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Article

Stakeholder Strategies for Sustainability Impact Assessment of Land Use Scenarios: Analytical Framework and Identifying Land Use Claims

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Abstract: Despite scientific progress in operationalizing sustainable development (SD), it is still hampered by methodological challenges at the regional level. We developed a framework to analyse stakeholder based, SD targets for future land use, which are characterized by different impact levels and spatial references. The framework allows for the analysis of land use demands in the context of SD. We identified societal use targets in north-eastern Germany, particularly for the area type's lowland fens and irrigation fields, represented through strategy documents. We used frame analysis to aggregate and condense the targets into land use claims. Results present a framework for the *ex-ante* Sustainability Impact Assessment of land use changes at the regional level and the determination and regionalization of the future societal demand for land use functions. For future land use at the regional level, manifold land use claims exist, but on smaller scales, area-specific targets are less apparent. Six key main-use claims and 44 side-use claims were identified at the regional level and for area types. Possible trade-offs among land use claims for land use functions can be identified at each governance level. Implications of the methodological approach are discussed according to moving development targets and SD as multi-sector and multi-level governance issues.

Keywords: land use conflicts; trade-offs; multifunctional land use; land use functions; multi-level governance; environmental policy integration; stakeholder analysis; frame analysis

1. Introduction

The structure and conditions of future land use in north-eastern Germany will be modified by driving forces such as agricultural policies, societal demands, climate change and demographic change. Due to the reconfiguration of agricultural policy [1] and energy policy at European and national levels, the spatially relevant use demands in the rural areas of north-eastern Germany have changed. For example, the demand and supply of renewable energies and resources have been emerging in recent decades [2]. These changed landscape configurations are reflected in regional planning concepts (e.g., GRK Berlin-Brandenburg 2011 [3]). Through related land use changes, different policy fields, sectors and societal actors (water economy, agriculture, forestry, nature conservation associations) are affected, leading to land use conflicts [4]. Sustainable development (SD) is characterized as a multi-level, multi-sectoral and cross-policy issue [5]. Land use changes always have intended and non-intended effects [6]. Consequently, land and water management stand in an area of tension between different region-specific uses and protection logics. It is necessary to understand the connection between the anticipated effects of land use changes and different political, societal and private targets. Considering the limitations of area and utilization competition, these modified landscape configurations will confront public and policy actors with multiple challenges for SD. To assess SD at the landscape level, it is essential to connect the future demand and supply of region-specific portfolios of functions related to land use [6,7]. Hence, an *ex-ante* Sustainability Impact Assessment (SIA) of the anticipated effects on land use related functions [8] in the research area of north-eastern Germany and, in particular, the types of area lowland fens and sewage farms is necessary. The modified landscapes may require adaption strategies implemented by government authorities and land owners to achieve regional SD. Policymakers and society must decide the extent to which the current and future multifunctionality of land use related functions should be guaranteed at regional scales. As an adaptation strategy to these challenges, integrated land use systems and adaptive institutions [9] are needed.

Sustainability Impact Assessment of Land Use Scenarios

The goal of *ex-ante* SIA is the multi-criteria evaluation of possible intended and non-intended consequences of future land use systems for SD. The concept of SD is a normative and societal construct whereby science can primarily provide the information basis, whereas society and policymakers decide on the configuration of future land use [10] and assess sustainable land use demands for an integrated and spatially explicit approach [8]. For an SIA of land use scenarios at a landscape level, it is necessary to connect the future political and societal demands and the supply of region-specific portfolios of land use functions (LUFs). LUFs are defined as the services and goods provided through land use in a region and include all relevant environmental, economic and social aspects [11]. However, the determination of the demand and the regionalization and operationalization of sustainability and spatial development targets from stakeholder strategies at supranational and national governance levels, for example, due to moving policy targets [12] involve many challenges. The assessment of the impacts of future-oriented land use strategies on regional SD therefore requires both the scientific estimation of the anticipated effects on ecological, economic and social aspects in a research region [13,14] and the contextualization of these effects in a normative, societal frame. Consequently, for a policy- and decision-relevant SIA of land use scenarios, it is necessary to identify topics that are compatible with societal discourses [8]. The operationalization of the SD of land use at a regional level, however, is complicated by methodological problems [15]. These problems include, for example, the challenging task of defining causal linkages between human and natural interactions, and considering stakeholder preferences, *i.e.*, societal norms [16], while ensuring a transparent and operational functioning of the assessment itself. In this regard, SIA should be understood as a process that aims to engage different stakeholder groups while facilitating the social learning process among stakeholders [17]. To operationalize SD from social-ecological systems in the context of multi-level governance and complex institutions, generalist approaches, such as the approach of Ostrom 2009 [18], exist. Integrative, science-derived SIA concepts exist for land use and particularly bioenergy studies at the regional level [10]. Burkhard *et al.* 2012a [7] present a quantitative approach to determining and mapping the demands for ecosystems and linking them with the supply for calculating and mapping ecosystem service budgets. The Framework of Participatory Impact Assessment (FoPIA) provides a participatory approach to connecting Impact Assessment with the concept of SD. In this case, the anticipated effects of land use scenarios are linked with the normative ideals of stakeholders via evaluating LUFs [19]. FoPIA combines an expert-based scenario assessment with local preferences regarding land use related sustainability issues and supports the exploration of alternative land use scenarios to reveal possible sustainability trade-offs among social, economic, and environmental LUFs [20]. However, a framework to link future land use with various development targets from policy strategies (e.g., the German bio-economy strategy or the biomass strategy of the federal state of Brandenburg) and regional actors' targets and plans at different scales and governance levels to evaluate anticipated effects of land use scenarios is missing. Furthermore, a framework to connect the anticipated effects with manifold and potentially contradicting stakeholder targets (Figure 1) is also lacking.

The following principal knowledge gaps related to the SIA of land use scenarios at the regional level are present: (i) the linking of a multi-criteria analysis of the effects of land use scenarios with normative targets from policy and actor strategies and plans at different governance levels is missing, (ii) a linkage of LUFs with policy and actor strategies and plans is missing, and (iii) the analysis of action logics of stakeholder targets to identify trade-offs and synergetic effects related to land use in the context of SD is missing. To assess SD at the regional level, multiple stakeholder strategies at European, national and regional scales must be connected. Accordingly, the *ex-ante* SIA of land use scenarios requires a framework with which a plurality of ecological, economic and social development targets at different governance levels can be operationalized. Additionally, for a decision-relevant SIA and for the support of discourses regarding SD, a framework to connect regional land use conflicts and development issues with policy, actors' and planning targets must be developed. This paper therefore addresses the following methodological aspects and research questions: (i) How can research be designed that links the endogenous potentials of a region with driving forces and external use demands and values? (ii) What future land use claims, specified in main- and side-use claims, exist in strategy documents? (iii) How can partially contradicting ecologic, economic and social targets with various impact levels be identified at different scales and analysed in the context of SD? This study thus aims to develop and apply a framework for an SIA of land use scenarios to address multiple external policy targets and actors' targets and plans for future land use, which are characterized through different impact levels and spatial references. An additional goal of this study is to identify the demand for region-specific portfolios of LUFs in the form of action (use and protection) logics in the research region of north-eastern Germany. These demand portfolios can be connected with the supply, depending on land use scenarios. To handle these sustainability issues, which are often characterized by concurrent utilization and protection logics, as a methodological approach a frame analysis [4] of the underlying action logics of the identified targets was conducted to identify future land use claims, specified in main- and side- use claims. According to Rein and Schön 1994 [21], a frame is what "an institutional actor uses to construct the problem of a specific policy situation". In the materials and methods section, we provide a description of the case study north-eastern Germany and the work steps done to apply the analytical framework to determine the demand for LUFs. In the results section, we describe the selection of documents for the demand analysis plus the identified main- and side-use claims related to LUFs. After that, we discuss the implications against present knowledge gaps and SD as a multi-level issue.

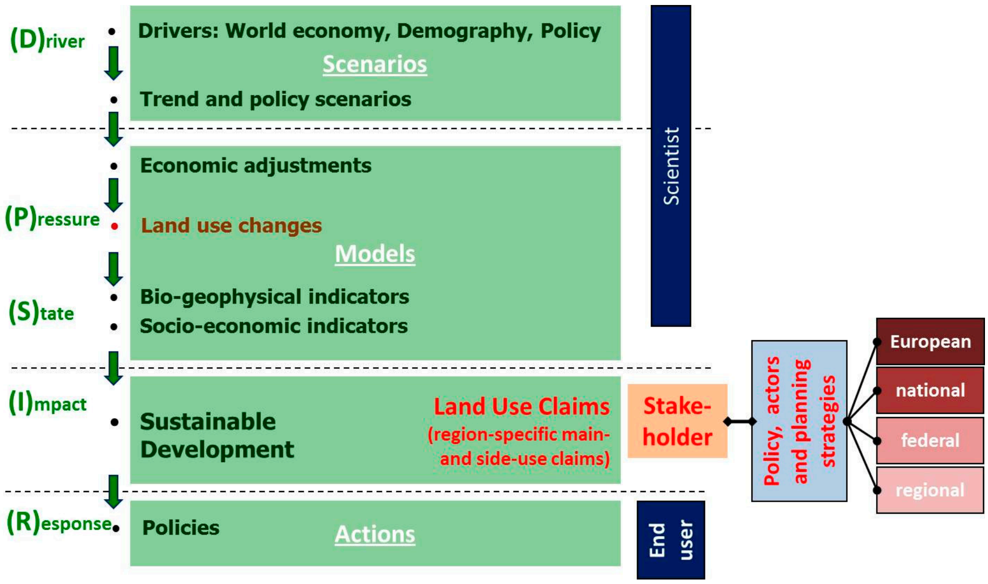

Figure 1. Analytical approach to stakeholder-based Sustainability Impact Assessment, adapted after Helming *et al.* 2011 [8], to integrate policy, actors' and planning targets at different governance levels.

2. Materials and Methods

2.1. Case Study

This framework for *ex-ante* SIA was developed and applied in the context of an integrated research project about sustainable water and land management strategies in north-eastern Germany. These strategies include, for example, the irrigation of cleared wastewater for the valorisation of contaminated land with short coppice rotations. As a spatial analytical framework, the Berlin/Brandenburg region and types of area lowland fens and irrigation fields are analysed in this paper.

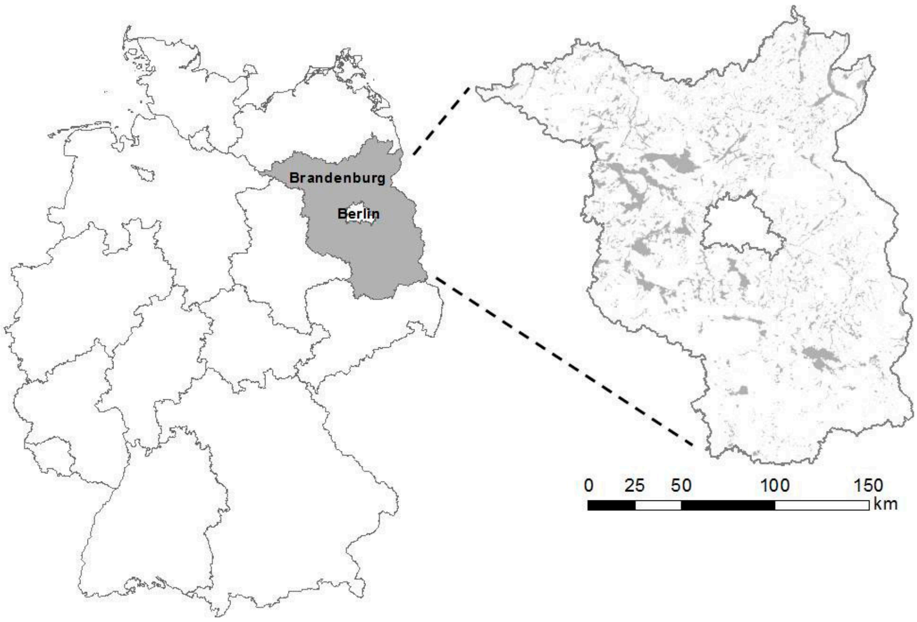

Figure 2. Map of the study region north-eastern Germany (Berlin/Brandenburg). Enlarged view on the right shows a peatlands map of Brandenburg. The map was compiled by the Humboldt University Berlin on behalf of the Environmental Agency Brandenburg (reference year: 2004). Geo-referenced information for irrigation fields is not available.

Accordingly, this paper presents a framework for the *ex-ante* SIA of land use changes at regional level, whereby the analysed lowland fens are located at several spots in Brandenburg and managed as grasslands, while the irrigation fields are located in the surroundings of Berlin but primarily on the territory of the federal state of Brandenburg (Figure 2). The peatlands area of Brandenburg recently has decreased from 2004. These types of area are confronted with many challenges for sustainable land management. According to Nitsch *et al.* 2012 [22], the policy incentives for supporting bioenergy and the high prices for agricultural commodities since approximately 2007 have increased the competition between arable land and permanent grassland in Germany and have often led to grassland conversion. This land use competition is still present. At the same time, the groundwater level in this region has been decreasing, which is anticipated to create challenges for SD, such as the drying of wetlands, decreasing biodiversity, the decreasing productivity of grasslands and forests, and the increasing conflicts among actors' interests [23]. Table 1 shows relevant location properties of the research region north-eastern Germany (Berlin/Brandenburg) and the analysed types of area.

Both area types are characterized by marginal agricultural revenues and by their hydrological sink function for water and matter fluxes. Differences exist particularly in the limited development possibilities (due to legal frameworks) for irrigation fields, the use of these areas for local recreation and the limited number of actors [24]. Furthermore, the research region is influenced through urban–rural disparities and the partially oversized infrastructure for sewage treatment in rural areas [25]. Influencing factors such as demographic change and climate change might further strengthen these disparities.

Table 1. Physio-geographic, socio-cultural and socio-economic location characteristics of the research area.

Characteristics	Region (Berlin/Brandenburg)	Area Type: Lowland Fens	Area Type: Irrigation Fields
Location	Diverse (agglomerations and rural areas)	Peripherally rural area	Located close to the city
Ownership structure	Diverse	Primarily privately owned	Primarily public domain
Hydrology	Low rainfall surplus of the water balance, compared to German conditions	High groundwater level; hydrological sink	Low groundwater level
Soils	Diverse (mainly glacial and peat soils)	Soils with different levels of degradation and peat layer thickness	Sandy to loamy soils being contaminated with organic and inorganic pollutants because of previous use as wastewater irrigation sites
Land use	Diverse (e.g., agricultural use)	Mostly agricultural production (intensive to extensive grassland use)	No agricultural production (e.g., grassland use, grazing)
Wastewater treatment and drinking water supply	Potentially oversized infrastructure for sewage treatment in rural areas [25]	No drinking water production	Close to areas for drinking water production by bank filtrate

2.2. Analytical Framework for Sustainability Impact Assessment

As a basis for the newly developed framework for SIA, the three-pillar model of sustainable development [26] and the Driver-Pressure-State-Impact-Response-Framework (DPSIR; [27]) are applied. To structure the SIA process and to derive decision-relevant topics (*States*) and targets for future land use development (*Impacts*), the DPSIR framework is used. This framework is applied in a plurality of studies to support policy-relevant decision processes regarding the *ex-ante* impact assessment of different land use strategies. It helps to analyse causal chains between socio-economic and bio-geophysical aspects and it facilitates the dialogue between experts and stakeholders [28]. In addition to the DPSIR framework, the concept of LUFs is applied for the conceptualization of the SIA of land use scenarios. Aimed at SIA, the concept of LUFs is used because, compared to the concept of ecosystem services, the concept of LUFs is seen to be more suitable for managed, anthropogenically modified land for that economic value creation is at least as important as ecosystem service maintenance [29]. In this sense, the LUF concept comes close to the concept of agro(eco)system services but goes beyond it in that it also considers functions for which ecosystem processes are not essential, such as infrastructure and non-land based production (see Section 3.2). Furthermore, according to Perez-Soba *et al.* 2008 [11], LUFs are a practical approach to operationalize stakeholder values in the context of SD. To handle the plurality of social requirements of land use and the production of public goods and services as a theoretical background, the concept of multifunctional land use is applied. According to Mander *et al.* 2007 [30], cultural landscapes are multifunctional due to their simultaneous provision of habitats and their productivity, regulation, social and economic functions. If certain functions outweigh others, the sustainable land use of the area is endangered [31]. For the assessment of SD of land and water use systems, it is therefore important that land use be multifunctional [8]. Thus, to assess the impact of land use scenarios on SD, a region-specific portfolio of LUFs depending on problem questioning and spatial context is required. This regional specification of the LUFs is a part of the results of the cross-strategy analysis (see Section 3.2). Figure 3 illustrates the essential connection of the societal demand and supply of region-specific LUFs and the application of the required concepts and methods in the *States–Impacts* interface to operationalize manifold and partially contradicting targets for future land use development that are aggregated and condensed to region-specific land use claims in terms of main-use claims and side-use claims. These regional specifications are the other part of the results of this study (see Section 3.3).

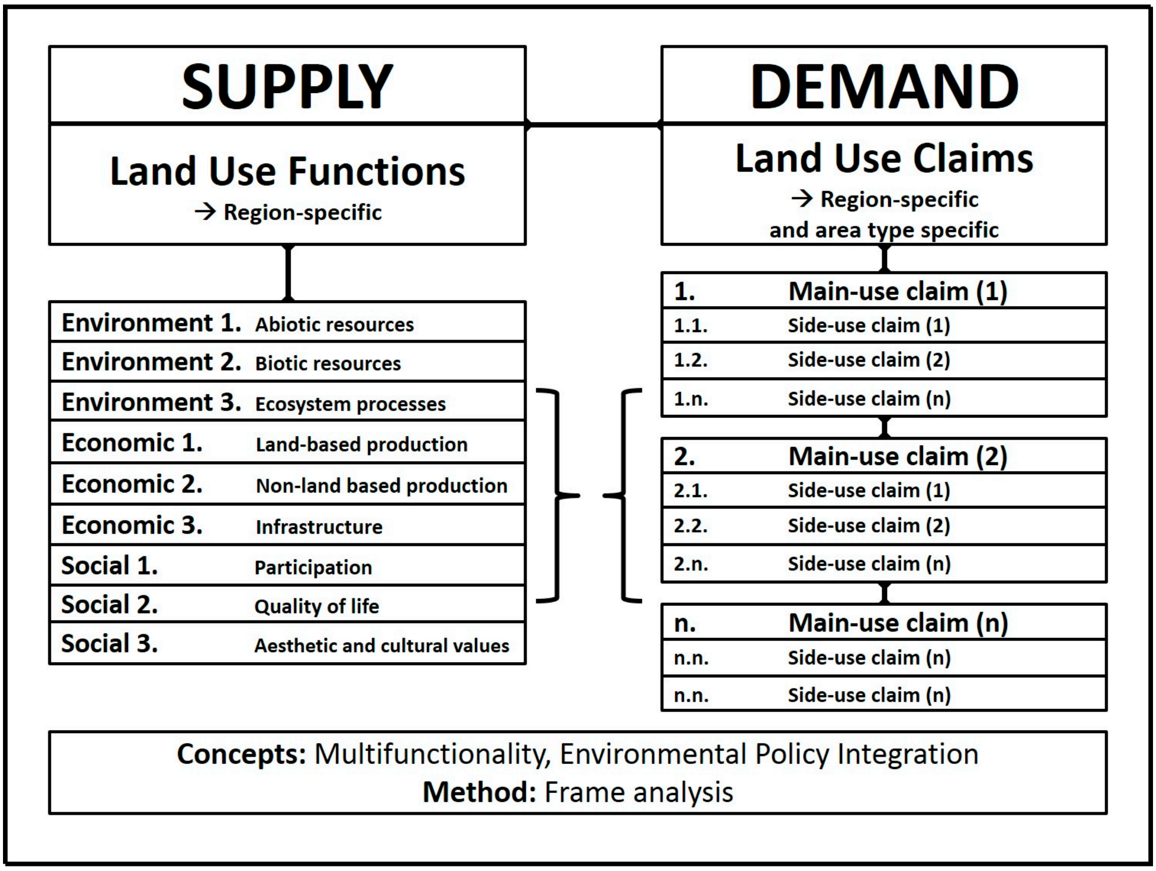

Figure 3. The required link between the region-specific demand and the supply of land use functions for Sustainability Impact Assessment. For this, the land use functions have to be specified to the actual regional context in terms of sustainability-relevant topics (see Section 3.2) and the demand in terms of land use claims (see Section 3.3).

Via frame analysis [4], the manifold and potentially contradicting normative environmental, economic and social targets for future land use that affect the LUFs are operationalized and discussed against the background of multifunctionality and Environmental Policy Integration (EPI; [5]). The concept of multifunctionality does not sufficiently take into account the different governance and impact levels of the land use claims related to future land use and potential trade-offs in the current European multi-level governance systems. Thus, for the strategy and trade-off analysis, the concept of EPI is used as a basis. The concept of EPI was developed to integrate the seemingly incompatible goals of economic competiveness, social development and ecological viability [4,5]. However, this integration is a pre-condition for SD [26].

Therefore, EPI has the goal of greening traditionally sectoral policies, such as agricultural, transportation and energy policy [32]. Moreover, this concept was developed to achieve the horizontal and vertical ecologization of multi-level and multi-sector policies and thereby ensure the livelihood of future generations [32]. Land and water management exist in an area of conflict among various logics of use and protection, which leads to land use conflicts. To analyse complex socio-ecological problem areas and adaptation strategies to make these systems more sustainable, knowledge of the different logics of the actions of the affected and involved actors is highly important. These sustainability issues are particularly related to contemporary and future public services and resource use [33].

2.3. Methods

Table 2 shows the required working steps for applying the developed analytical framework to assess SD in case studies and thus to operationalize targets at different scales and impact levels and the trade-offs and synergetic effects of the identified targets related to the demand for region-specific LUFs. In this way, the demand for region-specific LUFs in terms of main- and side-use claims in the context of the spatially heterogeneous land use in north-eastern Germany can be determined at the regional level.

Table 2. Working steps in the DPSIR framework to determine the political and societal demand for region-specific land use functions.

<table>
<tr><td>(S)tates
Sustainability-relevant topics</td><td>• Defining land use functions in connection to the sustainable development of land use systems and public service tasks within the research area.
• Identifying sustainability-relevant topics for future land use and linking them with land use functions.</td></tr>
<tr><td rowspan="3">(I)mpacts
Human well-being and sustainable development
<u>(Cross-strategy analysis)</u></td><td>• Identifying targets from stakeholder strategies and their linkage with sustainability-relevant topics and land use functions. If there are no statements in regional strategies, targets are selected from national and European development strategies for rural areas.</td></tr>
<tr><td>• To handle the plurality of demands for land use, as a second step, the identified targets for land use development in Berlin/Brandenburg are aggregated and condensed to land use claims in terms of main- and side-use claims via frame analysis.</td></tr>
<tr><td>• Frame analysis of land use claims to identify trade-offs and synergies.</td></tr>
<tr><td>(R)esponses</td><td>Recommendations for options based on the presented strategy analysis to achieve regional sustainable development.</td></tr>
</table>

2.3.1. Cross-Strategy Analysis

As the first step, the database for the strategy documents analysis must be defined. The normative impacts for SD and human well-being are derived from policy strategies (e.g., biomass strategy, strategy for the sustainable development of the federal state Brandenburg, national biodiversity strategy), planning concepts, federal state laws and actors' strategies (Table 3). Therefore, a literature survey of the strategy documents related to land and water management and to the extent of future resource use and public services in north-eastern Germany during 2013 and February 2014 was conducted. These strategies and concepts were analysed at different administrative *Nomenclature des unités territoriales statistiques* (NUTS) levels. Therefore, strategies at the national scale (NUTS = 0) and at the level of the federal states of Berlin and Brandenburg (NUTS = 1/2) were analysed. Additionally, strategies at European, regional and district levels

(NUTS = 2/3) were taken into account. Moreover, relevant land use systems on the types of areas, such as the output of cleared waste water, short coppice rotation or grassland use, were analysed. The focus of this study was on identifying superior policy strategies and supra-regional and regional planning concepts. To hierarchize the impact levels of the targets and to operationalize targets for different sectors and scales, this stakeholder analysis was based on the concept of EPI. The criteria of the document analysis, furthermore, are the affected sectors and the treatment of space. In contrast to Glæsner *et al.* 2014 [34], who analysed existing European policies to identify gaps and overlaps in supporting soil functions via cross-policy analysis, this study, aimed at *ex-ante* SIA, explored targets for land use in general. These strategies reflect the future societal spatial relevant demands for land use and are considered as normative targets for the development of land use in the region north-eastern Germany and both types of areas.

2.3.2. Land Use Functions and Sustainability-Relevant Topics

As a second step, the work of Perez-Soba *et al.* 2008 [11] was adapted and nine LUFs were defined in connection to the SD of land use systems and public service tasks within the research area. Hereafter, the appropriate sustainability themes for SIA were derived from the cross-strategy analysis. The problem areas of future public services and resource use related to land and water use in the Berlin/Brandenburg region (e.g., the water supply, the need for added value in rural areas and wastewater treatment or the utilization of secondary resources) must be covered with these topics. The adapted LUFs and designated topics were discussed within interdisciplinary expert meetings (e.g., hydrologist or economist) and partially modified. The motivation of the experts is to establish sustainable land use strategies in north-eastern Germany.

2.3.3. Identifying Targets for Future Land Use and Linkage with Land Use Functions

Because the identified targets reflect the public and private demand for future multifunctional land use, we associated these targets to the LUFs. As the analysed spatial segments are embedded within a spatial and socio-cultural context [8], supra-regional and regional development targets were used when area-specific targets for the LUFs were missing; e.g., the irrigation fields are subparts of the open space network in the surroundings of Berlin. During this working step, the plurality of target formulations in the analysed strategies was aggregated to a long list of main targets.

2.3.4. Frame Analysis for the Identification of Land Use Claims in Terms of Main-Use and Side-Use Claims

To handle the plurality and partially contradicting targets, which are characterized by different degrees of spatial abstraction and obligations, the targets were further aggregated and condensed into land use claims. If the aggregated targets were identified as a unique feature, they were considered main-use claims; else, they were associated as side-use claims to the main-use claims. Consequently, land use claims are defined as the future societal demand for goods and services related to region-specific land use. Main-use claims are defined as the substantial normative paradigms of the society on the future spatial land use. Side-use claims are defined as the underlying and promoting arguments why and how the respective main-use claim should be implemented in the future. Side-use claims thereby specify respective main-use claims. For this step, an orientation along the results of the policy analysis from Söderberg and Eckerberg 2013 [4] and the identified policy frames was conducted. Moreover, the integrative sustainability rules of the *Nachhaltigkeitskonzept der Helmholtz-Gemeinschaft* (HGF-concept), according to Kopfmüller *et al.* 2001 [35], were taken into account. This working step was conducted for north-eastern Germany and the area types. For north-eastern Germany, targets from the national and the federal state level (Berlin/Brandenburg) were summarized. In the next step, via frame analysis, the future spatially relevant land use claims were analysed to identify overlaps and trade-offs and synergies. To analyse the development strategies and the main- and side-use claims with regard to their horizontal and vertical integration during this working step, also an analysis of targets and interpretations against the background of EPI was conducted.

3. Results

3.1. Cross-Strategy Analysis

The database of policies and actor strategies and plans used for the identification and analysis of land use claims in terms of main- and side-use claims is summarized in Table 3. The highest number of strategy documents is selected at NUTS levels 1 and 2. At NUTS levels 0 and 3, few strategies are selected. The designated strategies cover a plurality of action fields and land use sectors. The impact levels of the strategies are different. The considered laws are mandatory while some strategies have only the character of voluntary incentives or awareness raising. Consequently, due to very high obligations the most likely land use claims, which adjust future land use, have their sources in European, national and federal state laws. The identified policy strategies and planning concepts have the characteristics of a vision and set stronger targets for future land use. Both strategy types have a high impact level. For the actor strategies, the impact level is defined as low because their implementation depends upon the degree of participation. Also, the references to the space of the targets differ greatly, as shown in Table 3. In particular, policy strategies are non-area differentiated, which means that the target formulations within the strategies have stronger spatial references. This situation is mostly the case in planning concepts. Area-concrete represents targets for a concrete spatial segment. In actor strategies at NUTS level 3, this condition is mostly the case.

Table 3. List of the analysed policy and actor strategies and planning concepts with different obligation levels, action fields, sectors and spatial references. Organized along NUTS levels. (Bold letters and numbers in square brackets are used in Tables 6–11 for referencing to the strategies).

Space Levels	**Type of Strategy**	**Strategies**	**Action Fields**	**Obligations** Level of Impact	**Sectors**	**Treatment to Space**
Euro-pean level	**Directives**	• Water Framework Directive (WRRL) **[SA]** • Renewable Energies Directive (RED) **[SB]**	Water management, *Energiewende*	High European law	Water economy, agriculture, energy economy	Non-area differentiated
National level **NUTS = 0**	**Laws/Reg-ulations Catalogues of measures**	• LEADER-Funding regulation (2007) **[S0]** • Contaminated Sites Ordinance; Bundes-Bodenschutz- und Altlastenverordnung (BBodSchV) (1999) **[S1]** • Natura 2000 (1992) [D] → FFH-RL Anhang I **[S2]**	Regional development; nature conservation	High National law	Agriculture, nature conservation	Area differentiated
	Policy strategies	• BMU & BMELV – National biomass action plan for Germany (2010) **[S3]** • BMU – National biodiversity strategy (2007) **[S4]** • BMU – German adaptation strategy to climate change (2008) **[S5]** • LAWA – Guidelines on water development (2006) **[S6]** • LABO – Position paper soil and climate change (2010) **[S7]** • BMEL – Bio-economy strategy (2013) **[S8]**	Bio-economy, bio-based *Energiewende*, adaptation to climate change	High	Trans-sectoral (transportation, chemistry, agriculture, energy and water economy)	Non-area differentiated
	Actor strategies	• Memorandum – Claims for the protection of running waters and reservoirs to ensure the drink water supply (2010) **[S46]** • German farmers' association (DBV; press releases from 2011-2014) **[S47]**	Water protection, biomass production	Low	Agriculture, water economy	Area-differentiated
Federal state level **NUTS = 1/2**	**Laws/Regula tions**	• LUGV – Implementation of the European water framework directive – Contributions of the federal state of Brandenburg to the management plans and programmes of measures for the river basin districts Elbe and Oder (2011) **[S9]** • Regulation of quality targets for certain hazardous substances and for the reduction of water pollution by programmes for Brandenburg – *Brandenburgische Qualitätszielverordnung* – BbgQV (2011) **[S10]** • Federal environmental agency Brandenburg (LUA) – Implementation of the water framework directive in the federal state of Brandenburg for the subject area groundwater – Background paper groundwater (2010) **[S11]**	Implementation WRRL, running waters, groundwater protection	High Federal law	Agriculture, water economy	Area-differentiated
		• LELF – Requests for agricultural grassland use in Brandenburg (2010) **[S12]** • Guidelines for promoting environmentally friendly agricultural production processes and for the preservation of the cultural landscape of the federal states Brandenburg and Berlin (KULAP 2007) **[S13]**	Grassland use, cultural landscape development	High	Agriculture, nature conservation, cultural landscape development	Area-differentiated

Table 3. *Cont.*

Space Levels	Type of Strategy	Strategies	Action Fields	Obligations Level of impact	Sectors	Treatment to Space
Federal state level NUTS = 1/2	Policy strategies	• Advisory board for the sustainable development of the federal state of Brandenburg – Recommendations for corner points of a sustainability strategy for the federal state of Brandenburg (2010) **[S14]** • Advisory board for the sustainable development of the federal state of Brandenburg: Recommendations for the sustainability strategy for the federal state of Brandenburg (2013) **[S49]** • MUGV – Biomass strategy of the federal state of Brandenburg (2010) **[S15]** • MWE – Energy strategy 2030 of the federal state of Brandenburg (2012) **[S16]**	SD, *Energie-wende,* biomass production	High	Agriculture, water and energy economy	Area-differentiated
		• MUGV – Corner points for the protection and usage of the fens (2014) **[S17]**	Lowland fens utilization and protection	High	Agriculture, Water economy	Area-differentiated
		• MUGV – Position paper – Use of cleared wastewater for the stabilization of water balance (2010) **[S18]**	Groundwater protection	Low	Water economy	Area-differentiated
	Measure catalogues and guidelines	• Catalogue of measures for climate protection and for adaptation to climate change (2008) **[S19]** • LUGV – Environmental indicators in the federal state of Brandenburg (2013) **[S20]** • Office for Statistics of Berlin-Brandenburg – Core indicators for the sustainable development of Berlin (2012) **[S21]**	SD, climate change adaptation	High	Trans-sectoral	Area-differentiated
		• Common action plan for the water administration of the federal states of Berlin and Brandenburg (2012) **[S22]** • Guidelines for the restoration of wetlands in Brandenburg (2004) **[S23]** • Federal environmental agency Brandenburg (LUA) – Risk assessment and restoration of former irrigation fields under consideration of the requests of BBodSchG/BBodSchV (2003) **[S24]** • Groundwater in Berlin – Deposits, usage, protection and threats (2007) **[S25]**	Water management, management of lowland fens and contaminated sites	High	Water economy, agriculture, nature conservation	Area-differentiated
	Supra-regional planning concepts	• Common spatial planning concept energy and climate for Berlin/Brandenburg (GRK; 2011) **[S26]** • Development plan for the rural areas of Brandenburg and Berlin (EPLR) 2007 – 2013 (2012) **[S27]** • Federal development plan Berlin-Brandenburg (LEP 2009) **[S28]** • Federal development program (2007) **[S29]** • Landscape program Brandenburg (2000) **[S30]** • Cultural landscapes – Chances for the regional development in Berlin and Brandenburg (2007) **[S31]**	*Energiewende,* Regional value creation, climate change adaption	High	Trans-sectoral	Area-differentiated

Table 3. *Cont.*

Space Levels	Type of Strategy	Strategies	Action Fields	Obligations Level of impact	Sectors	Treatment to Space
Federal state level **NUTS = 1/2**	**Actor strategies**	• German Federal Agency for Nature Conservation (BfN) Short-rotation coppices – An assessment from a nature conservation perspective (2010) **[S40]** • German Federal Agency for Nature Conservation (BfN) – Requests for short-rotation coppices in terms of nature conservation (2012) **[S41]** • DBU-Project – Energy biomass from lowland fens (2009) **[S42]** • BUND – Resolution fen protection (2010) **[S43]** • EU-LIFE-Project: Calcareous fens Brandenburg of the *NaturSchutzFonds* Brandenburg (Start: 2010) **[S44]** • Farmers association of the federal state Brandenburg (LBV; press releases from 2011–2014) **[S48]**	Nature conservation, biomass production	Low	Nature conservation, Agriculture	Area-differentiated
Regional and county level **NUTS = 2/3**	**Measure catalogues and Guidelines**	• Soil analysis after the BBodSchV of the former irrigation field *Karolinenhöhe* in Berlin **[S39]**	Soil protection, management of contaminated sites	Low	Trans-sectoral	Area-concrete
Regional and county level **NUTS = 2/3**	**Regional planning concepts**	• River development plan (GEK) for the *Randow* (2012) **[S32]** • Area-based local development strategy (GLES) for the county Barnim (2007) **[S33]** • Management planning Natura 2000 in the federal state Brandenburg – Short version – Management plan for the area "*Randow-Welse-Bruch*" (2012) **[S45]**	Implementation of WRRL, biomass production, nature conservation	High	Water economy, nature conservation	Area-differentiated
Regional and county level **NUTS = 2/3**	**Actor strategies**	• BfN, Berliner Forsten, county Barnim, NaturschutzFonds and Förderverein Naturpark Barnim e.V. – Test + development undertaking "Irrigation field landscape *Hobrechtsfelde*" **[S34]** • "Irrigation field landscape *Hobrechtsfelde*", Festschrift Hobrechtsfelde (2008) **[S35]** • NABU – Requests for short-rotation coppices in terms of nature conservation **[S36]** • Berliner Stadtgüter **[S37]** • ELaN Discussion Paper (4) – Actors, acceptance and conflict potentials in the sustainable land and water management within ELaN **[S38]**	Regional tourism, biomass production	Low	Trans-sectoral Environmental and nature protection organizations	Area-concrete

3.2. Land Use Functions, Sustainability-Relevant Topics and Targets

More than 40 region-specific sustainability-relevant topics for the selected LUFs were identified in the analysed strategies (Table 4). Through these criteria, the assessment of SD must be structured. However, only at the regional level, above the types of areas, each LUF target for these topics could be identified. An integrative landscape policy related to all three dimensions of SD for land and water management in north-eastern Germany and the analysed area types do not exist at the regional level; there are always just policy-, sector- and scale-specific overlaps within the landscape context. Most of the targets for the types of area could be identified at federal or state level, within regional planning concepts, and at the actors' level. In addition to sector-oriented targets for future land use, already many cross-cutting targets exist in the analysed policy and actors' strategies and plans.

Table 4. Definitions of the nine selected Land Use Functions (adapted from Perez-Soba *et al.* 2008 [11]) and respective region-specific sustainability-relevant topics. Numbers indicate the amount of sustainability-relevant topics per land use function and sustainability dimension.

Land Use Functions (LUFs)	Definitions of LUFs	Sustainability-Relevant Topics	Number =	
Primarily environmental Land Use Functions:				
ENV (1): Provision of abiotic resources	"The role of land use in the regulation of the supply and the quality of soil and water"	Water supply, water quality (running waters), water quality (groundwater), structure of water body, soil quality and quantity	**5**	
ENV (2): Provision of biotic resources	"Provision of habitats and factors that affect the capacity of the area to support the local or regional biodiversity"	Species richness, agricultural biodiversity, habitat richness, landscape connectivity	**4**	**14**
ENV (3): Maintenance of ecosystem processes	"The role of land use in the regulation of natural processes and ecological supporting functions"	Water depot, carbon and nutrient depot, adsorption and transformation of pollutants, climate regulation (global climate), climate regulation (micro-climate)	**5**	
Primarily economic Land Use Functions:				
ECO (1): Land-based production	"Provision of land for economic utilization (agricultural and forestry production and water economy)"	Biomass production, renewable energies (bioenergy), food production, (resource-) efficiency, profitability, agro-environmental measures/certification	**6**	
ECO (2): Non-land based production	"Provision of areas for touristic, industrial and commercial utilization"	Additional land use, renewable energies, regional tourism, (resource) efficiency, profitability	**5**	**16**
ECO (3): Infrastructure	"Provision for the public service tasks and value creation networks of land and water management in the region required infrastructure"	Water management, harvesting, logistics and energy infrastructure, wastewater treatment, drinking water supply, upkeep (profitability) of public service tasks	**5**	
Primarily Social Land Use Functions:				
SOC (1): Participation	"Distribution and opportunities for participation with land use-connected value creation"	Working places, income possibilities, human capital, public expenditures, rural development possibilities (value creation), rural development possibilities (raw materials)	**6**	
SOC (2): Quality of life	"A 'good' living standard in rural regions in connection with factors, which should improve the quality of life"	Demographic change, human health, (local) recreation, village infrastructure, housing quality	**5**	**14**
SOC (3): Cultural and aesthetic values	"With the local culture and the historic land management-linked values"	Cultural landscape development, regional identity, landscape scenery	**3**	

3.3. Land Use Claims, Specified in Main- and Side-Use Claims Related to Future Land Use

As the regional specification of land use claims, six main-use claims related to the aggregated and condensed targets could be identified from the strategy analysis. These main-use claims are *"land use for"* **(1)** *"sustainable intensification"*; **(2)** *"environment, resource and nature protection"*; **(3)** *"climate adaption and protection"*; **(4)** *"regional and rural development"*; **(5)** *"urban-rural interdependencies"*; and **(6)** *"quality of life"* (Table 5). The identified main-use claims mirror the changed supra-regional policy agenda with the emergence of climate adaptation and the utilization of renewable energies and regrowing materials and are reflected in superior policy strategies (e.g., biomass and bio-economy strategy) and regional planning concepts (e.g., the common spatial planning concept of energy and climate for Berlin-Brandenburg 2011).

Table 5. Definitions of the six main-use claims identified in the analysis of strategy documents (Table 3).

Main-Use claims: "Land Use for"	
1) Sustainable Intensification (adapted from Garnett *et al.* 2013 [36])	Agricultural and forestry land use in rural areas for food security and (green) growth because of the worldwide increasing demand for bioenergy, renewable resources and food while maintaining the non-provisioning services of ecosystems
2) Environment, resource and nature protection	Sustainable use of renewable and non-renewable abiotic and biotic resources
3) Climate adaption and protection	Averting climate change and the mitigation of impacts
4) Regional and rural development	Regional value chains for *(green)* growth and the provision of public service tasks
5) Urban-rural interdependencies	Exchange of public and private goods and services between agglomerations and rural areas; embedding land use in the spatial context to reduce disparities
6) Quality of life	Soft location factors affecting human well-being

3.3.1. Comparing Side-Use Claims for North-Eastern Germany and Types of Areas

For the land use development in north-eastern Germany (Berlin/Brandenburg), a plurality of side-use claims for the respective main-use claims could be identified. Tables 6–11 show the results of the frame analysis and the identified side-use claims for future land use in north-eastern Germany and on the area types. At landscape level, due to the missing targets related to future land and resource use and public services for the types of areas, the side-use claims are few or varying. The side-use claims differ among the types of area and the regional level through their different spatial localizations and socio-cultural embeddedness.

"Sustainable Intensification"

At regional scale, in a variety of the analysed strategies (e.g., German bio-economy strategy or the biomass strategy of the federal state Brandenburg), a further intensification of the agricultural usage and the extension of material and energetic biomass production for food and energy security is requested. Additionally, the increase in organic farming and the valorisation of alternative and local land-adapted use systems are wanted. To achieve a sustainable intensification, the increase in the resource efficiency and the usage of secondary resources are also wanted. In the case of the lowland fens, the area-specific side-use claims are in particular the ensuring of grassland use and the agricultural use. For the lowland fens, in addition to the regionally dominant main-use claim of sustainable intensification, the opposite trend exists; areas (arable and intensive grassland use) should be extended or even given over to natural development. In the case of the irrigation fields, the area-specific side-use claims are the valorisation of alternative land use systems (e.g., grazing or short coppice rotations) potentially by need-oriented irrigation with cleared wastewater.

Table 6. Main-use claim 1: "Land use for sustainable intensification" and related side-use claims as identified in the analysis of strategy documents (Table 3) for north-eastern Germany, lowland fens and irrigation fields in Berlin/Brandenburg.

Side-Use Claims:	North-Eastern Germany	Lowland Fens	Irrigation Fields
1.1. Intensification potentials for energetic and non-energetic biomass production	[SB,S3]	[S42]	[S18]
1.2. Mitigation of utilization competitions by biomass cultivation	[S8]		
1.2.1. → Cascade use	[S8]		
1.3. Locally adapted land use systems	[S8]	[S26,S30]	[S18,S24,S35]
1.3.1. → Value creation while maintaining peat layer		[S17]	
1.4. Valorisation of alternative land use systems			
1.4.1. → Need-oriented irrigation with wastewater	[S18]	[S18]	[S18]
1.4.2. → E.g., short coppice rotations		[S17]	[S18, S35]
1.5. Support of organic farming	[S13]		
1.6. Ensuring grassland use		[S4,S17,S30]	
1.7. Intensification potentials of grassland use/biomass potentials from extensive used grassland	[S12,S15]	[S4,S17,S30]	
1.8. Use of secondary resources	[S18]	[S18]	[S18]
1.9. Food and energy security	[S15]		
1.10. Increase of energy and resource efficiency	[S16,S49]		

"Environment, Resource and Nature Protection"

To protect the environment and abiotic and biotic resources, on the one hand, the sustainable resource use and energy usage as side-use claims are demanded. In particular, the implementation of the *Water Framework Directive* and the improvement of water quality and quantity are desired. Furthermore, soil protection and support of soil functions are wanted. On the other hand, the preservation of biological diversity and corresponding adaption actions, such as species or biotope protection, are addressed. In general, the reduction of land consumption is desired. Moreover, the ensuring of natural sink functions and the security of drinking water supply is wanted. For lowland fens, the sink functions and the matter depot plus the adsorption of pollutants are highlighted. For this, the soil protection and the avoidance of peat layer mineralization are desired as side-use claims. This aim can be achieved by the extensification or even renaturation of land use. In relation to irrigation fields, soil protection and the avoidance of soil pollutant mobilization, the functions of open-space areas and the reduction of land consumption and sealing are stressed.

Table 7. Main-use claim 2: "Land use for environment, resource and nature protection" and related side-use claims as identified in the analysis of strategy documents (Table 3) for north-eastern Germany, lowland fens and irrigation fields in Berlin/Brandenburg.

Side-Use Claims:	North-Eastern Germany	Lowland Fens	Irrigation Fields
2.1. Improving water quality ,water and preventive groundwater protection	[SA,S9,S20,S21,S30,S46]	[S30,S45]	[S18]
2.1.1. → Reducing eutrophication and pollution of running waters	[S22]	[S30]	[S18]
2.2. Soil protection			
2.2.1. → Soil fertility	[S8]		
2.2.2. → Avoidance of overuse and erosion	[S7,S8]	[S32]	
2.2.3. → Avoiding peat mineralization		[S17]	
2.2.4. → Prevention of the mobilization of soil pollutants			[S24]
2.2.5. → Decontamination			[S18,S24,S35]
2.2.6. → Intact vegetation layer			[S24]
2.3. Preserving and increasing biological diversity			
2.3.1. → Species and habitat protection	[S0,S2,S4,S19,S21]	[S2,S30]	[S45]
2.3.2. → Development of biotope networks	[S2,S19]	[S28]	[S28]
2.3.3. → Agricultural biodiversity	[S13,S15]	[S45]	
2.3.4. → Preservation of genetic variety	[S13]	[S13]	
2.4. Extensification of agricultural areas → renaturation		[S17]	
2.5. Developing and ensuring natural sinks			
2.5.1. → Nutrient depot	[S14]	[S30]	
2.5.2. → Adsorption of pollutants		[S23,S30]	[S35]
2.6. Security of supply			
2.6.1. → Drinking water	[S18]	[S18]	[S18]
2.7. Reduction of land consumption	[S7,S14]		[S24,S28]

"Climate Protection and Adaptation"

At regional level, for the adaption to climate change, the avoidance and reduction of GHG emissions, flood control and protection, the carbon sequestration of natural sinks and open-space areas, and the emerging use of renewable resources are emphasized. At the level of the area types, the sink functions (water and carbon depot) of lowland fens in the landscape balance are highlighted. For this, the water retention with higher groundwater levels and rewetting are demanded. In the case of the irrigation fields, the area-specific side-use claims are in particular the promotion of the functions of open-space areas (e.g., carbon sequestration and micro-climate), and to this end, the reduction of land consumption is claimed.

Table 8. Main-use claim 3: "Land use for climate protection and adaption" and related side-use claims as identified in the analysis of strategy documents (Table 3) for north-eastern Germany, lowland fens and irrigation fields in Berlin/Brandenburg.

Side-Use Claims:	North-Eastern Germany	Lowland Fens	Irrigation Fields
3.1. Saving and reduction of GHG emissions	**[S5,S8]**		
3.2. Developing and ensuring natural sinks			
3.2.1. → Water depot and retention	**[S4,S14,S19]**	**[S30]**	
3.2.2. → Storing of GHG emissions	**[S8]**	**[S15]**	
3.2.3. → Carbon sequestration		**[S26,S28,S30]**	**[S26]**
3.3. Stabilization of landscape water balance			
3.3.1. → Guarantee of groundwater recharge	**[S5,S8,S14]**		**[S34]**
3.3.2. → Water retention and higher groundwater levels	**[S30]**	**[S17,S30,S45]**	
3.3.3. → Rewetting of wetlands		**[S30,S45]**	**[S18]**
3.4. Preserving and developing functions of open space areas			
3.4.1. → Regional climate	**[S14]**		
3.4.2. → Carbon sequestration	**[S26]**		**[S26]**
3.5. Flood control and protection	**[S6]**		
3.6. Use of renewable resources	**[SB]**		
3.7. Reduction of land consumption	**[S7,S14]**		**[S28]**

"Regional and Rural Development"

Related to this main-use claim, the benefit of regional value chains for socio-economic and cultural development, such as the security of jobs and income in rural areas, is emphasized. For this, a diversification of the types of livelihoods is desired. This claim mirrors, on the one hand, the first pillar of the Common Agricultural Policy (CAP) with the support of agricultural areas as sources of food and raw materials in general and, on the other hand, the second pillar of the CAP with the support of multifunctional land use in rural areas. To achieve this main-use claim, the need orientation of public tasks and infrastructure is wanted. In the case of the lowland fens, the area-specific side-use claims maintain in particular the agricultural value creation. Also, economic incentives for environmentally friendly production schemes are requested. Intended at sewage farms to be cultural heritages and landscapes, the development opportunities as tourist attractions and the use of the area for renewable energies are stressed for the regional economy.

"Urban–Rural Interdependencies"

The coverage of urban demand for food, regional and organic products and energy, cultural landscape development and the need orientation of public service tasks and infrastructure in the spatial context are demanded as side-use claims at regional scale. In addition, the stabilization of the rural population is desired. Related to lowland fens, only the demand for cultural landscape development could be identified. Regarding the irrigation fields, due to their spatial proximity to Berlin, the urban–rural interdependencies and the corresponding demand-portfolio are stronger. This condition is mirrored by the desired use of the areas for regional tourism, particularly for local recreation.

Table 9. Main-use claim 4: "Land use for regional and rural development" and related side-use claims as identified in the analysis of strategy documents (Table 3) for north-eastern Germany, lowland fens and irrigation fields in Berlin/Brandenburg.

Side-Use Claims:	North-Eastern Germany	Lowland Fens	Irrigation Fields
4.1. Value creation (cost and resource efficient) in rural areas	[S27]	[S17]	[S27]
4.1.1. → Agricultural production while maintaining peat layer		[S17]	
4.2. Employment and creation of jobs	[S0,S14]		
4.3. Security of income in rural areas	[S0]		
4.3.1. → Diverse basis of livelihood	[S27,S29]		
4.3.2. → Potential for new economic fields in addition to traditional livelihoods	[S29]		
4.4. Rural development possibilities			
4.4.1. → Regional and organic products	[S8,S15]		
4.4.2. → Regional tourism	[S31,S33]		[S33,S34]
4.4.3. → Increasing qualification skills	[S27]		
4.4.4. → Cultural landscapes and monuments near Berlin			[S30]
4.5. Need orientation of public service tasks and infrastructure			
4.5.1. → Logistics and infrastructure	[S49]		
4.5.2. → Water management → 2-sided water regulation should enable locally adapted agricultural land use systems		[S17]	
4.5.3. → Drinking water supply	[S18]		
4.5.4. → Wastewater treatment	[S14]	[S18]	[S18]
4.5.5. → Village infrastructure	[S49]		
4.6. Consolidation of public households	[S49]		
4.7. Intensification potentials for renewable energies (non-organic)	[S16]		[S28, S37, S38]
4.8. Ensuring of regional energy and resource supply	[S8]		
4.9. Economic incentives for extensification actions	[S4]	[S4]	

Table 10. Main-use claim 5: "Land use for urban-rural interdependencies" and related side-use claims as identified in the analysis of strategy documents (Table 3) for north-eastern Germany, lowland fens and irrigation fields in Berlin/Brandenburg.

Side-Use Claims:	North-Eastern Germany	Lowland Fens	Irrigation Fields
5.1. Ensuring and developing cultural landscapes	[S14,S28,S30,S50]		
5.1.1. → Development and preservation of cultural landscapes → cultural-historical value of the cultivation of lowlands		[S47]	
5.1.2. → Ensuring and developing cultural landscapes and monuments near Berlin			[S30]
5.2. Cultural landscapes as tourist attractions and as development opportunities for the regional economy	[S28,S50]		[S30]
5.3. Coverage of urban demand for food, regional and organic products and energy	[S14]	[S42]	[S14]
5.4. Stabilization of population development	[S27]		
5.5. Need orientation of public service tasks infrastructure and adapted to spatial context	[S49]		
5.5.1. → Wastewater treatment	[S18]	[S18]	[S18]

"Quality of Life"

For this main-use claim, the functions of the regional climate regulation of open-space areas, the strengthening of regional identity and the preservation of human health and security are stressed at the regional scale. Additionally, cultural landscape development and the aesthetic and recreational value of cultural landscapes are underlined. For the area type, lowland fens as demands, especially their functions in the regional climate and the cultural landscape development, are identifiable. For the irrigation fields, the recreational value of open-space areas and partial areas of cultural monuments near Berlin are highlighted as side-use claims. Also, human health and the prevention of the mobilization of soil pollutants are stressed.

Table 11. Main-use claim 6: "Land use for quality of life" and related side-use claims as identified in the analysis of strategy documents (Table 3) for north-eastern Germany, lowland fens and irrigation fields in Berlin/Brandenburg.

Side-Use Claims:	North-Eastern Germany	Lowland Fens	Irrigation Fields
6.1. Ensuring and developing cultural landscapes	**[S14,S28,S30,S50]**		
6.1.1. → Development and preservation of cultural landscapes → cultural-historical value of the cultivation of lowlands		**[Act. S47]**	
6.1.2. → Ensuring and developing cultural landscapes and monuments near Berlin			**[30]**
6.2. Protecting human health and security	**[S2,S10]**		
6.2.1. → Avoiding direct contact			**[S24]**
6.3. Recreational value of landscapes and utilization of aesthetic values	**[S14,S50]**		**[S34]**
6.3.1. → Improving quality of landscape scenery in lowlands		**[S30]**	
6.3.2. → Enrichment of the landscape scenery of irrigation fields			**[S24]**
6.4. Strengthening regional identity	**[S28]**		
6.5. Open-space areas fulfil important functions for the regional climate			
6.5.1. → Fresh air production	**[S14,S30]**		
6.5.2. → Cooling effect	**[S14,S30]**		**[S28]**
6.5.3. → Lowland fens fulfil important functions for the regional climate → cooling effect		**[S28,S38]**	

3.3.2. Trade-Offs and Synergies among Main- and Side-Use Claims

Because of this complex constellation of land use claims, a plurality of land use conflicts and trade-offs can be enhanced through possible land use scenarios in the research area. The most obvious possible trade-offs are the interdependencies among the decreasing groundwater levels, the support for abiotic and biotic resources and the maintenance of ecosystem processes (Tables 12–14). Furthermore, land use and particularly bioenergy production on wetlands may increase GHG emissions. In addition, through the implementation of environmental standards in land use systems, the profitability might be endangered. Besides, spatial disparities can be increased through specific land use systems, and cultural landscape development may be threatened.

Table 12. Overlaps between main-use claims and side-use claims related to north-eastern Germany and solutions for sustainable development.

<table>
<tr><th>Main-Use Claims:</th><th>(1) Sustainable Intensification</th><th>(2) Environment, Resource and Nature Protection</th><th>(3) Climate Adaption and Climate Protection</th><th>(4) Rural and Regional Development</th><th>(5) Urban-Rural Inter-Dependencies</th><th>(6) Quality of Life</th></tr>
<tr><td>Trade-offs among main- and side-use claims</td><td colspan="2">Utilization competition between biomass cultivation
→ Sinking groundwater levels
→ threatened valuable wetlands
→ preservation of biological diversity</td><td>Land use/bioenergy may increase GHG emissions</td><td>Profitability</td><td colspan="2">Disparities may by increased through land use patterns
Cultural landscape development
Participation</td></tr>
<tr><td>Synergetic effects among main- and side-use claims</td><td colspan="3">Locally adapted land use systems, preservation of natural resources
Regional cycles, resource and energy efficiency
Cascade use of renewable resources</td><td colspan="2">Maintenance of ecological capability of rural areas
Regional cycles
Diversification of income possibilities</td><td>Cultural landscape development</td></tr>
<tr><td rowspan="2">Solutions and instruments for sustainable land use</td><td>Agro-environmental measures</td><td>Certificate Trading
Conservation areas
Biosphere reserves</td><td>Sustainable development of natural sinks and open-space areas</td><td colspan="3">Integrated development of rural areas</td></tr>
<tr><td colspan="6">Multifunctional land use</td></tr>
</table>

Table 13. Overlaps between main-use claims and side-use claims related to lowland fens in north-eastern Germany and solutions for sustainable development.

<table>
<tr><th>Main-Use Claims:</th><th>(1) Sustainable Intensification</th><th>(2) Environment, Resource and Nature Protection</th><th>(3) Climate Adaption and Climate Protection</th><th>(4) Rural and Regional Development</th><th>(5) Urban-Rural Interdependencies</th><th>(6) Quality of Life</th></tr>
<tr><td>Trade-offs among main- and side-use claims</td><td colspan="3">Intensification of biomass production
→ sinking groundwater levels
Sinking groundwater levels → threatened valuable wetlands
Land use/bioenergy may increase GHG emissions</td><td>Profitability</td><td>Disparities may by increased through land-use pattern</td><td>Cultural landscape development</td></tr>
<tr><td>Synergetic effects among main- and side-use claims</td><td colspan="3">Locally adapted land use systems (without permanent dewatering) → higher groundwater levels
Preservation of natural resources</td><td colspan="3">Maintenance of ecological capability of rural areas
Cultural landscape development
Regional cycles</td></tr>
<tr><td rowspan="2">Solutions and instruments for sustainable land use</td><td>Agro-environmental measures</td><td>MoorFutures
Conservation areas</td><td>Sustainable development of natural sinks</td><td colspan="3">Integrated development of rural areas</td></tr>
<tr><td colspan="6">Multifunctional land use</td></tr>
</table>

Table 14. Overlaps between main-use claims and side-use claims related to irrigation fields in north-eastern Germany and solutions for sustainable development.

Main-Use Claims:	**(1) Sustainable Intensification**	**(2) Environment, Resource and Nature Protection**	**(3) Climate Adaption and Climate Protection**	**(4) Rural and Regional Development**	**(5) Urban-Rural Interdependencies**	**(6) Quality of Life**
Trade-offs among main- and side-use claims	Intensification of biomass production → sinking groundwater levels Sinking groundwater levels → threatened valuable wetlands Land use/bioenergy may increase GHG emissions			Profitability	Disparities may by increased through land use pattern	Cultural landscape development
Synergetic effects among main- and side-use claims	Locally adapted land use systems Preservation of natural resources			Maintenance of ecological capability of rural areas Cultural landscape development Regional cycles		
Solutions and instruments for sustainable land use	Agro-environmental measures	Output of cleared wastewater Conservation areas	Sustainable development of open space areas	Integrated development of rural areas		
	Multifunctional land use					

Moreover, synergetic effects among the land use claims are present. The greatest synergies among the identified main- and side-use claims can be achieved through integrated rural development, locally adapted land use systems with the maintenance of ecological capability of rural areas and functions of open-space areas and natural sinks (Tables 12–14). Additionally, the implementation of multifunctional land use systems and regional cycles can lead to synergies. The vertical integration of the identified land use claims on the types of areas to land use claims identified at national and supra-regional levels, particularly for the side-use claims related to the ecological LUFs, is given. For instance, the main-use claims of "sustainable intensification", "environment, resource and nature protection" and "climate adaption and protection" are downscaled to the area types furthermost in terms of the concept of EPI. The horizontal integration of the environmental development targets of the analysed strategies into other land use sectors is partially given.

3.4. Solutions for Sustainable Land Use

In the analysed policy strategies for both types of areas it is highlighted that, among the affected sectors, coordinated water and land management intensities for sustainable land use concepts are needed. It is anticipated that the consequent application of multifunctional land use systems in north-eastern Germany and the analysed types would thus lead to an improved obtainment of the identified political and societal land use claims (Tables 12–14). To do so, it is necessary to identify effective governance strategies. Due to different property rights, rights of disposal and often sector-oriented policy targets, a consistent policy for the area types is missing. The emerging strategy for the SD of the federal state of Brandenburg includes an approach for trans-sectoral and cross-policy targets for land use and public services at a regional scale. Accordingly, the targets of the strategy for sustainable development and, for example, the consideration of sustainability criteria within biomass strategy, such as maintaining soil fertility, reflect the greening of primarily sector-oriented policies. Locally adapted land use systems with higher groundwater levels on the lowland fens, for instance, would lead to the majority of the identified political and societal demand for LUFs in Brandenburg. Due to the heterogeneity of the types of areas (e.g., different peat layers, degrees of contamination of soil with organic and inorganic pollutants), location-adapted land use systems with adapted water management systems are necessary. For lowland fens, a two-sided water level regulation and a corresponding mosaic of the area are required [3,37]. For the sewage farms, for instance, with irrigation and non-irrigation, the mobilization of soil pollutants must be avoided. A need-oriented infrastructure is thus necessary for each agricultural management system.

4. Discussion

4.1. Analytical Framework for Sustainability Impact Assessment

The applied DPSIR-based methodology is suitable for analysing problem areas for SD at the landscape level and to regionalize the vision of SD. Via identifying frames, the manifold targets in policy and actor strategies and in planning concepts can be aggregated to land use claims. The allocations of side- to main-use claims is certainly not indisputable because of the manifold interrelations that are present among the benefits of dimensional environmental, economic and social LUFs for SD related to the triple bottom line [8]. For example, the need orientation of public service tasks relates to the main-use claims *"regional and rural development"* and *"urban-rural interdependencies"*. To identify the future societal land use demands at regional level, however, the analysis of policy strategies must be extended through the analysis of supra-regional and regional planning concepts and actor strategies. Therefore, focusing only on the targets of the national strategy for sustainable development and the emerging strategy for sustainable development of the federal state of Brandenburg would not sufficiently consider the endogenous potentials related to the types of areas. Otherwise, their consideration is necessary to identify balanced land use concepts for regional development because they reflect the greening of sectoral policies at higher governance levels. However, it must be further determined whether targets for the development of land use in north-eastern Germany can be used as area-specific targets for sustainability-relevant topics.

4.2. Gaps Related to the Sustainability Impact Assessment of Land Use Scenarios

The presented framework is suitable to close gaps related to required methods for *ex-ante* SIA [6,38] and to improve the understanding of the regionalization and upscaling of SD. In contrast to the quantitative approach for mapping ecosystem service budgets of Burkhard *et al.* 2012 [7], with our framework, qualitative targets for all sustainability dimensions can be operationalized at different governance levels. For an indicator-based SIA of land use scenarios, building upon this study, a clear normative interpretation of the land use claims must be provided. However, by analysing only societal demands, region-specific environmental limits [15] are not identified. According to Schulte *et al.* 2014 [39], for instance, it is not evident whether the increasing societal demand for agricultural food and matter production can be achieved while maintaining non-provisioning ecosystem services. In comparison to the concept of ecosystem services [40], it seems that LUFs allow for the operationalization of a larger variety of policy, actors' and planning targets and the complex constellation of land use claims for SD equally and simultaneously. The concept of multifunctionality is widely used to handle the demand for private and public goods, but it does not sufficiently take into account the institutional and governance perspective of land use. Therefore, the analysed strategies and planning concepts have different legal bases and obligations. To analyse the impact levels of targets and their hierarchies, it is important to consider that competences within multi-level governance are structured hierarchically. Accordingly, decisions regarding land and water management at European and national levels must be incorporated into state laws [33]. The implementation of actors' strategies in decision-making strongly depends upon the degree of participation. The linking of existing concepts for assessing SD and the concept of EPI seems to be a helpful approach to closing these gaps and to operationalize SD. According to George and Kirkpatrick 2006 [41], the vertical integration of policy plans is particularly important for the success of SD strategies. Buijs *et al.* 2011 [42] applied a frame analysis aimed at stakeholder values related to park management at a local level. Söderberg and Eckerberg 2013 [4] applied the concept to analyse policy issues connected to emerging bioenergy and land use conflicts with forestry at the European level. According to Buijs *et al.* 2011 [42], framing theory can be very useful for analysing socio-spatial conflicts. According to Shmueli 2008 [43], this approach is particularly suitable for studying environmental issues. The present study applies a frame analysis of the action logics of stakeholders at European, national, regional and local scales with regard to identifying main- and side-use claims. Through frame analysis, normative targets with different characteristics can be handled and with the concept of EPI operationalized in the context of often-sectoral institutionalized land use claims (e.g., the intensification of agricultural production or the preservation of biological diversity and cultural landscapes) and SD in a multi-governance system.

4.3. Trade-Offs, Conflicts and Synergies

Land use in general is related to competition for land, which is steadily increasing [44], and the land and water management in north-eastern Germany and the types of areas affect many land use sectors and societal interests. The selected strategy documents are the result of a negotiation process of political and public actors about future land use. Consequently, multiple actors, such as farmers or nature conservationists related to the land use sectors, are affected as well. Because of this constellation of land use claims, a plurality of land use conflicts can be enhanced through land use scenarios. For instance, trade-offs between the identified main-use claims (1) and (2) for future land use developments in north-eastern Germany are present. For example, sinking groundwater levels due to intensified biomass production are increasing the pressure on threatened valuable wetlands and in turn endangering the preservation of biological diversity or natural sink functions. However, according to Burkhard *et al.* 2012 [45], trade-offs frequently arise in multifunctionally managed landscapes because the maximization of one ecosystem service results in a decrease in other ecosystem services. According to Bennett *et al.* 2009 [46], the intensified human usage of ecosystems leads to the intended increase of services such as food and timber production but the decline of others, such as flood control, genetic resources and pollution reduction. These trade-offs are frequently related to the impacts of land use scenarios on LUFs [20]. According to Gibson 2006 [17], in relation to achieving sustainability criteria along the triple bottom line, trade-offs are unavoidable in policy, program, planning and project decisions. Illustrating these trade-offs in decision-making should thus be a basic component of approaches to sustainability assessment [17]. Approaches to identify synergies within targets for future land use development such as regional cycles and ensuring regional energy supply with integrated rural development, the exchange of public and private goods and services between agglomerations and rural areas are scientifically neglected.

4.4. Moving Policy Targets and the Discourse Regarding Sustainable Development

SD is a permanent discourse, and consequently, the targets are not fixed [12,47]. Moreover, identifying suitable indicators for the assessment of SD in different types of areas is complicated because of moving policy targets and the on-going development of new sustainability indicators [12]. Consequently, assessing SD is not static but dynamic. Because SD is a societal negotiation process, it remains controversial what should be understood as SD in a region. According to Burkhard *et al.* 2012 [7], region-specific land use is sustainable when the supply of ecosystem services meets the societal demand. It seems that this is also the case for region-specific LUFs budgets. However, this process must be oriented to the scientific and to the political vision of SD to guarantee the satisfaction of the needs of future generations for region-specific LUFs. Therefore, more research is necessary to evaluate the compatibility of these targets with science-based sustainability criteria and concepts [35,47].

5. Conclusions

For the SIA of land use scenarios at a regional level, the analysis of societal use demands in specific areas against a political multi-level system and multi-sectoral interests is necessary. For this purpose, the integration of the concept of EPI into the SIA of land use scenarios at the regional level seems practical. To understand the demand for region-specific LUFs, it is highly important to be aware of the underlying arguments of political and societal land use claims. The identified main- and side-use claims related to future land use are institutionalized in politics and society. Moreover, the identified political and societal targets are often designed for the spatial utilization in the region. Thus, the developed framework to assess SD is particularly suitable for identifying and analysing the demand for region-specific LUFs in rural and semi-rural areas and assessing the effect of non-area-concrete land use scenarios on SD at a regional level. The developed framework allows addressing the following: (i) What are the most spatially relevant land use claims for future land use at the regional level, and for the types of area lowland fens and irrigation fields, and at which governance level is the demand for future land use created? (ii) What synergetic effects and trade-offs between the targets exist? (iii) What is the effect of land use scenarios on SD and human well-being? For SD, a multifunctionality orientation of land use is key. Moreover, considering the moving target issue and the introduction of new sustainability indicators, adaptive governance types and sustainability science as a learning process are needed [9,48,49]. In consecutive working steps, the results will be used as basis for a participatory impact assessment of the anticipated effects. This study is, therefore, the basis for an *ex-ante* impact assessment and the comparison of changes in the supply of region-specific LUFs by different land use systems with manifold targets for future land use development. To this end, the identified land use claims in terms of region-specific main- and side-use claims also must be relinked with LUFs. Furthermore, further research activities should focus on the hierarchisation of the single main- and side-use claims and the power structure among the involved actors.

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Author Contributions

The writing and the analytical approach of the developed framework to assess the impact of land use scenarios on sustainable development at a regional level is part of the PhD thesis of Till Hermanns. Katharina Helming particularly contributed to the development and writing of the presented framework. Katharina Schmidt particularly supported the execution of the strategy analysis and the writing. Hannes Jochen König and Heiko Faust contributed to the writing and development of the presented framework. All authors have reviewed and commented on this manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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