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What Are the Impacts of a Coastal Zone Protection Policy on Farmers' Livelihood Capital? Empirical Analysis From the Perspective of Farmer Participation

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To restore and protect the ecosystem service function of coastal zones, some farmers have changed their certain original production methods and lifestyles and some have even relinquished a portion of the economic benefits that could be obtained directly. What impacts do the coastal zone ecological protection policies bring to the livelihoods of coastal farmers? The strict coastline protection of Beibu Gulf, Hepu County, Beihai City, Guangxi Zhuang Autonomous Region, China, is taken as an example. Combined with the sustainable livelihood framework (SLF), this paper set up an evaluation index system for the livelihood capital of farmers in the Beibu Gulf coastal zone, obtaining 568 valid questionnaires through a field survey, and use the propensity score matching and difference-in-difference (PSM-DID) method to study the impacts of a coastal ecological protection policy on the livelihood capital of coastal farmers from the perspective of farmer participation. The results show that (1) the coastal ecological protection policy had a significant impact on the natural capital and social capital of coastal farmers that actively participated in coastal ecological protection, which increased by 0.181 and 0.052, respectively. (2) However, it did not have a significant impact on the total livelihood capital, human capital, physical capital or financial capital. Therefore, this paper presents policy suggestions for constructing coastal ecological compensation mechanisms and for promoting active participation by coastal farmers in coastal ecological protection efforts.

Keywords: coastal zone protection policy, livelihood capital, sustainable livelihood framework, PSM-DID, Beibu Gulf coastal zone

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INTRODUCTION

While implementation of ecological protection policies brings significant positive externalities to social development, it is unknown whether the welfare of local residents will suffer losses due to the limitations of these policies (Bennett et al., 2018; Nguyen et al., 2018). Recent years have witnessed the phenomena of natural resource exhaustion and ecological

environment deterioration in coastal areas become more serious (Ragueneau et al., 2018; Sievers et al., 2020; Yu et al., 2021). Many coastal areas are developing and utilizing marine resources on a large scale to rapidly develop the marine economy. Humans have also carried out large-scale and unrestrained development of coastal resources, which has led to serious damage and deterioration of coral reefs, mangroves and other coastal ecosystems, seriously restricting the sustainable development of the coastal ecology and social economy (Das, 2017; Kim et al., 2020; Zheng et al., 2020). For advocating ecological environmental protection in today's society (Rao et al., 2018), coastal zones provide valuable production and living space for human beings worldwide, and the strategic positions of coastal zones are becoming increasingly prominent worldwide (Yu et al., 2010; Islam and Shamsuddoha, 2018; Rojas et al., 2019). Therefore, it is urgent to carry out the necessary restoration and protection of coastal ecological environments, and a series of studies have been carried out in coastal areas to formulate coastal ecological environment protection policies (van de Graaff et al., 1991; Rojas et al., 2019; Economou et al., 2020; Lai and Leone, 2020). Current researches mainly focus on the significant positive externalities that are brought about by the formulation and implementation of coastal ecological protection policies on the social economy and environment (Bennett et al., 2018; Nguyen et al., 2018; Huang et al., 2020), but pay little attention to the differences of their impacts on the well-being of social groups, especially negative externalities that may have adverse impacts on the well-being of coastal farmers who are closely related to coastal ecological protection.

To respond to coastal ecological protection policies and restore and protect the ecosystem service function of the coastal zone, farmers in coastal zones have not only changed some of their original production methods and lifestyles but have also chosen to relinquish some of their direct economic benefits (Cabrera et al., 2005; Cai et al., 2017; Triyanti et al., 2017; Li et al., 2020). The most intuitive impact of coastal ecological protection policies on the well-being of coastal farmers is the change in livelihood capital (Mills et al., 2017; Triyanti et al., 2017; Hossain et al., 2018; Andrews et al., 2021), which can directly reflect whether a coastal ecological protection policy is comprehensive. If we do not study the changes in the livelihood capital of coastal farmers, then we cannot understand the real impacts of coastal ecological protection policies on the livelihood capital welfare of coastal farmers. Therefore, it is urgent to evaluate the specific impacts of implementing coastal ecological protection policies on the livelihood capital of coastal farmers, adjust coastal ecological protection policies in a timely manner to protect the livelihood capital welfare of coastal farmers, and encourage coastal farmers to actively respond to and participate in coastal ecological environment protection activities.

Previous studies have mainly used the sustainable livelihood framework (SLF) proposed by the Department for International Development (DFID) in 1997 to carry out empirical research on changes in farmers' livelihood (Bebbington, 1999; Kuang et al., 2020; Yin et al., 2020). The SLF was mainly used to study the livelihood of farmers in poverty-stricken areas (Gentle and Maraseni, 2012; Liu and Xu, 2016; Deng et al., 2020), the livelihood of land-lost farmers (Nguyen and Kim, 2020) and various factors that affect residential livelihood (Liu et al., 2018; Nicod et al., 2020). However, few studies have used this framework to study the livelihood capital of coastal farmers, and there is, in particular, a lack of systematic measurements of the impacts of coastal ecological protection policies on the livelihood capital of coastal farmers. Therefore, this paper uses the SLF to construct an index system for the livelihood capital of coastal farmers. Through a field investigation, we assessed the livelihood capital of coastal farmers before and after implementation of the coastal ecological protection policy of "Guangxi Zhuang Autonomous Region Ocean Bureau Natural Coastline Management and Control Implementation Measures (Trial)" that was begun in November 2016. Based on the perspective of farmer participation, the propensity score matching and difference-in-difference (PSM-DID) method was used to measure the impact of coastal ecological protection policy on the livelihood capital of coastal farmers. Combined with the results of the empirical study, this paper provides relevant policy suggestions to improve the livelihood capital of coastal farmers, promote active participation by coastal farmers in coastal ecological protection, and provide relevant policy suggestions for the government to carry out coastal ecological protection and construct coastal ecological compensation mechanisms.

LITERATURE REVIEW

The SLF proposed by the DFID in 1997 has been the most widely used method for livelihood capital research in recent years (Bebbington, 1999; Bhandari, 2013; Kuang et al., 2020; Yin et al., 2020). Livelihood capital mainly originated from the extensive research on poverty conducted by Chambers and Conway (1992). By using a poor fishing community in Baja California Sur, Mexico, as an example, Robles-Zavala (2014) extensively analyzed the factors that impair the safety and sustainable livelihoods of poor fishermen. This study found that these livelihoods are closely related to institutional and social factors but have little impact on economic factors. The study emphasized ensuring a fair and transparent distribution of fishery resources through an institutional framework. According to the data of poverty-stricken areas in Jumla, Nepal, Gentle and Maraseni (2012) analyzed how climate change has affected the sustainable livelihood of farmers in poverty-stricken areas. The results showed that the continuous changes in climate-aggravated resource degradation caused food shortages and other adverse situations and affected the sustainable livelihood of poor farmers. Wildayana (2017) analyzed the sustainable livelihood dilemma of peatland farmers in South Sumatra Province, Indonesia, and found that their livelihood sources showed a trend of diversification, which could be divided into rice planting, rubber plantations, oil palms, forests and fisheries, but were limited by farmland, technology, management and socioeconomic factors. Shackleton et al. (2011) studied

the impacts of diversified forestry products on the sustainable livelihood of urban and rural residents and clarified the benefits of forestry products to different families and the important impacts of forest products on sustainable livelihood capital and poverty alleviation of residents. Banks' (2016) research on Bangladesh showed that household assets play a major role in the livelihood of families and that the sustainable livelihood of low-income families is greatly affected by social capital. By studying the destruction and disappearance of mangrove forests, Orchard et al. (2016) found that local residents depended on mangrove systems to obtain income, maintain their livelihood and cope with changes, which provide significant contributions to the livelihood of the poor. Therefore, it is essential to attach importance to the diversification of farmers' livelihood methods, which can effectively protect the livelihood capital security of individual residents and even families (You and Zhang, 2017; Nicod et al., 2020; Wu et al., 2020; Yin et al., 2020).

Formulating and implementing coastal ecological protection policies is a hot issue worldwide, especially in coastal areas. To protect the environment and resources of the coastal zone, the United States enacted the "Coastal Zone Management Act" in 1972 and became the first country to legislate coastal zone management (Godschalk, 1992; Windrope et al., 2016; Schernewski et al., 2018). The coastal zone management policy of the United States is mainly accomplished by implementing various coastal zone management programs, which are mainly composed of coastal zone management programs at national and state levels (Birch and Reyes, 2018). Since the United States enacted the Coastal Zone Management Act, many countries around the world have recognized the deficiencies in their management and protection of coastal zone resources and the importance of coastal ecosystem services. Therefore, countries have successively issued a series of coastal zone ecological protection policies based on their national conditions (Rosier and Hastie, 1996; Ngoile and Linden, 1997; Uehara and Mineo, 2017; Bell-James et al., 2020; Caviedes et al., 2020; Hu et al., 2020a; Liu et al., 2020), and some scholars have proposed that coastal countries should formulate and implement integrated coastal zone management policies (Ducrotoy and Pullen, 1999; Warnken and Mosadeghi, 2018; Barragán Muñoz, 2020; Caviedes et al., 2020). Caviedes et al. (2020) studied the coastal protection policies of seven Central American coastal countries. The study found that the countries lacked common integrated management policies to improve coastal governance. Moreover, integrated coastal management helps to promote regional coordination and sustainable development of coastal marine spaces. In October 2019, the Marine Bureau of the Guangxi Zhuang Autonomous Region of China instituted the policy of "Marine Ecological Compensation Management in Guangxi Zhuang Autonomous Region." To maintain a sustainable balance between coastal ecological protection and the livelihood capital of coastal farmers, the coastal ecological compensation policy, issued by the local government, is an important measure to strengthen the construction of ecological civilization and ensure the livelihood of coastal farmers. In this case, it was very important to study the actual impact of the coastal ecological protection policy on the livelihood of coastal farmers.

What is the impact of implementing ecological protection policies on farmers' sustainable livelihood capital? How is the impact measured? Wang et al. (2017) used the SLF to evaluate the impacts of payments for ecosystem services on the livelihood capital of participants and non-participants. The study found that payments for ecosystem services had a strong stabilizing effect on the livelihood capital of the participants, while non-participants were generally negatively affected. Li et al. (2018) found that payments for ecosystem services usually achieved the goal of livelihood restoration, changed traditional livelihood activities of residents, increased residential income and were conducive to the sustainability of people's livelihood. Peng et al. (2019) found that payment for ecosystem services can diversify agricultural livelihood, keep farmers' livelihood strategies dynamic, and promote the sustainability of farmers' livelihood. Kinyondo and Magashi (2017) used the SLF to study the data of farmers in 13 regions of Tanzania and found that the government's support policies had a strong effect on improving farmers' livelihood. Adom and Boateng (2019) studied the reasons why the sustainable aid policy of Ghana over the past 50 years did not achieve the expected improvement of farmers' livelihood and agricultural productivity. The study found that when farmers' livelihood was threatened, farmers would choose alternative schemes to ensure the sustainability of their livelihood, and the study indicated that "livelihood transient" was an extended and complete form of livelihood analysis. Nigussie et al. (2021) used the SLF to study the impact of acacia plantation systems on farmers' livelihood in Ethiopia and found that plantation systems increased farm income and significantly improve the natural capital of degraded soil but that these systems led to increased food prices and the regulation of child labor might be difficult. Wang Y. et al. (2020) applied a partial least squares-structural equation model to study the impact of grain for green programs and ecological welfare forest programs on household livelihood decision-making. Based on survey data from 621 Syrian wheat farmers, El-Shater et al. (2016) used the propensity score matching (PSM) method and determined that the promotion of good planting technologies can effectively improve the sustainable livelihood of farmers. Yang et al. (2020) applied the PSM-DID method to study the impact of the paddy land-to-dry land program in the upstream area of the Miyun Reservoir in China on the livelihood of local residents.

Existing research shows that the application of the SLF is relatively mature, and research on the influencing factors of livelihood capital changes is abundant. However, few studies have focused on the impact of coastal ecological protection policies on changes in coastal farmers' livelihood capital, especially in combination with the SLF. Moreover, the impacts of implementing ecological protection policies on the livelihood capital of different farmers are different. Although quantitative analysis is the main method to measure changes in farmers' livelihood capital, few scholars have used the PSM-DID method to systematically analyze the impact of coastal ecological protection policies on farmers' livelihood capital. Therefore,

we use the SLF, combined with the PSM-DID method to carry out this study.

THEORETICAL FRAMEWORK AND RESEARCH HYPOTHESIS

The SLF proposed by the DFID is a widely used and influential theoretical framework (Kuang et al., 2020; Yin et al., 2020). Livelihood capital is the core part of the framework. Livelihood capital includes human capital, natural capital, physical capital, social capital and financial capital (Yang et al., 2020). Different scholars have slightly different definitions of each kind of capital because of different research topics. Based on previous studies and the actual situation of the study area, this paper constructs an appropriate theoretical framework of sustainable livelihoods (**Figure 1**).

Human capital is the basis of several other livelihood capitals owned by farmers. The quantity and quality of human capital of coastal farmers directly determine their ability and scope of owning and using other kinds of capital (Wang Y. et al., 2020; Yang et al., 2020). In this paper, human capital refers to the number of domestic workers, the health status of domestic workers, the technicians of family members and the number of family migrant workers owned by coastal farmers. After the implementation of the coastal zone ecological protection policy, the livelihood environment of farmers has become better and they are in better health. Due to the limitation of farmers' livelihood activities such as fishing, they will learn new work technicians or leave home to work to earn money to support their families. Therefore, we propose Hypothesis 1: the implementation of coastal ecological protection policy has a significant positive impact on the human capital of coastal farmers.

Natural capital is the state of natural resources owned by farmers to maintain family production and life. Due to the differences in research areas, the natural resources contained in natural capital are generally different (Wildayana, 2017; Cheng et al., 2021; Nigussie et al., 2021). In this paper, natural capital includes the abundance of marine animal and plant resources, the pollution situation and the air quality. When the coastal zone ecological protection policy is implemented, farmers' interference or damage to the coastal zone ecological environment will be reduced, and the richness of animal and plant resources will become better. Of course, it will also bring the improvement of farmers' living environment and air quality. Therefore, we propose Hypothesis 2: the implementation of coastal ecological protection policy has a significant positive impact on the natural capital of coastal farmers.

Physical capital refers to the capital created by a human through labor, which generally includes the fixed assets of housing and the physical equipment needed for production and life owned by farmers in the process of trying to establish a family livelihood (Yang et al., 2020; Liu et al., 2021). For the coastal zone, the amount of fixed assets owned by households is the most important factor in the physical capital, and the amount of these fixed assets largely determines the efficiency and quality of production and life of households. Due to the limitation of the coastal zone ecological protection policy, the fishing boats and other assets of coastal zone farmers who used to live by the sea cannot give full play to their value, which not only has a great negative impact on the production and living efficiency and quality of farmers' families, but also causes that the labor force of farmers' families cannot be fully utilized, which also leads to the waste of human capital. Therefore, we propose Hypothesis 3: the implementation of coastal ecological protection policy has a significant negative impact on the physical capital of coastal farmers.

Social capital refers to the social resources that people can use in their daily pursuit of family livelihood goals, mainly including social organizations and social relationship networks related to people (Banks, 2016; Benessaiah, 2021). Among the five livelihood capital indicators of the SLF, social capital indicators have the closest relationship with social organizations and social system rules in the process of social development. After the implementation of the coastal zone ecological protection policy, the government issued a series of welfare compensation policies for local

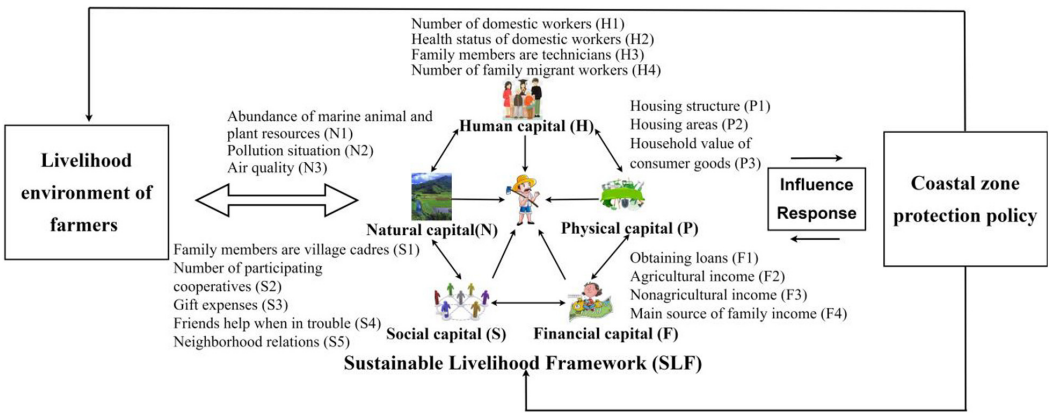

FIGURE 1 | The theoretical framework of the research.

villagers, such as increasing the number of rural cooperative organizations, increasing the opportunities for communication between farmers, and making the neighborhood relationship more harmonious. Therefore, we propose Hypothesis 4: the implementation of coastal ecological protection policy has a significant positive impact on the social capital of coastal farmers.

Financial capital mainly refers to the disposable, mobile and available funds, deposits and loans for farmers to achieve their livelihood (Yang et al., 2020; Liu et al., 2021). It is an important capital for farmers to maintain their livelihood. Generally speaking, the more disposable and mobile funds and the stronger the ability to raise funds, the higher the financial capital the family has, and the more willing the family members are to choose to go out for business or increase their family sideline work, so as to exchange more basic materials such as technology and equipment through the use of funds. As a result, there will be more family income and sources of income. After the implementation of the coastal zone ecological protection policy, the fishing of coastal zone farmers is limited, more farmers will go out to work or start businesses to increase their income source, and the government will issue a series of preferential loan policies to the villagers, which may increase the financial capital of coastal zone farmers. Therefore, we propose Hypothesis 5: the implementation of coastal ecological protection policy has a significant positive impact on the financial capital of coastal farmers.

STUDY AREA AND DATA SOURCES

Study Area

China's coastal zone has the highest economic density, maximum comprehensive strength and greatest strategic support in China (Hu et al., 2020b). China's coastal zone is 18,000 km in length and runs from the Yalu River estuary in Liaoning Province to the Beilun estuary in the Guangxi Zhuang Autonomous Region. Hepu County is under the jurisdiction of Beihai City, Guangxi Zhuang Autonomous Region, China and is subordinate to the Beibu Gulf. In December 2015, the "Regulations on the Use and Management of Sea Areas in Guangxi Zhuang Autonomous Region" were issued, which emphasized the protection and development of coastal zones and placed reasonable controls on coastal zones. On November 24, 2016, the Marine Bureau of the Guangxi Zhuang Autonomous Region enacted the "Guangxi Zhuang Autonomous Region Ocean Bureau Natural Coastline Management and Control Implementation Measures (Trial)," which divided the coastline into three categories: strict coastline protection, restricted coastline development and optimized utilization of the coastline. The control, regulation and supervision measures of coastal zone coastlines were emphasized. For example, (1) Coastline protection and control management should follow the principles of protection priority, economical utilization, scientific renovation and green sharing. (2) The main goal of the coastline restoration project is to improve the natural coastline restoration rate, focusing on beach restoration and maintenance, coastal structure cleaning and dredging, coastal wetland vegetation planting and restoration, coastal ecological corridor construction and other projects. (3) In terms of investment in coastline renovation, the marine authorities of coastal cities and counties in Guangxi Zhuang Autonomous Region should actively propose to the local people's government and financial departments to establish and improve the investment mechanism of coastline improvement and restoration funds, implement the special financial funds of autonomous regions and local governments on the basis of the central financial special funds, and actively introduce social capital participation. The coastline of the Shankou Mangrove Reserve in Hepu County is strictly protected by the coastline. Therefore, Hepu County is selected as the study area (**Figure 2**).

Data Sources

From December 28 to December 30, 2019, we first conducted a field pretest survey near the coastal villages in Hepu County, Beihai City, Guangxi Zhuang Autonomous Region, China. According to the actual results of the pretest survey, the questionnaire was modified and improved, and the field survey area was selected. Finally, nine administrative villages in Shankou town, including Shanxi village, Shandong village, Shanjiao village, Dandou village, Gaopo village, Beijie village, Xinwei village, Zhongtang village, and Beijie village, were selected as field investigation areas. A formal large-scale field survey was conducted by combining random sampling and stratified sampling from January 4 to 9, 2020. The field survey consisted of face-to-face formal interviews (Wang H. et al., 2020). To understand farmer dialects in the research area and to ensure effective interviews and the safety of team members, the 16 field research team members were divided into eight groups, each group has two members, including one male and one female, and one of them was well acquainted with the local dialect. Before the field investigation, team members were trained in detail, and basic preparations for the investigation were made in advance. A total of 580 questionnaires were issued. After excluding outliers and incomplete questionnaires, 568 valid questionnaires were obtained, with an effective response rate of 97.9%. Among them, 127 samples were used as the treatment group and 441 samples comprised the control group.

Index System Construction

In this paper, the sustainable livelihood capital index of coastal farmers is used as the result variable for evaluating the effects of coastal ecological protection policy implementation. By referring to the SLF proposed by DFID, combined with public statistical data of farmers in the Beibu Gulf coastal zone and a comprehensive understanding of the actual production and living conditions of coastal farmers via the field pretest survey, an index system (**Table 1**) suitable for evaluating the livelihood capital of coastal farmers was defined based on the five dimensions, and the total livelihood capital is the sum of them. The Delphi method (Abid et al., 2016) was used to calculate the weight of each secondary index, and average values were obtained according to the scores of 20 experts in the professional field.

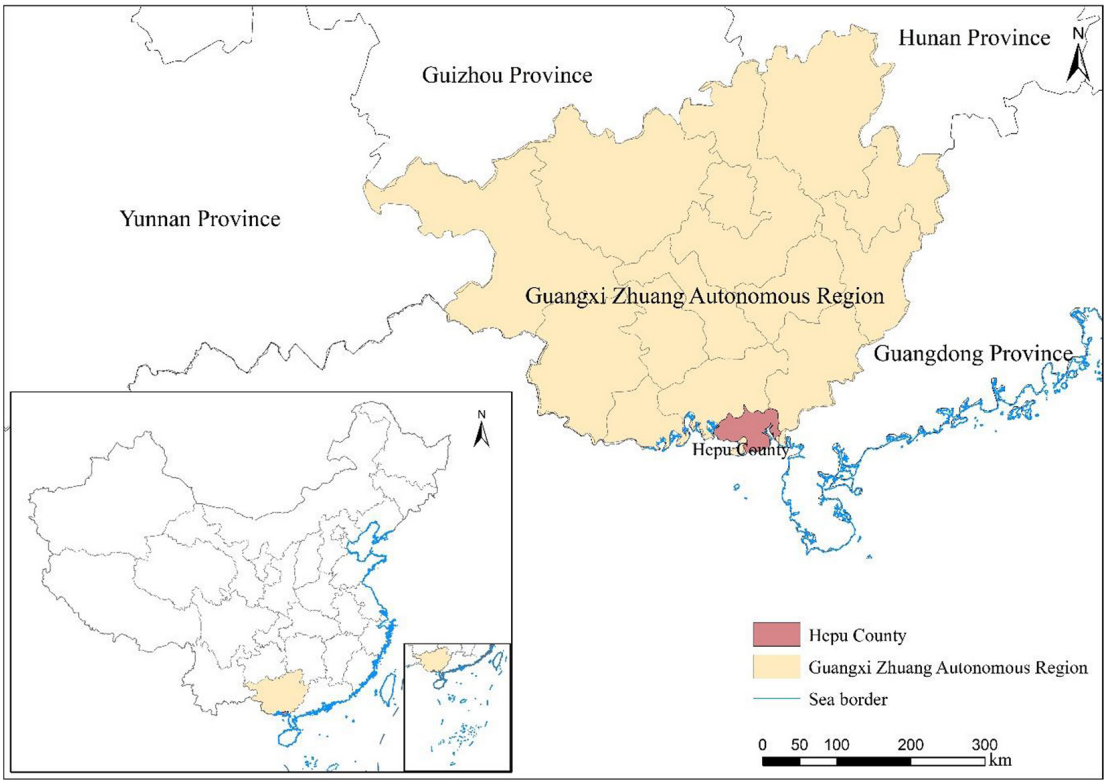

FIGURE 2 | Study area map.

CONSTRUCTION OF THE POLICY EVALUATION MODEL

The PSM-DID method is widely used in existing research for evaluating the implementation effects of policies (Heckman et al., 1997; Wang et al., 2019; Yang et al., 2020). First, the PSM method is used to calculate the propensity matching score. By using this score, we can find individuals in the control group who are as similar as possible to those in the treatment group to eliminate the selective bias problem caused by sampling. Then, combined with the difference-in-difference (DID) method, the real policy effect of the implementation of the Beibu Gulf coastal ecological protection policy on the livelihood capital of farmers who actively participate in coastal protection is estimated. In this way, we can eliminate the unobservable and time-varying differences between groups and eliminate common trends with time variations that may exist to ensure that the estimation results are as accurate as possible.

Propensity Score Matching Method

First, the propensity scores of the treatment group and control group were calculated by the logit model (Abid et al., 2016; Fei et al., 2021). The propensity score in the PSM model refers to the probability of coastal farmers participating in or not participating in coastal zone protection-related activities (such as coastal zone garbage cleaning, marine embankment construction and protection, coastal zone afforestation, mangrove protection, providing donations, etc.).

$$PS_i = P(X_i) = P(D_i = 1|X_i) = \exp(\beta X_i)/[1 + \exp(\beta X_i)] \quad (1)$$

In formula (1), PS_i refers to the probability of the PSM of each sample farmer. After implementing the ecological protection policy in the Beibu Gulf coastal zone, whether coastal farmers have actively participated in the coastal ecological protection activities is regarded as a binary virtual variable D_i. $D_i = 1$ indicates that an individual has participated and is the treatment group. $D_i = 0$ indicates that an individual has not participated and is the control group. X_i is a vector that is composed of a series of characteristic variables related to the livelihood capital of coastal farmers. $\exp(\beta X_i)/[1 + \exp(\beta X_i)]$ is the cumulative distribution function, which is the corresponding parameter vector. For the farmer i in the Beibu Gulf coastal zone, assuming that his or her propensity score is $P(X_i)$, the average treatment effect on the treated (ATT) of farmers who have actively participated in coastal ecological protection activities is as follows:

$$\begin{aligned} ATT &= E\{E[Y_{1i} - Y_{0i}|D_i = 1,\ P(X_i)]\} \\ &= \{E[Y_{1i}|D_i = 1,\ P(X_i)]\} - \{E[Y_{0i}|D_i = 1,\ P(X_i)]\} \quad (2) \end{aligned}$$

In formula (2), Y_{1i} and Y_{oi} represent the livelihood capital of farmer i who actively participates in coastal ecological protection activities when the ecological protection policy is implemented or not, respectively.

TABLE 1 | Sustainable livelihood capital index system of coastal farmers.

Capital types	Secondary index	Index description (unit)	Weight
Human capital (H)	Number of domestic workers (H1)	Specific quantity (person)	0.225
	Health status of domestic workers (H2)	Very poor = 1, kind of poor = 2, general = 3, relatively good = 4, very good = 5	0.290
	Family members are technicians (H3)	Yes = 1, no = 2	0.317
	Number of family migrant workers (H4)	Specific quantity (person)	0.169
Natural capital (N)	Abundance of marine animal and plant resources (N1)	Very poor = 1, kind of poor = 2, general = 3, relatively good = 4, very good = 5	0.435
	Pollution situation (N2)	Very serious = 1, kind of serious = 2, general = 3, relatively good = 4, very good = 5	0.342
	Air quality (N3)	Very poor = 1, kind of poor = 2, general = 3, relatively good = 4, very good = 5	0.223
Physical capital (P)	Housing structure (P1)	Steel structure = 1, concrete structure = 2, brick/wood structure = 3, civil structure = 4	0.290
	Housing areas (P2)	Total building area of household houses (m^2)	0.405
	Household value of consumer goods (P3)	The total value of household durable consumer goods (RMB)	0.305
Social capital (S)	Family members are village cadres (S1)	Yes = 1, no = 2	0.300
	Number of participating cooperatives (S2)	Specific quantity	0.180
	Gift expenses (S3)	Expenditure on family social network relationship (RMB)	0.174
	Friends help when in trouble (S4)	Yes = 1, no = 2	0.185
	Neighborhood relations (S5)	Very poor = 1, kind of poor = 2, general = 3, relatively good = 4, very good = 5	0.163
Financial capital (F)	Obtaining loans (F1)	Yes = 1, no = 2	0.238
	Agricultural income (F2)	RMB [0, 2,000) = 1, [2,000, 4,000) = 2, [4,000, 6,000) = 3, [6,000, 8,000) = 4, [8,000, 10,000) = 5, [10,000, 12,000) = 6, [12,000, 15,000) = 7, [15,000, 20,000) = 8, [20,000, 30,000) = 9, [30,000, 40,000) = 10, [40,000, 50,000) = 11, [50,000, 100,000) = 12;[100,000, + ∞) = 13	0.248
	Non-agricultural income (F3)	RMB [0, 2,000) = 1, [2,000, 4,000) = 2, [4,000, 6,000) = 3, [6,000, 8,000) = 4, [8,000, 10,000) = 5, [10,000, 12,000) = 6, [12,000, 15,000) = 7, [15,000, 20,000) = 8, [20,000, 30,000) = 9, [30,000, 40,000) = 10, [40,000, 50,000) = 11, [50,000, 100,000) = 12;[100,000, + ∞) = 13	0.276
	Main source of family income (F4)	Agricultural planting = 1, livestock breeding = 2, fishing = 3, migrant workers = 4, non-agricultural business = 5	0.240

When propensity scores are calculated, the balance test should be carried out between the treatment group and control group to verify that there are no significant differences in propensity scores between them. The average treatment effect (ATE) of the ecological protection policy in the Beibu Gulf coastal zone can be obtained by calculation.

$$ATE = \frac{1}{N_T}\left(\sum_{i\in T} Y_i^T - \sum_{j\in C} \lambda(P_i, P_j) Y_j^C\right) \quad (3)$$

In formula (3), *Nt* represents the number of sample households in the treatment group. *T* represents the matched treatment group. *C* represents the matched control group. Y_i^T represents the livelihood capital of the *j*-th sample farmer in the treatment group. Y_j^C represents the livelihood capital of the *j*-th sample farmer in the control group. P_i represents the predicted probability of the propensity matching score of the treatment group. P_J represents the predicted probability of the propensity matching score of the control group. $\lambda(P_i, P_j)$ represents the weight function of the probabilities P_i and P_J that are predicted by the propensity matching score. Generally, due to different matching methods, the weights assigned are also different. According to the sample data of farmers obtained from the field survey, the k-nearest neighbor matching method (one-to-one, i.e., $k = 1$) (Yang et al., 2020; Fei et al., 2021) is selected to estimate the propensity matching score.

Difference-in-Difference Method

Although the PSM method can eliminate the impacts of certain other factors by adding appropriate control variables, some factors are not observed or are not easily observed, which may have certain impacts on the livelihood capital of coastal farmers. It is important to eliminate the influence of these potential factors as much as possible. After the PSM method is used, the DID method (Ruggiero et al., 2019) is used to estimate the net impact of implementing a coastal ecological protection policy on the livelihood capital of farmers who actively participate in coastal ecological protection. Therefore, based on the above, this study constructed a DID model as follows:

$$Y_{it} = \beta_0 + \beta_1 * D_i + \beta_2 * P_t + \beta_3 * (D_i * P_t) + \beta_4 * X_{it} + \varepsilon_{it} \quad (4)$$

In formula (4), Y_{it} represents the result variables, which mainly include human capital, natural capital, physical capital, social capital, financial capital and total livelihood capital. The binary dummy variable P_t represents the time node of the study on the implementation effects of the Beibu Gulf coastal zone protection policy. This paper evaluates the implementation effects of the coastal ecological protection policy of the Beibu Gulf

issued in 2016. The two periods of data obtained through field research are 2013, before policy implementation, and 2019, after policy implementation, in which the retrospective recollections of the interviewed farmers were mainly used for 2013. Therefore, the current period after policy implementation is set as 2019, that is, $P_t = 1$. The base period before policy implementation is set as 2013, that is, $P_t = 0$. $D_i * P_t$ is the core explanatory variable of this study, that is, the interactive item of policy implementation effect evaluation, and β_3 is the estimation coefficient of the interactive item. X_{it} represents control variables, which mainly include road conditions, emergency tolerance, trust, life quality, policy understanding, gender, age, marital status, party members, permanent residence in rural areas, and education level. ε_{it} represents a residual term.

EMPIRICAL RESULTS AND ANALYSIS

Hypothesis Test

Common Support Test

To ensure the quality of the PSM, it is necessary to further test the common support of matching. If the common support area between the treatment group and control group is too narrow, then farmers outside the common support area will not be able to achieve the reasonable and effective matching, which will lead to an excessive loss of samples. The kernel density function, which is composed of the propensity scores of the sample farmers in the treatment and control group before and after matching, can be compared to conduct the common support area test (**Figure 3**). **Figure 3A** shows that there are differences in the kernel probability density between the treatment and control group before matching and that the common support area between the two groups is narrow. **Figure 3B** shows that after matching, the kernel probability density of the sample farmers in the treatment and control group tend to be consistent, and the common support area between the two groups increases, which also indicates that selection bias in the samples has been eliminated. Therefore, it can be concluded that it is necessary to match sample farmers in the two groups. The results of this study after matching the sample farmers of the treatment and control group through the k-nearest neighbor matching method (one-to-one, i.e,. $k = 1$) (Yang et al., 2020; Fei et al., 2021) meet the requirements of the common support hypothesis.

Matching Balance Test

When the PSM model is used to calculate propensity scores and pass the common support test, to ensure the accuracy and reliability of the matching results, it is necessary to test whether the propensity scores of the matching variables are still significantly different between the treatment and control group, so the matching balance test is needed. According to the balance test results shown in **Table 2**, compared with the results before matching, the bias ratios of variables after matching except for the divorce variable are significantly smaller, and the absolute values are even smaller than 10%. At the same time, the *t*-test results showed that the *p*-values of the matched variables are greater than 0.05, indicating that the t-values of all the matched variables of all the samples do not pass the significance level test at the 10% level. The results indicate that there are no significant differences between the two groups, and the results pass the matching balance test.

Model Regression Results

This study uses Stata 15.0 software and the PSM-DID model to study the impact of coastal ecological protection policy on coastal farmer livelihood capital in the view of farmer participation. This paper mainly analyzes the six result variable indexes of human capital, natural capital, physical capital, social capital, financial capital, and total livelihood capital. **Tables 3**, **4** show the results of the modeling process. First, the six result variables were regressed, and the results are shown in columns (1), (3), and (5) in **Table 3** and columns (7), (9), and (11) in **Table 4**. To exclude the influence of other possible factors on the livelihood capital of coastal farmers and interference with the empirical results, the control variables were added into the model, and the six result variables were then estimated by regression. The results are shown in columns (2), (4), and (6) in **Table 3** and columns (8), (10), and (12) in **Table 4**.

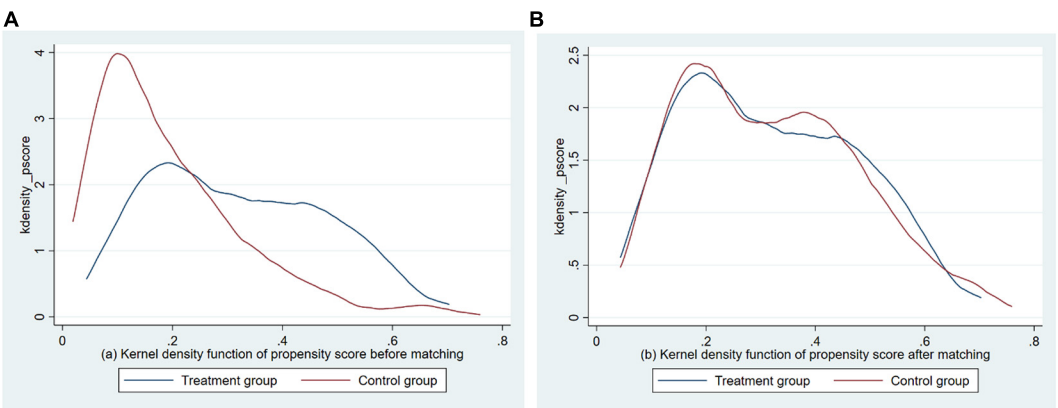

FIGURE 3 | The kernel density function of the trends of the scores **(A)** before and **(B)** after matching.

TABLE 2 | Results of the balance matching test.

	Unmatched	Mean		% bias	% reduct | bias|	*t*-test	
Variables	**Matched**	**Treatment group**	**Control group**			***t***	***p*** > | t|
Road conditions	U	2.614	2.519	12.300		1.230	0.219
	M	2.614	2.598	2.000	83.400	0.160	0.872
Emergency tolerance	U	2.740	2.837	−13.700		−1.290	0.197
	M	2.740	2.724	2.200	83.700	0.180	0.855
Trust	U	3.575	3.680	−15.000		−1.510	0.131
	M	3.575	3.528	6.700	55.200	0.520	0.602
Life quality	U	2.858	2.982	−17.400		−1.700	0.090
	M	2.858	2.835	3.300	80.900	0.280	0.783
Policy understanding	U	2.654	3.469	−78.800		−7.810	0.000
	M	2.654	2.646	0.800	99.000	0.060	0.950
Gender	U	0.717	0.592	26.400		2.560	0.011
	M	0.717	0.724	−1.700	93.700	−0.140	0.889
Age	U	49.913	45.662	25.200		2.520	0.012
	M	49.913	49.843	0.400	98.300	0.040	0.971
Unmarried	U	0.055	0.111	−20.300		−1.870	0.062
	M	0.055	0.063	−2.900	85.900	−0.270	0.791
Divorce	U	0.024	0.011	9.400		1.030	0.301
	M	0.024	0.008	12.000	-28.200	1.010	0.315
Widowed	U	0.008	0.014	−5.600		−0.520	0.607
	M	0.008	0.016	−7.600	-37.400	−0.580	0.563
Party members	U	0.079	0.057	8.800		0.910	0.363
	M	0.079	0.079	0.000	100.000	0.000	1.000
Permanent residence	U	0.835	0.812	6.000		0.590	0.558
	M	0.835	0.827	2.100	65.500	0.170	0.868
Education level	U	2.835	2.798	3.300		0.330	0.738
	M	2.835	2.835	0.000	100.000	0.000	1.000

(1) U represents Unmatched, M represents Matched. (2) For marital status, married status was taken as the control group and unmarried, divorced and widowed statuses were taken as the treatment group.

According to the total livelihood capital results, the results presented in **Table 4** (11) without control variables passed the significance test. However, according to the results presented in **Table 4** (12), when the control variables are added, the interaction coefficient is 0.119, but it fails to pass the significance level test, which indicates that the coastal ecological protection policy did not have a significant impact on the total livelihood capital of households that were actively participating in coastal ecological protection activities. It can be found that the emergency tolerance, trust, divorce and education levels of the control variables passed the significance test, which shows that these control variables would play a critical role in the total livelihood capital of farmers who were actively participating in coastal ecological protection activities. The results of these control variables also bring us new enlightenment. In the future, when formulating and improving coastal ecological protection policies, in order to effectively improve the overall livelihood capital welfare of coastal farmers, we can actively implement more beneficial policies to improve the local village infrastructure (such as roads, basic education facilities, etc.).

From the results of the human capital dimension, the results pass the significance test without adding control variables. When control variables are added, they fail to pass the significance level test, which indicates that the coastal ecological protection policy did not have a significant impact on the human capital of households actively participating in coastal ecological protection activities. Therefore, Hypothesis 1 has not been verified. However, the emergency tolerance, trust, age, divorce and education levels of the control variables all passed the significance test, which shows that these control variables had a significant impact on the human capital of farmers actively participating in coastal ecological protection activities.

From the natural capital dimension results, results without control variables pass the significance test at the 1% level. When the control variables are added, the interaction coefficient is 0.181, which passes the significance test at the 5% level. This shows that the coastal ecological protection policy played a critical role in the natural capital of farmers who actively participated in coastal ecological protection activities and that implementing the coastal ecological protection policy increased the natural capital of peasant households by 0.181. Therefore, Hypothesis 2 has been verified. Among the control variables, emergency tolerance, trust, unmarried and divorced all passed the significance level test, indicating that these three control variables also played a critical role in the natural capital of farmers who actively participated in coastal ecological protection activities.

TABLE 3 | Effects of the coastal ecological protection policy on the livelihood capital of farmers.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**H**	**H**	**N**	**N**	**P**	**P**
Di	0.0413	0.0553	−0.0598	−0.0634	0.00962	0.00617
	(0.0942)	(0.0913)	(0.0734)	(0.0709)	(0.0292)	(0.0281)
Pt	0.0591**	0.0419	−0.406***	−0.476***	−0.0811***	−0.0524***
	(0.0290)	(0.0352)	(0.0572)	(0.0748)	(0.0170)	(0.0202)
Di*Pt	0.0827**	0.0464	0.228***	0.181**	−0.0159	−0.00476
	(0.0400)	(0.0430)	(0.0856)	(0.0889)	(0.0257)	(0.0263)
Road conditions		−0.0153		0.0580		−0.0105
		(0.0239)		(0.0435)		(0.0116)
Emergency tolerance		0.0598*		0.0427		−0.0228*
		(0.0339)		(0.0442)		(0.0117)
Trust		0.0685**		0.122**		−0.00544
		(0.0344)		(0.0485)		(0.0133)
Life quality		0.000102		−0.0310		−0.0120
		(0.0263)		(0.0440)		(0.0138)
Policy understanding		−0.0411		0.0401		0.00975
		(0.0449)		(0.0332)		(0.0103)
Gender		−0.161		−0.0157		0.0583***
		(0.108)		(0.0778)		(0.0215)
Age		0.00970**		0.00269		−0.000475
		(0.00384)		(0.00241)		(0.000691)
Unmarried		−0.0122		0.284*		-0.0502
		(0.167)		(0.169)		(0.0421)
Divorce		−0.906***		−0.270		0.127
		(0.201)		(0.186)		(0.102)
Widowed		0.475		−0.272***		−0.310***
		(0.661)		(0.0787)		(0.105)
Party members		−0.233		−0.0877		0.0689*
		(0.174)		(0.0930)		(0.0396)
Permanent residence		−0.212*		0.0817		0.0141
		(0.125)		(0.0969)		(0.0216)
Education level		0.0996**		0.0108		−0.00882
		(0.0478)		(0.0295)		(0.00969)
Constants	2.734***	2.023***	3.417***	2.475***	0.895***	1.008***
	(0.0663)	(0.352)	(0.0557)	(0.263)	(0.0207)	(0.0778)
Samples	508	508	508	508	508	508
R^2	0.124	0.124	0.124	0.124	0.124	0.124

*(1) t-values are absolute values in parentheses. (2) *, **, and *** indicate significance levels of 10, 5, and 1%, respectively.*

However, the improvement of the natural capital of households that participated in coastal ecological protection activities was mainly due to the implementation of coastal ecological protection policies, which is consistent with one of the original intentions of the government, namely, to implement coastal ecological protection policies.

From the social capital dimension results, results without control variables pass the significance test at the 1% level. When the control variables are added, the interaction coefficient is 0.0522 and passes the significance test at the 5% level. The results showed that the coastal ecological protection policy played a critical role in the social capital of households that participated in coastal ecological protection activities and that implementing the coastal ecological protection policy increased family social capital by 0.052, which indicates that it has a significant positive effect. Therefore, Hypothesis 3 has not been verified. Although the emergency bearing capacity, trust degree and policy understanding degrees of the control variables passed the significance level tests, these three control variables also had significant impacts on the social capital of farmers who participated in coastal ecological protection activities. However, the improvement of the social capital of households participating in coastal ecological protection activities was mainly due to the coastal ecological protection policies. This finding was also consistent with one of the original intentions of the government, namely, to implement relevant coastal ecological protection policies.

From the physical capital and financial capital dimension results, both results without the control variables and those with control variables fail to pass significance level tests, indicating that the coastal ecological protection policy has no significant impacts on the physical capital and financial capital of households that

TABLE 4 | Effects of the coastal ecological protection policy on the livelihood capital of farmers (continued **Table 3**).

	(7)	(8)	(9)	(10)	(11)	(12)
Variables	**S**	**S**	**F**	**F**	**Z**	**Z**
D_i	0.0198	0.0132	0.311*	0.330**	0.322	0.342
	(0.0226)	(0.0206)	(0.165)	(0.165)	(0.232)	(0.225)
P_t	0.0694***	0.0284	0.537***	0.420***	0.178	−0.0565
	(0.0159)	(0.0186)	(0.0892)	(0.121)	(0.123)	(0.165)
D_i*P_t	0.106***	0.0522**	−0.0937	−0.147	0.307*	0.119
	(0.0274)	(0.0243)	(0.123)	(0.129)	(0.172)	(0.176)
Road conditions		0.00110		0.0183		0.024
		(0.00925)		(0.0741)		(0.103)
Emergency tolerance		0.0484***		0.0855		0.319***
		(0.0115)		(0.0768)		(0.115)
Trust		0.124***		0.0312		0.277**
		(0.0114)		(0.0882)		(0.117)
Life quality		0.0133		0.0945		0.0709
		(0.0118)		(0.0700)		(0.103)
Policy understanding		−0.0258**		−0.0596		−0.0746
		(0.0102)		(0.0839)		(0.113)
Gender		−0.0173		0.147		−0.00374
		(0.0249)		(0.165)		(0.248)
Age		−0.000336		0.00296		0.0152*
		(0.000865)		(0.00559)		(0.00811)
Unmarried		−0.0336		0.295		0.513
		(0.0471)		(0.300)		(0.446)
Divorce		−0.0243		−0.837		−1.850***
		(0.0413)		(0.653)		(0.656)
Widowed		−0.00112		0.643		0.528
		(0.0520)		(0.439)		(0.831)
Party members		−0.00804		−0.196		−0.428
		(0.0532)		(0.336)		(0.476)
Permanent residence		−0.0277		−0.255		−0.386
		(0.0300)		(0.216)		(0.285)
Education level		−0.00333		0.127*		0.220**
		(0.0111)		(0.0674)		(0.0975)
Constants	1.605***	1.127***	5.176***	4.265***	13.83***	10.86***
	(0.0149)	(0.0855)	(0.123)	(0.576)	(0.172)	(0.785)
Samples	508	508	508	508	508	508
R^2	0.124	0.124	0.124	0.124	0.124	0.124

*(1) t-values are absolute values in parentheses. (2) *, **, and*** indicate significance levels of 10, 5, and 1%, respectively.*

participated in coastal ecological protection-related activities. Therefore, Hypothesis 4 and Hypothesis 5 have not been verified.

DISCUSSION

The Impact of Coastal Zone Protection Policy on Farmers' Livelihood Capital

Coastal zones not only ensure a suitable ecological environment but also abundant marine products (Trung Thanh et al., 2021), and the strategic position of coastal zones in the world is also increasingly prominent (Yu et al., 2010; Islam and Shamsuddoha, 2018; Rojas et al., 2019). However, the burgeoning of the marine economy in coastal areas has also caused damage to coastal ecologies (Sievers et al., 2020; Zheng et al., 2020; Yu et al., 2021). It is urgent to formulate effective coastal ecological protection policies to restore and protect coastal ecological environments (Lai and Leone, 2020). Therefore, formulating coastal ecological protection policies is a research hotspot. Previous researches were basically about the positive impacts of the formulation and implementation of coastal ecological protection policies. For example, these impacts include increasing the biodiversity of coastal areas (Nguyen et al., 2018), improving the suitability of the living environments of residents (Bennett et al., 2018) and adjusting the climate environment (Yu et al., 2010). Although some scholars have found that implementing coastal ecological protection policies will reduce the income of coastal fishing families (Wang et al., 2017; Huang et al., 2020), they have not observed the different effects on the multidimensional welfare of coastal farmers who are most closely related to coastal ecological protection. In particular, the impact of implementing coastal ecological protection policies on the multidimensional welfare of

coastal farmers is not accurately measured by effective methods, hence this paper uses the PSM-DID method to measure the changes in farmers' multidimensional capital welfare before and after implementation of a coastal ecological protection policy.

To exclude the influence of other possible factors on the livelihood capital of coastal farmers and interference with the empirical results, we add control variables into the model and compare the results with the model without control variables. It can be found that the model results of the human capital and total livelihood capital have passed the significance test when the control variables are not added, but the model results have not passed the significance test when the control variables are added. Additionally, although the model results of the natural capital and social capital with control variables pass the significance test, the significance level of the model results is lower than that without control variables. This shows that the control variables do have a certain impact on the livelihood capital of coastal farmers, so it is necessary to add control variables in the study to exclude the interference of other factors as far as possible. Finally, through the analysis of the model results, this study found that implementing a coastal ecological protection policy did not reduce the total livelihood capital welfare of coastal residents and even significantly increased the natural capital and social capital of coastal farmers. These results demonstrate that the formulation and implementation of the local coastal ecological protection policy was relatively successful, which is worthy of reference for other similar areas.

Policy Implications

To restore and protect the ecosystem service function of coastal zones, some farmers not only changed their original production methods and lifestyles but also chose to relinquish some direct economic benefits. Coastal farmers are "rational people." Therefore, to encourage coastal residents to participate in coastal ecological protection activities more effectively, the government still needs to consider improving the total livelihood capital welfare of coastal farmers when formulating and implementing coastal ecological protection policies. The following are some policy implications: (1) These results show that although the coastal ecological protection policy did not reduce the total livelihood capital welfare of coastal farmers, it did not bring about benefits to the total livelihood capital welfare of coastal farmers. The local government should continue to improve the current coastal ecological protection policy in the future, hoping that the implementation of the coastal zone ecological protection policy can bring more positive benefits to the livelihood capital of coastal farmers. (2) Strengthening the support investment of coastal farmers' livelihood capital construction can be carried out at the macro and micro levels. At the macro level, it is necessary for coastal ecological environment management departments and governments at all levels to enact relevant and effective incentive policies. At the micro level, it is necessary to strengthen communication and cooperation among rural farmers in coastal zones through training and learning provided by non-governmental organizations and by various forms of planting and breeding to improve the total livelihood capital of coastal farmers. (3) The results show that the implementation of coastal ecological protection policy did not increase the financial capital of coastal farmers. To enrich the income sources of coastal farmers, local governments should introduce a series of preferential entrepreneurial policies and create a suitable economic environment, encourage coastal farmers to actively start their businesses under the guidance of relevant government policies, broaden the income sources of farm families in combination with the characteristics of coastal farm families and coastal zones, and lead coastal farmers to carry out concurrent production and life modes. (4) It is important to construct a suitable ecological compensation mechanism for coastal zones. This would mainly occur by clarifying the main body, compensation object, compensation standard and compensation method of coastal ecological compensation and implementing a coastal ecological compensation supervision mechanism to ensure the gradual improvement of the total livelihood capital welfare of coastal farmers.

Research Contribution and Deficiency

The main contributions of this paper are as follows: The first contribution is that existing research on coastal ecological compensation in China is still in its infancy, and previous studies have not combined the livelihood capital of farmers in coastal zones with the ecological protection policies of coastal zones, which can enrich this research field. The second contribution is the innovative use of the PSM-DID method and measurement of the specific impact of coastal ecological protection policies on the livelihood capital of coastal farmers based on the perspective of farmer participation.

This research remained to be further deepened later. First, this study selected only the strictly protected shoreline of Hepu County, which is a representative coastal zone in the Beibu Gulf, as the research area. In the future, we can carry out comparative studies on areas with strict protection of coastlines, restricted development of coastlines and optimal utilization of coastlines. Second, this paper evaluates the implementation effects of the coastal zone ecological protection policy that was issued in November 2016. However, the livelihood capital status of coastal farm families was obtained through a field investigation in 2019 and from farmer recollections in 2013, and the results of recall tracing may deviate from the actual situation of that year. Moreover, we must admit that due to the limitation of data acquisition, only two periods of data have been obtained, so we use the DID method in this paper, which may lead to some deviation in the evaluation of policy effect. In future research on evaluating the implementation effect of policy projects, on the basis of human and financial resources, the whole process of tracking research can be adopted to ensure the continuity and rigor of the research, and we can use the difference-in-differences-in-differences (DDD) method to evaluate the policy effect more accurately.

CONCLUSION

This study examines the impact of coastal ecological protection policy on the livelihood capital of coastal farmers based on

the perspective of farmer participation. Combined with the SLF proposed by DFID, this paper constructs a livelihood capital index system for coastal farmers. Through field research, 568 farmer questionnaires were obtained as research samples to represent the livelihood capital status of coastal farmers in 2013 and 2019. Then, based on the PSM-DID model, six livelihood capital categories were taken as the result variables, and the model results, with and without the control variables, were compared to study the effect of the coastal zone ecological protection policy implemented in 2016 on the livelihood capital of coastal farmers. The specific conclusions are as follows: (1) There were no significant effects of the coastal ecological protection policy on the total livelihood capital of households that participated in coastal ecological protection activities. However, the interaction coefficients of the natural capital and social capital of coastal farmers, with and without the control variables, passed the significance level test and indicated that for farmers who participated in coastal ecological protection activities, implementing the coastal ecological protection policy significantly increased their natural capital and social capital by 0.181 and 0.052, respectively. (2) It was worth noting that the impact of coastal ecological protection policies on the total human capital and livelihood capital of farmers participating in coastal ecological protection activities be approved by significance test when the control variables were not added but failed to test of significance after the control variables were added. In terms of the impacts of the coastal ecological protection policy on the physical capital and financial capital of farmers who participated in coastal ecological protection activities, their interaction coefficient failed to test of significance, either with or without the control variables. Therefore, the coastal ecological protection policy did not have significant impacts on the human capital, physical capital, financial capital or total livelihood capital of the households that participated in coastal ecological protection-related activities.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

PC: conceptualization, methodology, software, formal analysis, data curation, investigation, visualization, writing—original draft, writing—review and editing, and funding acquisition. HW: conceptualization, supervision, writing—review and editing, and funding acquisition. XN: writing—review and editing and funding acquisition. SZ: visualization and writing—review and editing. ZC: methodology. XW: investigation. AZ: supervision and writing—review and editing. JW: writing—review and editing and funding acquisition. All authors contributed to the article and approved the submitted version.

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