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Review

Land Use Planning and Green Environment Services: The Contribution of Trail Paths to Sustainable Development

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Abstract: Recently land-use planning and green environment services have been considered as inseparable parts of the design of trail paths for a sustainable development. At present there is need of a holistic overview of land uses and land cover, to be linked with the natural environment and regional development. The key determinants of such an approach embody changes in the wake of drivers and anthropocentric changes as well as changes in global greenhouse gases, causing climate change and affecting global biodiversity. In this study the key determinants and the main research objects of previously developed studies were systematically approached by a search of the literature through the Scopus database using these four fields of keywords: (a) "land use" AND environment AND development, (b) "trail path" in the "article titles" AND the subcategory of "land", (c) "land use" AND "sustainable development", and, (d) "sustainable" AND "trail". The derived documents were collected and organized into the following four main domains, being paired together by: (a) year and country/territory, and, (b) keyword and subject area. The classification of the documents was followed by the calculation of relevant "intensity ratios" as key determinants that disclose the well-defined and the emerging fields of further perspectives regarding land use planning and the particular emerging dynamics of the development of trail paths.

Keywords: land use; trail paths; green environment; sustainable development; intensity ratios; literature review

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1. Introduction

Among the most prevalent factors favored in development strategies and urban design policies are those of: land use and environment; territorial marginalization; development in margins and peripheries; ecological construction; and environmental conservation. In addition, taking into consideration the fast-accelerating process of urbanization among almost all developing and developed societies worldwide, there is an imperative need to assess through the integration of statistics and remote sensing data the effect of urbanization on both land-use land-cover change (LULCC) and the water environment. The ultimate goal of such policies is the development and the prioritization of ecological planning to support decision-makers in practice [1].

In the agrarian context the high expansion of the agroforestry system has significantly contributed to meeting the environmental and socio-economic needs of local communities following the principles of sustainable development. In this context it was recommended that the primary focus should be on changes observed in endangered habitats and ecosystems such as shrub/woodland, grassland, and barren land to enhance environmental protection. Indeed, among the natural enemies of such sensitive ecosystems are climate change and the reported higher global temperature, since temperature decrease is associated with the increase in woodland, grassland and farmland, and temperature increase with urbanized and unexploited lands. Therefore, global warming—caused by an increase in CO_2 resulting in LULCC and by human activities—may be the primary reason for global rising temperatures especially among densely populated cities. Consequently, the change

in regional thermal conditions reduces both local humidity and land-atmosphere flux exchange. Thus, a low atmosphere flux exchange is a key contributor to the spread of atmospheric pollutants and the deposition of atmospheric particles [2].

Another reality of the impact of land use on regional communities, such as those of coastal areas, is a greater environmental consciousness at promoting the overall process of coastal land-use planning in a collaborative and transparent way [3]. Indeed, since landscape is important to attract new rural residents and visitors, there is growing recognition among coastal territories on both sides of the Atlantic that the natural environment supports rural growth, but it is also of the utmost importance to consider the natural environment and rural development as unsupported assumptions that underlie policies in both regions [3]. Furthermore, it is also crucial for local communities to control the degree of land use, possibly at a different pace (moderate up to intensified) even within the mainland of the same country(ies), as in the case of Chinese provinces. Relevant research has also concentrated on conservation tillage benefits—including potential carbon sequestration, the embodying of nutrients, and increased yield—all being considered as key aspects of land-use natural-environment interactions to promote specific technologies that are directed to dryland farming systems at a local scale of analysis [4].

The scope of this review study is to present a holistic overview of the current status of land use and land cover, in alignment with the natural environment and regional development. The key determinants of ensuing changes in these contexts in the wake of drivers and anthropocentric changes as well as changes in global greenhouse gases (GHGs), causing climate change and affecting biodiversity in global biosphere, are also examined. While these key determinants are also the research objects of previously developed studies [5], an informed debate and consensus on growth, poverty and the environment nexus should be conceptualized to manage urban growth in transit corridors being characterized by mixed land use, compaction, walkability, and development focused around public transit areas. Therefore, modeling approaches to organize, sort, and analyze spatial data including aspects of land use, transportation, and environment have also been reported [6]. Moreover, the constraints referred to in the literature of transferring urban spatial forms out of the center, as well as the uncontrolled expansion of large cities and urban sprawl, have been imperative problems that necessitate the employment of indicators to quantitatively determine the characteristics of development of areas around large cities [7]. Such indicators can further identify issues and problems regarding spatial development of the natural environment. Finally, regions of high ecological significance, such as marine receiving environments for the open coasts, harbors, estuaries, or regions of high development in industry and in urban expansion—in which LULCC has changed intensively within the last few decades of analysis—have also been considered [8,9].

2. Methodology and Analysis

Land use and amenities have been directly and commonly related to rural development and environment [3,10], regional population, resources and environmental development [11], conservation tillage on sustainable land use following global long-term studies [4], as well as governmental-politics practices on land use, environment and development [12,13]. Under such a widespread and early-developed production of the literature, the methodology of this study has been developed by a search of the literature in the first trimester of the year 2023 using the following four fields of keywords in the Scopus database: (a) the joint co-presentation of the terms “land use” AND environment AND development in the “article titles”, (b) the joint co-presentation of the “trail path” in the “article titles” AND the subcategory of “land”, (c) “land use” AND “sustainable development”, and, (d) “sustainable” AND “trail”, out of the total of the “trail path”-derived documents. Subsequently, these derived documents were collected and organized into four main domains, being paired together by: (a) year and country/territory, and, (b) keyword and subject area. Selected literature studies taken from the review study conducted were

classified in fields and the four (coupled) domains. These reviewed studies have been presented in subsections of Section 2, below.

2.1. Key Aspects and Considerations on the Jointly Reported "Land Use" AND "Environment" AND "Development" Keywords

2.1.1. Built-Natural Environment Interactions

Land use can constitute the basis to develop indicators that can determine spatial development of the environment and that can simultaneously transfer urban spatial forms out of its center, as well as the uncontrolled expansion of large cities and urban sprawl. This situation has proven particularly problematic when these processes take place in environmentally sensitive areas, thus necessitating proper indicators that can quantitatively determine the characteristics of development of areas around large cities while defining problems and identifying issues of prioritization in spatial development of the natural environment [7].

The prevalent and most controversial issue that links land use in the natural-built environment is the identification of those mechanisms and concepts of urban management in general, together with the management of urban land uses in city centers in particular. Consequently, research has been directed to investigate the extent of how to use these factors optimally in order to achieve the best distribution of their uses in a sustainable way that could foster sustainable development in the city center by integrating the principles of sustainability in the urban management process [14–16]. Under this logic there is a vibrant sustainable center and the concepts of sustainability and sustainable development can be also determined by their clear objectives, dimensions, standards, and approaches, in addition to defining the sustainable city center and its components, disclosing those theoretically-generated indicators of sustainable urban management that could be extracted [14]. In addition, the relevant research can also point out those constraints towards adopting the principles of sustainability within the context of current urban management, which is mainly attributed to a questionnaire on non-conformal or abiding trends among the indicators surveyed and applied to the current urban management system [14].

Another critical point of natural-built environment interactions with land use is that contemporary urban agglomeration shows how cities grow and expand within a shorter period by overlooking the existence of natural ecosystems. Such undermined natural ecosystems are those embodying wetland and water-related resources all over the world which have historically been given less priority, an issue which is acute in urban areas, especially among developing and densely populating areas worldwide. In such economies the water and their water-related resources are not maintained properly, resulting in the continuous deterioration of wetlands and water bodies. Therefore, it is critical to carry out research to acknowledge some strategies and motivations of development in wetland which can, subsequently, contribute to the enrichment of the natural environment of the areas studied under the principles of natural chemistry and land-water ecology [17]. In a relevant study the water balance and the intensification of cases of flooding were considered in a land-use scenario, in order for suitable soil-water conservation measures to be recommended towards mitigating the adverse effects of bioenergy [18].

Another priority issue in the built environment refers to the development of campuses that are predominately characterized by low impact development (LID) for environmental sustainability. In these cases land use is the critical factor in the development of campuses that potentially pose an environmental threat, such as the impact of runoff. In such a case the environmental development could be held on large, contoured farm land, especially in remote and sub-rural areas, but this condition also affects the infiltration of rainwater, making necessary a master plan evaluation of the development of campuses using LID parameters. Such a master plan has to primary determine the optimal zone and the types of the scheduled LID [19].

In the relevant literature a contentious issue that has emerged regarding the urban-natural environment interactions is the design of an appropriate waste-sensitive infrastruc-

ture that can reduce peak discharges, which is directly linked with the ways in which land use can contribute to the operation of surface and sub-surface processes. Such an understanding of tropical urban environments remains under-examined, while the rainfall-runoff process in tropical urban systems experiences a high degree of non-linearity and heterogeneity. Consequently, in the relevant literature genetic programming was introduced to support a physically interpretative modular model being directed to catchment hydrological processes by employing a baseflow model and a quick flow model in order to provide a hydrograph simulation of flow. Such a model of catchment can meet wider applications regarding land use estimation and a better understanding and quantification of how land use contributes to the baseflow and quickflow components. This model also enables water management in urban contexts aiming at the sustainable development of water under particular climatic and weather characteristics, such as in tropical megacities [20].

Among the modeling-derived studies of high research interest are those that introduced land use regression (LUR) models in urban environments to predict air pollution exposure. In such LUR modelling the evaluation of black carbon, being based on bicycle and pedestrian measurements, was adapted to epidemiological studies by employing an appropriate cross-validation scheme and stationary measurement of better, realistic and plausible predictability than similar validation researches [21].

2.1.2. Geospatial Technologies and Analyses

Geospatial technologies support a plethora of land-use planning activities, and when delivered through a web interface/platform, then they facilitate the coordination between different entities involved in the planning process [22–25]. In the relevant literature conceptual design production was conducted to support a collaborative geographic information system (GIS), a web-based environment for coastal land-use planning among three parties; land use planners, applicants and/or developers, and community stakeholders were able to participate. An applet can allow everyone to view the system, but only real stakeholders can interactively post comments and voice concerns, by editing and adding markups. This system should nurture a coastal community which is environmentally-focused while promoting collaborative and transparent land-use planning [26].

In another geographical region the development of GIS aimed at determining the vulnerability of regionally significant marine receiving environments to land-use impacts, especially in the Auckland Region. The developed GIS can integrate ecological significance, in terms of hydrodynamic modelling and sediment load modelling. The first evaluation and classification stage considers the regional and ecological significance of marine receiving environments, open coasts, harbors and estuaries. The regional marine vulnerability is determined by studying these variables: fetch distance, percentage of intertidal areas, residence time, circulation patterns and their threshold values. This GIS analysis can better integrate land-use controls within particular catchments, such as in the case of the Auckland region, while disclosing important information on marine ecology, coastal vegetation, coastal fish and catchment characteristics [8].

It is also noteworthy that taking into consideration the interactions among land use, transportation, environment, urban growth and walkability, all are aspects of Transit Oriented Development (TOD). Therefore, by using the GIS an analytical integration of land-use, transportation, and the environment can be achieved to manage urban growth based on TOD in the metropolitan area of Jabodetabek, Indonesia. The research focus on GIS suitability is especially efficient in informing development around public transit areas and the improvements at managing urban quality considering the sharp increase in the number of passenger cars and motorcycles and the simultaneous decline of public transport. In this context it is of the utmost importance to identify the applicability of TOD principles in densely populated cities by using GIS as a modelling tool of analysis [6].

2.1.3. Land Use and Land Cover Considerations

The marginalization of geographical space is a multifaceted problem that is mainly attributed to environmental viewpoints of land use, landscape and development. This integrated approach offers an overview of the issues that can be jointly considered in alignment with practical real-world examples originating from environmental issues that manifest in marginal areas, including: land use and environment, territorial marginalization, development in margins and peripheries [27]. In such a context a well-informed debate on growth, poverty, and the environment nexus should consider land use and land cover reformations as well as the food-energy-environment trade-off, as the key issues and insights disclosed. Indeed, these key issues are also considered as anthropocentric challenges in the global biosphere, as seen in the interplay between climate change and human development in the United Nation's Millennium Development Goals [5].

The coupled investigation of land use and land cover in monitoring land-use efficiency in Europe showed that between 2012 and 2018, the number of countries moving towards efficient land use doubled, compared to the period 2006–2012 [28], revealing that notable progress towards achieving SDG 11.3.1 [29] was reported in such developed and highly industrialized countries as Portugal and Germany, while almost all the Balkan countries also moved towards more efficient land use [28]. This research trend implies the validity and the applicability of the SDG-land use simulations, scenarios and models, confirming that these scenario simulations of different sustainability levels are conducive to supporting the formulation of sustainable land-use plans covering almost any region of Earth [29–35], while plentiful studies have also reported on other European contexts [36–38].

The outcome of these studies provides comparative analyses between cities or parts of a region or districts of a city. It can be demonstrated that the analyses of such SDG-land-use associations are proven valuable tools to assess the impact of local urban and municipal planning (possibly relocation) policies on urban development. The key aspects of the interrelation between SDGs and the nexus approach in resilient cities and multifunctional land-use systems can stress the importance of economic incentives for successful nexus implementation, providing specific guidance on how to advance sustainable resource management [39–44].

A powerful research linkage has been developed among land use and land cover with socio-economic alternations, mainly focusing on environmental deterioration. Such debates are known as land use and land cover change (LULCC) and historically date back to the beginning of agriculture. In such a study the constraints and the determinants of LULCC in the Ethiopian rift valley region of the Gidabo river sub-basin have been examined for the period 1986–2019 through group discussions and informant interviews, showing an increased share of land cover (46.7%) on the agroforestry system. Such an increase can be the cumulative result of population density, cultural values (Songo, Babbo), traditional beliefs and land policy, resulting from climate change. Equally importantly, the consequences of this agroforestry system expansion are also beneficial to meet the socio-economic and the environmental needs of the local community [45].

In a similar study it was demonstrated that in land systems the equitable managing of trade-offs between planetary boundaries and human development needs presents primary challenges towards sustainability-oriented initiatives. Such initiatives also require knowledge of the nexus between land use, poverty, and environment [46]. Distinct spatial patterns or configurations of these rates point out other important factors at play, thus implying that the concurrence of external influences with local highly contextual development potentials introduces critical aspects to shape stable outcomes of the land-use poverty-environment nexus. Subsequently, by addressing such leverage points, more effective development interventions can be guided, being coupled with the need for land-change science in order to better understand our knowledge of place-based land-use indicators, processes and changes [46].

2.1.4. The Unification of Land Use with Environment and Development in the Asian Geographical Context

In the relevant literature the available spatial patterns of land use in alignment with the sustainable development of China is vast [47–57]. Among the selected studies reviewed a study can be highlighted suggesting the five partitions of the optimized objects, including these zones: eco-economic, model-agricultural, core-living, eco-conservation, and coordinated-development [58], in deploying environmental performance assessment to assist domestic agriculture management taking account of economic development and environmental benefits [59]. At this point it is noteworthy that pathways for integrating agricultural practices into ecosystem services, planetary boundaries and sustainable development goals are not only found in studies referring to China, but have also been reported in similar studies in which the definition of measures and the drawing of strategies to rationally manage the sustainable development of agricultural land use meets a wider research interest [60,61].

Other China-related studies investigated the role of ecosystem services (ES) towards current and future land use considering the implications of sustainable development goals [62], thus introducing an integrated research framework to establish and implement sustainable environmental protection policies and cross-regional and trans-provincial eco-compensation schemes to minimize trade-offs in ES. It was also indicated that forests and water bodies provided the highest overall ES capacity, while the lowest scores were reached in built-up and unused land areas of China [60]. The ES-based studies are not limited to the Chinese context, but have also reported on similar research settings worldwide [63–67].

Among the key ES development principles for island planning are those of ecological construction and environmental conservation. Consequently, an in-the-field study has focused on the world's largest alluvial island (and the third largest in China) of Chongming [1]. This area has sustained a steady urbanization progress at an accelerating pace since the 2000s, mainly due to favored developmental strategies and policies. The key aspects of further consideration are the relevance of the effects on the local environment from urbanization, as well as the policy and managerial implications of urbanization towards sustainable development [1].

The spatial evolution of densely contemporary rural areas characterizes substantial changes in the environment, climate, land use and cover types. In situ observations, statistical data and remote sensing images for a typical case, that of Jiangsu Province, China, in the period 1980–2012 have been examined, stressing that urbanization (92.7%) is primarily caused by the loss of farmland and generates an increase in emissions of pollutants from industrial sources and wastewater, which are most frequently derived from urban domestic sources. It is noteworthy that urbanization increases the scattering radiance and Earth's albedo and local scale warming, while a correlation analysis can be grounded on the temperature decrease with the increase in woodland, grassland and farmland, as well as by the temperature increase with the increase in urbanized and unexploited lands [2]. In this study it was reported that the temperature increase in Jiangsu province in China is attributed to an increase in carbon dioxide (CO_2) followed by the land use and land cover change due to human activities. The temperature increase is also related to changes in regional thermal conditions that reduce both local humidity and land-atmosphere flux exchange and simultaneously intensify the spread and deposition of atmospheric pollutants and their embodied particles [2].

The LULCC and the environmental effects in Changshu, Eastern coastal China, were also analyzed using high-resolution LandsatTM data in four yearly time intervals in the period 1990–2006 [9]. The variables of the analysis were those of socio-economic data and water environmental quality monitoring data from research institutes and governmental departments. The reported LULCC in Changshu during the aforementioned period was mainly attributed to industrialization, urbanization and agricultural structure reformations of local LULCC [9].

The evaluation of the coordinated development among subsystems of a system was designed by system division into several subsystems, the evaluation of these by employing the harmony degree and the development degree, as well as the classification criteria of idea goal state (ID), secondary objective state (SE) and inferior objective state (IN) [68], in order to investigate the land use, the natural environment and the socio-economic situation in the Chinese town of Tongzhou [68].

2.2. Key Aspects and Considerations on the Jointly Reported "Trail Path" AND Subcategory of "Land" Keywords

This section represents selected research studies of local interest in jointly addressing the role of land to trail paths. Therefore, the selected paradigms were collected for the Mediterranean basin countries of Italy [69] and Greece [70], and in Northern Europe (UK) [71], as well as in Asia (South Korea) [72].

In the relevant literature a study looked at a coastal urban reserve located in Bibione (Metropolitan City of Venice, Veneto, Northern Italy). This is among the major tourist beach resorts of the Mediterranean basin, with dune plantation forests for recreation, but also sensitive soil and vegetation forestry. Considering the necessity of clearly defined recreational trails and boundaries, a GIS-based and land-driven survey was employed considering the interpretative trails in sand dune plantation forests, where each cell of a sampling grid was surveyed in the field at a grain size of 10-m, being an appropriate scale for both visitors and to accurately assess vegetation and stand structure. The trail was tracked in alignment with the land suitability and visibility key factors that were applicable to the endemic dune plantation forests and the whole trail was optimized in order to firstly achieve the lowest cumulative-resistance value possible and secondly to amend to a situation where a fine-grained alignment of recreational trails of environmental impact is required [69].

In another landscape morphology a study looked at the behavioral attitudes of citizens of the mountainous region of Evros (mountainous regional unit of East Macedonia and Thrace, Northern Greece), while considering the contribution of the trail paths to the protection of the local culture and the promotion of the natural environment of the region. Through structured questionnaires and personal interviews data collection and analysis were accompanied by descriptive statistical methods as well as multivariate analysis techniques. The research results showed that the attitudes of citizens are directly or indirectly influenced by various factors, such as that of age, which directly affect the views of citizens towards the trail paths, with the younger ones having more positive views. Other important and positive predictors of citizens' viewpoints were the type of activity in the trail path and the easy route structure, which support leisure and hiking activities [70].

Another interesting aspect of linking trail path and land use is the growing role of social media data in providing new insights into phenomena about which there is little information from conventional sources, especially promoting the aesthetic management of landscape and collecting the perceptions of visitors to the Pennine Way National Trail (start: Edale, Derbyshire and end: Kirk Yetholm, Scottish Borders), United Kingdom (UK), which passes through land managed under the Environmental Stewardship Scheme (ESS). Public Twitter messages (tweets) is the main social medium that can support the assessment of how and to what extent ESS maintains landscape character within the trail corridor. In such a way abundant information from low-cost sources is valued as a competitive resource to complement, while not fully replacing, conventional data sources such as questionnaires and interviews, enhancing our experience of how social media and environmental management can effectively manage conservation bodies and areas worldwide [71].

From another cultural background, among the most challenging points of view regarding the shifting modes in urban and rural landscapes are the corresponding changes in social relations in South Korea and in particular the local governmental and developmental policies of ecotourism development [72]. Such policies often rely on a binary understanding

of landscapes, and like all binaries, pre-modern and modern landscapes they are inextricably interlinked. In the case of ecotourism development on Jeju Island (the largest island of South Korea) it is critical to discern how class struggles over material landscapes and discursively-produced, imaginary landscape ownership emerged. Consequently, the research focus was directed to utilize understanding of how the individual and collective experience of local people has generated tensions around urban-centered modernization in South Korea through the principles of political ecology, especially considering rural landscapes with uneven geography and versatile economic development, as an Asian NIC (Newly Industrialized Country) [72].

2.3. Key Aspects and Considerations on the Jointly Reported "Land Use" AND "Sustainable Development" Keywords

In the relevant literature there are numerous studies devoted to land use and sustainable development, especially considering the published United Nations Sustainable Development Goals (SDGs), showing a wider geographical, practical and management pluralism [29,51,62,73,74]. Researchers have also argued that while conventional instruments for land-use planning have been increasingly criticized, economic instruments (including taxes, subsidies and tradeable permits) in the context of land-use steering have received growing attention in practice and research [75]. In a similar study it was stated out that land-use configurations are explicitly related to the outcomes of numerous economic, social and environmental policies, therefore efficiency in the use of natural resources, such as space, can positively contribute to sustainability efforts from a regional development perspective [76]. In this context land-use configurations illustrate how local developmental trends have thwarted efforts to achieve sustainability and regional development as laid out in the United Nations Sustainable Development Goals (SDGs), as in the case of land and infrastructure usage within Irish metropolitan areas [76].

Indeed, since there is still a lack of SDG-oriented assessment of urban land use at national level, even in large and densely-populated countries such as China, there is still a need to address the problems of the randomness and fuzziness within evaluation, which tends to cause more uncertainties [77]. In this study spatial and temporal patterns of urban land-use sustainability for China at the prefecture level in the period 2004–2019 were reported by classifying the types of urban land-use sustainability [77]. The development level of urban land-use sustainability (ULUS) in China was high in the east and low in the west, while high-value hotspots were mainly distributed in primary and secondary urban agglomerations in China. The urban development level is primarily attributed to anthropocentric activities, whereas natural conditions constrain the improvement of the coordination level. It can also be noted that cities with a higher development level often had a wide range of coordination level, and suggestions were put forward for different regions to achieve sustainable land use [77].

A similar study employed remotely-sensed data on population and land covers to analyze spatiotemporal variations in the land consumption rate (LCR), the population growth rate (PGR) and the ratio of LCR to PGR (LCRPGR) of 31 provinces in China in the period 1995–2015, showing that nine SDGs had synergies with LCRPGR in developing economic zones, exceeding the total number of synergy relationships yielded by LCR and PGR, indicating that LCRPGR that considers both LCR and PGR exerts more impact on SDG implementations compared with the single perspective concerning LCR or PGR [78]. In addition, the improvement of land-use efficiencies can facilitate SDG implementation as an essential action in undeveloped or fast emerging economies, such as China, in order to better regulate urban expansion and population growth [78].

Another research tool of particular interest in Chinese land-use sustainable-development impact is the concept of land use functions (LUFs) that has been widely employed to study and manage sustainable development [79]. However, it has been reported that LUF employment is barely based on actual land use, therefore an improvement of the LUF framework can evaluate the monetary value of economic, social, and environmental LUF with the

use of land-use data, disclosing how different LUFs relate to each other at a regional level, such as in Shandong, China [29]. Monetary values of economic and social functions can be positively correlated, but are both negatively correlated with environmental function. In addition, it was also suggested that the quantitative trade-offs of these LUFs are insufficient, implying that their spatial balance requires further attention [79].

Another field of analysis is the historical impact of changes in land use and land cover (LULC) on land transformation planning, and anthropocentric and natural impact evaluation. In such a research approach, obtaining information on LULC change was able to provide scientific information for decision-making on achieving sustainable development in the Tano River Basin of Ghana [80]. This study covered the period 1986–2020 and it was shown that the research outputs were not only useful for formulating and implementing national policies and programs, but also in contributing to the assessment and monitoring of progress towards attaining Sustainable Development Goal 13 (climate action), considering that LULC change can further contribute to carbon emissions that lead to climate change and global warming [80]. In another African-context analysis the extent of degradation and pattern of land-use land-cover change (LULCC) in the Mount Bamboutos landscape in Western Cameroon was investigated using Landsat satellite images from 1980, 2000 and 2018. A sample of 261 household farmers was surveyed shaping a conceptual model that increases inclusive stakeholder participation and sustainability in local land use planning, and enhances our understand of the different agricultural activities in the landscape occurred [81].

Among the anthropocentric actions reported in the literature that significantly influence contemporary trends in (peri-)urban sustainability, especially considering the past decades of the human-caused depletion of natural resources and environmental pollution, is the adaptive reuse. Indeed, adaptive reuse developments incorporate a scientifically predefined set of conceptual theories, policy principles, and practical tools, as all the available data suggest, in order to achieve a good balance between invested capital, ecological conservation, preservation of the cultural heritage and sustainable urban regenerative renewal and to promote essential actions of adaptive reusing for urban and spatial masterplans towards advancing sustainable and circular cities [82].

2.4. Key Aspects and Considerations on the "Sustainable" AND "Trails" Keywords

The sustainability attributes of trails have been an emerging and steadily growing topic of research interest during the last two decades of analysis. The sustainability attributes cover a wide spectrum of topics and ways in which community-based tourism [83] could be implemented, such as:

- cultural heritage of historic areas such as that of the historical core of Saida (Old Saida), Lebanon [84],
- the Inca Trail passes in the northern frontier region of Ecuador where archaeological and historical tourism is considered a source of income and culture, incorporating and creating important cultural and natural tourism locations as well as an infrastructure that could generate income for the communities through revaluation [85].
- relating natural spaces to mental health among university communities where trail systems allow students to interact with nature without having to leave the area [86],
- the paddle-trail-related literature and the many different funding options to manage the creation and maintenance of paddle trails for paddle sports (e.g., kayaking and canoeing) [87],
- the transnational hiking trail via Carpathia connecting seven European countries and promoting an ecologically compatible landscape and infrastructure development, offering sound possibilities to revisit leisure time activities, in alignment with international encounters, natural experiences and the maintenance and further enhancement of the regional cultural heritage [88].

These studies have also focused on environmental management practices and the implications of running multiple activities on tracks and trails on public land, particularly in terms of social sustainability especially among developed and industrialized economies such as those of North America and Australia [83], and the presence of ecotourists on trails in Brazil [89]. It is also noteworthy regarding the paddle trails that these can support a variety of user funding mechanisms for trail development as well as paddler perceptions about trail development which are considered as viable forms of economic development. In addition, awareness of the value of paddle trails as an economic regeneration tool increases the willingness to pay. A range of management implications from this research included information and educational programs, marketing partnerships and targeted incentive offers to those groups that are unwilling to pay [87].

In this context the maintenance and the sustainability of existing or new trails are unavoidably related to the condition and the usability of trails, being the critical consideration of land managers charged with providing recreational access while preserving natural conditions, and to visitors who seek high quality recreational opportunities and experiences. While there exists an adequate number of trail management publications that provide prescriptive guidance for the design, the construction and the maintenance of natural-surfaced trails, published studies to provide a scientific basis for this guidance are sparse [90]. In this study the researchers modeled and clarified the influence of sustainability factors on trail soil loss, which could be effectively manipulated by trail professionals in order to sustain high traffic while minimizing soil loss over time. The emerging key factors were those of trail grade, slope alignment angle, tread drainage features, and the amount of rock in tread substrates, all offering an evaluation and improvement tool of sustainability [90].

In the last four decades of analysis, it has been reported that many European rural areas suffer from depopulation. Indeed, depopulation has become a significant issue for local culture and built-heritage conservation, making necessary the investigation of nature-oriented tourism and its vital contribution to the economic, social, and revitalization strategies adopted from local communities. In this context it is critical to further investigate how digital tools can be used to map and to create a territorial trail system between municipalities; and, subsequently, to determine the operations necessary for reactivation [91]. In this study a web platform was created with a system of virtual itineraries between villages in Italy, named "The Golden Leaves Paths". Then, the creation of analysis factsheets guided the maintenance of paths and the design of iconic signage with artistic illustrations based on the oak leaves leitmotif to be installed along the paths. It was argued that a local social promotion association can employ the outcomes, technical drawings, and strategies to reactivate paths, being considered as an inseparable element for nature-oriented tourism to foster the territorial and cultural heritage of the villages through the digital platform developed [91].

It is also noteworthy that when protected areas transcend multiple jurisdictions and landownerships, effective governance requires the engagement of multiple institutions. In the context, in the United States 11 National Scenic Trails (NSTs) extend across multiple states, landownerships, and jurisdictions, where the development of regional and national partnerships can enhance management capacity. In this respect, trail governance requires a systematic approach to support the coordination among governmental and nongovernmental partners at multiple scales [92]. In such an analysis secondary data were collected to define those trail characteristics and governance to better explore existing trail capacities. The four governmental dimensions that shape trail management of NSTs were those of: structural and foundational elements, landownership regimes, trail funding, and partnerships. Understanding these dimensions can inform managers of NSTs and other protected areas crossing multiple jurisdictions, guide effective governance and employ suiting strategies having recognized those strengths and gaps in institutional form and capacity [92].

The sustainability concept is also directly related to anthropocentric activities on trails, such as the physical exercise of hiking. Hiking is one of the most popular forms of exercise in the alpine region [93]. However, besides its health benefits, hiking is the alpine activity with the highest incidence of cardiac events. Most incidents occur due to overexertion or underestimation of the physiological strain of hiking. Therefore, individual exercise intensity for a hiking tour will be predicted and visualized in digital maps. A study first validated a 1-km outdoor cardio trekking test trail at 2 different study sites between Austria and Germany [93]. Then, exercise intensity measures on 8-km hiking trails were evaluated during hiking to estimate overall hiking intensity among 144 healthy adults (aged more than 45 years old) who performed a treadmill test in the laboratory and a 1-km hiking test outdoors. A portable spirometry device measured gas exchange, as well as heart rate, walking speed, ventilation, GPS location, and altitude throughout the tests, showing that individual prediction of exercise capacity in healthy individuals with an interest in hiking could prevent hiking-associated cardiovascular events caused by overexertion allowing individual hiking route recommendations derived from individual performance on a standardized cardio trekking test trail [93]. In a similar study, thru-hiking the Appalachian Trail (AT) is valued as an adventure of a lifetime that necessitates long-term planning and knowledge of challenges and practices in the outdoors [94]. One important but oft-ignored step is to establish awareness about sustainable practices captured in Leave No Trace (LNT) principles towards the lower possible impacts on the trail. Therefore, it is important for researchers to understand the practices of hikers relating to trail sustainability and LNT. Then, a better understanding of AT-hiking discussions can explore their connections with sustainable practices in the outdoors, particularly informing AT stakeholders and researchers in the field about the hikers' practices and the role of social media platforms to support sustainable trail management [94]. Similarly, in the relevant literature and European geographical context trail management priorities to improve sustainable design and visitor experience were identified [95]. In this case the most popular hiking trail in Portugal, located in the Algarve region, was investigated to reveal the recreational opportunities of the trail's management, development stage, preferred trail attributes and determinants of trail visitor loyalty. The recreational opportunity was based on a spectrum framework and the logistic regression model. Planners and managers could utilize these results to identify strategies for nature conservation and sustainable trail development, simultaneously maximizing trail-related experiences among loyal trail users [95].

In addition to hiking, another attractive and challenging form of physical exercise on trails is that of mountain biking. In this activity it is crucial to determine the impact upon the environment, which is primary determined by rider behaviors. Therefore, it is important to understand how mountain bikers interact with the natural environment and explore their attitudes towards sustainability [96]. In this European-based study the surveyed mountain bikers disclosed that the connection to nature was an important source of motivation and the use of mountain bike trails increased the riders' appreciation of and willingness to protect nature, with a large majority having taken direct action to do so [96]. It is also interesting that mountain bikers are willing to support the trail maintenance through the provision of personal labor or financially. Although most mountain bikers make use of wet or illegal trails, incidence of conflict is relatively low. Sustainable trails are supporting the sustainability of the trail itself in alignment with wider environmental sustainability while reducing the environmental impact and actively protecting nature [96].

Mountain biking is considered an extreme sport that demands a natural setting, while exerting a specific environmental impact if not regulated and designed correctly. Therefore, using GIS data in terms of topography, existing cycle paths and vegetation and comparing this with the guidelines set by the International Mountain Biking Association (IMBA) body, the IMBA formulated specific trail-design guidelines to adopt sustainable principles in trail design to lessen the environmental impact [97]. In this context researchers indicated four major environmental concerns, these being soil erosion, vegetation loss, water deterioration, wildlife impacts, along with their solutions. It was argued that the feasibility of the existing

trail and specific alternate sustainable trail routes in the same sites could shape different trailing systems such as white, green, blue, and black trails and planting designs in order to curb the soil erosion in the case area [97].

In addition to the bodily advantages of sustainable trails, the cultural value cannot be undermined. In such studies, heritage trails are critical to sustainable city planning since they play an important role in confronting severe and irreversible climate change [56]. Heritage trails include all the aforesaid types of body exercises such as walking, hiking, and biking, on paths that link features of historical interest. The physical destinations of sustainable trails are actually those of paths in parks, trails connecting villages, and walking routes in the historic centers of cities [98]. It can be also demonstrated that historic conservation is not a sustainable practice, since heritage sites can be constructed with non-sustainable materials, while occupying valuable space that city planners could otherwise use. Heritage trails can both provide access to cultural sites, and can be equally beneficial to the environment [98]. Indeed, heritage sites should promote emissions-free activities and simultaneously are commonly green spaces that offset carbon emissions. It is also reasonable that when creating buy-in, constructing heritage trails should also include a wide range of stakeholders from across the community [98].

The sustainable development of urban historical areas is relevant to their potential as cultural tourism sites, thus maintaining the local cultural assets and ensuring sustainability of any development intervention in these areas via a master planning process that balances all concurring developmental aspects [84]. The critical point here is the sharing of urban development in historic areas to achieve the sustainability goals of the involved areas through nodes of interaction that are stimulated by the heritage trail; conservation and rehabilitation, interpretation, and micro-economic development (as in the case study of the historical core of Saida (Old Saida), Lebanon) [84].

Another interesting association of sustainable trails and humanitarian values was studied, in order to explore the preferences of trail-running race participants for sustainable use of country parks in Hong Kong, measuring the willingness to pay of race participants for the provision of drinking water fountains, biodiversity conservation, trail maintenance and green auditing of race events [99]. The results showed a latent desire among trail runners to contribute to the preservation of natural areas through a surcharge on top of race entry fees. Mean willingness to pay for the provision of drinking water, conservation of biodiversity and trail maintenance was calculated in monetary values while, from stakeholder interviews, it was concluded that the proposed fund-raising mechanism of a surcharge on top of the race entry fee would be readily accepted by trail runners, race organizers, NGOs and the government. Sustainable trails should also tackle environmental degradation caused by trail running whilst instigating a more democratic management approach between the government and other park stakeholders [99].

Closing this literature overview of sustainable trails it is also interesting to note that similar studies have recommended that managerial support of the actions that need to be taken towards sustainable development and sustainable tourism in mountains would involve a training course on the actions needed for decision-makers, managers and politicians whose responsibility is to develop sustainable tourism in the mountains [100]. Given this broad recommendation, the content of the training and action needed should be based on the concept of territorial resilience, as well as aspects of complex thinking and planning based on a systemic approach [100].

From an environmental perspective significant topographical, ecological, use-related, and managerial diversity are highly linked to trail degradation, as well as to core types of trail impact, including: trail soil loss, widening and muddiness. Therefore, research focus on these key aspects should disclose a more precise and systematic understanding of trail impact, revealing the interrelationships developed between trail degradation processes [101]. In such a way, the sustainability advantages of trails are impacting on low grades and side-hill alignments, also considering the importance of landform grade to determine the susceptibility of trails to degradation and the influence of routing decisions;

these being preferably based on methodological considerations for trail alignment metrics and trail impact indicators [101].

From an economic perspective the most financially sustainable model of long-distance trail management is the community approach, containing a partnership between government and a not-for-profit organization. This proposal extends the income stream options and reduces overheads through the use of volunteers for maintenance. In addition, tourism strategies, such as marketing, promotion, and product and destination development, further extend the trail's financial sustainability by maximizing user numbers and partnering with businesses. This can further increase regional economic benefits and improve the user experience [102]. In particular, trails can substantially decrease the problems arising from increased visitor numbers to forested nature areas, under the preconditions that they provide users with a desirable experience, they establish visitor flows through landscapes and they provide effective risk management solutions [103], such as in the cases of Kunisaki Peninsula Usa GIAHS long trail [104] and at trail-race events held within 26 protected mountain areas in Catalonia where protected mountain area managers and trail-race managers were helped to diagnose the impact that such races have on the land, showing that profit-making organizations generated a greater degree of sustainability where development of the territory had been concerned than did non-profit entities [105].

3. Results

The graphical representation of the conducted literature search, based on the four fields of keywords (a) "land use" AND "environment" AND "development", (b) "trail path" AND subcategory: "land", (c) "land use" AND "sustainable development", and, (d) "sustainable" AND "trail", as well as the four main domains of (being paired together by two): (a) year and country/territory, and, (b) keyword and subject area, is shown in Figures 1–4, below.

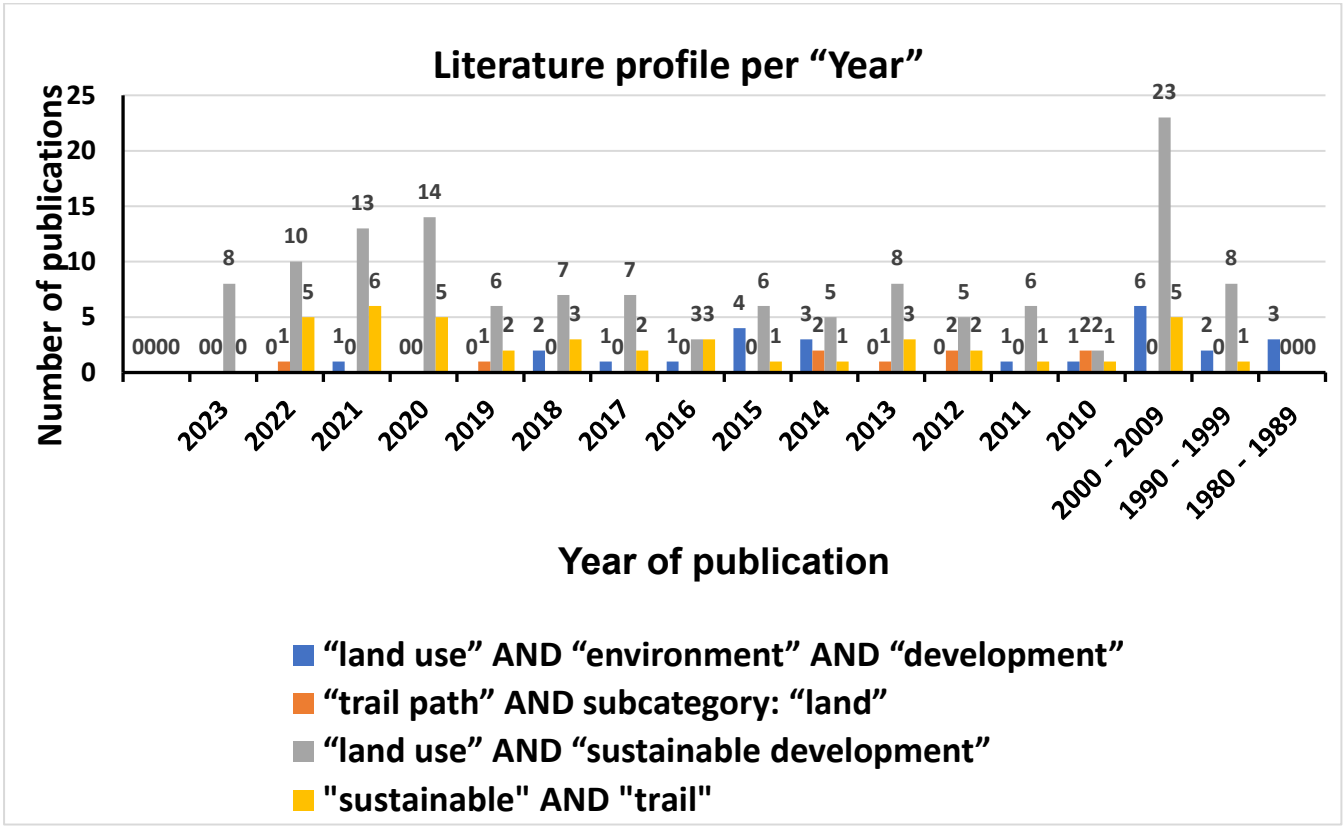

Figure 1. Literature profile of documents retrieved for the "Year" domain.

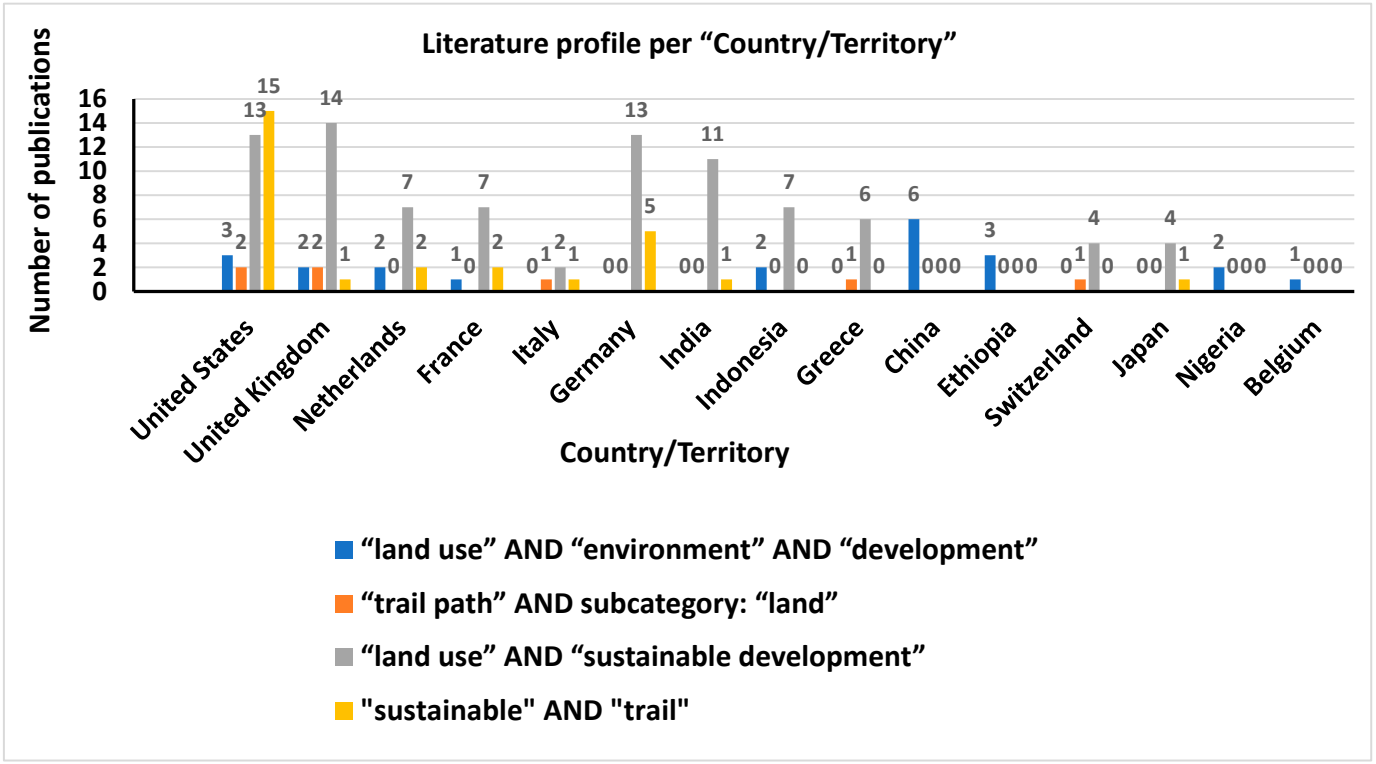

Figure 2. Literature profile of documents retrieved for the “Country/Territory” domain.

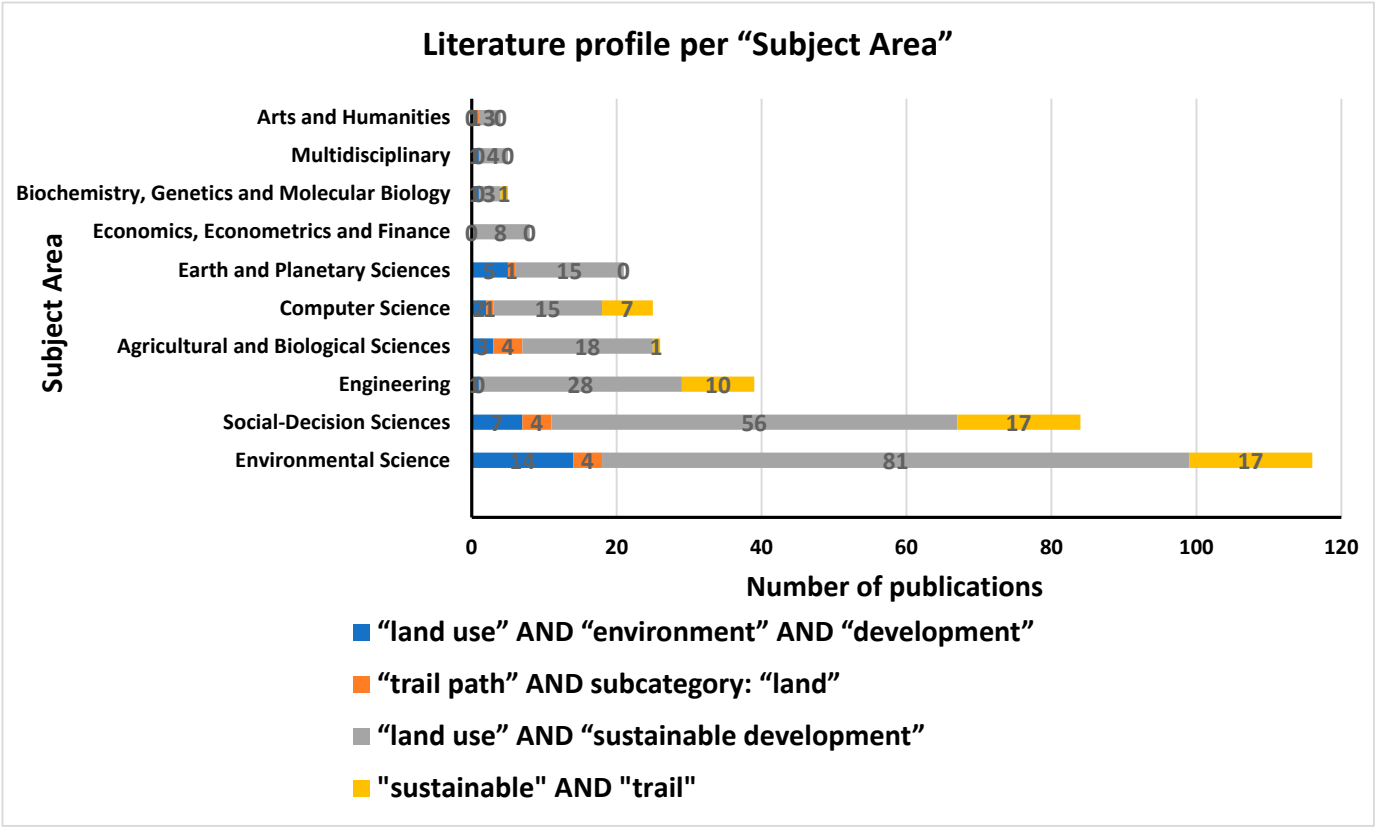

Figure 3. Literature profile of documents retrieved for the “Subject Area” domain.

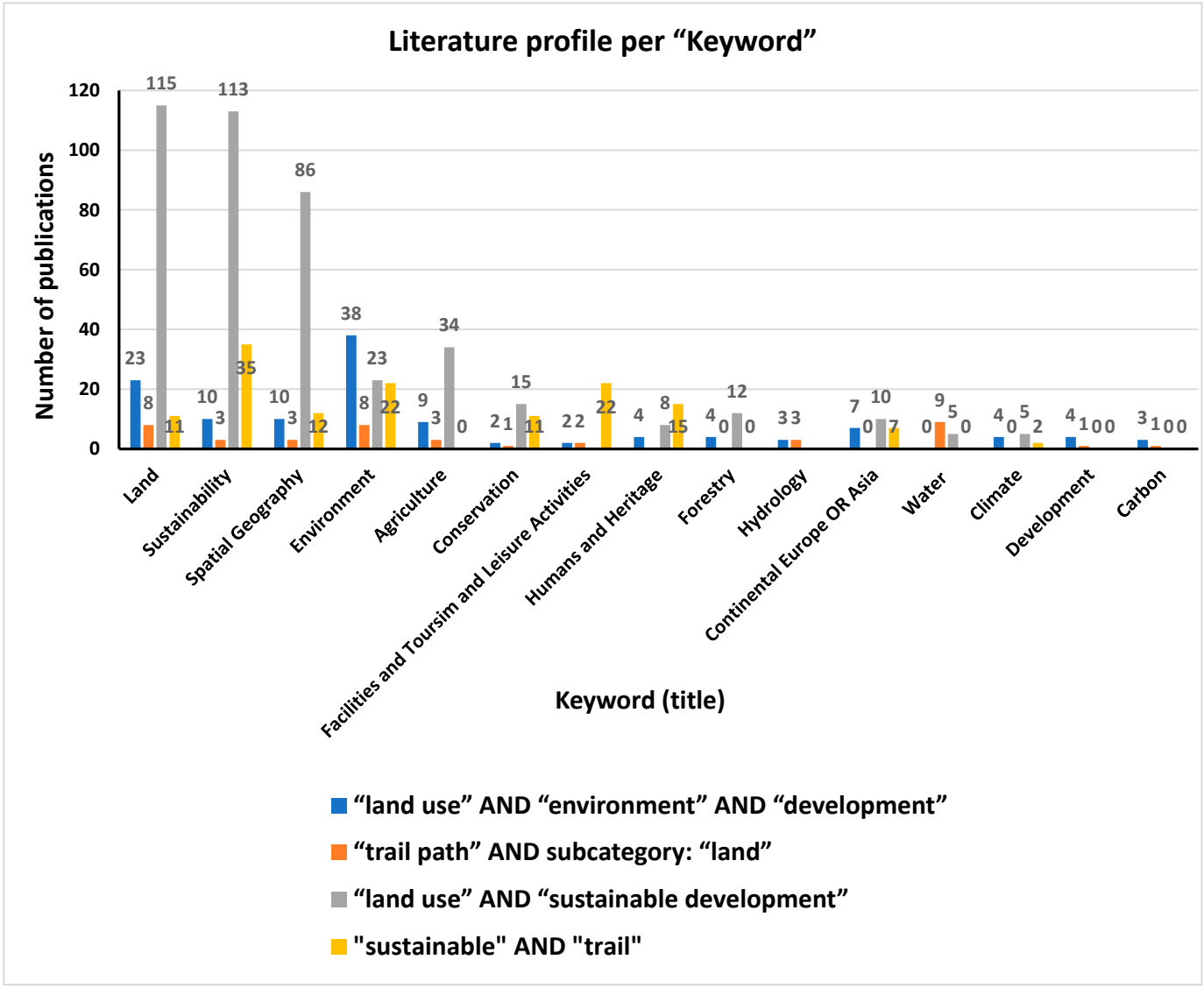

Figure 4. Literature profile of documents retrieved for the “Keyword” domain.

Figure 1 revealed that the two fields of keywords “land use” AND “sustainable development”, as well as that of “sustainable” AND “trail” sustain the higher number of documents reported in the timespan of last four decades, followed by the other two fields of keywords “land use” AND “environment” AND “development”, “trail path” AND subcategory: “land”. This field of keywords has shown a rather recently emerging field of analysis, being also attributed to a shift in everyday living conditions of citizens worldwide towards a healthier lifestyle and constant seeking for personal leisure activities in a clean and greener natural environment. Similarly, based on Figure 2 it was shown that countries of either densely populated (western) economies, or wide spatial areas of management and development (such as that of African and emerging economies) are particularly interested in the joint fields of keywords “land use” AND “sustainable development”, as well as that of “sustainable” AND “trail”, followed by the field of keywords “land use” AND “environment” AND “development”. Contrarily, sporadic and sparsely investigated studies were reported in the field of keywords “trail path” AND subcategory: “land”, being mainly reported in Mediterranean European countries, such as Italy and Greece, being also vulnerable to the concurring economic and energy crises, as well as the COVID 19 pandemic. In Figures 3 and 4 the literature profiles of the retrieved documents per “Subject Area” and “Keyword” are also depicted.

It is noteworthy that, based on Figure 3, the top 10 subject areas of the most frequently-published documents can be grouped in the following 5 pairs (in descending order): (Environmental Science, Social-Decision Sciences) > (Engineering, Agricultural and Biological Sciences) > (Computer Science, Earth and Planetary Sciences) > (Economics Econometrics and Finance, Biochemistry Genetics and Molecular Biology) > (Multidisciplinary, Arts and Humanities). The most reported fields of environment, socio-economics, agriculture, earth-planetary-nature, and computer science can be attributed to the plethora/high number of input data and modelling research specializations. Contrarily, the biological and humanitarian fields are sparsely and loosely related to the selected classifications of reviewing. Moreover, regarding the domain of "keyword" employed, Figure 4, it is noteworthy that the retrieved documents were highly dispersed in terms of definitions, terminologies, and research interests. Therefore, at an attempt to collect, to group and to organize this conceptually dispersed and heterogeneous material into homogeneous keywords, it was decided to keep traceable (for the scope of this review study) only the top 15 of them, in terms of all documents retrieved. This research practice enabled a more precise and concise representation, as shown in Figure 4 and Table 1, respectively.

Table 1. The keywords description of the top-15 keywords (in terms of frequency reported), regarding the four "fields of keywords" classified.

Keyword #	Keyword Description	Keyword Title
1	Land Use OR Land Cover/Change/Planning/Erosion OR Trail	Land
2	Sustainable(-ity)/Rural Development/and Economy	Sustainability
3	Geography/Geospatial/GIS/and Spatial Analysis Scale/Remote Sensing	Spatial Geography
4	Environment(s)al Areas/Assessment/Change/ Conditions/Effects/Factors/Legislation/Monitoring/Planning/ Protection/Temperature AND National Park/Trails/ Rural Roads/Trail Paths/Walking Paths	Environment
5	Agriculture/and Development/Land/and Alternative/Alpine/Cultural/Natural	Agriculture
6	Conservation OR Protection of Natural Resources/and Management	Conservation
7	Coordinated Development OR Recreation(-al) Facility OR Tourism OR Cycling OR Leisure	Facilities and Toursim and Leisure Activities
8	Human(s) Activity OR Heritage	Humans and Heritage
9	Forest(s)	Forestry
10	Hydrodynamic(s) Modelling/Characteristics OR Hydrology(ic)(al) Cycle(s)	Hydrology
11	Europe OR Eurasia/Asia	Continental Europe OR Asia
12	Water Accounting(s)/and Footprint/ Virtual Water/Management/Planning/Policy(-ies)/ Scarcity/Resource Management	Water
13	Climate/and Change/Environment	Climate
14	Development/Degree/Policy	Development
15	Carbon/and Dioxide/Sequestration/Footprint	Carbon

Based on Table 1 and Figure 4 it can be noted that the top 15 keywords of Figure 4 are actually embodied in more detailed and descriptive groups of keywords, thus, the correlation between the top 15 keywords (keyword titles) noted in Figure 4 and their compositional terms is represented in Table 1. The findings of Table 1 and Figure 4 also confirm the sporadically investigated field of keywords: "trail path" AND subcategory: "land", comparing to the wider and systematically approached other three fields of keywords:

"land use" AND "sustainable development"; "sustainable" AND "trail"; "land use" AND "environment" AND "development". Therefore, environmental concerns and sustainable development opportunities are common research objectives, compared to the rather newly emerging fields of land use and trail paths, respectively.

In addition to the already developed literature overview and the representation of results in Figures 1–4 and Table 1 above, it is also noteworthy that in addition to the fourth field of keywords, "sustainable" AND "trail", was formulated another field of keywords (the fifth), that of "trail paths" AND "natural environment". However, these combinations of keywords did not yield a measurable and significant number of studies, thus, it was decided that the fourth and the fifth field of keywords would only be descriptively presented in the "Discussion" section. In addition, based on the reported modeling approaches it can be argued that these approaches revealed issues that could link land-use and land-cover change (LULCC) as a causality of socio-economic and environmental domains that are of high priority especially among former rural spaces (of today urbanized characteristics) [106]. In such a way modeling approaches can keep a close connection with practical real-world examples of what, where and how environmental issues manifest especially among marginal areas. However, the predictive performance of such modeling should be considered low, due to uncertainty and lack of predictive variables that can properly capture the complex characteristics of local concentrations [107]. In response to these constraints there is an imperative need for using appropriate cross-validation schemes to estimate the predictive performance of the deployed models. In this context independent data selection in the step of model building can support a more precise understanding of the environment in the light of land uses, landscapes and urban development [107].

4. Discussion

Based on the source material collected and the documents retrieved from the Scopus database, this material has been categorized into the four domains and the four fields of keywords being grouped in two pairs of two domains each, shown in Tables 2 and 3, respectively. It can be stressed that while all selected classifications were organized in order to better demonstrate the retrieved documents and the logic behind the fields of keywords selected, it is also important to add that the critical point in this review study is not only to demonstrate the emerging classifications, but to stress the intensity of the reported documents, thus, arguing and concluding about those fields that should be prioritized as of utmost importance while detecting those challenging issues of future development and further investigation, nationally and globally. Therefore, the relevant calculated "intensity ratios", as these are collectively shown at the bottom lines of Tables 2 and 3 disclose (a) significant new knowledge, (b) the current dynamics, (c) the evolution trends, and (d) the emerging fields of prioritization, being primarily noticeable in the ratio of ("land use" AND "sustainable development" [vs.] "land use" AND "environment" AND "development"), and secondarily in the ratio of ("sustainable" AND "trail" [vs.] "trail path" AND subcategory: "land"). These ratios also reveal the pronounced role of literature—approaching and understanding the entities of sustainable development and, subsequently, the contribution of the trail paths into such a "sustainable development" literature framework, Tables 2 and 3.

Table 2. Intensity rations derived from the classification of the reported documents in alignment with the four "fields of keywords" and the first pair of domains "year; country/territory" classified.

2 Domains	**Year**				**Country/Territory**			
4 fields of keywords	"land use" AND "sustainable development"	"land use" AND "environment" AND "development"	"sustainable" AND "trail"	"trail path" AND subcategory: "land"	"land use" AND "sustainable development"	"land use" AND "environment" AND "development"	"sustainable" AND "trail"	"trail path" AND subcategory: "land"
Total number of publications (documents)	131	25	41	9	88	22	28	7
Intensity ratios	**5.24**		**4.56**		**4.00**		**4.00**	

Table 3. Intensity rations derived from the classification of the reported documents in alignment with the four "fields of keywords" and the second pair of domains "subject area; keyword" classified.

2 Domains	**Subject Area**				**Keyword**			
4 fields of keywords	"land use" AND "sustainable development"	"land use" AND "environment" AND "development"	"sustainable" AND "trail"	"trail path" AND subcategory: "land"	"land use" AND "sustainable development"	"land use" AND "environment" AND "development"	"sustainable" AND "trail"	"trail path" AND subcategory: "land"
Total number of publications (documents)	231	34	53	15	426	123	137	42
Intensity ratios	**6.79**		**3.53**		**3.46**		**3.26**	

From historical times dating back centuries ago until recently, the area of fertile land has been very limited, making necessary the process of regulating land relations, as well as the adoption of land management systems and suitable strategic directions in the field of land use. In such a context, decisions should be taken in the future in order to contribute to the sustainable development of not only agro-industrial production, but also rural areas in general [108]. Considering the unity of all retrieved documents and the aforementioned analysis of them, it can be argued that the development of landscape routes to serve human passengers of transportation, walkers and hikers is not new but it has been chronologically seen dating back to the 1980s [109], and geographically dispersed in areas such as the Appalachian Mountains in eastern North America [110,111], South-Central New Mexico, US [112] and in Eastern (mainly mountainous) Europe [70]. In such a geographical context trail paths are inseparable assets of tourism development in which further preservation, protection, and promotion of the countryside, cultural heritage, and tradition, are achievable, while the provision of effective protection and management of areas of exceptional natural beauty and sensitive ecosystems with wildlife should be also undertaken. This valuable and multifaceted contribution of the trail paths to the protection and promotion of cultural customs of walking and the natural environment in general has been demonstrated, having the younger age group considered the most affectionate and positively appreciative towards the trail paths. Other human determinants of the promotion of trail paths are the exact type of activity serving as a leisure activity, especially whether the trail is pleasant and attractive or using the most easily accessible (hiking) routes for all locals and visitors [70].

Relevant key aspects of strategic planning and policy are that the landscape changes are commonly driven by major replacements of farmland by urban and rural settlements, artificial ponds, forested and constructed land. Industrialization, urbanization, agricultural structure adjustment, and rural housing construction are also determiners of driving forces of landscape changes [9]. Land management and environmental protection policies can also support the transformation of the pastoral sector, pastoral land use and the concurring economics and financing, as in the case of post-socialist Mongolia. Such policies also reflect the influence of development economists from the Asian Development Bank who have been advising the Mongolian government, and their conviction that exclusive private rights to land are a necessary precondition of an efficient rural market economy [13]. While environmentalist agendas are important to reflect a familiar western interest in promoting western conservationist ideology to harbor wildlife and biodiversity, Mongolian practices are cast as "traditions" to be utilized for the greater goal of conservation as conceived of in western terms, rather than composing wider social and political institutions of land use [13].

These institutions of land use in real-world applications should consider a wide spectrum of prerequisites such as the available planning systems; spatial, environmental, and water-management planning. The origins of these systems are not purely rural-oriented, but are also induced by urbanization and industrialization [10]. Therefore, new regional strategies have emerged to tackle this planning-designing problem of land uses, since these strategies can balance rural development and protection of the natural environment [10]. From a methodology point of view of such a multi-parametric approach the social media data should be seen as a resource that can complement, rather than replace, conventional data sources such as questionnaires and interviews. Furthermore, guidance should be provided on how social media could be effectively used by conservation bodies, such as in the case of Natural England, which are charged with the management of areas of environmental value worldwide [71].

It is also noteworthy that such pluralistic planning should also consider land use and natural environment services that are scientifically related to climate change mitigation [113,114], having also mapping and spatial analysis for climate change in Greece [115,116] and other Mediterranean areas [117,118]. It is also noticeable that, of generally applicably integrated studies, most synergies with environmentally-related

SDGs, such as water quality and biodiversity conservation, were observed when perennial crops had been produced on arable land, pasture or marginal land in the "cool temperate moist" climate zone and "high activity clay" soils, while most trade-offs were related to food security and water availability [119]. Previous land use and feedstock type were more impactful to develop synergies and trade-offs than climatic zone and soil type [119].

5. Conclusions, Concerns and Future Research Orientations

According to the conducted analysis and the derived findings, it is important to note that in land systems equitably managing trade-offs between planetary boundaries and human development needs composes a grand challenge in sustainability-oriented initiatives. Informing such initiatives requires deep knowledge of the nexus between land use, poverty, and environment. In such an approach, human development and ethnicity should play a decisive role in land use not only in the natural environment, but also in other areas of human interest in the built environment. Indeed, ethnicity is strongly related to poverty in all land-use types almost independently of accessibility, implying that social distance outweighs geographical or physical distance. In turn, accessibility, almost a precondition for poverty alleviation, is of further benefit to ethnic majority groups and people living in paddy or permanent agriculture. These groups are able to translate improved accessibility into poverty alleviation and the overall land-use-poverty-environment nexus. In addition, effective development interventions can be guided by land change sciences, enabling a better integration and understanding of joint land-based indicators and process-based drivers towards land use change [20] and sustainable development [120].

Based on the review study, the classification of the retrieved documents into four fields of keywords was compared in two pairs of two fields of keywords each, while intensity ratios were also calculated, showing the primary noticeable ratios of ("land use" AND "sustainable development" [vs.] "land use" AND "environment" AND "development"), having intensity ratios at the first pair of domains "year; country/territory" in the range 4.00–5.24. In addition, the secondary noticeable ratios of ("sustainable" AND "trail" [vs.] "trail path" AND subcategory: "land"), supported intensity ratios at the second pair of domains "subject area; keyword" in the range 3.26–6.79. These ratios supported a better understanding of sustainable development entities and, consequently, the exact contribution of the trail paths into a "sustainable development" analysis.

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