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How China Achieves the Delicate Balance in Ecological Poverty Alleviation: A Systems Thinking Perspective

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Abstract: Ecological poverty alleviation (EPA) is a syngenetic approach to tackling challenges in alleviating extreme poverty and ecological protection. Such an approach is crucial to help countries facing these two challenges to accelerate their progression towards meeting the United Nations Sustainable Development Goals in 2030. Prior research on EPA was focusing on understanding EPA from a national perspective and limited consideration was given to regional pertinence. This study uses systems thinking to construct causal loop diagrams (CLDs) and analyzes the mechanisms of EPA in Lanping County, Yunnan Province based on qualitative material. It reveals that the dynamics mechanism of EPA in Lanping County consists of seven reinforcing feedback loops and ten balancing feedback loops. Results indicate that external support, funding resources, employment, and endogenous-driven industrial development are the key drivers to successful EPA. Policies should be taken to avoid the risk of returning to poverty caused by the withdrawal of external support. This study proposes an effective tool with system foresight for exploring the mechanism of EPA and provides reference suggestions for poverty alleviation and development worldwide.

Keywords: ecological poverty alleviation; systems thinking; causal loop diagram; ecological protection; China

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1. Introduction

Poverty is a global problem, and "ending poverty of all forms" is at the forefront of the United Nations (UN) Sustainable Development Goals. As a developing country with the largest population of people facing extreme poverty in the world once [1], China today had lifted all 98.99 million people out of poverty according to the statistics from the Ministry of Agriculture and Rural Affairs of China [2]. China's ability to alleviate so much extreme poverty within a few decades is remarkable and can serve as a roadmap for other developing countries to emulate.

In the course of our study, we uncovered a close coupling relationship between ecology and poverty, similar to the extant literature, e.g., Chen et al. [3]. For example, in China, more than 95% of the people facing extreme poverty are located in key counties with a fragile ecological environment [4]. Because residents in these areas often lack other development opportunities, they have to rely on natural resources to obtain survival resources and production, such as deforestation and over-cultivation. Without sufficient funds and technologies to protect the environment, such activities are often destructive to the environment, which in turn leads to ecosystem degradation. This creates a vicious cycle for these residents, trapping them even deeper into poverty, while the environment continues to degrade further [5–7]. Obviously, it leads to a lose-lose situation. How do

residents break free from this vicious cycle? We believe the literature on Ecological Poverty Alleviation (EPA) can offer some insights in this regard.

As one of the instruments for ending poverty, EPA is regarded as a critical way to meet the dual goals of poverty reduction and environmental protection and achieve win-win outcomes [8]. It is a policy system consisting of a comprehensive and practical set of poverty alleviation approaches that protect the environment, such as ecological construction, ecological compensation, ecological industry, ecological employment, ecological relocation, and other specific pathways [9]. EPA can play an effective role in poverty alleviation, especially in ecologically fragile areas with many people suffering from extreme poverty [10,11]. According to 2020 data from China's State Forestry and Grassland Administration, EPA has helped more than 20 million people get out of poverty by raising their income while increasing the area of forest and grassland by nearly 60 million hectares [12]. EPA has also produced a lot of economic benefits for these people, such as increased financial assistance, employment, source of income [8], and social and ecological benefits [13,14].

Notwithstanding the huge dual potential of EPA in alleviating poverty and protecting the environment, the previous literature on EPA has been scant [8]. Much of the existing literature has focused on examining the effects and mechanisms of EPA's policy instruments such as payment for ecosystem services (PES) [15], ecological tourism [16,17], ecological resettlement [18,19], and clean energy development [20,21], while some other studies explore the impact of EPA policy on poverty alleviation [22] or ecological protection [23] but not both. We posit that given the complexity of EPA and the multiple stakeholders and contextual factors that are often intimately intertwined in real-world cases, a systems thinking perspective would provide deep insights into the key feedback structures that influence the success of EPA's implementation. Our views are equally supported by other researchers. For example, Lei et al. [8] recognized EPA as a complex system involving multiple policy instruments, governmental agencies, social forces, and agents. Huan et al. [24] analyzed three major pathways of implementing EPA from the perspective of eco-civilization progress, including promoting green development, establishing ecological public-welfare compensation mechanisms, and organizing ecological relocation. Therefore, we hope to contribute to the literature by filling this gap through our study.

Adopting a systems thinking perspective and serving as the foundation for the development of a simulation model in future research, the research questions that we seek to answer through our study are:

- How does EPA achieve the win-win outcome of ecological protection and poverty alleviation?
- Which key feedback loops influence the outcomes of EPA?
- How do the key feedback loops influence the outcomes of EPA?

To answer these questions, it is necessary to systematically analyze the mechanisms underlying EPA practices. Therefore, this study investigates the implementation of EPA in China by reviewing the development of EPA practices in Lanping County, a typical poverty-stricken mountain county in Yunan province, to explore how poverty was alleviated via localization approaches under the framework of EPA. It uses systems thinking and causal loop diagrams (CLDs) to represent the interactions of key factors and understand the behavior of the system. The findings of this study could provide valuable guidelines for the effective planning and implementation of EPA in China and worldwide.

2. Methods

The idea of systems thinking arose around 1960 as a platform to understand dynamic behavior [25]. Senge [26] defined "systems thinking" as a conceptual framework, a body of knowledge and tools to make the patterns/trends and the associated feedback structures that generate them within a complex system clearer. Systems thinking helps us see beyond the individual variables and consider the effects of the systems on these variables. It provides us with an effective technique to identify leverage points that could be used to design interventions to change the system behavior effectively. Due to its effectiveness

in helping us develop a nascent understanding of a complex system, systems thinking is popularly being applied to the analysis of complex systems across different disciplines, including social sciences, engineering, business and management, computer science, and medicine [27].

Causal loop diagrams (CLDs) are a qualitative diagramming language used often when applying systems thinking to model a complex system. The goal of the CLDs is to allow us to identify key feedback structures that are responsible for the patterns/trends that the system generates. It is an important tool that can be used when we are thinking in systems and/or when we are setting the foundation for the eventual modeling of a complex system using system dynamics methodology [28]. Rather than writing equations, CLDs-based, free-form diagramming can contribute to shaping a qualitative discussion about key feedback effects. Capturing the structures that are generating these effects will then allow us to gain deep insights into the complex system and develop an accurate quantitative formulation of the magnitude of the effects during simulation modeling [29].

Ecological Poverty Alleviation (EPA) is a dynamic and evolving process, which involves a wide range of resource management strategies and practices, multiple sectors and various stakeholders, and comprises numerous feedback structures. This process of EPA is now very poorly understood and research in this area has been scant. Thus, we posit that understanding the EPA process will benefit significantly from applying CLDs in the identification and analysis of the key feedback structures in EPA. Our assertion is supported by similar research in the literature when analyzing complex systems. For example, Hjorth [30] found that common sense and holistic systems thinking are essential starting points for improvements in the quality of decision-making and the learning and innovation in poverty alleviation efforts.

For the above-mentioned reasons, this study adopts a systems thinking perspective through the application of CLDs to study the structure and dynamic behavior of the EPA mechanism and investigate the pattern of the system that would emerge from the interaction of feedback loops. A typical CLD consists of a set of symbols representing a dynamic system's causal structure: variables, causal links with a polarity and symbols that identify feedback loops with their polarity [31]. In the CLD, the causal relationship between any two variables in the system is generally represented by arrows. The arrows are used as causal keys to connect a single causal chain, and multiple causal keys are connected to form a causal feedback loop. A positive causal link ("+") indicates that the two linked variables will increase or decrease in the same direction, while the negative causal key "−" implies an inverse or opposing relationship. Time delay (//) is used for modeling postponed effects. In a reinforcing feedback loop ("R"), the dependent variable creates an outcome, which then stimulates further action, producing more in the same direction in the loop. As a result, the state variable keeps increasing, while in a balancing feedback loop ("B"), the dependent variable passes in the opposite direction, reducing the corresponding outcome.

We adopted the practices described in [32,33] to construct our CLD and the steps involved are shown in Figure 1. The CLD development is divided into four stages: problem identification and data collection, data analysis, causal loop diagrams, and policy analysis. Phase one was primarily about problem identification and definition, such as defining the purpose of the research to guide qualitative textual data collection and delimit the scope and boundary of the CLDs [34,35]. Phase two is data analysis by encoding the text content based on grounded theory. The encoded causal loops and their feedback polarities were identified and cross-checked with the qualitative data that we collected. In the stage of causal loop diagraming, based on the data analysis results, this study uses the iterative system model development method by gradually adding new structures to the system [36]. Following best practices in [37,38], the causal relationships and feedback polarities between codes are based on cross-checking with textual support to assure the high reliability and validation of our analysis. To further enhance the reliability and validity of our analysis, the validation procedure was performed by two authors who did not participate in the

initial CLD building process. Controversial variables and relationships were discussed and refined through collective discussion among all authors. At last, further exploration of the keys to successful EPA is discussed based on the analysis of CLDs.

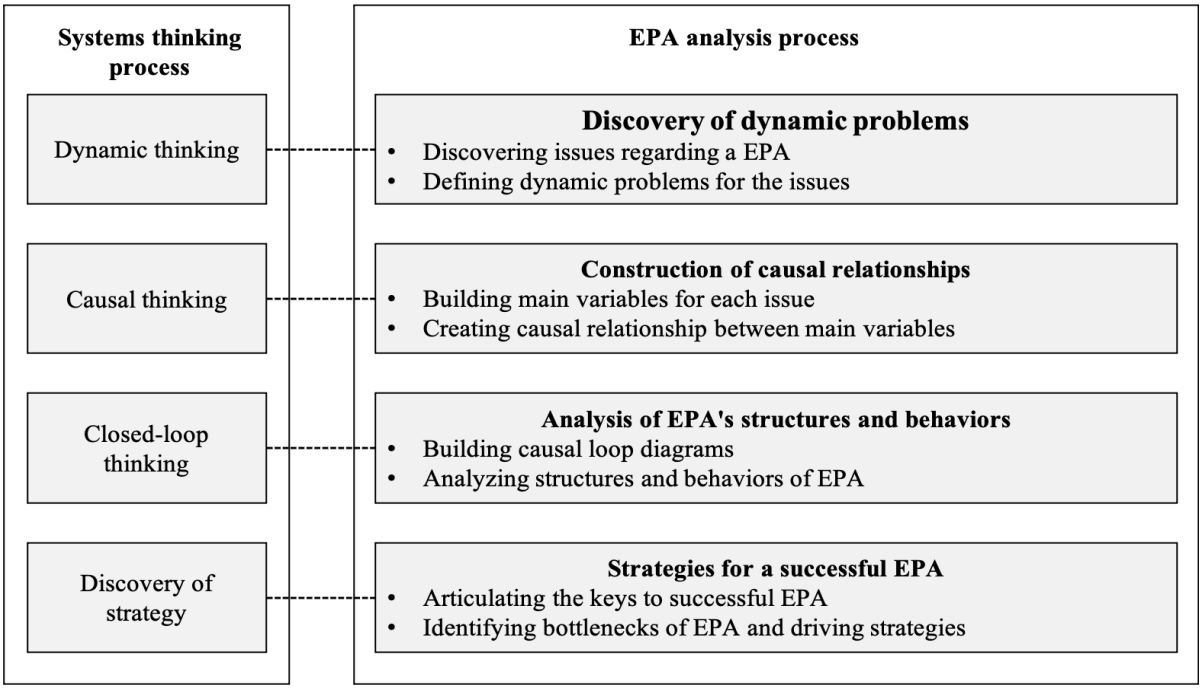

Figure 1. Systems thinking process of EPA.

3. The Case of Lanping County

3.1. Study Area

Lanping Bai and Pumi Autonomous County of Nujiang Lisu Autonomous Prefecture in Yunnan Province (Lanping County for short) is located in the longitudinal valley area of the Hengduan Mountains Range in Nujiang Lisu Autonomous Prefecture, Yunnan Province, with a land area of 4371 square kilometers. More than 98% of the county's area is high mountains and valleys. The forest coverage rate is 71.49% and the standing tree volume is 34.88 million cubic meters (Figure 2). It is rich in mineral resources, water energy resources, biological resources, and tourism and cultural resources. However, due to its history of development and the lack of cultivated land, the economic, social and environmental foundations of Lanping County are extremely fragile [39].

Lanping County is located in the Border Area of Western Yunnan, which is also one of the fourteen concentrated poor areas with special difficulties (CPASDs) in China (Figure 2). The jurisdiction includes 4 townships, 4 towns, and 108 village committees. There are 14 indigenous ethnic groups in Lanping County, such as Bai, Pumi, and Lisu. The minorities' population accounts for 94.9% of the total population. Lanping is also one of the deeply impoverished counties in the "three districts and three prefectures" and is one of the 73 key counties supported by the state in Yunnan province. At the end of 2004, the county's poverty-stricken population was 170,472, accounting for 86.9% of the total population. By 2020, Lanping has successfully removed itself from being labelled as a poor county in China.

We have selected Lanping County as the case for in depth analysis for three reasons. First, it is rich in ecological resources, which is the basis for the development of EPA. Lanping has actively implemented the EPA practices in the past few years by comprehensive consideration of natural resource and local characteristics. Second, Lanping is a mountainous area occupied by minorities who are extreme poor. Due to many similar poverty situations in other counties in China, the effective application of EPA practices in Lanping can help to

shed light on how other counties can achieve similar achievements in poverty alleviation. Third, in the process of data collection, we found that the information on Lanping is relatively complete as compared to other counties. For example, the implementation plans and summary reports of poverty alleviation are available on the government websites of Nujiang Prefecture and Lanping County, which allows us to apply data triangulation techniques during data analysis more effectively to ensure the rigor and validation of our results.

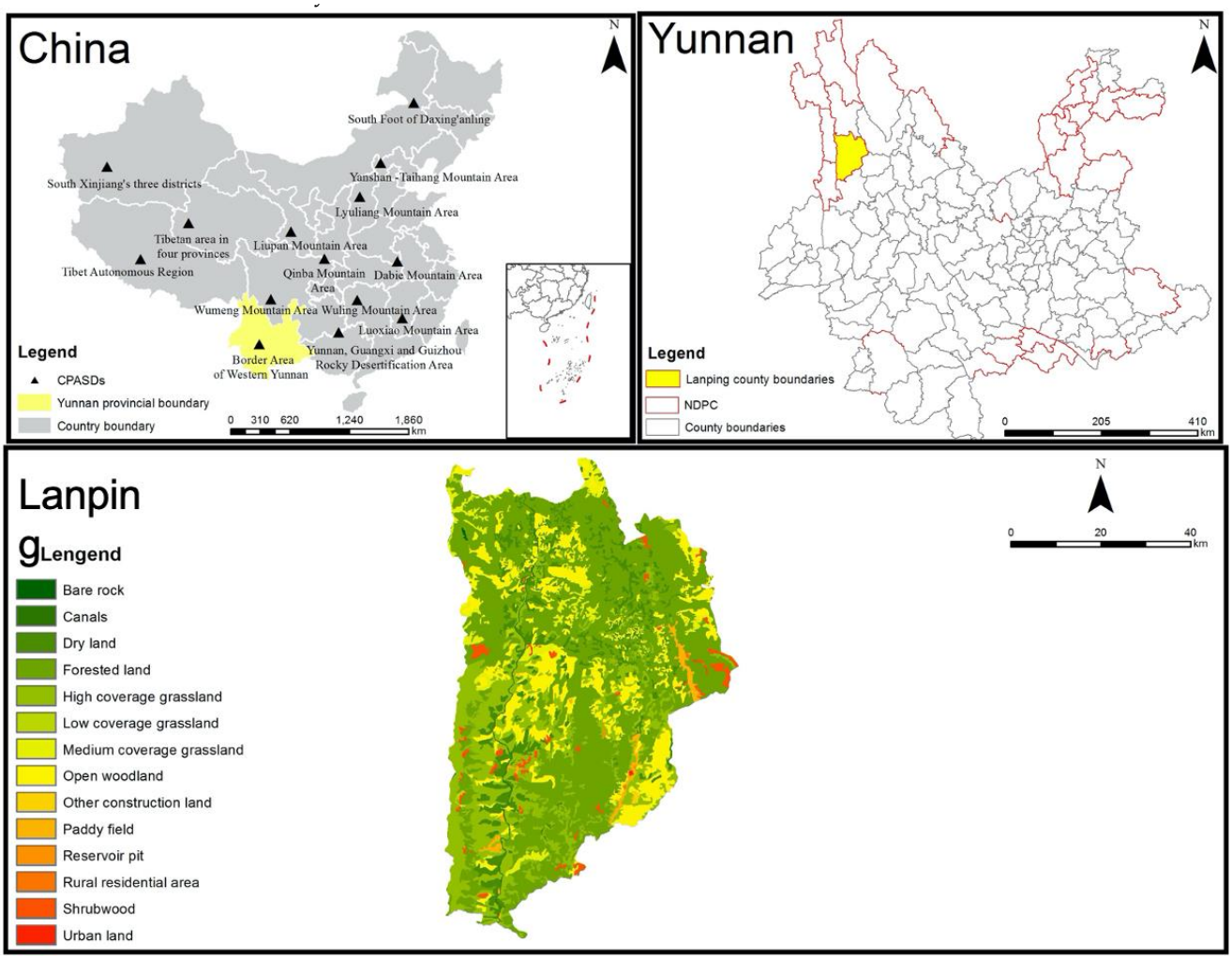

Figure 2. Location of Lanping County and its land use.

3.2. Main Measures of EPA in Lanping County

Since 2016, Lanping has invested a total of 711.34 million yuan in EPA practice and agricultural benefit funds. A total of 132,000 people have directly benefited from this investment. The ecological effects that are generated as a result of this investment in EPA are also significant. The investment has resulted in the increase of 482,667 hectares of forest land and 2000 hectares of grassland; while at the same time, the challenge of local ecological deterioration has been effectively controlled and reduced, especially the natural disasters such as soil erosion, mudslides, and landslides along the Lancang River. Based on our analysis of the data, we posited that the EPA measures would take into consideration these factors: (1) ecological restoration projects and ecological compensation; (2) ecological resettlements; (3) ecological industry; and (4) rural cleaner energy projects.

3.2.1. Ecological Poverty Alleviation through Ecological Restoration Projects and Ecological Compensation

Ecological restoration projects are critical to rebuilding the ecosystem and reducing poverty. They provide an important way for the central and provincial governments to support local poverty alleviation and achieve ecological compensation.

Natural forest conservation project. Lanping was listed as a pilot county for the implementation of the natural forest conservation project (NFCP) by the People's Government of Yunnan Province in October 1998. The first phase of NFCP was implemented from 2000 to 2010, and the second phase was implemented from 2011 to 2020. This policy contributes to Lanping's forest recovery. Under this project, the commercial logging of natural forests was completely stopped. The project equally played a crucial role in poverty alleviation. For example, the NFCP covers an area of 154,646 hectares and hired 2291 forest rangers who are largely from poor communities living in the area. 1753 registered poor households have also been given ecological transfer payments in 2017 as the natural forest was being conserved which lifted them out of poverty [40].

Returning farmland to forest and grasslands project. Returning farmland to forests and grasslands is a strategic initiative taken by the Lanping government to accelerate the greening of land and the construction of Ecological Civilization. Since the launch of a new round of returning farmland to forests in 2014, Lanping has returned many of its farmlands to forests as the primary project of ecological construction. According to Lanping's policy of subsidy, the compensation for returning farmland to the forest is 22,489 yuan per hectare. This provided a great incentive for people to return their farmlands. Not surprisingly, as of 2021, a total of 13,767 hectares of farmland has been returned to forests, involving 21,167 farmer households with 76,201 people. A total sum of 167 million yuan was cashed out and distributed to poor households living in the area, boosting the average household income by 7900 yuan [41].

Forest ecological benefit compensation. With the goal of protecting forest ecological security and increasing compensation for ecological benefits, the forest ecological public welfare area of Lanping had increased to 126,000 hectares. During the Thirteenth Five-Year Plan period, Lanping has cashed out under this compensation programme a total of 105.12 million yuan to farmers. 15,856 registered poor households with 57,081 people have benefited from these programs.

All of these EPA compensation programmes have been pivotal in protecting the ecological resources in Lanping while providing a much needed boost to the finance of people living in Lanping, lifting many of them out of poverty.

3.2.2. Poverty Alleviation through Ecological Industries

Industry is the engine for development for any county and provides the main support to lift poverty-stricken groups out of poverty. Lanping is fortunate to be endowed with many ecological resources such as species, Chinese herbal medicine resources, and landscape, that offer favorable conditions for the development of ecological industries. Lanping's government achieved the development of vibrant and contributing ecological industries by actively searching for pathways to realize the maximum value of its rich ecological resources, turning them into high-demand products wanted by the market. While doing so, Lanping's government played close attention to scaling its supply capacity of ecological products gradually, balancing the preservation of the ecological environment and the development of capabilities of people living in the areas.

Ecological forestry. Lanping's government invested heavily on afforestation. The investment resulted in numerous forestry development projects which attracted further private investment and supported the establishment of forest cooperative organizations. The innovative afforestation approach which entails interplanting characteristic crops, such as forest medicinal plants, forest vegetables, and forest seedlings, has built a vibrant economy that further spurred the investment in long and short-term development in the same area.

Notwithstanding the economic benefits, the investment in ecological forestry has also effectively improved land utilization, which enhanced the quality of afforestation and reinforced the economic benefits gained. From 2016 to 2020, Lanping built a forest industry base of 5900 hectares dominated by walnut and lacquer trees. By the end of September 2020, the county's forestry industry projects had involved 15,953 households benefiting more than 62,490 farmers. The construction of forestry industry projects also created enormous job opportunities. These projects recruited a total of 18,033 workers (largely from the poor communities in Lanping), and more than 34 million yuan had been paid to these workers, aiding many of them to be lifted out of poverty.

Ecological agriculture. The unique geographical ecological environment and the obvious three-dimensional climatic conditions make Lanping rich in unique and highly agricultural products such as biological medicinal materials, high-quality grains, woody oil crops, wild vegetables, black-boned sheep, and downy chickens. Leveraging on this ecological agriculture, Lanping has developed well-known agricultural brands including Liangwang tea, green thorn tea, and other special agricultural products. By 2019, the county had driven 16,000 households with 56,000 registered poor people out of poverty by introducing 14 leading enterprises to participate in the rural land circulation of 3000 hectares and achieve mass agriculture production. 643 professional cooperatives had also lifted 8500 households with 31,000 registered poor people out of poverty. Through developing the characteristic planting industry, Lanping helped 97,000 registered poor people overcome poverty, with an annual per capita income increase of more than 1000 yuan [42].

Ecotourism. With unique natural tourism resources and rich ethnic culture, Lanping is known as the "Museum of Natural Geomorphology", and "Gene Bank of Biological Species". In recent years, Lanping has organically combined poverty alleviation with the development of the tourism industry. During 2018 and 2020, a total of 8 tourism-related characteristic villages were built, and around 200 tourism poverty alleviation demonstration households were supported. The subsidy for tourism-featured villages was 20 million yuan per village, and the subsidy for tourism poverty alleviation demonstration households was 100,000 yuan per household. This is a significant amount of money for the extreme poor.

3.2.3. Poverty Alleviation through Ecological Resettlement

Ecological resettlement for poverty alleviation is one of the key interventions that had helped Lanping win the battle against poverty as many of its lands are not sustainable for farming. During the Thirteenth Five-Year Plan period, the county targeted the relocation scale of 11,818 households with 44,541 people. The relocated population accounts for 25.6% of the county's rural population, and 38.5% of its registered poverty-stricken population. Some of the relocated people were engaged in agricultural activities through land transfer, leasing, and shareholding, and other methods, while the rest were relocated to urban areas where they are being supported with either opportunities for business development or employment. The Lanping government also implemented demolition and reclamation of the emigration area to promote ecological rehabilitation. These measures are pivotal in helping move people trapped in poverty in their existing residences and integrated them effectively into a new space that provided them with better job and business opportunities while at the same time accelerating the ecological restoration of Lanping.

3.2.4. Poverty Alleviation through Clean Energy Projects

Lanping's government carried out several rural clean energy construction projects, including implementing photovoltaic poverty alleviation projects, building rural household biogas digesters and fire-wood-saving stoves, and promoting the use of solar water heaters, micro-hydrogenerators, and solar street lights around its county. Besides building the infrastructures needed to assure stability and affordable energy to the people in Lanping, these projects also offered job opportunities to people in Lanping especially those who are in extremely poor communities. The projects included 30,000 kW of poverty alleviation photovoltaics, which are mostly supported by 100 village-level photovoltaic poverty alleviation

power stations. These projects helped more than 5000 registered households to increase their income steadily [43]. 622 households have installed solar energy to effectively reduce the consumption of forest resources, and promote energy conservation and emissions reduction.

4. Application of Systems Thinking to EPA in Lanping County

4.1. Problem Definition and Data Collection

Proper problem definition is the one of most important phases of the systems thinking and CLD modeling process [34]. The problem here may be presented as a set of patterns, a series of trends instead of the conventional sense as an existing condition that must be alleviated. Therefore, problem definition is also named the reference mode in Jargon [44]. When it comes to EPA, the improvement of social and ecological benefits is the indicator that must be considered as the original intention of this policy. In the case of Lanping, the most important ecological goal is to protect forest resources, which is repeatedly emphasized in the implementation of ecological restoration projects and ecological compensation. Besides the protection of the current natural forests, Lanping has been working on afforestation and returning farmland to forest and grasslands. Figure 3a shows the cumulative new forest and grassland area gained from 2016 to 2020. For social benefits, poverty incidence is a central indicator for measuring poverty [45]. As Figure 3b shows, Lanping has marked progress in reducing poverty during the Thirteenth Five-Year Plan period. Even though EPA is not the only reason for the decrease in poverty incidence, it is undeniable that it plays a vital role based on the analysis in the previous part. These two indicators illustrate that the behavior of the EPA system in Lanping is developing in the right direction.

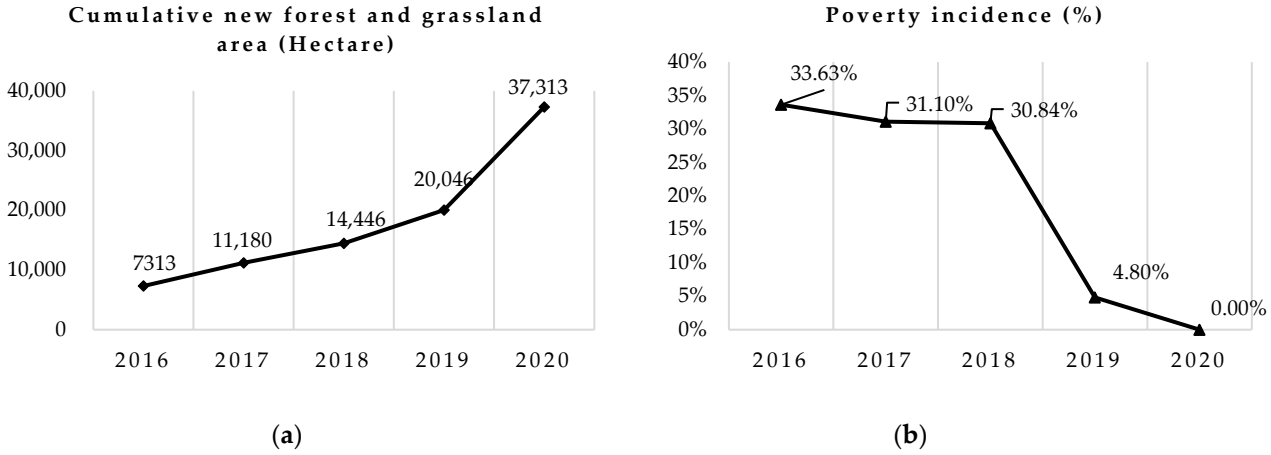

Figure 3. Reference modes of EPA in Lanping. (**a**) Cumulative new forest and grassland area in Lanping from 2016 to 2020; (**b**) Poverty incidence of Lanping from 2016 to 2020.

Figure 3 could constitute the reference modes of the EPA system. The objective of this study is to understand the fundamental structure that determines the change of the system's behavior. In other words, we aim to explore how the EPA can achieve the dual goals of eradicating poverty and improving the ecological environment. For this purpose, secondary data pertaining to the EPA of Lanping County both at the national and county levels were utilized. This included existing documentation, reports, previous research studies, and related news articles from the government or media's official websites. In this phase, 72 documents were obtained as the qualitative data for analysis basis by collecting relevant literature data with the keywords "Lanping + ecological poverty alleviation".

4.2. Variable Selection and Confirmation of the Characteristics of the Relationship between Variables

In this phase, open coding is adopted to abstract variables related to the change of cumulative new forest and grassland area and poverty incidence. The themes identified in the opening process were sorted according to their relationship with different EPA

measures. The variables are described in Table 1. It shows that there are many identical variables between ecological restoration projects and ecological compensation and ecological resettlement. The two EPA measures are captured in one causal loop diagram.

Table 1. The main variables abstracted from coding.

EPA Measures	Variables
Ecological restoration projects and ecological compensation	Afforestation; Deforestation; Forest cover rate; Environmental vulnerability; Disaster incident; Disaster economic losses; Income per capita; Poverty level; External support; Ecological Public welfare jobs; Employment rate; Ecological restoration projects; Ecological compensation investment
Ecological industry	Poverty level; External support; Ecological forestry; Ecological agriculture; Ecotourism; Tourism infrastructure; Tourist site attractiveness; Environmental quality; Environmental protection efforts; Afforestation; Deforestation; Tourists; Tourism revenue; Economic development; Demand of service; Large-scale production; Output value of forestry; Output value of agriculture; Employment rate; Public participation; Environmental awareness
Ecological resettlement	Afforestation; Deforestation; Forest cover rate; Environmental vulnerability; Disaster incident; Disaster economic losses; Income per capita; Poverty level; External support
Clean energy projects	Poverty level; External support; Ecological infrastructure; Clean energy development; Deforestation; Forest cover rate; Environmental vulnerability; Disaster incident; Disaster economic losses; Income per capita; Poverty level; External support; Economic development; Tourism revenue; Employment rate; Energy subsidy; Clean energy source; Forest consumption

4.3. Building and Analyzing Causal Loop Diagrams of EPA in Lanping County

Due to the large number of variables involved, the causal loop diagram building process is divided into two parts. Firstly, this study describes and analyzes the mechanism of each EPA measure in terms of structure and behavior. Then it gives a merged model encompassing all the elements under consideration. The arrows are presented in different colors in order to distinguish ecological (green) and economic (blue) benefits.

4.3.1. Causal Loop Diagram of Ecological Restoration and Resettlement Projects and Ecological Compensation

The causal loop diagram of ecological restoration projects and ecological compensation is shown in Figure 4. As a border mountainous area, Lanping has been facing the problems of a poor environment for survival and development and insufficient long-term construction investment. Farmers have to make money through commercial forest harvesting. The forest consumption was up to 64.36 million m^3 in 1997. The destruction of the forest leads to the occurrence of soil erosion and brings further economic losses. In order to maintain basic living needs, farmers can only continue to exploit natural resources and increase the intensity of development, resulting in a more serious ecological imbalance. The deterioration of the ecological environment further constrains economic development, exacerbates poverty, and eventually falls into the vicious reinforcing loop of "ecological deterioration-poverty aggravation" (R1).

So as to eliminate the backwardness of the poor areas in Lanping, central and provincial governments allocated a series of special help-the-poor funds to support the EPA projects, including the *Central Forestry Reform and Development Fund*, *Central Reservoir Resettlement Support Fund*, and so on. Benefiting from this external financial support, Lanping carried out many ecological restoration and protection projects. Lanping government was able to establish nature reserves, relocate residents from ecologically fragile areas and combine massive afforestation efforts and timber harvest bans to protect forests (B1 and B2) [46]. Meanwhile, the construction and management of ecological restoration projects provided job opportunities for the poor population. Especially, the *Work Plan for Ecological Poverty*

Alleviation launched by the National Development and Reform Commission together with five other ministries in 2018 clearly indicated that providing ecological public welfare jobs is an important way to poverty reduction and these jobs should be aimed at relatively low-income people. Hence, employment raised earnings and family income and reduced the plundering of natural resources (B3). The forestry-based ecological compensation provided supplemental income to low-income sellers of ecosystem services by encouraging them to plant trees (B4 and B5). These measures have positive effects on Lanping's forest recovery and poverty alleviation.

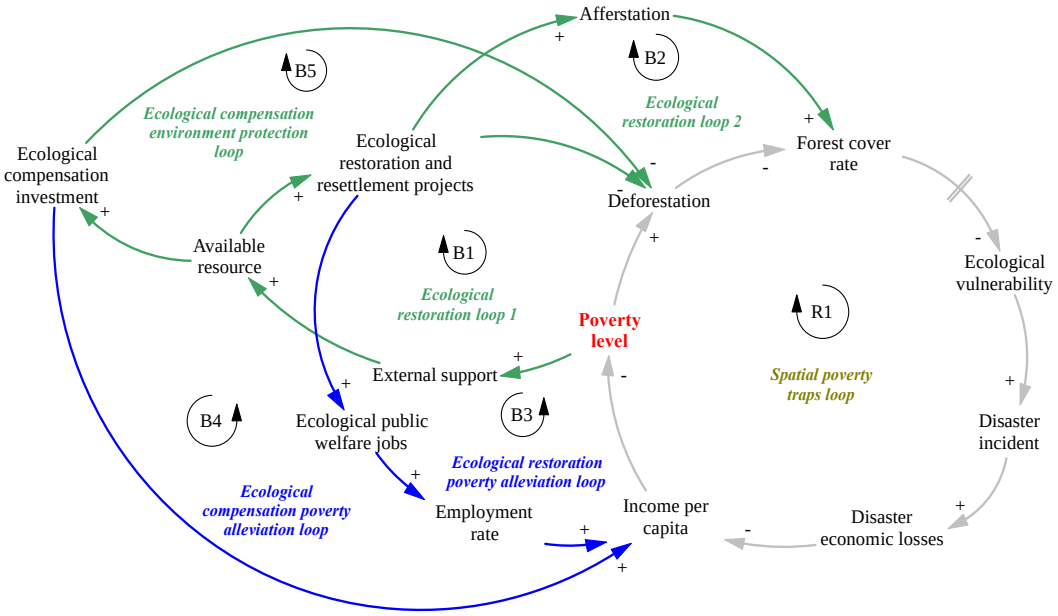

Figure 4. Causal loop diagram of ecological restoration and resettlement projects and ecological compensation.

4.3.2. Causal Loop Diagram of Ecological Industries

With special funding for the ecological industry, the Lanping government launched some initiatives to boost the development of its ecological forestry, agriculture, and tourism through poverty alleviation loans, grant funding, tax preference, and specialist skill support (Figure 5). It established the development model of "company + cooperative + farmers + industry" to promote large-scale production in forest and agricultural fields. The companies provided one-stop services in these industry supply chains by being responsible for planting, management, production and processing, and sales. Registered poverty households can obtain income from land transfer fees, labor fees, and project dividends [47]. Due to this, Lanping was transforming the traditional small-scale mode of production into large-scale production, which contributed to reducing the input and consumption of natural resources in the process of agricultural production and improving agriculture quality and efficiency at the same time [48]. The increase in forestry and agricultural output will boost economic growth and drive more investment in these fields (R2).

Tourism development represents a good approach to realizing poverty alleviation and economic growth by improving tourism receipts, generating increases in job creation, and raising incomes [49]. Meanwhile, pro-poor tourism can provide socio-cultural and even environmental benefits [50,51]. Ecotourism is another important strategic choice for poverty alleviation in Lanping. At the stage where ecotourism begins, the Lanping government has improved the preservation and restoration of ecological resources and enhances tourism infrastructure to attract tourists (R3, R4, and R5). The increase in tourism brought more revenue to the economy. This in turn provided more available resources for exploiting and utilizing tourism resources in Lanping. At the same time, the development of ecological industries not only expanded employment opportunities but also injected new vitality into

the rural economy and raised income-generating capacity for poor rural households (B6 and B7). In addition, the ecological industries offered many tools for public participation and provide them with huge economic benefits, including employment opportunities, increased income, and business opportunities [52]. Therefore, residents can better perceive the value of the ecosystem and increase local environmental awareness, and reduce their behavior that damages the environment (R6).

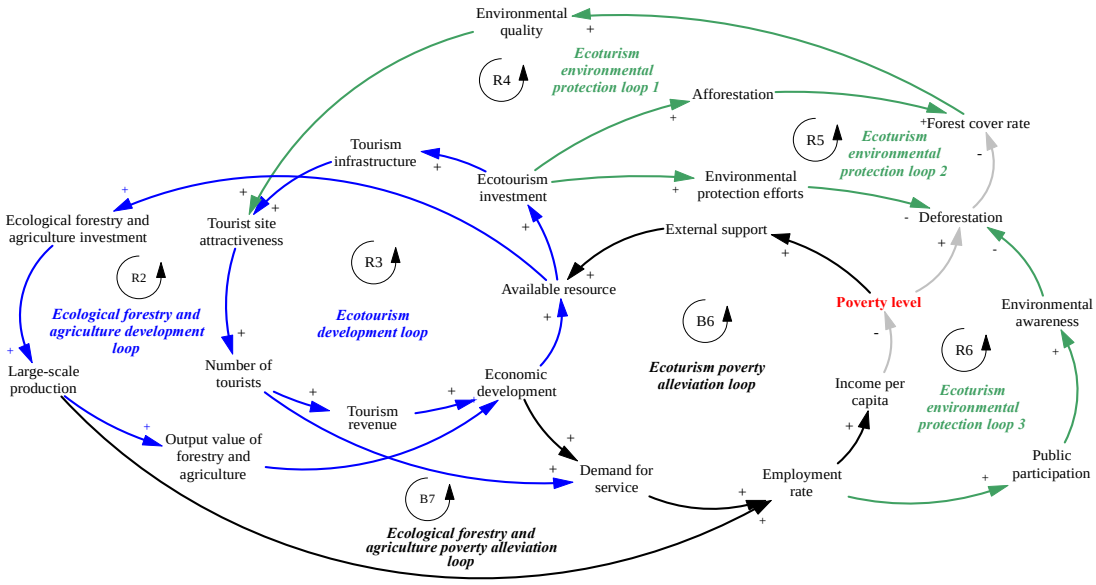

Figure 5. Causal loop diagram of ecological industries.

4.3.3. Causal Loop Diagram of Clean Energy Projects

Clean energy development is also another important impetus for poverty alleviation in Lanping. The government released policies to promote clean energy sources such as solar power and biogas by attracting investment and providing bank loans. Among them, the photovoltaic poverty alleviation projects benefit poor households in many ways. As shown in Figure 6, on the one hand, the infrastructure construction for photovoltaic generation and transmission can create a large number of jobs (B8). On the other hand, owners who set up micro photovoltaic installations and connect them to the grid can obtain considerable revenue and subsidies (B9). In these ways, photovoltaic poverty alleviation projects contributed greatly to increasing the income of poor households and reducing poverty [53]. Meanwhile, the development of clean energy promoted access to and use of clean energy, which was conducive to reducing the consumption of forests and other non-renewable resources (B10). Moreover, the development of clean energy can be an important driving force for economic growth and promote the further benign development of clean energy (R7).

4.3.4. Merged Causal Loop Diagram of EPA in Lanping

Figure 7 shows a merged causal loop diagram of four EPA measures in Lanping. EPA weakens the vicious cycles of the ecological poverty trap (R1) by decreasing deforestation and increasing afforestation at the same time, which will improve the forest cover rate. Thus, the lucid water and lush mountains formed by ecological restoration projects and ecological compensation provided a good environment for the follow-up development of ecological industries. In return, the development of the economy offered financial support for ecological protection. EPA helped Lanping give consideration to both ecological protection and economic development. In other words, EPA aims to use the moderate development of natural resources to achieve green development transformation, realizing the coupling of economic development and ecological improvement. Meanwhile, the coupling of economy and ecology is based on the value of being "people-centered". It is oriented to improving

the living conditions of the poor and supplying them with more employment opportunities, therefore promoting the improvement of people's livelihood in poor areas. However, besides fiscal spending through transfer payments ("blood transfusion"), EPA is more focused on helping the poor to become self-reliant through job creation and skill upgrades. The same is true for economic growth in poverty-stricken areas. Support in EPA industries generates inner productivity ("blood-making") to enhance the virtuous cycle of economic development. In the early stage of EPA, the main available resources come from external support. The economic growth driven by external support can promote the adjustment of industrial structure and provide sustainable support for further EPA practice in the long run.

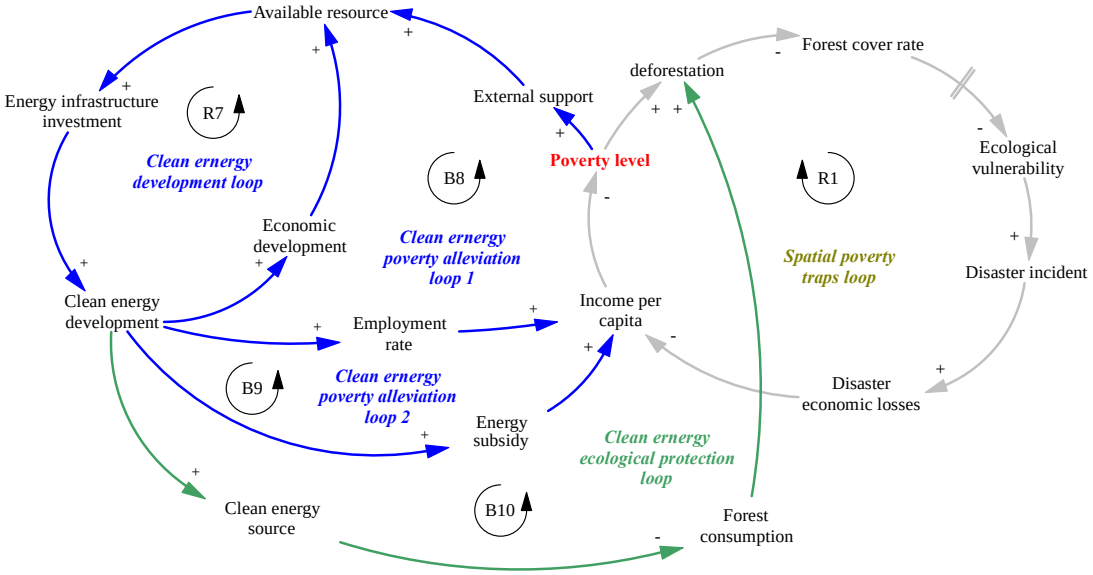

Figure 6. Causal loop diagram of clean energy projects.

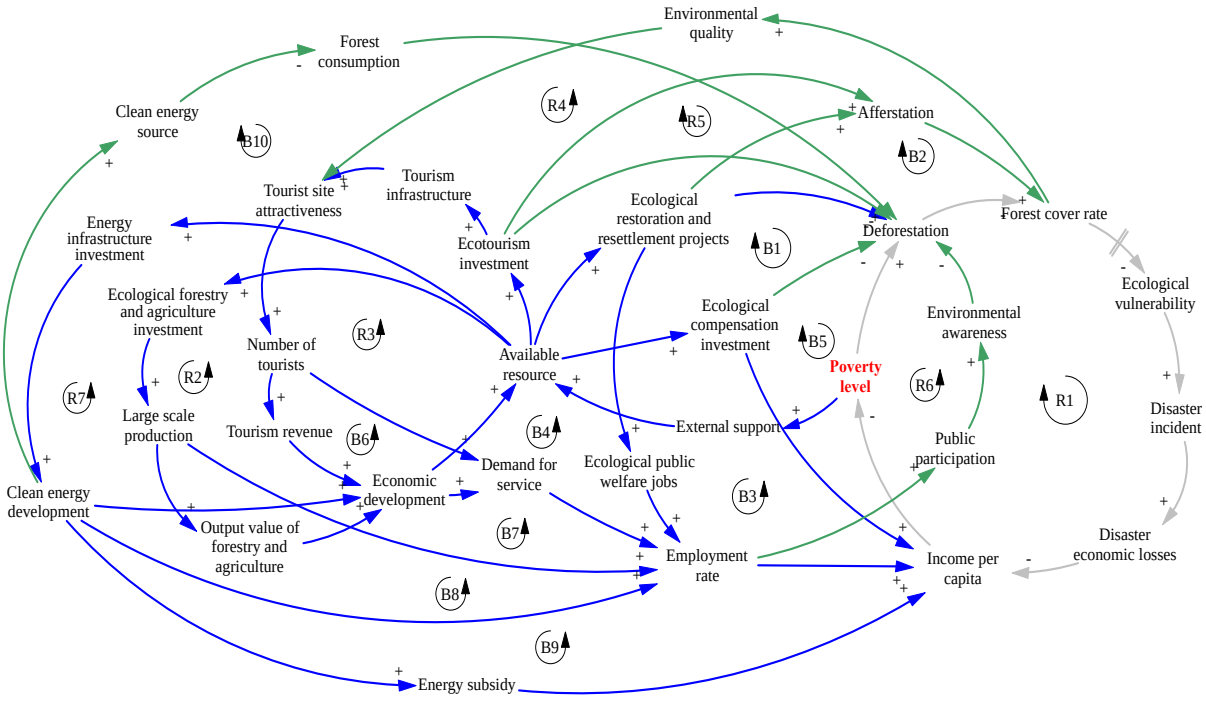

Figure 7. Merged causal loop diagram of EPA in Lanping.

5. Discussion

5.1. Analysis of the Mechanism of EPA

Lanping's practices suggest that EPA can be a successful strategy to achieve the delicate balance of environmental protection and poverty alleviation. In order to provide a general understanding of the mechanism of EPA, and following the generalizability framework introduced in Lee and Baskerville [54], Figure 8 gives a simplified depiction of the EPA mechanism in Lanping County to reveal how EPA achieves the win-win outcome of ecological protection and poverty alleviation (Question 1). We generalized the mechanism by linking the various elements together, including inputs, activities, outputs, outcomes, and impacts. The reason is that this logical relationship can enhance the understanding of EPA and provide an implementation experience that others can follow from the perspective of project management.

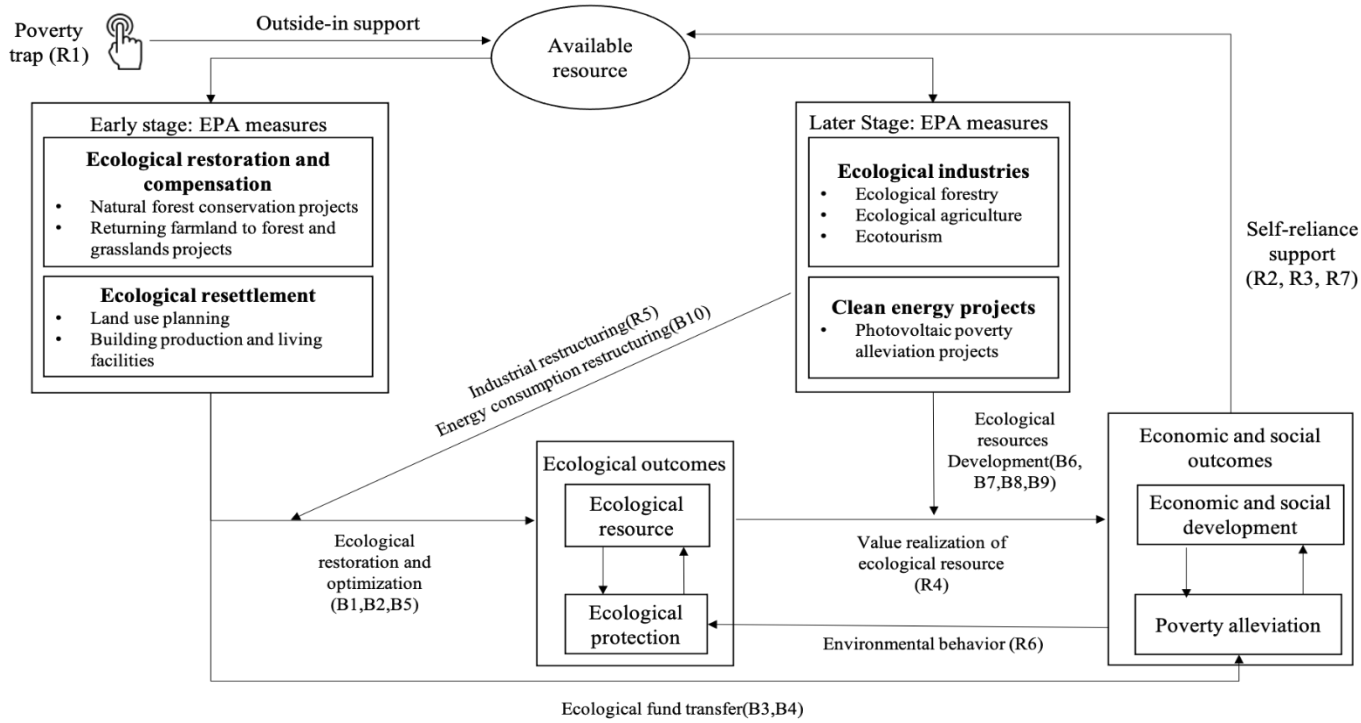

Figure 8. The mechanism of EPA in Lanping County.

As shown in Figure 8, the spatial poverty trap in Lanping is the policy trigger to implement EPA. The lack of economic and social resources requires Lanping government to seek help from outside, such as funding from central and provincial governments. Therefore, at the early stage of EPA, the main measures mainly focused on realizing financial transfer payments through key ecological engineering construction projects, including ecological restoration, compensation, and resettlement. This process can not only protect the ecological environment and increase the supply of ecological resources but also promote employment and increase income sources for the poor population. The capital injection of outside-in resources solved the urgent needs of the local area, but it brought limited economic benefits and cannot fundamentally solve the poverty problem. At the later stage, the Lanping government implements ecological industries and clean energy projects to promote the value realization of ecological resources. The profitability characteristics of these measures help Lanping attract more social capital from external sources and guarantee the profitability of the local economy and the EPA resource's self-reliance. Meanwhile, the development of ecological industries and clean energy projects can contribute to optimizing the structure of industry and energy consumption, which is beneficial to consolidating the ecological outcomes of EPA. Economic growth provides a long-term support for EPA and fundamentally solves the poverty problem. In addition, reducing poverty and developing

the economy and society can awaken people to the need and value of protecting the ecological resource and promote environmental awareness and behavior in the long term. Thus, through the implementation of EPA, the human-nature relationship in poor areas has been continuously optimized, maximizing the overall benefit of poverty alleviation through coordinating and unifying the relationship between the ecological environment and economic development. Therefore, EPA helps establish a holistic system for the coordinated development of ecology, and economic and social subsystems to enhance the sustainable development ability of poor areas and poverty-stricken populations.

In conclusion, EPA realigns poverty reduction based on the ecological environment and resource endowments compared to previous anti-poverty strategies. It aims to utilize the natural ecological resources in scientific and effective procedures to achieve sustainable economic and social development and ecological environment at once [24]. The construction of ecological restoration projects and ecological compensation can directly slow forest resource exploitation and achieve rapid poverty reduction by providing employment and subsidies. They are conducive to breaking the vicious circle of the poverty trap fast and efficiently in the short term. Meanwhile, the development of ecological industries and clean energy could enhance the local human capital and financial capital with internal self-reinforcing features and build the resilience of the economy and society in the long term. In addition, these projects can also bring enormous environmental benefits. For instance, through the implementation of cleaner energy construction projects, Lanping saves 60,000 tons of standard coal every year, which is converted into 15,000 tons of carbon dioxide emission reduction.

5.2. Implications

Each pathway of EPA is not isolated; the pathways are linked to and promoted by each other. The CLDs illustrate that EPA can systematically realize both external support and internal forces to form a synergy and help to identify some of the key causalities and feedback loops to improve the system's behavior (Questions 2 and 3). The analysis results show that there are four most significant drivers of the system, including external support, available resources, employment rate, and industrial development.

The availability of outside-in support from external entities is important in the activation of EPA practice. Like Lanping County, most areas in extreme poverty have been trapped in poverty for generations and their situation would continue to deteriorate without external intervention. The self-reinforcing mechanism of the poverty trap determines that the only solution to get out of it is to gain external support. However, the fragile foundations of the local economy and environment reduce its attractiveness to external capital. Therefore, the Chinese central government makes EPA a national strategy to compensate for the lack of funds and sets central and provincial special funds for different EPA projects. EPA projects such as NFCP and ecological compensation are effective for "blood transfusion" to assist the poor at the early stage of poverty alleviation.

The continuity of funding resources is the key driver of the EPA's success. Public finances can provide significant funding sources for EPA projects. However, it is too difficult to fully meet the needs of Lanping and other long-term poverty-stricken areas. On the one hand, public financial resources are still limited in the face of huge demand in poor areas. On the other hand, public projects usually have a qualified construction period. Furthermore, this non-reimbursable financial support can cause a huge government financial burden and increase the dependence of poor areas on external support. Thus, promoting the participation of social capital is necessary. Taking the profit maximization pursued by capital into consideration, the poor areas need to achieve the realization of ecological product value through the development of ecological industries.

Providing employment is an important guarantee of sustainable EPA. Stable employment and wage are one of the best pathways out of poverty [55]. Through labor participation, poor people can earn an income and realize their value to society, which helps stimulate their endogenous power to get rid of poverty actively. Through the provision of jobs, the

poor people will be trained, improved in skills, and enhanced in employability. Even if the jobs provided by poverty alleviation projects are lost in the future, the improvement of employability and increase of social capital make poor people more likely to gain employment by themselves. At the same time, the importance and value of environmental protection increase their environmental consciousness. This helps to cultivate green production and lifestyle and improves environmental benefits in the long term.

The endogenous-driven industrial development is the driving force of sustainable economic growth. Although ecological restoration projects and ecological compensation can protect the environment and increase the income of poor people to a certain extent, their impacts on economic development are limited. On the one hand, the capacity of ecological restoration projects to absorb labor is inadequate. For instance, only one person from a poor household can engage in an ecological public welfare job due to limited positions. On the other hand, such an income might meet the living needs of poor people, but it cannot promote the accumulation of the means of production. Only by deeply exploring the intrinsic value of ecological resources can economic growth be achieved. In the practice of EPA, ecological industries including ecological forestry, ecological agriculture, and ecotourism provide several ways to improve the reintegration of resources. An endogenous-driven industrial development helps transform the "blood transfusion" to "blood-making" and enhance self-reliance in sustainable poverty alleviation. In conclusion, the coupling of ecology and industry is a sustainable guarantee to enhance the market competitiveness of industries in poor areas.

The improvement of poverty alleviation ability is a long and arduous process. For the poor, improving individuals' motivation and capacity for poverty alleviation need the accumulation of knowledge and wealth in the long term. For the local area, the adjustment and upgrade of the economic structure depends on the coordination of supply-side and demand-side factors [56]. With the completion of poverty alleviation in Lanping, the support of external resources is gradually reduced. However, the transformation of ecological resources into ecological products is a long, slow development cycle that needs continuous capital investment. The ecological effects of EPA such as habitat recovery and species recolonization take years or decades to reveal themselves, which means bold and sustained actions from governments, the private sector, and the public are required in the years to come [24]. Therefore, the exit mechanism of external support must be effectively connected with the self-reliance development of the local economy. Viewed from another perspective, according to the discussion in The Limits to Growth [57], the economy cannot grow indefinitely. Taking ecotourism as an example, the increase in tourists will raise the environmental load and ecological disturbance. Ecological resources will be damaged if the environment is loaded beyond the carrying capacity of the local ecosystem. Thus, solving the problem of absolute poverty doesn't mean the end of EPA. How to ensure the sustainability of EPA is a subject that needs long-term research.

6. Conclusions

The case of Lanping shows that EPA is a systematic and dynamic project, and that systems thinking is a useful method for understanding how different EPA pathways can achieve a win-win of poverty alleviation and ecological protection together. This study presented CLDs to illustrate the key variables and their interactions that will influence the outcome of EPA in the future. The analysis of the CLDs highlights that support from external entities, funding resources, employment, and endogenous-driven economic development are the key drivers to the success of the EPA. To especially, a successful EPA requires making good use of external support to stimulate internal strength. In addition, interventions should be designed to avoid the risk of returning to poverty caused by the withdrawal of external support in the short term.

This study is meaningful because it provides a lens through systems thinking to understand the EPA and avoid adverse consequences. It explains how the different parts of the EPA system interrelate with each other and how systems work for the win-win goals of

ecological protection and poverty alleviation as an integrated system. This study also can contribute baseline work for future research to assess the outcome of EPA through System Dynamics simulation.

Despite these contributions, some study limitations and future research directions are worth noting. The first drawback of this study is that it uses secondary data as a material resource. Its breadth and depth are relatively limited even though secondary qualitative data analysis offers many advantages [58,59]. Future research can systematically obtain the mental models of relevant stakeholders by introducing powerful qualitative methods. For example, group model building can be used to investigate the EPA mechanism by inviting multiple stakeholders to share their understanding of EPA. Meanwhile, although the CLDs can present the dynamic characteristics contained in the EPA mechanism, they are limited in terms of detailed policy assessments and recommendations. Therefore, future research can incorporate quantitative data to develop and investigate the behavior of the EPA system over time through System Dynamics modeling, which will be the next step of this study.

Secondly, there are interactions between different approaches. For example, ecological resettlement is helpful to implement ecological restoration projects. The houses and buildings on the old sites of the villages will be demolished after the villagers moved out. Village homesteads and land that are suitable for afforestation in the ecological migration areas will be protected and restored in the ecological restoration projects. Ecological resettlement also can contribute to providing labor for the ecological industries. As shown in Figure 5, the improvement of environmental quality caused by ecological restoration projects and resettlement can promote eco-tourism development. The many connections and reciprocities between different approaches are complicated, but the current materials are not rich enough to illustrate them comprehensively and systematically.

Last but not least, this study focused on one case study from a typical poverty-stricken county rather than a developed area in eastern China. In future studies, the effectiveness of EPA practices in different areas should be compared and investigated.

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