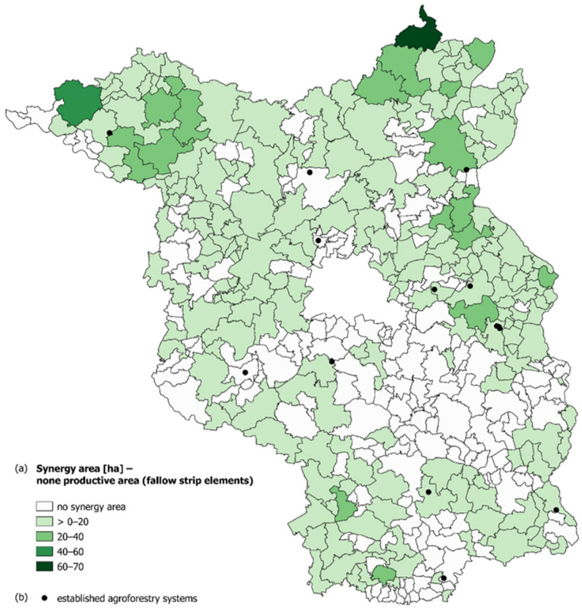

Figure 9. Land use synergies on agricultural land; (**a**) distribution of agricultural synergy areas with respect to fallow strip elements; (**b**) localization of established agroforestry systems.

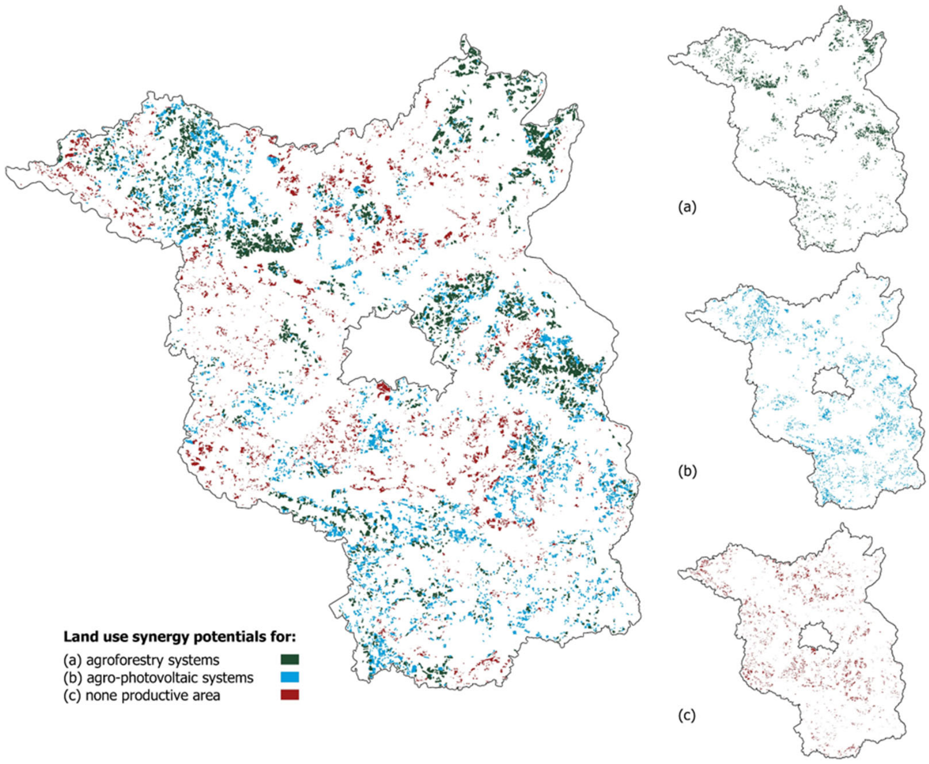

Figure 10. Distribution of the areas with respect to the probability of occurrence of land use synergies in the case of site-adapted establishment of the respective land use systems. (**a**) agroforestry systems, (**b**) agro-photovoltaic systems, (**c**) none productive area.

Figure 10a shows the distribution of areas with high synergy potentials regarding agroforestry systems. Especially in the northwest, northeast, and east of Brandenburg, synergy effects can be expected if agroforestry systems have been established and managed in a site-adapted and targeted manner. Figure 10b shows the distribution of areas with high synergy potential regarding agri-photovoltaic systems; in the northwest and east to south of Brandenburg, increased synergy potentials could be localized in connection with the establishment of agri-photovoltaic plants. In the west and northeast, only a few areas could be localized with synergy potentials in connection with such plants. Figure 10c shows a broad distribution of localized areas on which land use synergies in connection with the establishment of nonproductive areas such as fallow land or landscape features are expected. The regions in which the nonproductive area can lead to synergy effects are particularly located in the north, on the northwestern border of the state, in the west, and in the center of Brandenburg, which is south of Berlin.

4. Discussion

4.1. Summary of Findings

Our study identified multiple interests in agricultural land use, as also confirmed by Steinhäußer et al. [10], for example. We identified sustainable agricultural production, climate protection in the form of renewable energy production, and environmental protection as the key interests in agricultural land. However, all these land use interests have been the subject of public and political debates [54–57] because of their direct impact on the environment and climate in both a positive (e.g., reduction of greenhouse gas emissions) and negative sense (e.g., nitrogen inputs to water bodies). If different land use interests can be met, land use conflicts and land use synergies can emerge.

In our study, we showed that the number of identified land use conflicts exceeds the number of areas with land use systems, which can lead to synergies to a large extent. Different reasons can be given for this. On the one hand, the establishment of land use systems (e.g., agroforestry systems) that may lead to land use synergies can be associated with high investment costs [58]. At the same time, until the end of 2022, there was no legal basis, either at the European or national levels, for the promotion of agroforestry systems or areas with agri-photovoltaic systems. On the other hand, a lack of knowledge transfer about the mutual positive effects can also be assumed to be a reason for this. We suspect that the cause lies in several different reasons.

For Brandenburg, we localized numerous different land use conflicts. These were widely distributed throughout the entire study area. The most frequently identified conflicts on agricultural land were between agricultural use or food production, on the one hand, and environment and climate protection, on the other hand. Thus, the most frequently identified and localized land use conflicts corresponded to the main land use interests and public and political debates, which can be justified by more ambitious goals regarding the environment and climate protection [54–57,59]. In contrast to the land use conflicts, we identified and located only a few land use systems that could lead to synergies, even though these can provide a significant contribution to the stated protection goals. We assumed that the low number of such land use systems is because of the poor framework conditions so far. At the same time, our study revealed that there are numerous agricultural parcels in the study area that have synergy potential, provided that the land use systems that can lead to synergies are established in a targeted and site-adapted manner.

We showed that our mixed methods approach is suitable for the identification and localization of both land use conflicts and land use synergies. For our investigation, we based our work on Torre et al. [4], who focuses on the identification and localization of land use conflicts. We expanded the scope of the application to include land use synergies and synergy potential areas. Thus, in addition to the areas of conflict, we were able to identify the areas that were of great importance in the context of environmental protection and climate protection and sustainable development.

4.2. Limitations and Further Research

Similar to Torre et al. [4], we were able to identify and locate numerous land use conflicts but also land use synergies beyond these. To do this, we used a wide range of available data and information. However, the availability of information and data, as well as their quality, limited the scope of our investigations. For example, few data were available on existing land use systems that could lead to synergies. A further limitation is the scope of the considered study area. We considered the entire territory of the state of Brandenburg. Investigations that refer to a smaller level of observation can include more detailed information, such as the site suitability of certain woody plants in connection with the designation of synergy potential areas for agroforestry systems.

As our research has shown, numerous studies have addressed land use conflicts [4,11,19]. The trade-offs are also intensively addressed in the literature [60–62]. However, few studies deal with land use synergies [28,30]. There is a significant need for research in this area. The insights gained from research can make a significant contribution to meeting national, European, and even global goals regarding climate, environmental, and resource protection. In addition, sustainable and appropriate land use systems can enable targeted and site-appropriate land use that considers environmental and climate protection objectives. Land use conflicts and synergies should be considered together in the future because a change of perspective can also create synergies from land use conflicts. It is precisely these synergies that need to be exploited, whether in connection with agricultural use or other land uses, to address the call for new pathways for sustainable agricultural land use [63]. Future investigations of the potential mechanisms and processes for the spatial variations of land use conflicts and synergies may lead to a better understanding of how land use conflicts and land use synergies arise.

Agriculture can make a significant contribution to environmental and climate protection, as well as sustainable development, by specifically promoting the establishment and maintenance of land use systems leading to synergies when established in a targeted and site-adapted manner. Therefore, it is the task of political actors to increasingly include and offer targeted measures for funding ecosystem services within the framework of agricultural subsidies.

4.3. Conclusions

We focused on identifying and mapping the conflicts and synergies that may arise from different land use interests on agricultural land. We considered and contrasted agricultural production in general and food production in particular, here as the key land use interest, with other land use interests. Our results show that renewable energy production and environmental protection conflict with agricultural production because of the current objectives of the state government to mitigate climate change, expand renewable energy production, preserve biodiversity, and protect resources [59]. By combining agricultural production with these land use objectives, such as renewable energy production via agri-photovoltaic systems, synergy effects can be achieved if applied in a targeted and site-adapted manner.

The investigation of land use synergies is critical insofar as an effective contribution to the mentioned areas of protection can be made by targeted exploitation of these effects. At the same time, conflicts can be reduced or mitigated. We identified numerous areas that show increased potential regarding the occurrence of synergy effects when one of the above-mentioned land use systems is established. However, it must always be kept in mind that actual land use is also influenced by intangible factors, such as cultural, historical, social, or ownership issues.

Our approach offers the possibility to examine every possible combination of land use interest for possible synergy effects and identify potential areas on which a contribution to the achievement of specific objectives (e.g., environmental protection) can be made. Therefore, the findings provide important information for zoning and planning to delineate and identify areas for particular land uses; they are also of high political interest, for example, to reduce land use conflicts and achieve political and social objectives through the use of synergy effects.

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Appendix A

Table A1. Land use classification approach: key land use classes, types, and objectives.

Land Use Classes	Land Use Sub-Classes	Land Use Objectives
(A) Primary Production	A1 Agriculture	A10 Food production
		A11 Fodder production
		A12 Production of renewable raw materials
	A2 Forestry	A21 Timber production
	A3 Mining and quarrying	A31 Mining of raw materials
	A4 Aquaculture	A41 Aquaculture
		A42 Fishing
	A5 Other primary productions	A51 Hunting
		A52 Picking of natural products
(B) Secondary Production	B1 Industrial production	B11 Production of industrial products
	B2 Energy production	B21 Renewable energy production
		B22 Fossil energy production
		B23 Nuclear energy production
(C) Tertiary Production	C1 Services	C10 Services
(D) Infrastructure	D1 Transport	D10 Road transportation
		D11 Railway transportation
		D12 Bicycle lanes
		D13 Water transportation
	D2 Logistic and storage	D21 Logistic and storage
	D3 Supply	D31 Supply of population
	D4 Waste management	D41 Waste utilization
		D42 Waste storage
(E) Residential use	E1 Residential use	E10 Residential use
(F) Recreational	F1 Recreational and leisure sites	F10 Recreation
		F11 Leisure
(G) Conservation	G1 Nature conservation	G10 Protection of landscapes
		G11 Conservation of nature
		G12 Other protection objectives
	G2 Managed resource Protection	G21 Drinking water protection
	G3 Other mineral uses	G22 Mineral use
(H) Natural area	H1 Without use	H10 No land use

References

1. United Nations. *World Population Prospects 2019: Highlights*; United Nations, Department of Economic and Social Affairs, Population Division: New York, NY, USA, 2019; Available online: http://www.europeanmigrationlaw.eu/documents/UN-WorldPopulationProspects2019-Highlights.pdf (accessed on 16 May 2021).
2. Begon, M.; Howarth, R.W.; Townsend, C.R. (Eds.) Die Ökologie des Menschen: Bevölkerungswachstum, Krankheiten und Versorgung mit Nahrung. In *Ökologie*; 3. Aufl. 2017, Nachdruck 2014; Springer: Berlin/Heidelberg, Germany, 2016; pp. 521–566. ISBN 978-3-662-49905-4.
3. Statistisches Bundesamt. Einwohnerzahlen in Brandenburg von 1961 Bis 2021. Available online: https://de.statista.com/statistik/daten/studie/155142/umfrage/entwicklung-der-bevoelkerung-von-brandenburg-seit-1961/ (accessed on 15 February 2023).
4. Torre, A.; Romain, M.; Habibullah, M.; Luc, B.; Anne, C.; Armelle, C.; Ségolène, D.; Philippe, J.; Thierry, K.; Haï, P.V.; et al. Identifying and measuring land-use and proximity conflicts: Methods and identification. *SpringerPlus* **2014**, *3*, 85. [CrossRef] [PubMed]
5. Hersperger, A.M.; Ioja, C.; Steiner, F.; Tudor, C.A. Comprehensive consideration of conflicts in the land-use planning process: A conceptual contribution. *Carpathian J. Earth Environ. Sci.* **2015**, *10*, 5–13.
6. Arnold, S.; Lucas, C.; Pauly, R. Der neue Nutzungsartenkatalog zur erweiterten tatsächlichen Nutzung in der amtlichen Flächenstatistik. *Wiss. Stat.* **2020**, *72*, 44–56.
7. Von der Dunk, A.; Grêt-Regamey, A.; Dalang, T.; Hersperger, A.M. Defining a typology of peri-urban land-use conflicts—A case study from Switzerland. *Landsc. Urban Plan.* **2011**, *101*, 149–156. [CrossRef]
8. Wehrmann, B. *Land Conflicts: A Practical Guide to Dealing with Land Disputes*; GTZ: Eschborn, Germany, 2008; ISBN 9783000239403.
9. Adam, Y.O.; Pretzsch, J.; Darr, D. Land use conflicts in central Sudan: Perception and local coping mechanisms. *Land Use Policy* **2015**, *42*, 1–6. [CrossRef]
10. Steinhäußer, R.; Siebert, R.; Steinführer, A.; Hellmich, M. National and regional land-use conflicts in Germany from the perspective of stakeholders. *Land Use Policy* **2015**, *49*, 183–194. [CrossRef]
11. Yang, S.; Dou, S.; Li, C. Land-use conflict identification in urban fringe areas using the theory of leading functional space partition. *Soc. Sci. J.* **2020**, 1–16. [CrossRef]
12. Brown, G.; Raymond, C.M. Methods for identifying land use conflict potential using participatory mapping. *Landsc. Urban Plan.* **2014**, *122*, 196–208. [CrossRef]
13. Zou, L.; Liu, Y.; Wang, J.; Yang, Y. An analysis of land use conflict potentials based on ecological-production-living function in the southeast coastal area of China. *Ecol. Indic.* **2021**, *122*, 107297. [CrossRef]
14. Hite, J.C. Land Use Conflicts on the Urban Fringe: Causes and Potential Resolution, Clemson. 1998. Available online: https://tigerprints.clemson.edu/cgi/viewcontent.cgi?article=1318&context=sti_pubs (accessed on 3 March 2022).
15. Magsi, H.; Torre, A. Approaches to understand land use conflicts in the developing countries. *Macrotheme Rev.* **2013**, *2*, 119–136.
16. Mirady, S.; Gonzales, S.E.; Castillo, M.M.; Alvizu, P.; Oliviera, M.A.; Perez, J.; Quilici, A.; Rada, M.; Yaber, M.C. Large-scale shrimp farming in coastal wetlands of Venezuela, South America: Causes and consequences of land-use conflicts. *Environ. Manag.* **1994**, *18*, 647–661.
17. Valle Junior, R.F.; Varandas, S.G.; Pacheco, F.A.; Pereira, V.R.; Santos, C.F.; Cortes, R.M.; Sanches Fernandes, L.F. Impacts of land use conflicts on riverine ecosystems. *Land Use Policy* **2015**, *43*, 48–62. [CrossRef]
18. Adisa, R.S. (Ed.) *Land Use Conflict between Farmers and Herdsmen—Implications for Agricultural and Rural Development in Nigeria: Rural Development—Contemporary Issues and Practices*; InTech: Rijeka, Croatia, 2012; ISBN 978-953-51-0461-2. Available online: http://www.intechopen.com/books/rural-development-contemporary-issues-and-practices/land-use-conflictbetween-famers-and-herdsmen-implications-for-agricultural-and-rural-development-in (accessed on 14 May 2022).
19. Henle, K.; Alard, D.; Clitherow, J.; Cobb, P.; Firbank, L.; Kull, T.; McCracken, D.; Moritz, R.F.; Niemelä, J.; Rebane, M.; et al. Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe—A review. *Agric. Ecosyst. Environ.* **2008**, *124*, 60–71. [CrossRef]
20. Zhang, Y.J.; Li, A.J.; Fung, T. Using GIS and Multi-criteria Decision Analysis for Conflict Resolution in Land Use Planning. *Procedia Environ. Sci.* **2012**, *13*, 2264–2273. [CrossRef]
21. Zhang, Y.; Liu, Y.; Zhang, Y.; Kong, X.; Jing, Y.; Cai, E.; Zhang, L.; Liu, Y.; Wang, Z.; Liu, Y. Spatial Patterns and Driving Forces of Conflicts among the Three Land Management Red Lines in China: A Case Study of the Wuhan Urban Development Area. *Sustainability* **2019**, *11*, 2025. [CrossRef]
22. Grass, I.; Batáry, P.; Tscharntke, T. Combining land-sparing and land-sharing in European landscapes. *Adv. Ecol. Res.* **2021**, *64*, 251–303. [CrossRef]
23. Stave, K. Participatory System Dynamics Modeling for Sustainable Environmental Management: Observations from Four Cases. *Sustainability* **2010**, *2*, 2762–2784. [CrossRef]
24. Gorripati, R.; Kolagani, N.; Thakur, M. Promoting Climate Resilient Sustainable Agriculture through Participatory System Dynamics with Crop-Water-Income Dynamics. *Res. Sq.* **2022**. [CrossRef]
25. Akıncı, H.; Özalp, A.Y.; Turgut, B. Agricultural land use suitability analysis using GIS and AHP technique. *Comput. Electron. Agric.* **2013**, *97*, 71–82. [CrossRef]

26. Amini, S.; Rohani, A.; Aghkhani, M.H.; Abbaspour-Fard, M.H.; Asgharipour, M.R. Assessment of land suitability and agricultural production sustainability using a combined approach (Fuzzy-AHP-GIS): A case study of Mazandaran province, Iran. *Inf. Process. Agric.* **2020**, *7*, 384–402. [CrossRef]
27. Charabi, Y.; Gastli, A. PV site suitability analysis using GIS-based spatial fuzzy multi-criteria evaluation. *Renew. Energy* **2011**, *36*, 2554–2561. [CrossRef]
28. Li, Q.; Zhou, Y.; Xu, T.; Wang, L.; Zuo, Q.; Liu, J.; Su, X.; He, N.; Wu, Z. Trade-offs/Synergies in Land-use Function Changes in Central China from 2000 to 2015. *Chin. Geogr. Sci.* **2021**, *31*, 711–726. [CrossRef]
29. Kangas, K.; Brown, G.; Kivinen, M.; Tolvanen, A.; Tuulentie, S.; Karhu, J.; Markovaara-Koivisto, M.; Eilu, P.; Tarvainen, O.; Similä, J.; et al. Land use synergies and conflicts identification in the framework of compatibility analyses and spatial assessment of ecological, socio-cultural and economic values. *J. Environ. Manag.* **2022**, *316*, 115174. [CrossRef]
30. Ma, X.; Zhu, J.; Zhang, H.; Yan, W.; Zhao, C. Trade-offs and synergies in ecosystem service values of inland lake wetlands in Central Asia under land use/cover change: A case study on Ebinur Lake, China. *Glob. Ecol. Conserv.* **2020**, *24*, e01253. [CrossRef]
31. Deutscher Fachverband für Agroforstwirtschaft. Agroforstwirtschaft: Die Kunst, Bäume und Landwirtschaft zu Verbinden. 2020. Available online: https://agroforst-info.de/wp-content/uploads/2020/12/2020_DeFAF_Brosch%C3%BCre_final_Web.pdf (accessed on 28 January 2022).
32. Mosquera-Losada, M.R.; Santiago-Freijanes, J.J.; Rois-Díaz, M.; Moreno, G.; den Herder, M.; Aldrey-Vázquez, J.A.; Ferreiro-Domínguez, N.; Pantera, A.; Pisanelli, A.; Rigueiro-Rodríguez, A. Agroforestry in Europe: A land management policy tool to combat climate change. *Land Use Policy* **2018**, *78*, 603–613. [CrossRef]
33. Udawatta, R.P.; Rankoth, L.; Jose, S. Agroforestry and Biodiversity. *Sustainability* **2019**, *11*, 2879. [CrossRef]
34. Fraunhofer-Institut für Solare Energiesysteme ISE. Agri-Photovoltaik: Chance für Landwirtschaft und Energiewende, Freiburg. 2020. Available online: https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/APV-Leitfaden.pdf (accessed on 3 May 2022).
35. Schindele, S. Nachhaltige Landnutzung mit Agri-Photovoltaik: Photovoltaikausbau im Einklang mit der Lebensmittelproduktion: Szenarioanalyse zur Inanspruchnahme landwirtschaftlicher Nutzflächen durch Photovoltaik in Deutschland bis 2050. *GAIA Ecol. Perspect. Sci. Soc.* **2021**, *30*, 96–105. [CrossRef]
36. Baudry, J.; Alomar, O.; Begg, G.; Büren, C.; Chenaux, B.; Elmquist, H.; Flamm, C.W.; Gosme, M.; Guerin, O.; Jeanneret, P. EIP-AGRI Focus Grpup: Benefits of Landscape Features for Arable Crop Production. 2016. Available online: https://ec.europa.eu/eip/agriculture/sites/default/files/eip-agri_fg_ecological-focus-areas_final-report_en.pdf (accessed on 27 August 2022).
37. Qing, W.; Hualin, X. A Review and Implication of Land Fallow System Research. *J. Resour. Ecol.* **2017**, *8*, 223–231. [CrossRef]
38. Knickel, K.; Douwe van der Ploeg, J.; Renting, H. Multifunktionalität der Landwirtschaft und des ländlichen Raums. In *Perspektiven in der Landnutzung: Regionen, Landschaften, Betriebe. Entscheidungsträger und Instrumente*; Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V., Band 39; Landwirtschaftsverlag GmbH: Münster, Germany, 2004; pp. 75–83.
39. Amt für Statistik Berlin-Brandenburg. *Statistisches Jahrbuch 2020—Brandenburg*; Amt für Statistik Berlin-Brandenburg: Potsdam, Germany, 2020; pp. 1–645.
40. Ministerium des Inneren und für Kommunales des Landes Brandenburg. Anzahl der Landkreise, kreisfreien Städte, Gemeinden und Ämter in Brandenburg. 2020. Available online: https://service.brandenburg.de/de/kommunale-verwaltungsstruktur/20108 (accessed on 27 May 2021).
41. Deutscher Wetterdienst. Temperatur: Vieljährige Mittelwerte 1991–2020. Available online: https://www.dwd.de/DE/leistungen/klimadatendeutschland/mittelwerte/temp_9120_akt_html.html?view=nasPublication&nn=16102 (accessed on 24 April 2021).
42. Deutscher Wetterdienst. Niederschlag: Vieljährige Mittelwerte 1991–2020. Available online: https://www.dwd.de/DE/leistungen/klimadatendeutschland/mittelwerte/nieder_9120_akt_html.html?view=nasPublication&nn=16102 (accessed on 24 April 2021).
43. Amt für Statistik Berlin-Brandenburg. Erste Ergebnisse der Landwirtschaftszählung 2020 für Brandenburg. 2021. Available online: https://www.statistik-berlin-brandenburg.de/pms/2021/21-01-21.pdf (accessed on 21 January 2021).
44. Statistisches Bundesamt. Strukturwandel in der Landwirtschaft Hält An. Available online: https://www.destatis.de/DE/Presse/Pressemitteilungen/2021/01/PD21_028_412.html (accessed on 21 January 2021).
45. Wolff, S.; Hüttel, S.; Nendel, C.; Lakes, T. Agricultural Landscapes in Brandenburg, Germany: An Analysis of Characteristics and Spatial Patterns. *Int. J. Environ. Res.* **2021**, *15*, 487–507. [CrossRef]
46. Ministerium für Wirtschaft, Arbeit und Energie. Erneuerbare Energien. 2021. Available online: https://mwae.brandenburg.de/de/bb1.c.478388.de (accessed on 19 October 2021).
47. Hartmann, A. Wie Viel Fläche Wird für Biogas Benötigt? Available online: https://www.statistik-bw.de/Service/Veroeff/Monatshefte/PDF/Beitrag08_07_08.pdf (accessed on 4 September 2021).
48. Machl, T.; Ewald, W.; Donaubauer, A.; Kolbe, T.H. Entwicklung eines Werkzeugs zur landesweit flächendeckenden Analyse landwirtschaftlicher Transportbeziehungen in Bayern. *Z. Geodäsie Geoinf. Landmanag.* **2016**, *3*, 197–205.
49. Reckleben, Y.; Schäfer, N.; Weißbach, M. Steigerung der Effizienz bei Straßentransporten mit unterschiedlichen Reifentypen für Traktoren. *Landtechnik* **2013**, *68*, 196–201.
50. Aid Infodienst e.V. 3614 2015 Gute Fachliche Praxis—Bodenbewirtschaftung und Bodenschutz. 2013. Available online: https://www.ig-gesunder-boden.de/Portals/0/doc/Literatur/BLE_GfP_3614_508_web.pdf (accessed on 20 December 2022).

51. Deutscher Verband für Landschaftspflege e.V. DVL-Publikation-Schriftenreihe-9_Landschaftselemente_in_der_Agrarstruktur. Available online: https://www.dvl.org/uploads/tx_ttproducts/datasheet/DVL-Publikation-Schriftenreihe-9_Landschaftselemente_in_der_Agrarstruktur.pdf (accessed on 20 December 2022).
52. Böhm, C.; Hübner, R. Bäume als Bereicherung Für Landwirtschaftliche Flächen: Ein Innovationskonzept für die Verstärkte Umsetzung der Agroforstwirtschaft in Deutschland, Cottbus. 2020. Available online: https://agroforst-info.de/wp-content/uploads/2020/03/Innovationskonzept-Agroforstwirtschaft.pdf (accessed on 28 January 2022).
53. Ministerium für Landwirtschaft, Umwelt und Klimaschutz. Im Vergleich—Brandenburg Braucht Landwirtschaft. 2021. Available online: https://agrarbericht.brandenburg.de/abo/de/start/agrarstruktur/im-vergleich/# (accessed on 12 February 2022).
54. Europäische Kommission. *Grüner Deal: EU Investiert Mehr Als 110 Millionen Euro in LIFE-Projekte für Umwelt und Klima in elf EU-Ländern*; Europäische Kommission: Brüssel, Belgium, 2022.
55. Leggett, J.A. The United Nations Framework Convention on Climate Change, the Kyoto Protocol, and the Paris Agreement: A Summary. 2020. Available online: https://sgp.fas.org/crs/misc/R46204.pdf (accessed on 3 June 2022).
56. Ehlerding, S. Klimaschutz Ist Keine Ideologie: Debatte um Klimawandel und Weldernährung. Der Tagesspiegel [Online], 30 July 2019. Available online: https://www.tagesspiegel.de/politik/debatte-um-klimawandel-und-erderwaermung-klimaschutz-ist-keine-ideologie/24849784.html (accessed on 7 March 2022).
57. United Nations. Transforming Our World: The 2030 Agenda for Sustainable Development. 2015. Available online: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf (accessed on 3 March 2022).
58. Böhm, C.; Tsonkova, P.; Mohr, T.; Schröder, C.; Lorenz, C.; Ludewig, M.; Bösel, B.; Dommel, J.; Wagner, N.; Domin, T. Konzept zur Förderung von Agroforstflächen als Agrarumwelt- und Klimamaßnahme (AUKM) im Rahmen des Kulturlandschaftsprogramms (KULAP) des Landes Brandenburg. 2020. Available online: https://agroforst-info.de/wp-content/uploads/2020/06/Konzept_Agroforst_AUKM__Druck.pdf (accessed on 13 March 2022).
59. Sozialdemokratische Partei Deutschlands; Christlich Demokratische Union Deutschlands; Bündnis 90/Die Grünen. Ein neues Kapitel für Brandenburg—Zusammenhalt, Nachhaltigkeit, Sicherheit: Ein Kapitel für Brandenburg. Gemeinsamer Koalitionsvertrag von SPD Brandenburg, CDU Brandenburg und Bundnis 90/Die Grünen Brandenburg. 2019. Available online: https://www.brandenburg.de/media/bb1.a.3833.de/Koalitionsvertrag_Endfassung.pdf (accessed on 3 June 2022).
60. Bai, Q.; Labi, S.; Li, Z. Trade-Off Analysis Methodology for Asset Management, West Lafayette, Indiana. 2008. Available online: https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2653&context=jtrp (accessed on 4 June 2021).
61. Hinz, R.; Sulser, T.B.; Huefner, R.; Mason-D'Croz, D.; Dunston, S.; Nautiyal, S.; Ringler, C.; Schuengel, J.; Tikhile, P.; Wimmer, F.; et al. Agricultural Development and Land Use Change in India: A Scenario Analysis of Trade-Offs Between UN Sustainable Development Goals (SDGs). *Earth's Future* **2020**, *8*, e2019EF001287. [CrossRef]
62. Klapwijk, C.J.; van Wijk, M.T.; Rosenstock, T.S.; van Asten, P.J.; Thornton, P.K.; Giller, K.E. Analysis of trade-offs in agricultural systems: Current status and way forward. *Curr. Opin. Environ. Sustain.* **2014**, *6*, 110–115. [CrossRef]
63. Spangler, K.; Burchfield, E.K.; Schumacher, B. Past and Current Dynamics of U.S. Agricultural Land Use and Policy. *Front. Sustain. Food Syst.* **2020**, *4*, 98. [CrossRef]