

Review

# Rural Ecological Problems in China from 2013 to 2022: A Review of Research Hotspots, Geographical Distribution, and Countermeasures

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**Abstract:** Due to the changes in land use types and industrial agglomeration brought by the long-term rapid urbanization, the ecology of China's rural areas has been greatly impacted. The health of residents and other living beings living in rural areas has been affected. In recent years, the ecology of the rural environment has been paid attention to. This study performed a bibliometric analysis of 167 papers on the Web of Science from 2013 to 2022. It shows that policy management and environmental science were two main research fields in solving the ecological and environmental crisis in China's rural areas. Additionally, it was found that the study areas often spanned administrative districts, and the research was mainly based on the integrity of the overall ecosystem. The cases studied were mainly distributed in the following three types of areas: continuous river basins and lake basins; economically developed regions; and less developed areas with relatively fragile ecosystems. Ecological elements such as water, soil, air, and vegetation were all included in the study aims. Finally, from the perspective of institutional reform, comprehensive approaches to solving China's rural ecological environmental problems in the current research were identified, including the revision of laws and regulations, economic means, technological innovation, and public participation.

**Keywords:** rural area; ecological problems; environment pollution; bibliometric analysis; policy management

## 1. Introduction

The process of rapid urbanization has caused ecological and environmental problems in rural areas [1–3]. Urbanization is a series of different processes that transform rural areas into a mix of rural and urban spaces [4]. These processes always introduce many problems, including issues and conflicts in various aspects such as population, the economy, and society [5], among which the conflict between the ecological environment and economic development is particularly significant [6]. Therefore, environmental sciences, ecology, geography, and urban studies are the most frequently used subject categories in the study of urbanization processes. In recent decades, the United States and China have been hotspots in urbanization research [7]. Compared with other areas, urbanized areas have faced more environmental problems [8]. Rural areas often have a large amount of unused land and ecological natural resources and are the areas where the land properties have changed the most in the process of urbanization [9].

The urbanization process has brought many ecological and environmental problems to rural areas in developing countries, and the sum of all effects has affected global climate change. As the largest developing country, China has experienced a rapid urbanization process since the 1980s [10], especially in the past decade. It has led to the decline of ecosystem

services in many rural areas and caused severe environmental problems, including ecological risks, such as water [10,11], air [12], and soil pollution [13,14]. In 2013, nearly one-fifth (19.4%) of China's arable land was polluted [15]. About 3.3 million hectares of arable land (2.4% of total arable land) has been degraded and is not suitable for cultivation [16]. The quality of arable land in most of the remaining areas is poor or moderate. The productivity has been stripped away due to decades of overuse [17]. The water environment testing data in 2017 showed that among the 1940 surface water quality sections (points), the proportion of excellent (I–III) water quality was 67.9% [18]. This means that 32.1% of the surface water quality was poor. The proportion of poor and extremely poor groundwater accounted for 66.6% [19]. The counties with an “average” ecological environment quality accounted for 24.5%, and the counties with a “relatively poor” and “poor” quality accounted for 33.5% [19].

Polluted rivers, land, and air in rural areas hinder the clean production of arable land [18] and directly threaten the health of rural residents [20–22], ecosystem sustainability [23,24], and species diversity [25]. As of November 2020, China still had 509.78 million people living in rural areas [26], and these regions accounted for more than 2/3 of China's total land area. Analyzing and understanding the ecological problems in China's rural areas during urbanization are significant for proposing solutions. They can also provide references for other developing countries in the world. In the long run, the sustainable development of rural areas will affect the healthy development of cities [27]. Understanding the changes, processes, and causes of ecological problems is vital to managing environmental changes effectively. It plays an essential role in promoting the sustainable development of the rural environment, society, and economy. Governments and researchers need to understand the causes of rural ecological deterioration and its impact on globalization and climate change, as well as effective countermeasures [28].

China has a vast area with diverse geographical landforms and resource conditions [29]. Different geographical regions have various ecological and environmental problems. Based on different natural resource conditions, environmental problems have different subsequent impacts [30]. It is necessary to sort out the types and distribution characteristics of rural ecological and environmental problems in general and then to further classify and study the characteristics of ecological and environmental problems in different regions, landforms, and natural resources [31]. However, existing research is often focused on one or several specific cases to indicate a certain area or a certain type of ecological and environmental problem. There has been a lack of more systematic and integrated research results. Therefore, it is necessary to review the relevant literature and summarize the characteristics of the subjects, objects, themes, and methods of the existing research. We conducted a quantitative and qualitative review of 167 academic papers in related fields through literature database searches and reviews. We hope that this review will help to clarify the focus of China's rural ecological problems at a holistic level and can provide assistance in formulating strategies to promote sustainable rural development and the relationship between rural and urban development.

The Chinese government proposed an ecological focused civilization construction strategy in November 2012 [32], for which improving the rural living environment was one of the priorities [33]. This meant that the Chinese government was aware of the ecological problems brought about by rapid development and the ecology of rural areas received unprecedented attention [34]. Remarkable achievements have been made in urbanization. In 2012, China's urbanization rate reached 52.57% [35], roughly equivalent to the world average. Since 2022, China's urbanization rate has shifted from high speed to a gradual slowdown [36]. The ten years since the ecological civilization strategy was proposed is the final stage of the rapid urbanization process in China.

This study reviewed the literature of the past ten years (2013–2022). The main steps of this study were as follows: (1) determining and analyzing whether there was a pattern in the geographical distribution of ecological and environmental problems in China's rural areas; (2) identifying the relationship between pollution sources and the urbanization

process; (3) assessing how strong the implementation of rural ecological restoration policies is in China, and what improvements managers and residents should make in terms of policies, laws, and behaviors. We hope this review will help clarify the focus of China's rural ecological problems at the macro level and can assist in formulating strategies and promoting sustainable rural development and its relationship with urban development.

## 2. Materials and Methods

### 2.1. Searching for, Finding, and Selecting Articles

The included papers were from the Web of Science core collection. We used the keywords “rural/village”, and “ecological/environmental problem”, and “China”. These keywords were searched for in the title, keywords, and abstract. The search period was from January 2013 to the present after introducing the “Ecological Civilization Construction” strategy. Searches were limited to journal articles, excluding books and book chapters. In total, 246 studies were found in the search.

We manually screened the studies by reading the title, abstract, and full text, if necessary. Our screening was based on the following criteria: (1) the research scope or geographic area of interest should be rural areas in China, referring to “populations mainly engaged in agricultural production”; (2) considering the object of ecological problems, the research content of the article should include specific ecological factors, such as water, air, grassland, and water bodies. Studies on topics other than ecological issues in rural areas (such as rural poverty issues and rural ecotourism research) were manually deleted. Finally, 167 papers were obtained.

### 2.2. Classification and Analysis

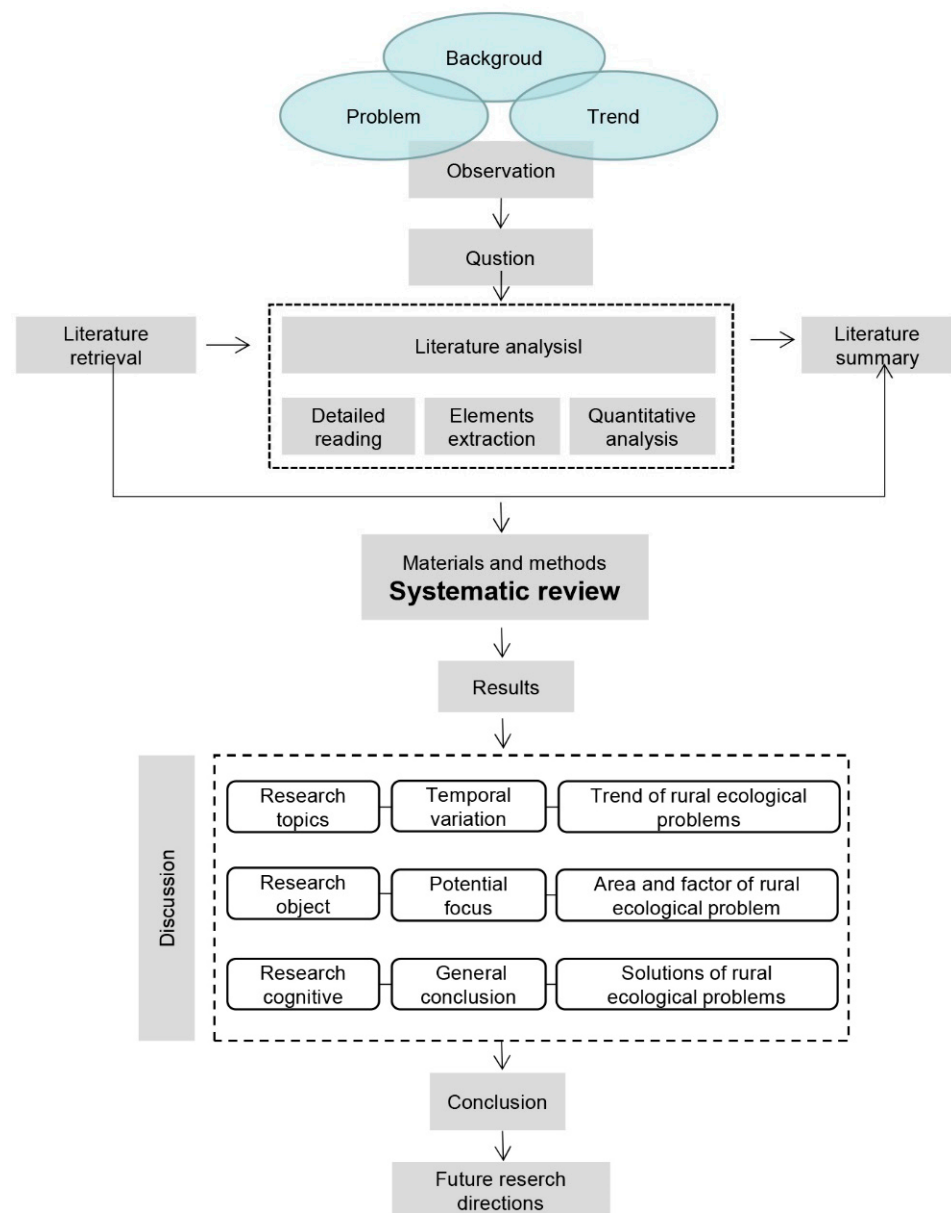
We quantitatively analyzed the information of papers, including citation analysis, trend and change point detection, and text and topic mining. We strived to identify commonalities in interdisciplinary research studies and research with multiple case studies. We used a framework to analyze the literature according to the following procedure (Figure 1):

(1) Analysis of the basic information of the literature. This part included the number of publications analysis and citation analysis. This was helpful in clarifying the output performance and trends of the articles to judge how the temporal change of the topic of rural ecology has changed.

(2) Analysis of research topics and researcher fields. This was helpful in extracting data on the potential focus of the research. Sorting out which keywords were often mentioned in the field, and which scholars (considering their academic background) were paying attention to these topics, can assist in judging the key factors affecting China's rural ecology.

(3) Analysis of the geographical distribution of the study cases. A geographic information system (GIS) and its spatial analysis tools were used to conduct a sub-visualization analysis of the geographical distribution of the research objects. Accordingly, the critical locations of rural ecological problems in China can be characterized.

(4) The causes of ecological problems and their solutions. We summarized the solutions to rural ecological problems proposed in the literature to summarize and classify feasible methods to deal with China's rural environmental problems and provide relevant managers and stakeholders with followable improvement paths.

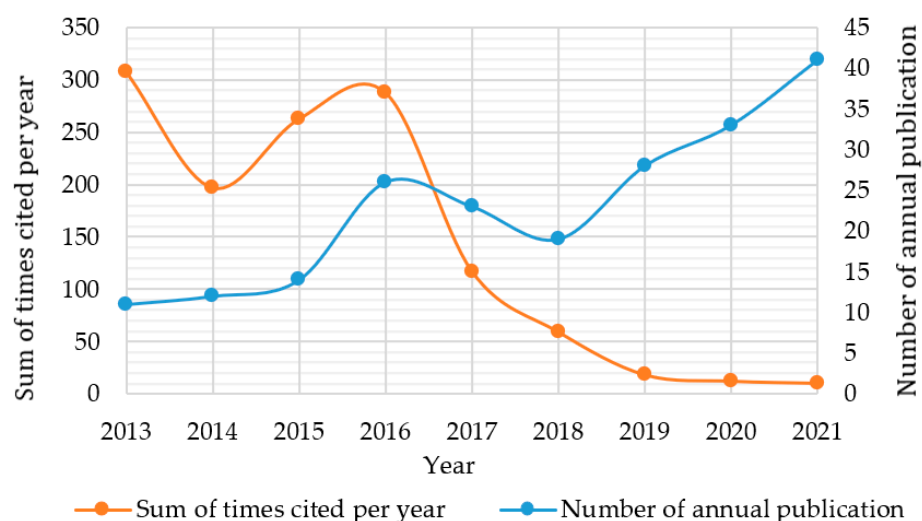


**Figure 1.** The Systematic Review Processes.

### 3. Results

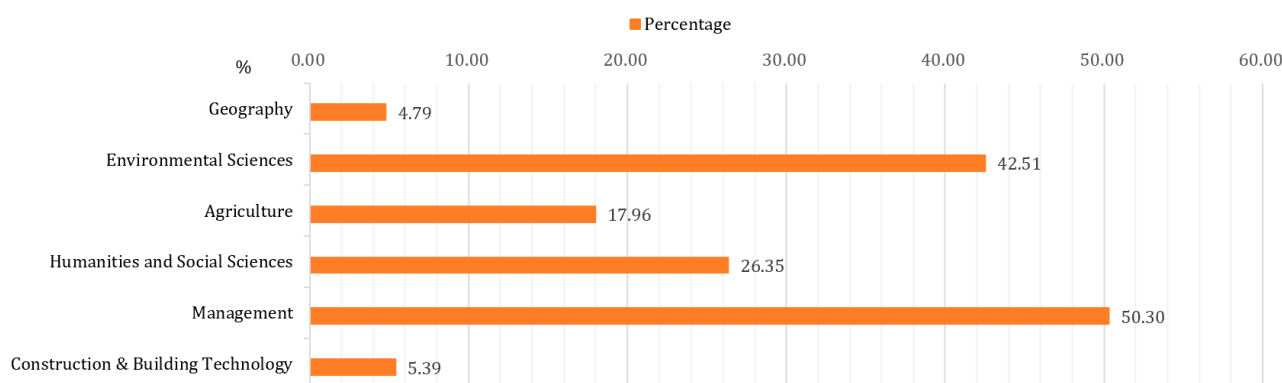
#### 3.1. Research Attention Fluctuated and Grew, with Management Policy and Environmental Science Attracting the Highest Attention

Annual publication trends showed a volatile increase in research attention on ecological and environmental issues in rural China from 2013 (Figure 2). In the early period from 2013 to 2015, the growth was slow. It can be inferred that the Chinese government's strategic policy of "building an ecological civilization" at the end of 2012 had an important impact on the research, and the research was in a new stage of exploration. After three years of exploration and research, the number of papers increased rapidly in 2016, while the number of papers declined in 2017 and 2018. This indicates that the research entered a stage of reflection and, to some extent, re-exploration. Then, in 2019, it started to rise again. However, the number of article citations showed a fluctuating downward trend, indicating that in the 8 years after the emergence of the new policy, due to the uncertainty of the research and the diversity of new ideas, the reference degree of the research was low.



**Figure 2.** Trend change of annual publications and annual citations.

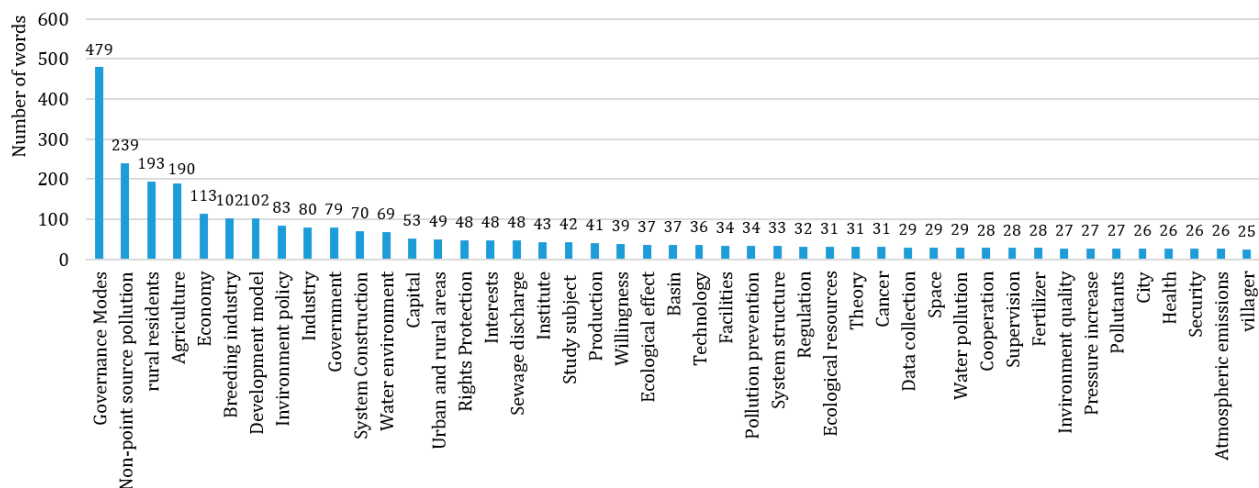
Two fields—policy management and environmental science—have attracted the most attention in the rural ecological environment. In total, 84 of the 167 papers belonged to the management field, accounting for the highest proportion of 50.30%. This shows that management methods and measures were critical driving forces in solving ecological problems. In contrast, current management and regulations must constantly be revised and supplemented to adapt to new changes. This was followed by 71 papers in the field of environmental science, accounting for 42.51% of the total. These articles studied the specific causes and consequences of ecological problems, as well as measures and suggestions for them, in addition to the impact of environmental pollution on human beings. From these articles, it was found that the field of environmental science proposed specific and feasible methods for solving ecological problems from a technical perspective. Finally, there were 44, 30, 9, and 8 articles in the fields of humanities and social sciences, agriculture, construction technology, and geography, accounting for 26.25%, 17.96%, 5.39%, and 4.79%, of the total, respectively (Figure 3). It is worth noting that 67 of the articles mentioned above involved multiple fields, accounting for 40.12%, which reflects the complexity and comprehensiveness of the rural ecological environment.



**Figure 3.** Fields of literature.

Research topics in a particular field (“hot topics”) can be defined by high-frequency words in the titles, abstracts, and keywords. In general, high-frequency words tend to summarize the content of research articles and help to focus and refine the core ideas of the research. In order to find common themes and research hotspots in the literature, word frequency analysis was carried out on the titles, abstracts, and keywords of 167 selected papers. After removing the words used in the search, 45 words that appeared with more

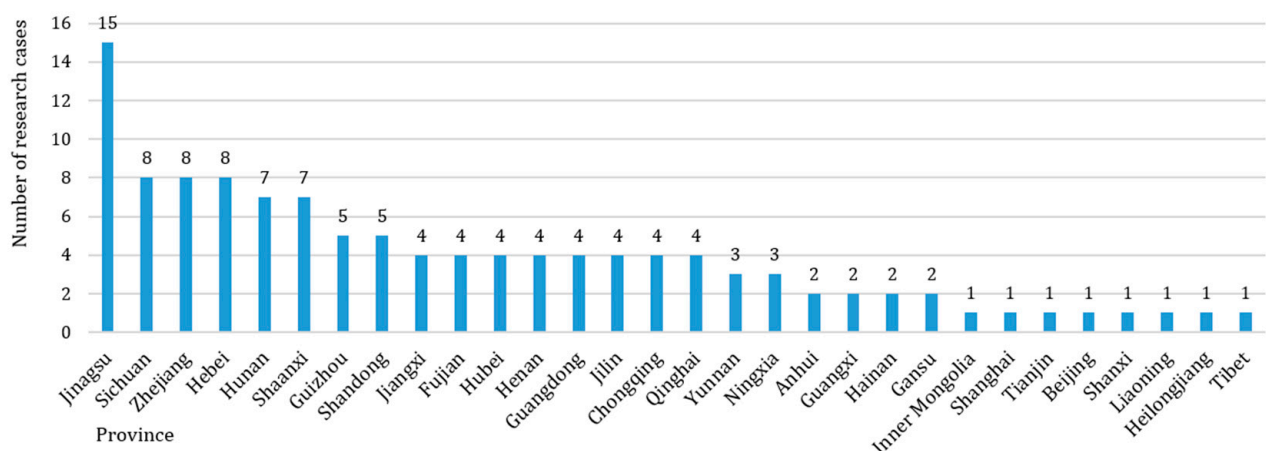
than 25 occurrences were counted, as shown in Figure 4. In the study of rural ecological environmental issues, the focus was on governance mode ( $n = 479$ ), non-point source pollution ( $n = 239$ ), rural residents ( $n = 193$ ), agriculture ( $n = 190$ ) and economy ( $n = 113$ ). The distribution of other fields was relatively even. Related extensions not only focus on farming ( $n = 102$ ), environmental policies ( $n = 83$ ), and industry ( $n = 80$ ), but also on the willingness of rural residents ( $n = 39$ ), main interests ( $n = 48$ ), and cooperation ( $n = 28$ ), as well as human health considerations ( $n = 26$ ) and diseases such as cancer ( $n = 31$ ).



**Figure 4.** Words with more than 25 occurrences in titles, abstracts, and keywords.

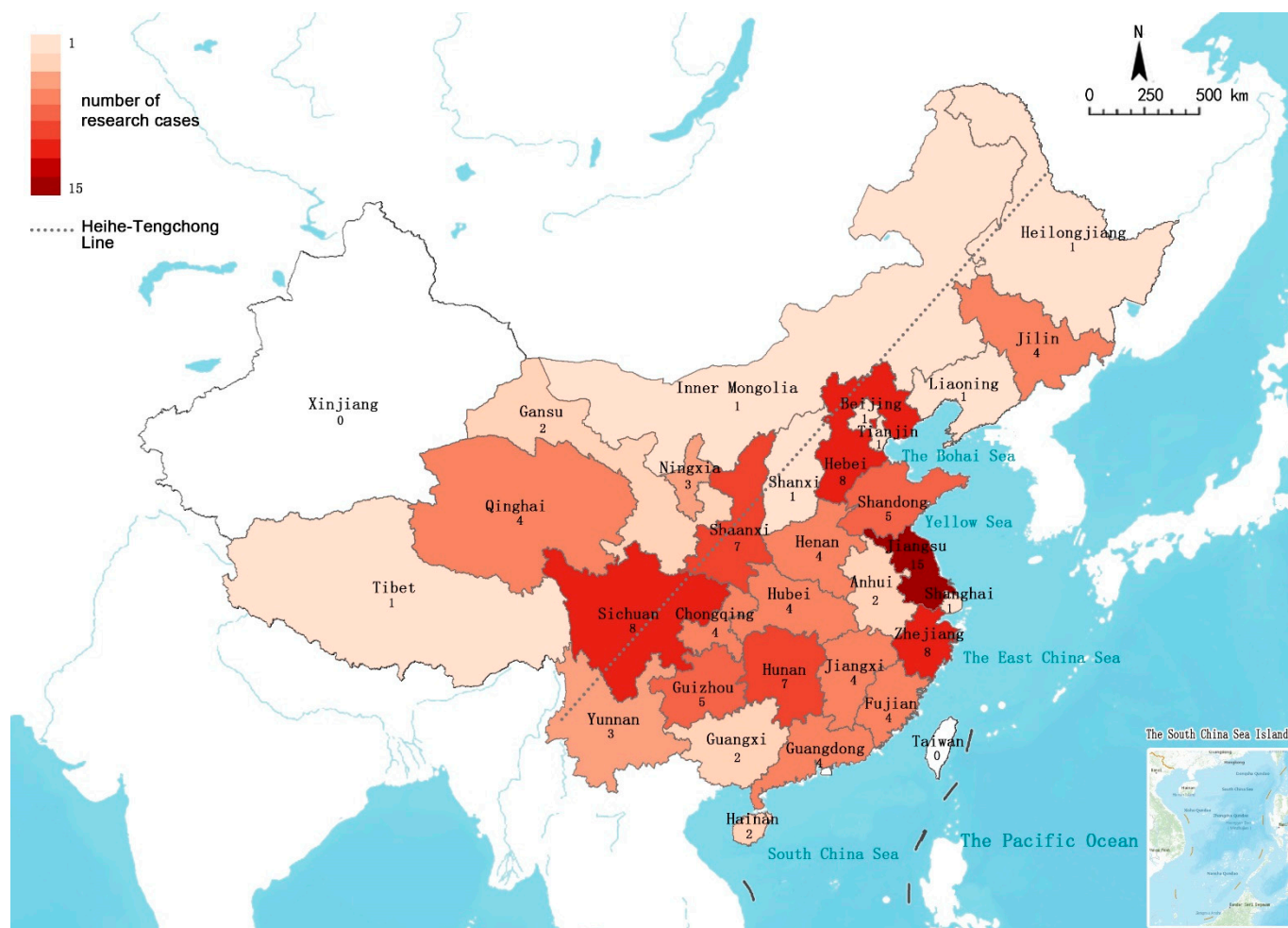
### 3.2. Research Is Cross-Administrative, with Special Ecological Areas Receiving the Most Attention

From the sites selected for the study cases, 50 of the 167 articles had a national scope. This indicates that rural ecological and environmental problems existed nationwide and had certain commonalities. The overall large-scale research was vital. There were also 117 literature cases scattered across various regions of China. The research team conducted spatial drop point and kernel density analysis on the locations of these cases and spatially classified the case locations, resulting in 14 typical study case clusters (Figures 5 and 6). For the whole of China, the eastern and southern provinces had relatively rich research results, while the central and northwestern regions had less relevant results, which conforms to the law of the Heihe–Tengchong line (Figure 6).



**Figure 5.** Number of cases by province in China.



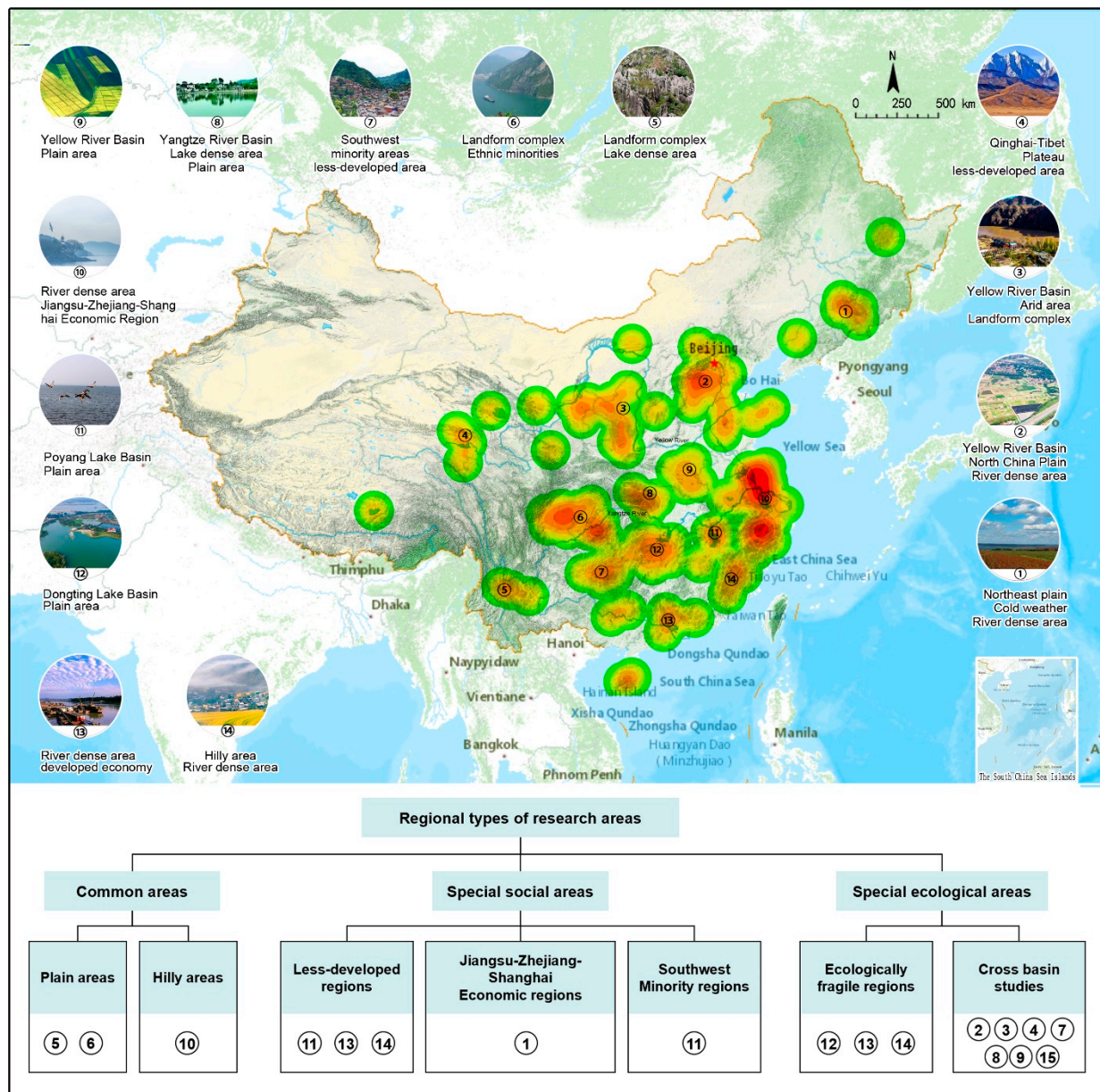


**Figure 6.** Interprovincial distribution of study cases in China.

In general, the selection of case sites showed two characteristics: (1) More studies were conducted in areas with special ecological resources, especially in areas with a complex hydrological environment and fragile ecology, which also explains why Jiangsu ( $n = 15$ ), Sichuan ( $n = 8$ ), Hunan ( $n = 7$ ), and other provinces had more study cases. These three provinces had the densest rivers and lakes and a relatively high concentration of agricultural population in China. During long-term agricultural production and rapid urbanization, the rural areas here formed relatively acute ecological and environmental problems. (2) Emphasis was placed on the overall regional research. “Region” here refers to physical geographic subdivisions, river basins, and economic zones, not limited to administrative districts. For example, rural ecological research in whole river basins, the Jiangsu–Zhejiang–Shanghai economic zone, and underdeveloped areas was the focus of typical case studies.

Further analysis of the location of the cases (Figure 7) led to the following conclusions:

(1) The largest number of study cases was found along river and in lake basins, because these areas are the most suitable for human settlement, industrial development, and planting crops [37,38]. Therefore, water, soil, and air were highly polluted there [39,40]. Among them, the middle and lower reaches of the Yangtze River basin [40–43], the upper reaches of the Yellow River basin [44,45], and the Poyang Lake [46,47] and Dongting Lake [48–52] basins in South China were the concentrated areas for research on rural ecological problems. This shows that water pollution is currently the most significant environmental problem in rural China, and it often coexists with soil and air pollution [53]. The overall study of water pollution at the basin level can better explain the spatial and temporal distribution of human-made and natural water pollution [54].



**Figure 7.** Heatmap of geographic distribution and regional types of study cases.

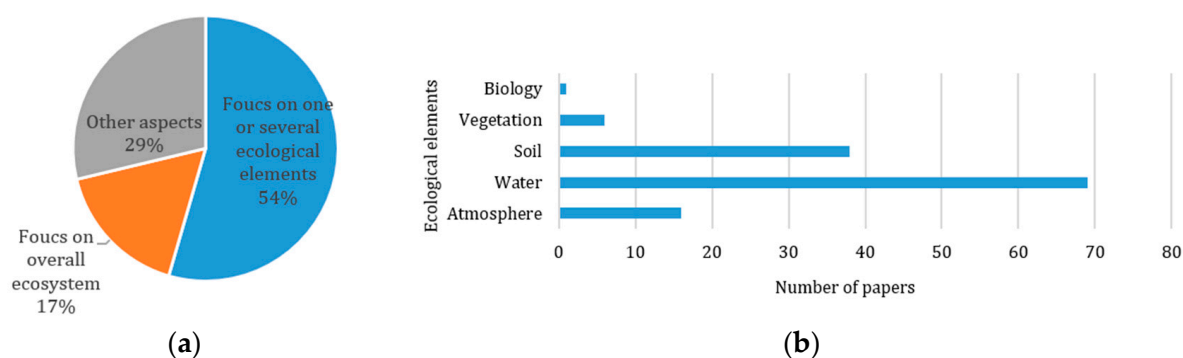
(2) The Jiangsu–Zhejiang–Shanghai economic zone was a hot area for rural ecological research. It is located in the lower reaches of the Yangtze River with an abundant water network. It has a well-developed industrial and agricultural industry base [55,56]. The trend of urban–rural and regional integration is strong here, and it is one of the most developed regions in China’s rural economy [57]. From relevant studies, the rural environmental problems mainly derive from two aspects. On the one hand, in the rapid urbanization process, the economic–societal–ecological contradiction in this region was more prominent. This contradiction was remarkably reflected in the ecological environment of rural areas [58,59]. On the other hand, this area had a more complex rural land use pattern [60] and thus presented multiple types of ecological problems. For example, there were cases in which economic benefits were obtained at the expense of ecological and environmental effects [61,62]. The Jiangsu–Zhejiang–Shanghai economic zone was the pioneer area for constructing rural ecological civilization in China. The case study here can provide valuable inspiration for rural areas in other areas.



(3) The ecosystem in underdeveloped areas is often relatively simple and fragile [63], which was also the focus of rural ecological research. Studies in these areas focused more on how to prevent and control natural disasters in rural areas. For example, the grassland ecosystem in Northwest China was severely degraded and prone to drought and waterlogging [64]. Moreover, it was easy to significantly impact on the economic income and life of local herdsmen [65–67]. The Yunnan–Guizhou–Sichuan region in the southwest had abundant rainfall, which varied dramatically with the seasons, and was prone to floods and droughts [68]. In addition, it is mountainous, and debris flows are prone to occur in summer [69]. Many scholars studied the ecosystem problems [70], ecological risks [71], driving factors [72], and development trends [73] in one underdeveloped area. In addition to the above problems, the research concerned included rocky desertification [74,75] and soil erosion [76].

### 3.3. Relevant Ecological Elements behind the Overall Ecological Crisis

Among the 167 articles (Figure 8a), 91 explicitly addressed one or more ecological elements. They focused on the evaluation of the status quo of ecological elements [62,77,78], the changing trend [79,80], and related engineering techniques to solve ecological problems [81,82]. Twenty-eight articles discussed the common issues and solutions in the ecosystem at the macro level [10,83,84]. In addition, 48 papers on rural ecology focused on policy reasons, industrial transfer [85–87], social management [88,89], environmental supervision [90–93], etc. There was also a focus on solid waste treatment [94,95].



**Figure 8.** Ecological elements of concern in the literature. (a) Among the 167 articles, 91(54%) explicitly addressed one or more ecological elements. 28(17%) articles discussed the common issues and solutions in the ecosystem at the macro level. 48(29%) papers on rural ecology focused on policy reasons, industrial transfer, social management, environmental supervision, etc. There was also a focus on solid waste treatment; (b) Among the 91 studies focusing on ecological elements, those focusing on water bodies were the most abundant, with 69 studies. There were also 38 studies on soil. The following main ecological elements were the atmosphere, vegetation, and biodiversity.

Among the 91 studies focusing on ecological elements (Figure 8b), those focusing on water bodies were the most abundant, with 69 studies. Among them, agricultural non-point source pollution [93], industrial sewage discharge [79,96,97], and rainwater runoff pollution [98] received the most attention, followed by the discussion on natural water protection [99]. In addition, there were a few studies concerning groundwater research [96,100]. There were also 38 studies on soil. As land is directly affected by agricultural pollution, some studies focused on agricultural farming methods [101] and the effects of pesticides and fertilizers on the soil [102,103]. Moreover, the soil was often studied together with water and vegetation [104]. The following main ecological elements were the atmosphere [78], vegetation, and biodiversity [105,106].

### 3.3.1. Water Crisis

With the increase in industrial and agricultural activities, the problem of water pollution has become increasingly serious. Studies have shown that the qualification rate of urban drinking water (85.51%) was much higher than that of rural drinking water (51.12%) in China [107]. The hydrology and influence processes in river and lake basins are complex, and the water quality deterioration is exacerbated by human disturbance [108]. In particular, rural township enterprises have developed rapidly and have become the main source of pollution [10]. First, the toilets and laundry of rural residents contributed to total phosphorus. Second, manure and sewage from large livestock farms in suburbs and villages were other significant sources of pollution. Livestock farm wastewater often contained high concentrations of fertilizer, including nitrogen, phosphorus, and potassium, leading to eutrophication and pathogenicity [109]. Due to the ineffective implementation of relevant environmental laws and regulations in rural areas, many such wastewaters were directly discharged into local ditches [104]. Third, the pollution of rivers had become more severe due to the non-point source pollution caused by the excessive use of pesticides and chemical fertilizers [104].

The drinking water situation for rural residents was not optimistic. Water infrastructure was challenging in some rural areas, leaving many residents without access to safe drinking water services [110]. Therefore, they used poorly filtered surface water, shallow groundwater, and rainwater. Another reason was the lack of effective water quality monitoring. For example, in some water plants in Hubei Province, the bacterial parameters in the water exceeded the national standards [111]. Another example was the high concentration of Pb, Hg, and Cr 6+ in drinking water in Ya'an, Sichuan, which caused serious public health impacts [112]. For example, algae blooms in Taihu Lake in 2007 were mainly caused by excessive use of pesticides, fertilizers, and various detergents, of which 25.1% were nitrogen and 60% were phosphorus [113].

In recent years, the situation has improved compared to 2012. During the search, it was found that the literature on severe water pollution in rural areas has decreased in recent years, indicating that the degree of water pollution has gradually reduced. Drinking water problems in many villages have been resolved. Through the 13th Five-Year Plan efforts, China has built a relatively complete rural water supply engineering system. At present, the rate of centralized water supply in rural areas has reached 88%, and the penetration rate of tap water has reached 83% [114]. The overall level of rural water supply security has been significantly improved. In this context, the water crisis in rural China has a different focus. First, the water resources are insufficient, and the water consumption is relatively large, especially agricultural water consumption (irrigation water). In 2019, China's total water consumption was 602.12 billion m<sup>3</sup>, of which 368.23 billion m<sup>3</sup> was agricultural water, accounting for 62.1% of the total water [115]. In 2021, China's total water consumption was 592.02 billion m<sup>3</sup>, of which 364.43 billion m<sup>3</sup> was agricultural water, accounting for 61.5% of the total water [116]. The sustainability of agricultural water use has been challenged [117]. Second, water resources are unevenly distributed across the country, such as in the western regions where water resources are scarce and agricultural water is especially scarce [118]. Third, although the scope of water supply projects is relatively wide, the qualification rate of water supply in rural areas is still much lower than that in cities [107]. In addition, the untimely maintenance of mechanical failures of water supply facilities in rural areas and insufficient water supply management capacity have also resulted in inadequate tap water utilization [119]. The data indicate a strong need for developing and implementing a simplified Water Safety Plan approach explicitly designed for small rural systems in China [120].

### 3.3.2. Soil Pollution

The primary pollution sources of rural soils included industrial wastewater, domestic and livestock wastewater, runoff, and other non-point source pollutants. Livestock and poultry farming in China also seriously threatened the carrying capacity of arable

land [121,122]. In recent years, China's livestock and poultry industry has developed rapidly, with the average annual growth rate of pigs, sheep, and poultry in various regions being generally high, even exceeding 12% [123]. Farmland was the most important way to absorb nitrogen pollution from livestock and poultry [124]. In 2012, China's average nitrogen load per unit of cultivated land area exceeded 138.13 kg/hm<sup>2</sup>, and the average nitrogen load in Sichuan and six other provinces exceeded 202.98 kg/hm<sup>2</sup> [125].

Heavy metal pollution of cultivated soil is also one of the environmental problems in China's rural areas. According to the national soil pollution survey conducted by the Ministry of Ecology and Environment [16], the rate of soil pollution in China's cultivated land exceeding the standard is 19.4%. The main pollutants are heavy metals, of which the excess rate of cadmium pollution sites is 7.0%, followed by nickel, arsenic, copper, mercury, lead, and chromium [125,126]. In addition to the influence of natural factors such as the parent material and parent rock, heavy metals were also influenced by human factors. First, the causes of heavy metal pollution in farmland soil in China included natural parent materials, artificial pollution, and their superposition. On a regional scale, the geochemical properties of soil parent materials and parent rocks directly affected the content of heavy metals in soils [127]. The average contents of Cd, As, Hg, and Pb in lava and limestone parent soils were significantly higher than those in aeolian sand parent soils. Second, the soil heavy metal content in local areas (such as the Yangtze River Delta and Pearl River Delta) is affected by human factors. For example, heavy metal pollutants from industry, sewage irrigation, agricultural fertilizers and pesticides, and residential life are discharged into the farmland soil.

There were soil degradation problems in Northwest China, including land desertification, salinization, and soil erosion. Rocky desertification also existed in the Kost Mountains of Guizhou Province [128]. The residents' awareness of soil and water conservation was weak, which aggravated soil erosion. Causes also included road construction, housing construction, farming on steep slopes, tourism development, and animal trampling.

### 3.3.3. Air Pollution and Vegetation Degradation

Air pollution in rural areas mainly came from crop straw burning and coal burning in winter. However, the central government attached great importance to the phenomenon of straw burning and vigorously promoted the utilization of straw as a resource [129]. In the major grain-producing areas, such as the Han River Plain and the three northeastern provinces, crop straw's seasonal and structural excess made it difficult to effectively prohibit villagers from burning straw directly in the open [130]. The straw plants were mainly wheat, rice, and corn [131]. The smoke from straw combustion included a large amount of sulfide, ethylene, acetaldehyde, and formaldehyde, which polluted the regional atmosphere [132]. It also disrupted the soil structure, leading to the death of microbes at the surface and the mineralization of humus and organic matter [133]. Another cause of air pollution in rural areas was burning coal for winter heating in the northern regions. The northern heating area included 12 provinces, including Heilongjiang and Shandong. Coal combustion produced large amounts of PM, SO<sub>2</sub>, NO<sub>x</sub>, and CO [134].

China's grassland ecosystems experienced extensive degradation. Climate change and overgrazing were the main reasons [135]. To increase income, herders overgrazed in summer, and the number of livestock grazing per unit of time far exceeded the actual carrying capacity of the pasture [136]. The management system of pastures did not meet the needs of local economic development and herders.

### 3.3.4. Production and Household Waste

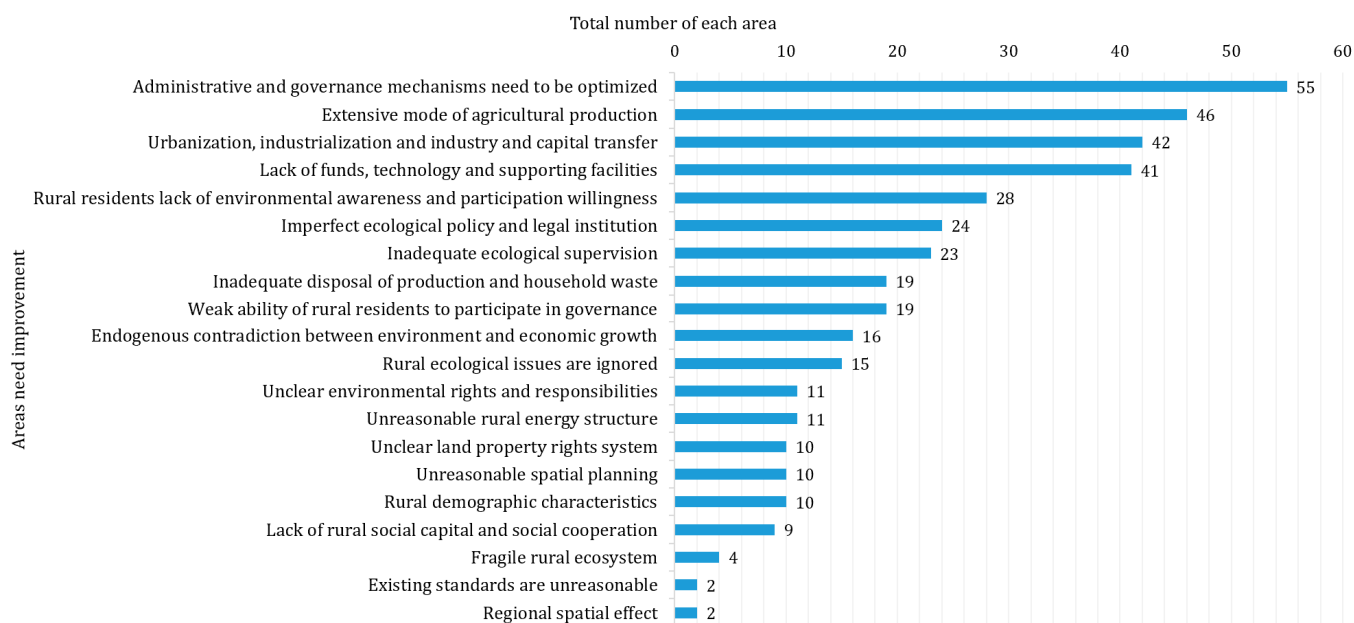
Rural household waste was one of the factors affecting rural living environments. For example, items of the rural household waste in the Three Gorges Reservoir area included kitchen waste, bamboo, ash, rubber, plastic, waste-paper, textiles, used batteries, expired medicines, and pesticides [137]. Among them, kitchen waste, bamboo, and other organic matter content exceeded 60%, and waste plastics (including expired drugs, agricultural

mulching film, pesticides, and fertilizer packaging) totaled nearly 15% [138]. Currently, the garbage collection, storage, transportation, and disposal systems for rural residents in the central and western regions are incomplete [139]. Household waste disposal depends on economic conditions and requires infrastructure and social support. There were also obvious regional limitations, especially the lack of possibility to install equipment in the vast mountainous and hilly areas [140]. The reasons also included villagers' poor environmental protection awareness, an inadequate legal system for ecological protection, and weak government supervision [141].

### 3.4. Impact of Ecological Crisis and Comprehensive Solutions

The rural ecological environment problems have brought many far-reaching impacts. First, the polluted water, soil, and atmosphere may lead to the loss of biodiversity [106]. High concentrations of *Escherichia coli* in Ma Lake in Shandong Province caused the extinction of many fish, shrimp, and crabs due to domestic water discharge [132]. Another significant impact was the increased human health risk, with cancer incidence and mortality rising in rural areas [45]. There were more than 400 cancer villages in China [142,143]. Some surveys have shown that these villages were close to polluted rivers and soils, and cancer mortality in these villages was positively correlated with the distance between contaminated sites [144]. The third effect was that grain yields were greatly reduced. For example, rice production in Zhejiang Province, China, has recently declined due to cadmium content standards [145].

The overview of rural ecological problems in China shows that many areas require improvement [146], as shown in Figure 9. It can be concluded that areas for improvement include government support, appropriate incentive policies, sound resource planning, technical support, and broad mass participation [21]. Although some progress has been made, proper laws and regulations, policy guarantees, and technical and economic support are still lacking [147]. Many efforts should be made to solve the above problems.



**Figure 9.** Visual comparison of areas that need improvement.

First, we should improve the laws and regulations on the rural environment to make up for the deficiencies of existing regulations and policies [148]. Laws and regulations should be improved in all aspects. For example, new domestic sewage discharge standards, industrial sewage discharge standards, safe drinking water laws, and water-saving incentive policies should be formulated [149]. However, due to the unbalanced development in China, we should consider the actual local situation and adopt more region-specific



policies [150]. For example, water-saving approaches should be encouraged in water-scarce regions, including drip irrigation, rainwater harvesting, and recycling technologies [151]. Water quality improvement policies, such as advanced water treatment technologies, need to be introduced. Stricter water quality monitoring should be adopted in areas with abundant water resources. Likewise, soil, air, and solid waste should have specific laws and regulations for different regions. For example, for pastures in northwestern China, the grazing time, and the number of livestock per unit area should be specified [152]. Effective enforcement and oversight are essential to ensure the proper implementation of laws and regulations. For example, environmental performance indicators should be added to assess the political achievements of local officials [153]. There should be rewards and penalties for senior managers, mid-level managers, and field law enforcement officers. They also need regular training to understand the value of their work better and learn the necessary law enforcement skills.

The eastern rural areas have been significantly improved in terms of the ecological environment. For these areas with better ecology, some scholars have begun to study the classification and division of land, hoping that, from this perspective, it can better help the sustainable development of rural ecology [154]. Some scholars have also begun to study more sophisticated areas of pollution prevention, such as the pesticide packaging waste recycling policy [155]. Some scholars have begun to consider the sustainable development of rural areas from the combination of the economy and ecology. For example, northern and central Jiangsu have high ecological environment scores, but many rural areas have experienced social phenomena such as population loss, aging, and rural economic decline [156]. Social issues go beyond ecological impacts and become an essential factor affecting the sustainable development of rural areas. From the behavior perspective, some scholars have also studied the factors affecting villagers' domestic waste disposal behavior [157] and villagers' willingness to participate in domestic sewage treatment [158]. In general, in rural areas in the eastern region where the ecological environment is already good, scholars have started land use classification and advanced pollution prevention and control to improve the environment further. On the other hand, scholars use social issues and human behavior as the starting point to study various issues such as rural ecology.

Second, economic measures should be taken to improve ecological and environmental management in rural China, which are better incentives [159]. For example, we can establish a water penalty mechanism for exceeding a given quota [118] for water conservation. When water users exceed their allowance, they would be required to pay several times the standard water rate. This measure can encourage water users to conserve water and find ways to reuse water [160]. Another example is subsidies for new filtration equipment in wastewater treatment plants [161]. Regarding waste sorting, residents can obtain bonus points for sending their plastic products to garbage collection stations, and a certain number of points can be redeemed for daily necessities. In winter heating in northern China, as the price of low-sulfur coal is relatively high, government subsidies can encourage residents to use low-sulfur coal to reduce the emission of pollutants into the atmosphere [162]. In general, economic means can improve the efficiency of environmental protection in terms of both household and enterprise pollution.

Third, technological innovation is one of the effective measures to improve the rural ecological environment, especially the combination of technology, economic incentives, regulatory standards, and other means. For example, the discharge of animal manure will seriously pollute the soil, which is one of the fundamental reasons for the eutrophication of water bodies. However, animal manure is the key anaerobic fermentation material for biogas energy [121]. The combination of livestock and poultry farming with biogas systems can significantly reduce the nitrogen index in the environment [163]. At the same time, the generated biogas is also crucial for rural energy [164]. This complete process and system require better economic, policy, and technical support. As another example, by improving the thermal insulation performance of buildings (adding thermal insulation layers to walls, replacing door and window materials), coal consumption for rural heating can be reduced,

reducing air pollution [165]. There is also a series of technological innovations, such as straw fuel utilization (SBF) [166], biofuel cycle systems [167], and integrated courtyard ecosystems (CIEs) [168], which can improve the rural energy structure and living environment. Rural areas in China should also support related R&D activities and technology transfer. At the same time, we can introduce foreign advanced technology and equipment, organize personnel training, and learn professional knowledge.

Finally, different stakeholders should work together, including the government, entrepreneurs, villagers, and others [169], to promote the improvement of the rural ecological environment [170]. Due to the large number of groups involved, their needs are different [171]. A possible suggestion is to create a system of round tables for regular and equal negotiations and discussions. Emerging issues can also be addressed, exchanging progress and experiences along the way. A public participation mechanism should also be established to raise public environmental awareness. The active participation of farmers is more likely to achieve good results. It should be clear that this is a long-term process but one that can be periodically assessed against short-, medium-, and long-term goals. Awareness-raising campaigns, including television campaigns, newsletters, and workshops, should be carried out regularly to increase understanding. It should also be clear that environmental improvements are also of public interest.

## 4. Discussion

### 4.1. Complexity

China's rural ecological problems have presented many typical representations of "complex systems" [172]. China's rural ecological problems have the characteristics of a cross-regional distribution in space (dynamic), and the coexistence of long-wave general conditions and transient incidents in time (emergence) [173]. These two characteristics are unique to the complex system network. The reason for the complexity, on the one hand, may be due to the complexity of the way Chinese farmers interact with the environment. Compared with China's urban areas, as well as North America's large farms, Europe's Rhine Valley, and other agricultural areas, China's rural areas are rich in ecosystem types. They include grassland, wetland, woodland, atmosphere, farmland, tidal flat, ocean and many other ecosystem types. This has resulted in very different agricultural production practices and lifestyles, resulting in complex ecological impacts and various ecological and environmental risks. In regions such as Jiangsu, Zhejiang, and Shanghai, this complexity is most prominent. On the other hand, the composition of stakeholders in rural China is more complex [174], involving many production practices and lifestyles. In the evolution of rural China from the traditional "work at sunrise and rest at sunset" to the modern large-scale and industrialized agricultural industry, completely different values have been formed, and various ecological behaviors under different value orientations have been developed [122,175]. Since the ecological civilization strategy was proposed in 2013, it can be seen from the literature that a consensus among stakeholders has tended to be formed, but it is still diverse.

### 4.2. Comprehensive

On the one hand, the comprehensiveness meant that there were many ecological elements involved in China's rural ecological problems. China's rural areas cover many ecosystem types, such as grasslands, wetlands, rivers, woodlands, atmosphere, and farmland, and are relatively fragmented. Although these ecosystems are geographically adjacent or separated, they form a comprehensive giant system through the circulation of matter and energy. Therefore, most of the improvement measures proposed in these studies referred to the importance of "overall planning". The causes of ecological problems were often not entirely local, and it was necessary to propose countermeasures from the perspective of cross-regional and cross-administrative regions. On the other hand, it was manifested as a need for multidisciplinary, multidomain comprehensive solutions. From the literature analysis, it is apparent that the research fields of rural ecological problems in China roughly

included two categories. The first focused on management, humanities, and social sciences and tended to explore the causes and countermeasures of rural ecological problems from the perspectives of governance systems, laws and regulations, and social research. The second was represented by the fields of environmental science and agriculture and was committed to the study of ecological and agricultural issues through technical means. This shows that rural ecological problems involve all aspects of the ecosystem and are closely related to production methods. They cannot be solved from a single discipline and require the coordination and cooperation of multiple disciplines.

## 5. Conclusions

It has been 40 years since China entered a stage of rapid urbanization in 1980. This paper analyzed and summarized the literature on rural ecological environment issues in the past ten years, that is, from 2013 to 2022. It was found that rural ecological problems have become the focus of public attention. Many people's attention is starting to shift from cities to rural areas. The problems existing in China's rural areas are relatively complex, and the ecological environment needs multidisciplinary participation to improve. Considering the differences in geographical location, climatic conditions, ecological resources, topography, economic conditions, and the customs and habits of residents, we cannot solve all problems in one way, nor can we fully learn from the experience of successful villages. It is necessary to propose a variety of solutions by type and region, in a multilayered and flexible manner according to local conditions.

Based on the results obtained in our study and the above conclusions, future research should focus on the below.

First, villagers' acceptance and implementation of environmental protection policies and how to effectively guide and influence their behavior requires research attention.

Second, China's rural areas are often scattered, and the construction methods and management policies of city infrastructure are difficult to apply to rural areas. It is necessary to implement different measures for water supply, garbage collection, energy recycling, and heating according to the characteristics of different villages.

Third, China has invested a lot of capital in rural areas for infrastructure construction and environmental improvement. However, it is worth paying attention to how these projects are used, maintained, and operated in the later period.

There are some limitations to our study. Most of the existing studies were single cases and focused on their own sub-fields, such as heavy metal pollution and straw recycling. There was a lack of sustained attention to the same ecological problems in the same areas, such as analyses of trends in the same problems over the past 10 years. The dynamic change research trend can provide a better reference. However, this study may inspire future ecological environment governance in rural areas. We also hope that these Chinese case experiences can help other parts of the world at similar stages of development.

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