



Compensation mechanisms for fishermen quit fishing: A case of Jiangsu province, China

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ABSTRACT

The ‘Ten-year Ban on Fishing’ policy was designed by the Chinese government to protect the biodiversity of the Yangtze River basin. Fishermen are the ultimate implementers of the fishing ban policy. Therefore, a scientific compensation mechanism for fishers to stop fishing is the basis for ensuring the continuous implementation of the policy. First, we conducted a survey with 309 fishermen in eight cities along the Yangtze River in Jiangsu province. We also analyzed living conditions of fishermen before and after quitting fishing based on descriptive statistical analysis. Based on the theory of sustainable livelihood, a binary logistic regression model was used to analyze the relationship between fishermen’s willingness to quit fishing and five types of livelihood capital (natural, material, human, financial, and social capital). The results showed that fishermen face severe livelihood sustainability issues after ceasing to fish and that their willingness to quit is closely related to the five types of livelihood capital. Based on this, and according to different age groups, this study constructed a compensation mechanism for retired fishermen from two aspects: monetary and social security compensation. The research results can provide a theoretical framework for other provinces in the Yangtze River basin to formulate a compensation system for fishermen.

1. Introduction

The Yangtze River is the third largest river in the world. It is rich in fishery resources, a representative area of biodiversity, and the cradle of freshwater fisheries in China [1]. However, like most rivers in the world, owing to rapid social and economic development and accelerated modernization, the Yangtze River has experienced great disturbance from human activities. Fishery sustainability and biodiversity protection present enormous challenges [2]. Recently, the Chinese government has attached great importance to this issue and introduced a series of policies to protect the Yangtze River. Since the official implementation of the spring fishing moratorium in the middle and lower reaches of the Yangtze River basin in 2003, the fishing ban in the basin has been constantly improving. However, the biological integrity index of the Yangtze River continues to decline yearly and reached the worst ‘fish-free’ grade in 2019. Many endangered and rare fish and finless porpoise populations continue to decrease, and *Psephurus gladius* in the Yangtze River has become extinct [3]. To avoid the vicious circle of ‘the lesser fish resources are caught, the worse the ecology is caught, the poorer the fishermen are caught’, the Chinese government has officially issued a document proposing: ‘In 2020, the key waters of the Yangtze River basin

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will be banned from fishing all year round, and the ban will be promoted in different waters by classification and stage'. It also marked the official opening of the 10-year ban on fishing in the Yangtze River basin.

The smooth passage of the Yangtze River Protection Law on December 26, 2020, also provides solid legal backing for banning fishing in the Yangtze River basin. Starting January 1, 2021, fishing was prohibited in critical waters of the Yangtze River basin. With 111,000 fishing boats and 231,000 fishermen returning to shore, the Yangtze River basin has begun a historical turning point of 'people returning to fish entering'. However, whether the implementation of the fishing ban policy is sustainable, whether the fishermen can achieve a sustainable livelihood after complete withdrawal of fishing, and whether there will be a counter-fishing phenomenon depend, to a certain extent, on whether the compensation system issued by the government can meet their internal needs. In China, there is no unified compensation mechanism for retired fishermen, and existing compensation methods cannot meet their diverse needs. Therefore, how to establish a scientific compensation mechanism for retired fishermen is the most important thing at present.

The Watershed fishing ban is an important measure for implementing the watershed's green development and the Yangtze River's excellent protection strategy. Fishermen are the ultimate executors and implementers of a no-fishing policy, so their enthusiasm and initiative to participate are key for the successful implementation of the procedure [4,5]. However, from the perspective of education, social services, and organization, the overall quality of fishermen is not high [6]. Therefore, in the formulation and implementation of the policy, it is necessary to respect the identity of fishermen as participants, fully understand their willingness to quit fishing, the status quo of life and business after quitting fishing and its influencing factors, to promote the continuous implementation of the ten years policy. System, economy, culture, perception, motivation, and cognition often influence fishermen's willingness to participate in fishing policies. This is transformed into concrete actions for participation [7]. Research on participation intention of the compensated object has always been a popular issue at home and abroad. According to existing studies, economic factors such as income level and compensation standards are essential factors affecting willingness to participate [8,9]. However, economic factors are not the only factor that affects willingness to participate [10]. The individual characteristics of fishermen, such as gender, age, and education level [11], and social capital factors, such as interpersonal and institutional trust [12], also affect participation willingness.

Farmers and fishermen are extremely vulnerable to poverty. Therefore, the basic livelihood of fishermen after quitting fishing and going ashore and their transition from production to business have aroused widespread concern in society. The macroevolution of the livelihood capital of fishermen in different fishery development periods and the microevolution of the livelihood capital of individual fishermen before and after 'going ashore' directly affect whether their livelihood is sustainable [13]. Low education level, single skills, serious aging, and lack of initiative consciousness of fishermen, coupled with loopholes in the objective implementation of national policies, and social employment market difficulties, are direct factors leading to transition challenges from industry to industry [14]. In the current fishermen situation, employment is characterized by low income, lack of employment security, and difficulty in finding 'good' jobs. Most fishermen remain attached to the fishing industry [15]. Therefore, the government should formulate relevant incentive policies to improve and ensure sustainable livelihoods [16,17], promote green economic growth in the basin, and achieve a win-win situation of ecological protection and livelihood improvement [18].

A review of the existing research (Table 1) shows that most studies have analyzed fishermen's willingness to quit fishing and the factors restricting them from switching to other occupations after withdrawing from fishing. Based on the existing ecological compensation experience, respecting the leading position of fishermen and considering their livelihoods are prerequisites [19] for formulating scientific and reasonable compensation standards. In addition, factors such as the number of fishermen, duration of fishing, and price of fish obtained are also essential [20] in approving fishermen's compensation, and the formulation of compensation standards for fishermen's withdrawal from fishing needs to be based on their willingness to quit fishing [21]. Fishermen can be classified as low-income people, and the sustainability of their livelihoods after exiting the land is the most critical issue. This study considers Jiangsu Province as an example. A field study was conducted on the willingness of fishermen to quit fishing and their livelihoods after withdrawing from fishing in eight cities along the Jiangsu section of the Yangtze River basin. Binary logistic regression was used to analyze the relationship between the fishermen's willingness to quit fishing and their livelihood capital. We hope that the results of this study can be extended to other provinces and cities in the Yangtze River basin and promote the continuous implementation of a fishing ban policy based on improving the quality of life of fishermen who have retired from fishing to protect the

Table 1

The main conclusions of existing research and the views of this paper.

Research direction	Research content	Main conclusion	Views of this paper
Willingness to quit fishing	Overall characteristics of fishermen [6]	The overall quality of fishermen is not high	1. Implementing the fishing ban policy has damaged fishermen's livelihood capital. 2. Fishermen's individual characteristics and livelihood capital affect their willingness to quit fishing.
	Influencing factors of willingness to quit fishing [7,12]	Economic compensation and individual characteristics are the main influencing factors	
Living situation of fishermen	Living capital [13]	Livelihood capital changes, affecting the normal life of fishermen	3. Compensation mechanisms need to take complete account of the sustainable livelihoods of fishermen.
	Change of production and business [14,15]	Fishermen's own characteristics and policy loopholes make it difficult for them to change industries	
Compensation mechanism	Policy making [16,17]	Create incentives to improve livelihoods	4. According to the situation, the compensation mechanism is divided into economic and social security compensation.
	Compensation standard [19, 21]	The compensation standard shall be formulated according to the actual situation of fishermen and their willingness to compensate	

biodiversity of the Yangtze River basin.

2. Materials and methods

2.1. Theoretical analysis and research framework

2.1.1. Theoretical analysis

As renewable biological resources, fishery resources can achieve relative stability through self-regulatory abilities. However, if fishing intensity exceeds the compensatory capacity of population regulation mechanisms, it leads to overfishing and even extinction. Therefore, the economic principles of fishery resources should be dynamically analyzed based on the optimal control theory [22]. The optimal harvesting strategy for fishery resources is shown in Fig. 1. The population number $x(t)$ is controlled by the capture rate $h(t)$, and x^* is the optimal population number. Therefore, if $x(0)$ is at point A and $x > x^*$, the optimal capture rate is the maximum capture rate, h_{max} , which reduces the population size from x to x^* . If $x(0)$ is at point B and $x < x^*$, fishing should be banned at the optimal capture rate of 0, thus increasing the population quantity from x to x^* . Nowadays, currently, owing to perennial overfishing, the population of fishery resources in the Yangtze River is already lower than the optimal population number x^* . Therefore, the Yangtze River must recover its fishery resources through long-term fishing prohibition policies.

However, fishing is an essential source of income for fishermen of the Yangtze River, which have lost their ability to achieve sustainable livelihoods since the ban. From the utility theory perspective [23] (Fig. 2), Z is assumed to be the budget curve and U is the utility curve. Assume that the fishermen' initial utility for point A on the U_0 , now because of the supply of the Yangtze River out of policy, decreases the implementation of the Yangtze River fish product X_1 . As prices rise, the price of other fish products, X_2 , remains the same, and the fishermen' utility level is reduced to point B on U_1 , their quality of life falls sharply, and their livelihood is likely unsustainable. Fishermen must be compensated to reach their former utility levels. CV represents the minimum compensation given to fishermen when they fix their utility levels before the fishing ban. Therefore, reasonable scientific compensation is the key to the normal life of fishermen after they retreat from fishing.

2.1.2. Research framework

Fishermen are highly vulnerable to poverty after retreating from fishing and going ashore. Therefore, this study argues that sustainable livelihoods should be fully considered when formulating compensation standards. Sustainable livelihoods are effective research methods for analyzing the sustainable development of society [24], the environment, and resources. In recent years, scholars have widely used them in poverty alleviation research. It has been found that there are differences in the factors affecting individual livelihoods [25], which are interlinked with livelihood capital, strategies, and livelihoods [26,27]. Thus, we propose different strategies to cope with livelihood risks according to individual preferences [28].

In China, there is no uniform compensation standard for retiring from fishing. A scientific and reasonable compensation mechanism is the core element to ensure smooth implementation of the fishing ban. Therefore, this study improves the traditional sustainable livelihood analysis framework by fully considering the unique characteristics of fishermen groups and forms a livelihood analysis framework as shown in Fig. 3. Factors such as uncontrollable natural disasters, fluctuating fish prices, fragile water ecology, and development capacity constitute vulnerability, leading to changes in the five significant livelihood capitals. Government compensation policies and support, market player participation, and social organization support directly influence willingness to quit fishing and promote no-take policies. The vulnerability of fishermen and the influence of third parties (government, market, and society) require the government to develop a scientific compensation mechanism to promote sustainable livelihoods after withdrawing.

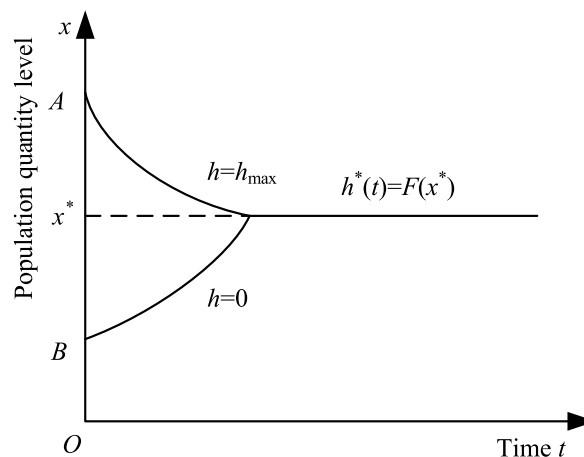


Fig. 1. Maximum harvest strategy of fishery resources.

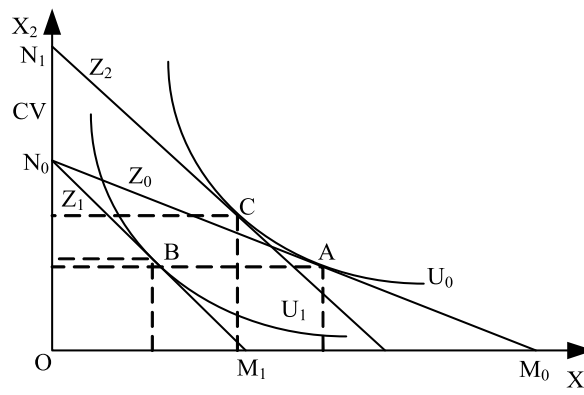


Fig. 2. Changes in fishers' prohibited fishing utility level.

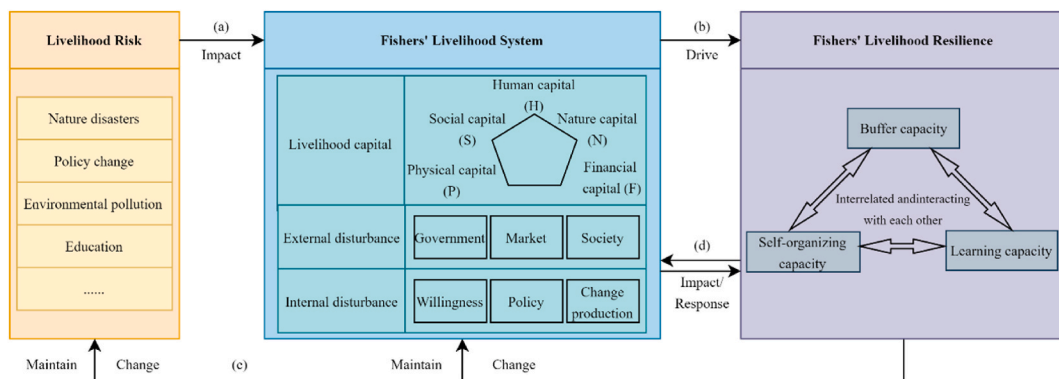


Fig. 3. Schematic diagram of the analysis framework for sustainable livelihoods of retired fishermen.

2.2. Research methods

2.2.1. Calculation of livelihood capital value

Based on the quantitative research of Sharp [29] (2003), You et al. [30] (2017), and Lan et al. [31] (2021) on sustainable livelihood capital, combined with the actual living conditions fishermen in the Jiangsu section of the Yangtze River, five livelihood capitals, namely human (H), natural (N), financial (F), physical (P) and social (S) capitals, were selected as primary indicators. On this basis, ten secondary indicators were selected to construct the index system of the sustainable livelihood capital of fishermen, as shown in Table 2.

The entropy method is an objective weighting method. According to the variation degree of each index, the weight of each index is calculated by information entropy. For the aforementioned target set X consisting of n samples and m evaluation indexes. Firstly, the

Table 2
Fishermen' sustainable livelihood capital index system in the Jiangsu section of the Yangtze River.

Criterion level	Index level	Variable evaluation
Human capital (H)	Number of household labor (H1)	1 = 1; 2 = 2; 3 = 3; 4 = 4; 5 = 5 or more
	Education level (H2)	1 = Cannot read, 2 = primary school, 3 = junior high school, 4 = high school, 5 = college degree or above
Physical capital (P)	House area (P1)	1 = less than 100 m ² ; 2 = 100–200 m ² ; 3 = more than 200 m ²
	Value of living information (P2)	1 = less than 20,000 CNY; 2 = 20,001–50,000 CNY; 3 = 50,001–70,000 CNY; 4 = 70,001–100,000 CNY; 5 = more than 100,001 CNY
Natural capital (N)	Catch (N1)	1 = less than 1 t; 2 = 1–3 t; 3 = 3–5 t; 4 = 5–7 t; 5 = more than 7 t
	Use of water mass (N2)	1 = Rarely; 2 = less; 3 = average; 4 = relatively rich; 5 = very rich
Financial capital (F)	Cash receipts (F1)	1 = less than 5000 CNY; 2 = 5001–6000 CNY; 3 = 6001–7000 CNY; 4 = 7001–8000 CNY; 5 = more than 8001 CNY
	Total bank deposits (F2)	1 = less than 20,000 CNY; 2 = 20,001–40,000 CNY; 3 = 40,001–60,000 CNY; 4 = 60,001–80,000 CNY; 5 = more than 80,001 CNY
Social capital (S)	Friends and family correspondence (S1)	1 = Almost no; 2 = few; 3 = half; 4 = most; 5 = almost all
	Number of large funding needs with resource (S2)	1 = Almost no; 2 = few; 3 = half; 4 = most; 5 = almost all

positive and negative indexes are standardized by Eq. (1). Then, x_{ij} is used to calculate the specific gravity p_{ij} of the j item evaluation index of the i sample (Eq. (2)), information entropy e_{ij} (Eq. (3)), and entropy weight w_{ij} of the i item index (Eq. (4)) [32]. The calculation formula is as follows.

$$x_{ij} = \begin{cases} \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})}, & \text{(The positive indicators)} \\ \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})}, & \text{(The negative indicators)} \end{cases} \tag{1}$$

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^n x_{ij}}, i = 1, \dots, n, j = 1, \dots, m \tag{2}$$

$$e_{ij} = -k \sum_{i=1}^n p_{ij} \ln(p_{ij}), i = 1, 2, \dots, n, j = 1, \dots, m \tag{3}$$

Where, $k = 1/\ln(n) > 0$, and $e_{ij} \geq 0$.

$$w_{ij} = \frac{1 - e_{ij}}{\sum_{j=1}^m (1 - e_{ij})}, i = 1, 2, \dots, n, j = 1, 2, \dots, m \tag{4}$$

According to the results of Zhou et al. [33] and Chang et al. [34], the livelihood capital value, S_i , of fishermen is determined using Eq. (5):

$$S_i = \sum_{j=1}^m w_{ij} x_{ij} \tag{5}$$

2.2.2. Correlation analysis of livelihood capital and intention to return fishing

External factors such as the environment and policy affect willingness to quit fishing. This is closely related to livelihood capital, which is an essential indicator of whether production and life are sustainable. Therefore, this study used a binary logistic regression model to conduct a correlation analysis on willingness to quit fishing and livelihood capital in the Jiangsu section of the Yangtze River [35], as shown in Eq. (6):

$$P = \frac{\exp(\beta_0 + \beta_1 x_1 + \dots + \beta_n x_n)}{1 + \exp(\beta_0 + \beta_1 x_1 + \dots + \beta_n x_n)} \tag{6}$$

where, P is the probability of willingness to quit fishing, β_0 is a constant term, β_n is the regression coefficient of x_n , and \exp is the incremental function of P . When $\beta_n > 0$, the probability of fishermen quit fishing increases with an increase in the variables. In contrast, the probability of fishermen quit fishing decreases.

2.3. Data sources

This study obtained the required data and materials through semi-structured interviews, questionnaire surveys, and data collection

Table 3
Basic situation of survey participants.

Project	Type of project	Number of households(households)	Percentage (%)	Cumulative Percentage (%)
Age of head of household	20–30 years old	9	2.9	2.9
	31–45 years old	36	11.7	14.6
	46–60 years old	150	48.5	63.1
	Aged 60 and above	114	36.9	100
Education level of head of household	No formal education	0	0	0
	Primary school	174	56.3	56.3
	Junior high school	102	33.0	89.3
	High school	24	7.8	97.1
	Junior college or above	9	2.9	100
Number of family members	2 persons and below	0	0	0
	3-4 people	75	24.2	24.2
	5 or more people	234	75.8	75.8
Number of people supported and dependent	0 people	6	1.9	1.9
	1-2 people	135	43.7	45.7
	3 or more people	168	54.4	100

from government departments. To ensure objective, accurate, and comprehensive data, random field visits were conducted in fishing villages in eight cities along the Yangtze River in Jiangsu Province between August and September 2021. At least 30 questionnaires were distributed to each town to ensure reasonable distribution of data samples. Finally, 324 questionnaires were distributed, 309 of which were valid (*The questionnaire is described in Appendix A*). This study has been performed in accordance with the Declaration of Helsinki. Written informed consent for participation was obtained from respondents who participated in the survey.

Other relevant data were obtained through interviews with the Fisheries and Fishery Bureau of the Department of Agriculture and Rural Affairs of Jiangsu Province, relevant departments of each prefecture-level city, the Jiangsu Provincial Statistical Yearbook, and the China Fisheries Statistical Yearbook.

3. Results and discussion

3.1. Descriptive statistical analysis

3.1.1. Demographic statistical analysis

Through the collation and analysis of 309 effective surveys, the demographic statistics of participating fishermen were obtained, as shown in [Table 3](#).

As shown in [Table 3](#), 85.4% of the fishermen interviewed were over 46 years old and 36.9% were over 60 years old, belonging to the retiree age group. From the perspective of the education level, high school or above accounted for only 10.7% of the total sample. Over half of the fishermen had only received primary and secondary level education. Regarding family size, 75.8% have five or more members. Regarding the number of people who needed support, 54.2% of the fishermen needed to support their children and older adults with three or more people. In general, the aging population, low education level, heavy family burden, and other problems also limit the quality of the transition from production to business, which means that if the government does not help fishermen who have quit, they will face unsustainable livelihood problems.

3.1.2. Income and expenditure

Economic income and expenditures are indispensable components of social life. By comparing the difference between income and expenditure in different regions, the economic situation of the fishermen can be understood as a whole. Analysis of the survey data revealed ([Table 4](#)) that the average annual income of fishermen was RMB 110,000. Still, the sample number in the income range of RMB 50,000 or less is the largest at more than one-third, indicating a large gap between the rich and poor. Spending is similar, with fishermen spending RMB 75,000 per year, but over half spend less than RMB 50,000 per year. Before the subsidy, most fishermen could make a basic living through fishing.

3.1.3. Participation in social security

Social security is a system whereby the state or government guarantees the primary livelihood of temporarily or permanently incapacitated citizens who, for various reasons, have difficulties making ends meet. [Table 5](#) shows that the vast majority of the fishermen surveyed have taken out basic medical and pension insurance for urban and rural residents, with a certain degree of risk resistance. However, 18.4% of fishermen have yet to purchase essential medical insurance for urban and rural residents, and 22.3% have yet to buy basic pension insurance. The government should pay particular attention to the livelihood security of these fishermen during the implementation of a fishing ban.

Table 4
Analysis of the income and expenditure of fishermen before the withdrawal.

	Type (RMB)	Number of frequency (N)	Percentage (%)
Income	50,000 and below	120	38.8
	6–100000	72	23.3
	11–150,000	42	13.6
	16–200000	15	4.9
	21–250,000	33	10.7
	26–300000	27	8.7
	More than 300,000	3	1
Spending	50,000 and below 6–100000	168	54.4
	11–150,000	66	21.4
	16–200000	30	9.7
	21–250,000	33	10.7
	26–300000	6	1.9
	More than 300,000	6	1.9

Because of regional differences, the income and expenditures of fishermen vary considerably. The highest payment was RMB 229,400 (Suzhou) and the lowest was RMB 45,900 (Changzhou). The average annual expenditure of fishing and fishery households is RMB 80,300, which varies significantly among the regions. The highest cost was RMB 174,700 (Suzhou), and the lowest was RMB 21,200 (Changzhou). This implies that the livelihood compensation policies for Suzhou and Changzhou should be different.

Table 5
Participation in social security by retired fishermen.

	Category	Number of frequency (N)	Percentage (%)
Whether or not to purchase basic medical insurance for urban and rural residents	Yes	252	81.6
	No	57	18.4
Whether or not to purchase basic urban and rural residents' pension insurance	Yes	240	77.7
	No	69	22.3

3.2. Analysis of willingness to quit fishing

3.2.1. Estimation and analysis of sustainable livelihood capital value of fishermen

According to the calculation results of livelihood capital in Table 6, natural capital (0.3974) is the highest, and the physical mean (0.3589) is close to that of human capital (0.3472). Financial capital (0.2942) was lower than the first three types of livelihood capital, whereas social capital (0.2458) was the lowest.

From the perspective of natural capital, the weight of fishing is the highest at 0.6432. This is because fishing is the primary means of maintaining their basic livelihood, and fishing volume is directly related to the basic income of fishermen. To increase family income and improve the quality of life, fishermen generally choose to increase their fishing volume. Although fishery resources in the Jiangsu section of the Yangtze River are decreasing annually, it can still sustain the primary livelihood of fishermen. Water quality indirectly affects the abundance of fishery resources in these waters, which, in turn, affects the number of fish caught.

Regarding material capital, the proportion of subsistence (0.6723) was higher than that of housing (0.3277). The livelihood of fishermen includes the number of household appliances, furniture, livestock, fishing gear, and others. The amount of fishing gear also affects the amount of fishing, thus affecting income.

From the perspective of human capital, the family labor force (0.5972) plays a dominant role because the larger the family labor force, the more people participate in fishing labor. However, the fishing industry does not have high requirements for education, and the education level of existing fishermen is generally low; therefore, the proportion of human capital is smaller than that of the labor force, which is consistent with the field survey.

From the perspective of financial and social capital, income is mainly from fishing. Because the fishermen's social relations network is minimal when an economic situation occurs, the first thought of the fishermen is to raise excessive money from their friends and family around them rather than to make bank loans. This also conformed with the survey results. As fishermen are older and less educated, they tend to be more conservative. When faced with practical difficulties, they consider using their relationships instead of turning to banks.

3.2.3. Correlation analysis of livelihood capital and fishing withdrawal intention

As listed in Table 7, the sig. values of the five livelihood capitals of the fishermen were all less than 0.05, indicating that the correlation between each livelihood capital and intention to quit fishing was significant. Livelihood capital was also closely related to willingness to stop fishing in terms of the sig. values and human, physical, and social capital are positively correlated with willingness to quit fishing. In contrast, natural and financial capital were negatively connected to willingness to quit fishing. We can also see that the five types of livelihood capital most closely related to the desire to quit are social, financial, physical, human, and natural.

There was a significant positive correlation between social capital and willingness to quit fishing. This is because the higher the social capital of fishermen, the more comprehensive their social network and the more help they have in obtaining information on retreating from fishing and switching to other occupations, which makes fishermen respond positively to the national policy and voluntarily withdraw.

There was a significant positive correlation between material capital and willingness to quit fishing. This is because when the material capital of fishermen is sufficiently high, their life pressure after fishing is much less. Fishermen easily accept the conversion arrangement on a sufficient material basis. Additionally human capital is positively correlated with willingness to quit fishing, which is vital. This is because the higher the human capital of fishermen, the larger the family labor force and the higher the education level of the labor force, which will promote the reemployment of fishermen after fishing and the more diversified the work and income.

Table 6
Fishermen' livelihood capital variables and their estimated values.

Criterion level	Index level	Average value	Standard deviation	Weighting	Generating capital value
Human capital (H)	Number of household labor (H1)	2.765	1.240	0.5972	0.3472
	Education level (H2)	1.324	0.890	0.4028	
Physical capital (P)	House area (P1)	52.909	59.619	0.3277	0.3589
	Value of living information (P2)	5.026	2.650	0.6723	
Natural capital (N)	Catch (N1)	11,800	9806	0.6432	0.3974
	Use of water mass (N2)	0.62	0.77	0.3568	
Financial capital (F)	Cash receipts (F1)	10.983	13.674	0.5846	0.2942
	Total bank deposits (F2)	2.782	3.254	0.4154	
Social capital (S)	Friends and family correspondence (S1)	8.476	6.352	0.4563	0.2458
	Number of large funding needs with resource (S2)	0.826	2.985	0.5437	

Table 7
Analysis of willingness to quit fishing and the livelihood capital of fishermen.

Variables	β	S.E	Wals	df	Sig.	Exp(β)
Human capital	0.632	0.237	5.246	1	0.019	1.476
Natural capital	-0.451	0.171	4.654	1	0.023	0.583
Physical capital	0.697	0.275	7.133	1	0.007	2.228
Financial capital	-0.680	0.226	7.747	1	0.006	0.563
Social capital	0.593	0.208	8.218	1	0.005	1.790
Variables	-1.567	1.133	2.557	1	0.096	0.183

There was a significant negative correlation between financial capital and willingness to quit fishing. This is because when the financial capital of fishermen is low, their fishing income is also low; therefore, they have to find another source of income to encourage them to change their industry. However, when the financial capital of fishermen is high, the income from fishing can maintain their family expenses, which leads to excessive dependence on fisheries and reluctance to quit fishing.

Lastly, there is a significant negative correlation between natural capital and willingness to quit fishing. This is because when fishery resources are scarce, fish caught by fishermen decrease correspondingly. Thus, their incomes will fall, encouraging fishermen to change their production and trade independently. On the other hand, when fishery resources are abundant, fishermen catch more fish, and their income increases, leading to increased dependence on fishing and reluctance to quit fishing.

3.3. Discussion

Ecological compensation policies have been implemented to improve the livelihood capital levels of policy participants [36], thereby narrowing the gap between the rich and poor [37]. Exploring the ecological compensation mechanism for fishermen enables them to survive normally after quitting fishing [18]. Therefore, a compensation mechanism must be developed based on an understanding of the relationship between willingness to quit fishing and the livelihood capital of fishermen. A scientific compensation mechanism must be constructed based on the determination of the compensation content.

As seen from the above analysis, it can be known that older age, low education level, single social network, weak material foundation, and excessive dependence on natural resources are the main problems affecting the sustainable livelihood of fishermen after quitting fishing. A single financial compensation model cannot meet the needs of all fishermen. Therefore, it is necessary to fully consider the livelihood sustainability of fishermen and formulate a scientific compensation model. Living demands and social security are the main factors affecting the sustainable livelihoods of fishermen in the Jiangsu section of the Yangtze River. Based on this, the compensation content can be determined by combining monetary and social security compensations. Monetary compensation includes fishing license recovery and scrap compensation for special production equipment. Social security compensation provides compensation for unemployment benefits, re-employment training, pensions, medical insurance, and education protection for children. The compensation content is shown in Fig. 4.

Implementing the ‘Ten-year Ban on Fishing’ policy has affected the lives of fishermen. In the context of vulnerability, livelihood

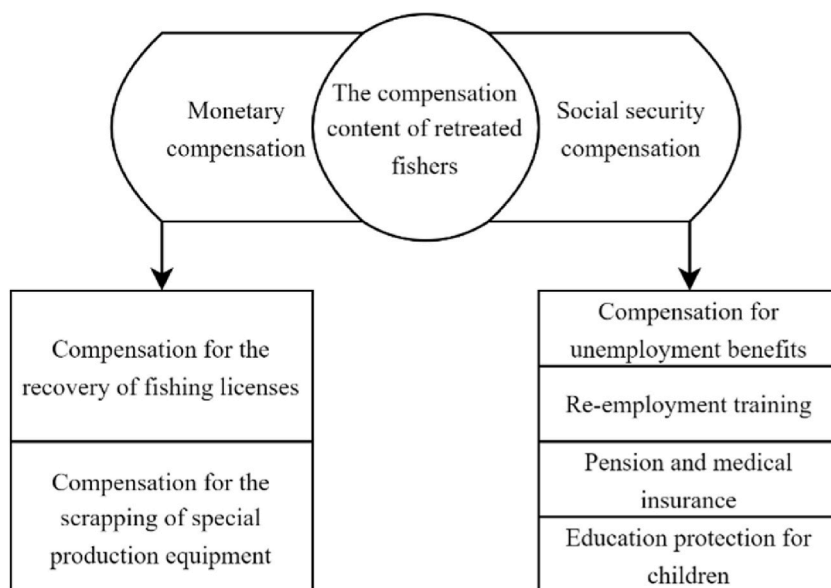


Fig. 4. The compensation content of fishermen in the Jiangsu section of the Yangtze River.

strategies are disrupted, and livelihood capital has to be restructured to ensure sustainability. Firstly, through monetary compensation for the loss of natural, material, and financial capital. Second, the human capital can be improved through social security compensation. Finally, government and community guidance can help enhance the sense of belonging of fishermen and improve their social capital [38]. Owing to the differences among individual fishermen, their needs differ. Therefore, this study proposes a framework for differential compensation according to age group. Monetary compensation is based on the specific losses incurred by fishermen. Social security compensation should include material and non-material security that concerns families and social status. Therefore, this study divided fishermen into three age groups according to the field investigation and age segmentation standards proposed by the United Nations World Health Organization. Young people under the age of 44 are more focused on reemployment and children's education. Therefore, their social security compensation includes reemployment training, children's education, and unemployment insurance. Middle-aged people aged 45–59 pay more attention to pensions and reemployment. Social compensation includes reemployment training, unemployment insurance, and pension insurance. Elderly individuals over 60 years have reached retirement age. Therefore, social security compensation can be paid directly through a monthly pension. The framework of the fishermen's compensation mechanism is illustrated in Fig. 5.

This study's compensation mechanism for fishermen also applies to other provinces and cities in the Yangtze River basin. However, the compensation for fishermen is a dynamic process. The needs of fishermen differ at different stages after quitting fishing [39]. Therefore, this study's research results only apply to the early stage of implementing the 'Ten-year Ban on Fishing' policy (3–5 years). After to 3–5 years of policy implementation, it is necessary to reinvestigate the lives and work of fishermen, grasp their latest needs, and dynamically adjust the compensation focus.

4. Conclusions

Based on the survey data from 309 fishermen in eight cities along the Yangtze River in Jiangsu Province, this study analyzed the relationship between the livelihood capital of fishermen and their willingness to quit fishing using a binary logistic regression model. Based on the theory of sustainable livelihoods, this study explores the construction of a scientific compensation framework for fishermen who retire from fishing. The study found that fishermen could not transfer jobs after quitting fishing because of their older age, low education level, single professional skills, and other problems. The original livelihood capital of retired fishermen has been damaged, resulting in severe problems. Willingness to quit fishing is closely related to livelihood capital. Among them, human, physical, and social capital are positively correlated with willingness to quit fishing. In contrast, natural and financial capital are negatively correlated with willingness to quit fishing. The formulation of the compensation mechanism for fishermen who quit fishing needs to be differentiated into monetary and social security compensation based on age division according to individual differences.

Ethical approval

Human Research Ethics Committee of Hohai University approved this study (No. hhu.20220091).

Author contribution statement

Zheng Wu: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper. Guiliang Tian: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data. Yiwen Li: Analyzed and interpreted the data; Wrote the paper. Qing Xia: Analyzed and interpreted the data.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. XXX

Questionnaire on the implementation of the 'Ten-Year Ban on Fishing' policy

This questionnaire aims to investigate the current life situation of fishermen and the demand for compensation mechanism under a ten-year fishing ban. This questionnaire survey is completely anonymous and will certainly not have any negative impact on your life or work. Thank you for your participation, thank you!

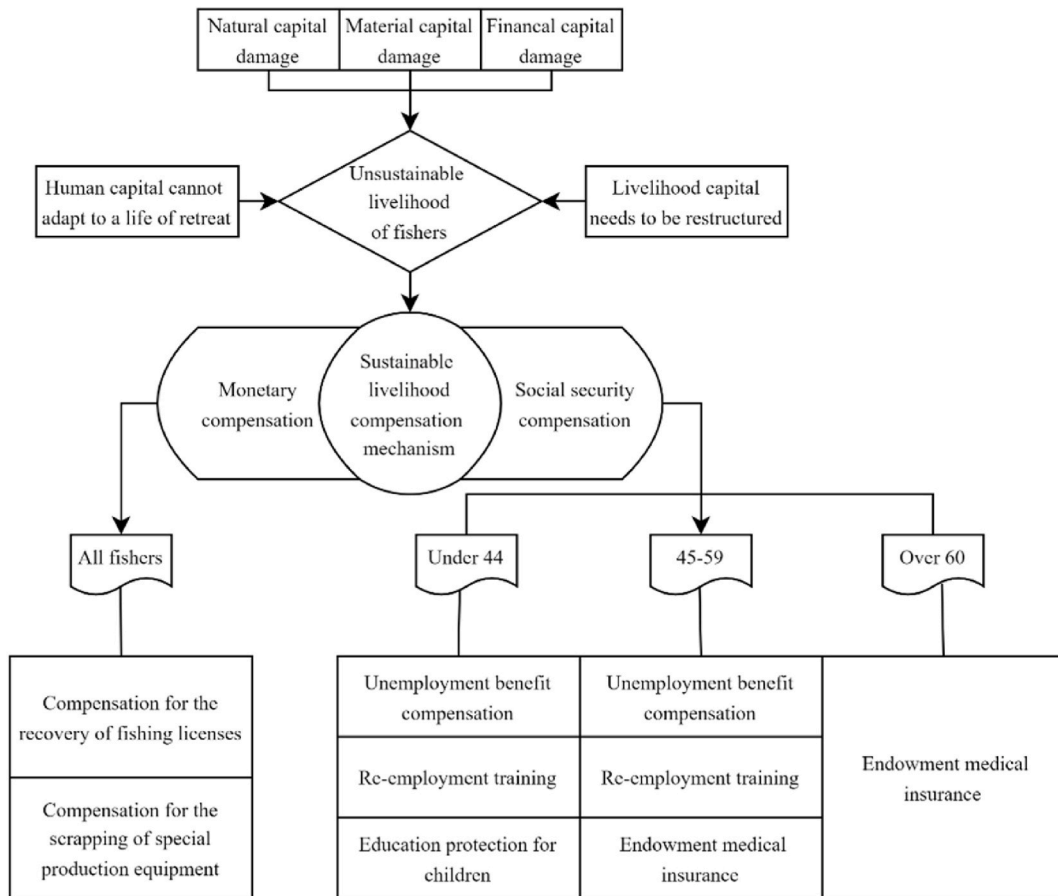


Fig. 5. The compensation mechanism based on sustainable livelihoods of fishermen.

Part 1 **Basic situation of fishermen**

1. What is your age range?
A. 20–30 B. 31–45 C. 46–60 D. Over 60.
2. What is your education level?
A. Primary school education B. Junior high school education.
C. High school education D. Bachelor degree or above.
3. What is the population of your family?
A. 6 B. 5 C. 4 D. 3 E. Others_____
4. What is the number of people you need to support?
A. 5 B. 4 C. 3 D. 2 E. Others.
5. Do you have your own arable land ? If yes, what is the area?
A. Less than 1 acre B. 1–5 acres C. More than 5 acres.
6. Do you have medical insurance?
A. Yes B. No.
7. Do you have endowment insurance?
A. Yes B. No.
8. What was your average annual income while fishing?

9. What is your average annual expenditure while fishing?

Part 2 **Understanding of the return policy**

10. How much do you know about the fishermen’ return policy?
A. I know it very well. B. Yes, but not very well. C. I don’t know.
11. Has the government publicized the policy?

- A. Yes B. No.
12. How satisfied are you with the return policy?
A. Very satisfied. B. Generally satisfied. C. Not satisfied.
13. What are the main factors that affect your satisfaction with the return policy?
A. Subsidies for scrapped ships. B. Preferential school subsidies for fishermen' children.
C. The compensation is small. D. The return policy has not been fully improved. E. Pension, medical insurance compensation is less.
- F. Change of production and industry. G. Others _____
14. How much compensation do you expect?
15. Do you have any other views on the implementation of the no-catch policy?

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