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ARTICLE

Exploring the Determinants of Willingness and Behavioral Actions on Occupation Transition Among Fishermen on the Liaodong Peninsula Coast, China

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ABSTRACT

As marine ecosystems have deteriorated and protective measures have been implemented, marine fishery yields have decreased. The reduced economic returns from fishing activities prompt individuals from coastal communities to seek alternative employment. However, constraints such as limited educational qualifications led many to remain reluctant to leave the marine fishing sector. This research analyzed the influencing factors from four perspectives: household characteristics, working conditions, government and community support, and the natural environment, by a field survey in three coastal cities of Liaoning Province—Dalian, Zhuanghe, and Dandong. Through bivariate probit regression model analysis, the findings showed that 70% of fishermen expressed a willingness to pursue occupational transfers, while only 30% have completed this transition. We found that educational background and working experience have a negative influence on the willingness of fishermen to transition to a new occupation. The fishery community influences both fishermen's willingness and behavior regarding their occupation transition. The use of the internet in marketing has a positive effect on fishermen's willingness to transition. Additionally, mitigation measures are essential in shaping both the willingness and behavior of fishermen during

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occupational transitions. Based on these findings, we propose several recommendations to promote the sustainable development of fishery communities. First, career development training should be provided to fishermen to enhance their adaptability and skill sets, facilitating smoother occupational transitions. Second, it is important to strengthen support systems and foster mutual understanding. Finally, the effectiveness of mitigation measures should be improved to assist fishermen better as they navigate occupational changes.

Keywords: Fishermen Livelihood; Occupation Transition; Willingness and Behavior; Bivariate Probit Model

1. Introduction

The marine environment is essential for human development, providing abundant resources that contribute to long-term sustainability. With advancements in marine development technology and increasing demand, the production of marine fishery products has expanded significantly[1,2]. For instance, in China, from 1978 to 2023, the gross production of fishery captures increased from 4.3 million tonnes to 13.07 million tonnes, reflecting a compound annual growth rate of 2.5% (China Academy of Fishery Sciences, 2023)[3]. However, this growth has led to high exploitation levels of fishing resources. According to a report from the Fishery Machinery and Instrument Research Institute, Chinese Academy of Fishery Sciences, Liaodong Bay historically had 155 fish species, but by 2016, only 92 species remained, representing a 40.6% decrease[4]. The Bohai Sea exemplifies the "fishing down" phenomenon, where larger, high-trophic-level fish are replaced by smaller fish and invertebrates as overall biomass declines[5,6]. The economic implications of overfishing are profound, particularly for coastal communities that rely heavily on marine resources for their livelihoods. The decline in fish stocks not only threatens food security but also disrupts local economies and cultural practices tied to fishing traditions.

As fishermen seek alternative employment due to diminishing catches, many encounter barriers such as limited educational qualifications and a lack of opportunities in other sectors. Cinner[7] examined the readiness of 141 Kenyan fishermen to cease fishing under hypothetical scenarios of declining catch and found that socioeconomic conditions significantly influenced their decisions; specifically, fishermen from poorer households were less likely to exit a severely declining fishery. Islam[8] and Huynh[9] analyzed the vulnerability of fishing livelihoods to climate variability and change. They identified factors such as exposure to floods and cyclones, sensitivity (e.g., dependence on small-scale marine fisheries for livelihoods), and lack of adaptive capacity regarding physical, natural, and financial capital. The socio-demographic characteristics of households—particularly education level, labor force participation, availability of fishing equipment, and social support—played a significant role in shaping the adaptation strategies of the surveyed households.

The infrastructure development and community support also play an essential role in fishermen's daily life. Bodin and Crona[10] investigated the role of social capital and leadership within a rural fishing community. Their study revealed high levels of social capital, as quantified through social network analysis, but a low willingness to report rule-breaking. They also identified that key individuals possessed few connections to financial institutions and important markets. Zheng[11] utilized officially published data to perform a Granger causality test, analyzing the job transfer pathways of fishermen. Their research indicated that non-marine fisheries and part-time industries are primary pathways for marine fishermen transitioning to new occupations, with technological progress in capture fisheries serving as a significant driver. Factors such as continued urbanization, increased part-time employment, and income disparities between fishermen and rural residents hinder this conversion. Interestingly, fishermen's per capita fixed asset investment and income did not significantly impact conversion rates. Fabinyi[12] found that the small-scale fishery industry is facing a decline in fishery resources and an increase in exploitation intensity making it difficult for households to transition into new livelihoods. Only households with more assets can diversify successfully,

while others face heightened vulnerability. Praptiwi [13] argued that tourism development has been promoted as an alternative livelihood to reduce small island communities' dependence on declining marine resources.

As fishery capture yields decline, surplus labor in the fishing sector increasingly seeks alternative employment opportunities, which in turn contributes to a reduction in the number of individuals engaged in fisheries. According to the National Statistical Bulletin on Fishery Economy, the total fishing population decreased from 20.6594 million in 2013 to 15.9857 million in 2023, representing a 22.62% reduction over the decade [14,15]. Similarly, the number of fishery employees declined from 14.4306 million in 2013 to 11.7623 million in 2023, corresponding to an 18.49% decrease [14,15]. Tracking survey data from Li [16,17] indicates that higher local per capita disposable income in rural areas positively influences the transfer of labor out of the fishing sector. Furthermore, income disparities among former fishermen have widened, reflecting increasing heterogeneity in economic outcomes following occupational transition. According to the National Statistical Bulletin on Fishery Economy 2023 [14], the national per capita net income of nearly 10,000 fisherman households reached 25,777.21 yuan, an increase of 4.72% compared to the previous year. In terms of industry output, the value of fishing activities grew by 4.5% year-on-year in 2023, while the output value of the fishery industry and construction sector increased by 7.9%, and the output value of fisheries circulation and service industries rose by 8.98% [14]. Notably, among the three major sectors, fisheries circulation and services contributed the most to the overall increase in fishery value, indicating a significant transformation in the profit structure of the fishing industry.

Effective management strategies are crucial for reversing these trends. Continued efforts are needed to ensure that fisheries can thrive in harmony with marine ecosystems while securing livelihoods for future generations. The Chinese government [18–21] has implemented various regulations to protect fishery resource stocks, reduce the fishing capacity, promote the aquaculture and marine ranching, restructure the subsidy systems to encourage sustainable practices, including a ten-year ban on fishing, restrictions on fishing areas and dates, minimum mesh sizes for fishing gear, and stock enhancement plans. Wu [22] examined the factors influencing fishermen's decisions to quit fishing in Jiangsu Province, China, based on the government's ten-year ban on fishing policy designed to protect biodiversity in the Yangtze River basin. Their results showed that fishermen face severe sustainability issues with their livelihoods after ceasing to fish, with their willingness to quit closely related to five types of livelihood capital. Previous scholars have extensively studied the issue of fishermen's transformation within the production and industry sectors.

Despite a growing body of research on the transformation of fishermen, most studies adopt a macroeconomic perspective, often overlooking the specific characteristics and lived experiences of fishery communities. There is an inadequate amount of first-hand investigation into how natural events (such as typhoons, heatwaves) and the internet influence fishermen's livelihoods and how fishery communities provide support for occupational transitions. Addressing this gap requires integrating regional surveys with broader studies that encompass the entire coastal area.

This study aims to explore the factors that restrict fishermen from taking the necessary steps to transition within the production and industry sectors, as well as to understand how to mobilize those with a high intention of willingness for occupation transition but low action on behavioral transition. Focusing on the Liaodong Peninsula, the analysis considers four key aspects: personal characteristics of fishermen, working conditions and expenditure patterns, infrastructure development, and natural environmental influences. By employing bivariate probit model analysis, this research aims to elucidate the determinants of both the behavior and willingness of local individuals regarding occupational transitions.

2. Hypothesis

From **Figure 1**, this study selected Dalian, Zhuanghe and Dandong in the southeastern coastal area of Liaoning Province as the main survey areas. Among them, Zhuanghe is a county-level city under the jurisdiction of Dalian, located in the southern part of the east side of

the Liaodong Peninsula and the northern shore of the Yellow Sea. Although Zhuanghe is administratively under the jurisdiction of Dalian, it has a certain degree of independence in terms of geography, economy and fishery structure, so it is listed separately as a survey sub-sample. As a sub-provincial city, Dalian has a developed economy and diverse fisheries, representing the urban fishing area along the Liaoning coast. Dandong is in the southeast of Liaoning Province. For this research, we selected Donggang City, a county-level city under Dandong, as the survey site. In 2019, Donggang's total fishery output reached 422,000 tons, with a total output value of 4.433 billion yuan. Of this, marine fishing contributed 112,000 tons (including 90,200 tons from deep-sea fishing), while marine aquaculture accounted for 310,000 tons [23]. The fishery sector represented more than half of the city's total agricultural economy, highlighting its central role in local rural development [23].

Building upon this foundation, the article further explores how the intention to change production and industry influences the behavior of displaced fishermen in Dalian, Zhuanghe, and Dandong. It aims to identify the determinants affecting both the willingness and behavior of these fishermen regarding their transition to alternative livelihoods by utilizing the Theory of Planned Behavior (TPB). To capture the heterogeneity in the transition process, fishermen are classified into four descriptive categories based on their responses: (1) willing to transfer and already done, (2) willing to transfer but not yet, (3) unwilling to transfer but already done, and (4) unwilling to transfer and not yet. These four scenarios are not formulated as statistical null hypotheses; instead, they serve as an analytical framework for examining the alignment and mismatch between intention and behavior, thereby enabling a nuanced exploration of the factors that shape fishermen's livelihood transitions.

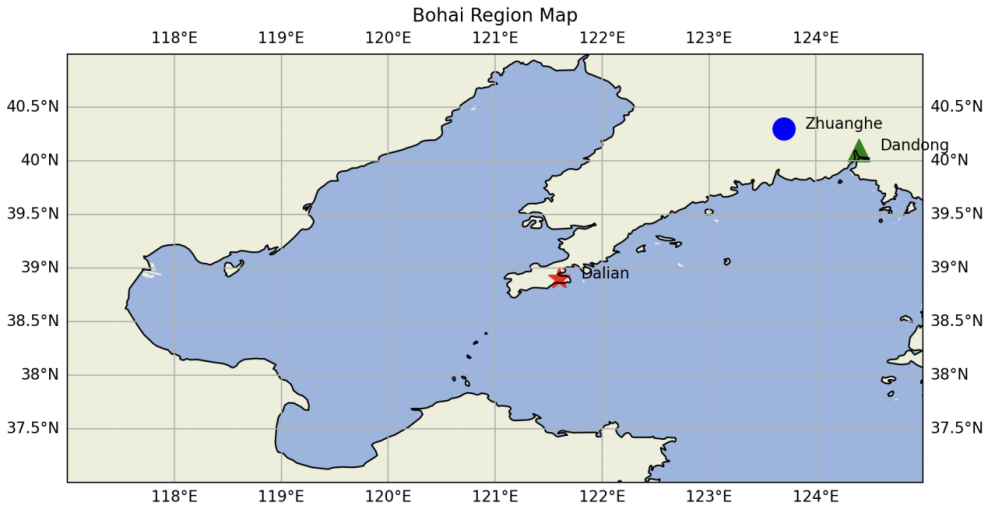

Figure 1. Regional map of the Bohai Sea Area, China.

Note: This figure is based on data from the GEBCO 2024 dataset (https://download.gebco.net/) and created by Python version 3.9.6. The red star represents Dalian city, the blue circle represents the Zhuanghe city, the green triangle represents Dandong city.

H1. *Demographic and personal factors do not significantly predict fishermen's willingness or behavior to transition to alternative occupations.*

H1a. *Age exhibits a positive linear relationship with both willingness and behavior toward occupational transition.*

H1b. *Educational attainment is positively associated with willingness and behavior regarding occupational transitions.*

H1c. *Years of fishing experience negatively correlate with transition willingness and reduce the likelihood of behavioral change.*

H1d. *Better physical health predicts higher transition willingness and an increased odds of actual behavioral shifts.*

H2. *Occupational characteristics significantly influence fishermen's willingness and behavior regarding job transitions.*

H2a. *Ownership of fishing equipment is expected to be negatively associated with the likelihood of occupational transition. Fishermen who own their equipment are hypothesized to have lower odds and a reduced hazard rate of changing occupations compared to those who do not own equipment.*

H2b. *Higher fishery-related expenditures are predicted to be positively associated with the likelihood of occupational transition. Increased expenditures are hypothesized to correspond to higher odds and a higher hazard rate of pursuing alternative employment.*

H2c. *A greater share of household income derived from fisheries is expected to be inversely related to both willingness and actual transition behavior. As the proportion of income from fishing increases, the odds and hazard rate of occupational change are hypothesized to decrease.*

H3. *Social and infrastructural factors significantly influence fishermen's willingness and behavior regarding occupational transitions.*

H3a. *Access to information networks is hypothesized to be positively associated with the likelihood of occupational transition. Fishermen with better access are expected to have higher odds and hazard rates of changing occupations.*

H3b. *Higher quality of local infrastructure is expected to be negatively associated with occupational transition. Better infrastructure is hypothesized to correspond to lower odds and hazard rates of occupational change.*

H3c. *More comprehensive professional collaboration is predicted to be negatively associated with willingness and behavior regarding occupational change. Enhanced social security is hypothesized to reduce the odds and hazard rates of transition.*

H3d. *Better community support or service is expected to be positively associated with occupational transition. A stronger influence from the fishery community increases fishermen's willingness to seek information and make informed choices regarding their occupational transitions.*

H4. *Extreme natural events significantly influence fishermen's willingness and behavior to transition from their current occupations.*

H4a. *The increased frequency of natural incidents is hypothesized to be positively associated with the willingness and behavior to change occupations.*

H4b. *Higher levels of natural disaster subsidies are expected to be negatively associated with occupational transitions.*

H4c. *A greater magnitude of losses from extreme natural events is hypothesized to be positively associated with willingness and behavior to pursue alternative employment.*

The relationship between environmental factors and occupational transitions among fishermen underscores the need for comprehensive policies that address both ecological sustainability and economic resilience. Understanding these dynamics can provide valuable insights for developing strategies that support fishermen in adapting to changing environmental conditions and facilitate their transition to alternative livelihoods.

3. Data Descriptive Analysis and Model

3.1. Descriptive of Willingness and Behavior Transition

Within each research region, we implemented stratified random sampling to ensure representativeness across ecological and economic strata: in Dalian City, Daheishi Subdistrict was selected to represent urbanized coastal communities; in Zhuanghe City, three typical fishing villages—Daliang, Xishagang, and Haiyang—were chosen; and in Dandong City, three border-adjacent villages—Donggang, Xiaosi, and Dayao—were included.

Within each selected village, a systematic sampling strategy was employed at the household level. Specifically, every second household was approached for participation (i.e., 1st, 3rd, and 5th). If a selected household declined to participate, the next immediate household was approached as a replacement. In households with more than one eligible fisher, one respondent was randomly selected using the Kish grid method to avoid se-

lection bias.

All selected participants were invited to participate in the survey by scanning a study-specific QR code, which provided information about the research purpose, informed consent, and direct access to the online questionnaire. Data collection was conducted via a secure online survey platform, which improved both the efficiency and coverage of the process. This field survey was conducted in August and September 2024 in Liaoning Province, China.

According to the Kish formula for sample size calculation (assuming p = 0.5, Z = 1.96, e = 0.05), the minimum required sample was 384 [24]. Ultimately, 555 valid responses were collected, exceeding this threshold and thereby enhancing the statistical power and representativeness of the empirical analysis.

The study examined two key dependent variables: willingness to transition and actual behavior on transition among the three locations. From **Table1**, the distribution of responses for these variables reveals interesting patterns. For willingness to transition, most respondents (69.19%, n = 384) indicated a positive inclination (coded as 1), while 30.81% (n = 171) showed no willingness (coded as 0). In contrast, when it comes to actual behavior transition, the pattern is reversed. Only 30.63% (n = 170) of the respondents reported having made a transition (coded as 1), while the majority, 69.37% (n = 385), had not yet transitioned their behavior (coded as 0). This discrepancy between willingness and actual behavior highlights a potential gap between intention and action in the fishing community's transition process, warranting further investigation into the factors that may facilitate or hinder the translation of willingness into concrete behavioral changes.

Table 1. Distribution of willingness_transition and behavior_transition in Bohai sea coastal area.

	Category	Frequency	Percent	Cumulative Percent
Willingness_Transition	0	171	30.81	30.81
	1	384	69.19	100
Behavior_Transition	0	385	69.37	69.37
	1	170	30.63	100
	Total	555	100	

3.2. Personal Characteristics of Fishermen

The dataset comprises 555 observations covering six key demographic and health-related variables: gender, age group, education, work experience, health status, and frequency of medical check-ups. For gender (nominal variable), 58.6% of the sample are male (n = 325), and 41.4% are female (n = 230). For the age group (ordinal variable), the median is 3 with an interquartile range (IQR) of 2–3, indicating that most respondents fall within the 26–40 years age category. Regarding education, the median is 3 (IQR: 2–4), indicating that most respondents have completed secondary education or hold an associate's degree. For working experience, the median is 2 (IQR: 2–3), indicating that the majority have 2–10 years of work experience. The health status shows a median of 2 (IQR: 1–2), indicating a generally positive self-perception of health among respondents. The frequency of medical checkups has a median of 1 (IQR: 1–2), indicating that most respondents undergo medical checkups once or twice a year.

3.3. Fisherman's Working Characteristics

Regarding the working conditions and income situation of fishermen, this research selected six variables. To highlight the operation of technology, we choose a GPS system and communication devices. Some economic variables, such as fishery income level and the proportion of fishery income in household and fishery budgets for device maintenance. From **Table 2**, the distribution of Occupation type (occ_type, nominal) shows 61.8% full-time, 29.6% part-time, and 8.7% temporary workers, indicating a predominance of full-time or artisanal fishing practices. The adoption rates for GPS systems and communication devices are 34.8% and 33.9%, respectively, indicating that while some fishermen incorporate modern technology, the majority still rely on traditional methods. Fishery income (ordinal): The median category is 3 (IQR: 2–3), suggesting most respondents

have moderate fishery-related income levels. The median Budget allocation (ordinal) is 2 (IQR: 1–3), indicating that budget constraints are common and may limit investment in equipment or technology.

Table 2. Descriptive results of fishermen's personal characteristics, working conditions, social relationship and environmental incidents.

Variable	Category	Definition	Frequency (%)	Median (IQR)
gender	Nominal	1-male; 2-female	Male 325 (58.6%) Female 230 (41.4%)	/
age group	Ordinal	1- 18–25; 2- 26–30; 3- 31–40; 4- 41–50; 5- 51–60; 6- over 61	/	3 (2–3)
education	Ordinal	1-junior high school; 2-Secondary school; 3-associate degree; 4-bachelor's degree; 5-master's degree	/	3 (2–4)
working experience	Ordinal	1-less than one year; 2-2~5 years; 3- 6~10 years; 4-over than 10 years	/	2 (2–3)
health status	Ordinal	1-Excellent; 2-Good; 3-Average; 4-Poor; 5-Very poor	/	2 (1–2)
medical checkup	Ordinal	1-once a year; 2-twice a year; 3-one time over two years; 4-never	/	1 (1–2)
occ type	Nominal	1-full-time; 2-part-time; 3-temporary worker	Full-time 343 (61.8%) Part-time 164 (29.6%) Temporary 48 (8.7%)	/
gps system	Nominal	1-yes; 2-no	No 362 (65.2%) Yes 193 (34.8%)	/
communication devices	Nominal	1-yes; 2-no	No 367 (66.1%) Yes 188 (33.9%)	/
ifishery income	Ordinal	1-Less than 10,000 Yuan; 2-10,000–50,000 Yuan; 3-50,000–100,000 Yuan; 4-Over 100,000 Yuan	/	3 (2–3)
ifishery_income_prop	Ordinal	1- Less than 25%; 2-25–50%;3-51–75%;4-More than 75%	/	3 (2–4)
ibudget allocation	Ordinal	1- Less than 25%; 2-25–50%;3-51–75%;4-More than 75%	/	2 (1–3)
infrastructure service	Ordinal	1-Excellent; 2-Good; 3-Average; 4-Poor; 5-Very poor	/	4 (4–5)
professional coop	Ordinal	1-Very strong and collaborative; 2-Moderately strong and cooperative; 3-Somewhat weak and independent; 4-Very weak and isolated	/	2 (1–2)
community impact	Ordinal	1-Significant impact, providing substantial support and guidance; 2-Moderate impact, providing some support and advice; 3-Minimal impact, with limited support or interaction; 4-No impact, operating independently of community support	/	2 (1–2)
internet marketing	Nominal	1-yes; 2-no	No 175 (31.5%) Yes 380 (68.5%)	/
internet research	Nominal	1-yes; 2-no	No 237 (42.7%) Yes 318 (57.3%)	/
typhoon	Nominal	1-yes; 2-no	Yes 368 (66.3%) No 187 (33.7%)	/
heatwave	Nominal	1-yes; 2-no	Yes 308 (55.5%) No 247 (44.5%)	/
natural events impact	Ordinal	1-Over 30,000 RMB in losses in the past year; 2-Over 50,000 RMB in losses in the past two years; 3-Over 100,000 RMB in losses in the past three years; 4-Uncertain, but the losses were significant; 5-Uncertain, with no noticeable impact	/	2 (2–3)
mitigation measures	Nominal	1-Insurance; 2-Switching to alternative industries; 3-Other	Insurance 375 (67.6%) Switching 154 (27.8%) Other 26 (4.7%)	/

3.4. Social Relationship and Support

In the social relationship and support dimension, this research focused on satisfaction with infrastructure, professional development, cooperation, community influence, and internet usage in the market, such as online stream sales of fishery products and research on fishery diseases and technical issues. The median score of infrastructure service (ordinal) is 4 (IQR: 4–5), indicating that respondents generally perceive local infrastructure as good to excellent. The median of professional cooperation is 2 (IQR: 1–2), reflecting limited professional development opportunities for most respondents. The median of community impact is 2 (IQR: 1–2), suggesting that community support and engagement are perceived as moderate to low. Internet for market accounting: 68.5% of respondents report using the internet for management purposes. Internet for research accounting: 57.3% use the internet for research-related activities.

Overall, these results highlight a generally positive perception of infrastructure among respondents, but indicate significant limitations in professional development and community support. Additionally, while internet access is relatively common, there are disparities in how it is utilized and perceived in terms of need and effectiveness.

3.5. Natural Environmental Incidents

Based on the regional climate and disaster profiles, typhoons—which cause significant economic and health consequences for coastal communities—and heatwaves—which adversely affect agricultural and fishery productivity, particularly under conditions of global warming—were selected as focal hazards, as they represent the most significant threats to local livelihoods and public health [25,26].

According to the descriptive results, 66.3% of respondents have experienced typhoons, while 55.5% have experienced heatwaves. The median of Natural events impact (ordinal) category is 2 (IQR: 2–3), indicating moderate perceived impact from natural disasters. And 67.6% of respondents rely on insurance as their main mitigation strategy, while fewer have adopted alternative measures such as switching industries or other strategies.

3.6. Bivariate Probit Model

We employ a bivariate probit model to analyze the interdependent decisions of job transition willingness (Z_n^W) and actual transition behavior (Z_n^B) among small-scale fishers. The model accounts for both observed determinants and unobserved heterogeneity influencing these correlated choices. The structural equations are as shown in Equations (1) and (2).

$$Z_n^W = \beta_0^W + \beta_h^W X_{h,n} + \beta_i^W X_{i,n} + \beta_j^W X_{j,n} + \beta_k^W X_{k,n} + \varepsilon_n^W$$

$$Y_n^W = \begin{cases} 1, \ if\ Z_n^W > 0\ (Willing\ to\ Transition) \\ 0, \ otherwise\ (Not\ Willing\ to\ Transition) \end{cases} \tag{1}$$

$$Z_n^B = \beta_0^B + \beta_h^B X_{h,n} + \beta_i^B X_{i,n} + \beta_j^B X_{j,n} + \beta_k^B X_{k,n} + \varepsilon_n^B$$

$$Y_n^B = \begin{cases} 1, \ if\ Z_n^B > 0\ (Actually\ Transitioned) \\ 0, \ otherwise\ (Did\ Not\ Transition) \end{cases} \tag{2}$$

Subscript and Superscript Meanings:

Subscript n: Denotes the individual (e.g., the n-th fisherman in the sample).

Subscripts h: Individual characteristics (age, education level, health condition)

Subscripts i: Job status (fishing equipment, fishing income, fishing budget)

Subscripts j: Community support (such as social co-

hesion, mutual aid, shared resources, or emotional support)

Subscripts k: Environmental factors (typhoon, heatwave, natural events impact, mitigation measures)

Superscript W: Refers to "Willingness" (the intention or willingness to transition)

Superscript B: Refers to "Behavior" (the actual transition behavior or outcome)

Error Term (ε): Accounts for all random, unmeasured influences on an individual's decision, ensuring the model acknowledges that not all determinants are observed.

$\mathbf{Z_n^W}$: The latent variable representing the willingness of individual n to transition, determined by a weighted sum of individual characteristics, job status, community support, and environmental factors, plus an error term.

Y_n^W: Observed willingness indicator: 1 if $\mathbf{Z_n^W}$ >0 (willing to transition), 0 otherwise (not willing).

$\mathbf{Z_n^B}$: The latent variable representing the behavior of individual n to transition, determined by a weighted sum of individual characteristics, job status, community support, and environmental factors, plus an error term.

Y_n^B: Observed transition indicator: 1 if $\mathbf{Z_n^B}$ > 0 (actually transitioned), 0 otherwise (did not transition)

4. Results

In this study, we employed a bivariate probit model to analyze the determinants of fishermen's willingness and behavior regarding occupational transitions. The model was estimated by maximum likelihood estimation, yielding a log-likelihood value of -583.40332. The overall model fit was statistically significant [Wald $\chi^2(44, N = 555) = 169.54$, $p < 0.0001$)], indicating that the included variables collectively have strong explanatory power. Key findings include significant negative effects of education level ($\beta = -0.3045$, $p < 0.001$) and GPS system use ($\beta = -0.3652$, $p < 0.05$) on transition willingness, while working experience ($\beta = -0.2696$, $p < 0.01$) and fishery income proportion ($\beta = -0.2383$, $p < 0.01$) significantly influenced transition behavior (**Table 3**).

Interestingly, the correlation between the error terms of Equations (1) and (2) was weak and not statistically significant [$p = -0.0334$, LR test: $\chi^2(1) = 0.156$, $p = 0.693$], suggesting the decision processes for willingness and behavior may be relatively independent. These results provide valuable insights into the factors influencing occupational transition among fishermen, with implications for policy design and implementation in the fisheries sector.

Table 3. Results of Bivariate probit on fishermen's occupation transfer in Liaodong Peninsula coastal area.

Willingness (Behavior)	Coefficient	Std. Err.	*p* > |z|
gender	−0.1520 (−0.1960)	0.1206 (0.1292)	0.207 (0.129)
age_group	−0.1414 (−0.0721)	0.0722 (0.0710)	0.050** (0.309)
education	−.3045 (0.0406)	0.0689 (0.0693)	0.000*** (0.558)
working_experience	−0.0440 (−0.2696)	0.0890 (0.0960)	0.621 (0.005***)
health_status	0.1356 (−0.1209)	0.1355 (0.0984)	0.133 (0.219)
medical_checkup	−0.1639 (−0.1071)	0.0784 (0.0881)	0.037** (0.224)
occ_type	−0.1017 (−0.0770)	0.1235 (0.1235)	0.410 (0.533)
gps_system	−.3652 (.0168)	0.1493 (0.1639)	0.014** (0.918)
communication_devices	0.8616 (−0.2743)	0.1584 (0.1775)	0.586 (0.122)
ifishery_income	−0.1371 (0.1125)	0.0900 (0.0935)	0.128 (0.229)
ifihsery_income_prop	−0.0950 (−0.2559)	0.0719 (0.0744)	0.186 (0.001)
ibudget_allocation	−0.0336 (0.08549)	0.0832 (0.0916)	0.687 (0.351)
infrastructure_service	−0.0429 (0.1119)	0.1024 (0.1069)	0.675 (0.295)
professional_coop	0.0664 (0.0041)	0.0981 (0.0957)	0.499 (0.966)
community_impact	−0.2241 (−0.2405)	0.0981 (0.1022)	0.022** (0.019**)
internet_marketing	0.2993 (−0.1602)	0.1489 (0.1492)	0.044** (0.283)
internet_research	0.0782 (−0.2544)	0.1647 (0.1688)	0.635 (0.132)
typhoon	−0.0351 (−0.1864)	0.1556 (0.1573)	0.821 (0.236)
heatwave	−0.1503 (−0.0010)	0.1237 (0.1319)	0.224 (0.940)
natural_events_impact	−0.0590 (−0.0533)	0.0527 (0.0563)	0.263 (0.344)
mitigation_measures	0.3234 (0.5094)	0.1231 (0.1166)	0.009*** (0.000***)
_cons	3.1223 (1.3726)	0.8475 (0.8658)	0.000*** (0.113)
Log likelihood		−583.4033	
$Wald\chi^2$ (44, N=555)		169.54	
p-value		0.0000	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The bivariate probit model allows us to test for correlation between the unobserved factors influencing willingness and behavior in the occupational transition process. The model estimates a correlation coefficient (rho) of −0.0334 between the error terms of the willingness and behavior equations. However, this correlation is not statistically significant (p = 0.693), suggesting that the unobserved factors affecting willingness to transition and actual transition behavior are not strongly related.

While this finding does not directly measure the effect of willingness on behavior or vice versa, it suggests that separate univariate probit models for willingness and behavior might be appropriate for our analysis. However, the choice between bivariate and univariate models should also consider theoretical foundations and overall model fit. After considering the two conditions, we find the following relationships between the influencing factors and the transition of willingness and behavior.

4.1. Analysis of Fishermen Personnel Information

Table 4 presents the results of the bivariate probit model, examining the factors influencing fishermen's willingness and behavior regarding occupational transition. The coefficients for willingness and behavior of transition are presented alongside their respective marginal effects. Gender shows a negative association with both willingness (−0.1517) and behavior (−0.1968) of transition, although these effects are not statistically significant. While the median of the age group (31–40 years) reflects sample demographics, the negative coefficient (−0.1418) specifically captures accelerated resistance beyond 40 years. However, its effect on transition behavior is not statistically significant. Education level exhibits a strong, significant negative association with willingness to transition (−0.305, p < 0.001), contrary to expectations. Interestingly, it shows a positive, albeit non-significant, relationship with transition behavior (0.0402). Working experience does not significantly affect willingness to transition, but it has a strong negative impact on transition behavior (−0.2699, p < 0.001), indicating that more experienced fishermen are less likely to transition to new occupations. Health status shows positive but non-significant associations with willingness (0.1359) and negative non-significant associations with behavior (−0.1207). Lastly, the frequency of medical checkups has a significant negative effect on willingness to transition (−0.1633, p < 0.1), but its effect on behavior is not statistically significant.

The marginal effects, represented by z-scores, provide additional insight into the relative importance of these factors. Education level (−4.66) and working experience (−2.87) show the strongest marginal effects on willingness and behavior, respectively. These findings suggest a complex interplay between individual characteristics and occupational transition dynamics among fishermen, with notable disparities between factors influencing willingness and those affecting actual transition behavior.

Table 4. Marginal effects from the Bivariate probit model on fishermen's occupation transfer in Liaodong Peninsula coastal area.

	Variables	Willingness of Transition	Behavior of Transition	Margin of Willingness	Margin of Behavior
Fishermen's individual base characteristics	gender	−0.1517	−0.1968	−1.26	−1.53
	age_group	−0.1418*	−0.0730	−1.98	−1.03
	education	−0.305***	0.0402	−4.66	0.58
	working_experience	−0.044	−0.2699***	−0.49	−2.87
	health_status	0.1359	−0.1207	1.51	−1.23
	medical_checkup	−0.1633*	−0.1065	−2.11	−1.21
Fishermen's working conditions	occ_type	−0.1024	−0.0774	−0.83	−0.63
	gps_system	−0.3646*	0.0168	−2.48	0.10
	communication_devices	0.0875	−0.2738	0.55	−1.55
	fishery_income	−0.1363	0.1127	−1.52	1.21
	fishery_income_prop	−0.0910	−0.2387***	−1.29	−3.32
	budget_allocation	−0.0331	0.0864	−0.40	0.95

Table 4. *Cont.*

	Variables	Willingness of Transition	Behavior of Transition	Margin of Willingness	Margin of Behavior
Infrastructure and collaboration	infrastructure_service	−0.0418	0.1116	−0.41	1.05
	professional_coop	0.0687	0.0041	0.7	0.04
	community_impact	−0.2256**	−0.2422**	−2.33	−2.40
	internet_marketing	0.3000*	−0.1600	2.03	−1.08
	internet_research	0.0762	−0.2543	0.46	−1.52
Natural events	typhoon	−0.0343	−0.1886	−0.22	−1.20
	heatwave	−0.1508	−0.0105	−1.22	−0.08
	natural_events_impact	−0.0588	−0.0537	−1.12	−0.95
	mitigation_measures	0.3243***	0.5095***	2.68	4.60

Note: The table reports both univariate marginal effects (columns 3–4) and marginal effects on transition probabilities (columns 5–6) estimated from the bivariate probit model.

4.2. Analysis of Fishermen' Working Situation and Livelihoods

Examining fishermen's working conditions reveals further insights into the factors influencing occupational transitions. The use of GPS systems shows a significant negative association with willingness to transition (-0.3646, $p < 0.1$), suggesting fishermen with access to advanced navigation technology are less inclined to consider career changes. This could be attributed to increased efficiency and potentially higher income resulting from the use of GPS.

The proportion of income derived from fishing operations was collected through a four-category scale: 0%–25%, 25%–50%, 50%–75%, and 75%–100%. The regression results reveal a significant negative association between fishery income dependence and occupational transition behavior ($\beta = -0.2387$, $p < 0.001$), indicating that fishermen with fishery income dependence of ≤ 25% exhibit stronger resistance to transitioning out of the sector. This finding underscores that individuals who rely more heavily on fishing income are more likely to persist in traditional fishing livelihoods, reflecting the economic inertia created by dependence on marine resources.

Other factors, such as occupation type (occ_type), use of communication devices, fishery income (ifishery_income), and budget allocation (ibudget_allocation), do not show statistically significant effects on either willingness or behavior during the transition. However, the direction and magnitude of these coefficients provide valuable context for understanding the complex dynamics of occupational transition among fishermen.

The marginal effects, as indicated by the z-scores, highlight the particular importance of fishery income proportion (-3.32) in influencing transition behavior, and GPS system use (-2.48) in affecting willingness to transition. These results suggest that technological and economic factors play crucial roles in shaping both the attitudes and actions of fishermen regarding occupational transitions.

4.3. Analysis of Fishery Community and Support

Community impact has a significant negative effect on both willingness (-0.2256, $p < 0.05$) and behavior (-0.2422, $p < 0.05$) of transition. This suggests that stronger community ties may discourage fishermen from considering or pursuing occupational changes, possibly due to social pressure or a sense of obligation to maintain traditional ways of life.

Internet marketing demonstrates a significant positive association with willingness to transition (0.3000, $p < 0.05$), indicating that fishermen who engage in online marketing are more likely to consider alternative occupations. This aligns with findings that suggest access to information and market opportunities can influence adaptive capacity.

Infrastructure service and professional cooperation do not show statistically significant effects, but their coefficients suggest potential influences on transition dynamics. The positive coefficient for infrastructure service on behavior (0.1116) suggests that improved infrastructure may facilitate actual transitions, although this effect is not statistically significant.

These findings highlight the complex interplay between social, technological, and community factors in

shaping fishermen's occupational transitions. The results underscore the importance of considering social organization and access to information technologies when designing policies to support adaptive responses in small-scale fisheries that face environmental changes.

4.4. Analysis of Natural Environmental Events

Mitigation measures demonstrate a strong, positive, and highly significant effect on both willingness (0.3243, $p < 0.001$) and behavior (0.5095, $p < 0.001$) of transitioning. This is the most substantial finding in this section, with the largest marginal effects (2.68 for willingness and 4.60 for behavior). It suggests that fishermen who engage in or are aware of mitigation strategies are significantly more likely to consider and actually pursue occupational transitions. This underscores the importance of adaptive capacity and risk management in shaping livelihood decisions.

The direct impacts of natural events, such as typhoons and heatwaves, show negative but non-significant associations with both willingness and behavior towards transition. The negative coefficients might indicate a tendency for fishermen to persist in their current occupation despite environmental challenges, possibly due to a lack of alternatives or a strong occupational identity.

The typhoon variable shows a stronger negative association with transition behavior (-0.1886) compared to willingness (-0.0343), although neither is statistically significant. This suggests that while extreme weather events may not greatly influence willingness to change occupations, they may pose practical barriers to making such transitions.

Heatwaves exhibit a more pronounced negative association with willingness (-0.1508) compared to behavior (-0.0105), suggesting a potential psychological impact on considering occupational changes; however, these effects are not statistically significant.

These findings highlight the complex relationship between environmental stressors, adaptive strategies, and occupational transitions in fishing communities. While direct environmental impacts do not appear to drive transitions significantly, the strong positive effect of mitigation measures suggests that building adaptive capacity and resilience may be crucial in facilitating occupational transitions when necessary.

5. Discussion

The analysis presented in Section 4 demonstrates that the influence of these variables differs between willingness to transition and actual transition behavior, highlighting a clear diversification in determinants. The following discussion will address the factors influencing willingness and those influencing behavioral transition, and will conclude with policy recommendations for government intervention.

5.1. Insights of Willingness Transition

The analysis reveals that age exhibits a negative correlation with the willingness to transition into occupations, which contradicts the initial hypothesis. Importantly, the impact of age on willingness to transition is not necessarily linear. Fishermen's occupational transitions are driven by life-stage factors (e.g., child-rearing burdens peak at 31–40, physical capacity declines post-50) that create non-linear decision boundaries [27,28]. However, this relationship may vary across different types of fisheries and socio-economic contexts [29].

Education shows a similar pattern, displaying a negative correlation with willingness to transition but a positive association with actual transition behavior. This suggests that while higher education may not always translate into greater willingness to change occupations, it does facilitate successful occupational transition once the decision is made [30]. Years of experience in the fishing industry are negatively correlated with both willingness and behavior of transition, indicating that more established fishermen may be less inclined to consider or undertake occupational change [31]. Although the health status does not reach statistical significance, the frequency of medical check-ups is negatively correlated with the willingness to transition. This marginally significant effect implies that health considerations may influence decision-making processes, potentially indicating that fishermen may not accurately assess their health conditions, or that health concerns may paradoxically reinforce their attachment to their current

occupation.

Regarding working conditions, the type of employment (full-time, part-time, or temporary) did not have statistically significant effects on transition willingness or behavior. The utilization of advanced fishing equipment, such as GPS systems and automated sorting devices, was found to influence willingness to transition positively. Although this finding may appear counterintuitive (as access to advanced technology might reinforce commitment to fishing), it can be explained through two possible mechanisms. First, the "resource liberation effect" suggests that advanced technologies improve fishing efficiency, freeing up time for alternative livelihoods[32,33]. Second, technologically equipped fishermen may better anticipate long-term risks (e.g., stock depletion) and proactively plan transitions. This aligns with evidence that agricultural mechanization often precedes livelihood diversification as a risk mitigation strategy[34,35].

Conversely, fishery income has a negative impact on this willingness, suggesting a complex relationship between economic factors and occupational transition tendencies. It is noteworthy that the specific challenges faced by marine fishermen, within the broader context of "three rural" issues, have not received commensurate attention in the literature. Mai[36] posits that many marine fishermen experience multifaceted exclusion—political, economic, cultural, and social—due to their economic disadvantages and relatively small population. This marginalization has intensified over time, positioning them as a particularly vulnerable group in contemporary society. The dearth of social attention to their plight significantly influences fishermen's willingness to transition, underscoring the need for more nuanced policy approaches to address these socio-economic complexities.

From a community and social perspective, the impact of community factors on fishermen's willingness to transition is complex and multifaceted. Recent studies have found that community influence negatively affects fishermen's willingness to pursue occupational transitions, particularly when policy dissemination processes are rigid, top-down, and lack sensitivity to local social dynamics[37,38]. Key obstacles identified include one-dimensional, hierarchical administrative communication that leads to inflexible policy implementation, identity conflicts among village leaders who serve as primary policy disseminators, and a lack of empathy from these disseminators due to class-based differentiation within fishing communities[39]. Interestingly, the increasing prevalence of internet technology among fishermen presents a nuanced picture. While digital platforms facilitate faster and broader dissemination of information, their impact varies across different domains. Empirical evidence suggests that internet use for marketing information absorption and research is positively associated with fishermen's willingness to transition, as broader access to market information and research capabilities encourages consideration of alternative occupations[40]. These findings underscore the importance of both social structure and technological access in shaping the pathways and barriers to occupational transformation in fishing communities.

Regarding natural environmental influences, the listed events do not achieve statistical significance; however, mitigation measures have a positive influence on the willingness for occupational transition. To enhance the effectiveness of rural policy dissemination, it is crucial to prioritize not only the promotion of the policy itself but also to introduce mechanisms for commercial engagement. Developing specific dissemination strategies tailored to local conditions and the unique characteristics of target villages is essential for improving outcomes.

5.2. Dynamics of Behavior Transition

The inconsistency between fishermen's willingness and their actual behavior is attributable to the complex interplay of economic, social, psychological, and policy-related factors. Only when these factors are adequately addressed can willingness be more effectively translated into actual behavior[41–43].

Working experience exhibits a strong negative correlation with the willingness to transmit occupations. This suggests that as fishermen accumulate experience, they may become more entrenched in traditional practices, which can hinder their ability to adopt innovative methods. This finding aligns with Anna[44], who observed that Indonesian fishermen, particularly those

who are self-employed with workers, report higher levels of happiness than non-fishermen. Moreover, fishermen generally maintain an optimistic outlook on life, associating their occupation with positive expectations for future economic changes.

Although fishery income itself is not a significant factor, the proportion of fishery income within total family income has a negative correlation with occupational transition behavior. This relationship implies that economic stability may reduce the urgency for behavioral adaptation; fishermen with higher incomes may feel less compelled to alter established practices. In the long run, income disparities are intimately linked to issues of inequity and poverty, which are central to China's rural revitalization program [45]. For example, the development of eco-tourism and recreational fishery marine ranches illustrates how diversifying fishery income can influence occupational transition choices [46].

The impact of the community plays a role in influencing behavioral transitions. Particularly through internet usage for marketing information and research learning shows a negative influence on occupational transition. Based on these studies [47,48] it is highlighted that traditional fishing communities face significant challenges due to deteriorating natural conditions, leading many fishermen to lose their reliance on the sea for their livelihoods.

Mitigation measures and extreme events, such as typhoons, have a substantial impact on behavioral transitions. Environmental degradation not only threatens economic stability but also triggers social problems and contradictions within fishing communities, creating instability in these social systems.

In summary, the dynamics of behavioral transitions among fishermen are influenced by a complex interplay of personal experience, equipment reliance, economic factors, and external pressures from environmental changes and policy implementation challenges. Addressing these factors holistically is essential for fostering adaptive behaviors and ensuring the sustainability of fishing communities. Future research and policy interventions should consider these multifaceted influences to effectively support fishing communities in adapting to changing circumstances.

5.3. Comparison Between Willingness and Behavior Influence on Fishermen Occupation Transition

A comparative analysis of factors influencing occupational transitions among fishermen reveals distinct patterns in their effects on willingness versus actual behavior. A notable trend reveals that factors that do not significantly influence willingness often have a substantial impact on behavior, suggesting a complementary relationship between these two aspects of occupational transition.

In the realm of personal characteristics, age and education primarily influence the willingness to transition, while working experience significantly affects behavioral transition. This dichotomy underscores the complex interplay between cognitive readiness and the practical implementation of occupational changes.

The analysis further indicates that community impact has marginally significant negative effects on fishermen's willingness and behavior to transition. This finding raises important questions about how community dynamics may create barriers to change. This underscores the necessity for supportive community structures and effective communication strategies to facilitate smooth transitions. Some researchers [49–51] propose several strategies aimed at improving fishermen's satisfaction with their resettlement lives, emphasizing the importance of community construction and cultural promotion. Complementing this perspective, Jiang [52] highlights the pressing challenges faced by coastal fishery resources in Zhoushan, where insufficient resources are unable to sustain commercial fisheries. This situation necessitates urgent action for livelihood fishermen to transition to alternative industries. They advocate for promoting habitat restoration, enhancing ecological forms, and increasing the value of fishery services to accelerate the path toward common prosperity for coastal fishermen.

The analysis of natural environmental events reveals that factors such as typhoons and heat waves do not significantly influence fishermen's willingness to transition. This finding may suggest that fishermen have become desensitized to these events or view them as inherent aspects of their occupational reality. Notably, the

positive association between mitigation strategies and both willingness and behavior transitions suggests that proactive approaches can enhance the adaptive capacity of fishermen. These strategies may include implementing better resource management practices, improving infrastructure, and providing training for alternative fishing methods.

In line with recent literature, it is crucial to recognize that fishermen's perceptions of environmental changes play a significant role in their adaptive responses. Seara[53] emphasizes that understanding the subjective perceptions of fishermen regarding their capacity to adapt is essential for developing effective policies to support resilience in the face of climate change. Furthermore, enhancing adaptive capacity through community engagement and tailored support mechanisms can empower fishermen to respond more effectively to environmental challenges.

In conclusion, while natural environmental events may not directly influence fishermen's willingness to transition, their impact on behavior transitions is significant. The findings highlight the importance of implementing effective mitigation measures to bolster adaptive capacity and ensure the sustainability of fishing communities in an increasingly volatile climate. Addressing the barriers posed by community dynamics and communication methods is crucial for facilitating effective transitions among fishermen. By fostering strong community ties and improving information dissemination, stakeholders can better support fishermen in adapting to changing conditions and enhancing their livelihoods. Future research should focus on developing integrated approaches to address both the willingness and behavioral aspects of occupational transitions in fishing communities.

6. Conclusion

As previously mentioned, this research investigates the determinants of both willingness and actual behavior regarding occupational transition among fishing communities in Liaoning Province. The analysis is structured around four key dimensions. First, individual characteristics of fishermen are considered, including gender, age, educational background, and health status. Second, working conditions are examined, such as the type of current occupation, the impact of fishing equipment, years of work experience, fishery income, the proportion of fishery income in total household income, and the allocation of the fishery budget. Third, aspects of social support are assessed, including satisfaction with current infrastructure, professional cooperation within the fishery community, community impact, and internet usage. Fourth, the effects of natural events are explored, focusing on experiences with typhoons and heatwaves, the perceived impact of these events, and the adoption of mitigation measures.

This comprehensive analysis highlights the complex interplay of factors influencing fishermen's willingness and behavioral transitions in their occupations. Key findings reveal that educational attainment has a counterfactual on willingness and behavior; higher educated individuals tend to express a desire to stay in the fishery field, but in practice, they are more likely to transition to other sectors. Working experience affects actual behavioral change, underscoring the nuanced nature of occupational transitions. Community impact has marginally negative effects on willingness to transition, while impeding adaptive behaviors, emphasizing the need for supportive community structures and effective communication strategies.

Environmental factors have a substantial negative effect on willingness and behavioral adaptation, suggesting potential desensitization to environmental risks among fishermen. There is a need for a more holistic approach to community engagement and information dissemination in fisheries management. As highlighted by recent research, involving local fishing communities in policy-making processes, and recognizing their knowledge as a cornerstone for fisheries management could be crucial in addressing these challenges. Mitigation measures emerge as vital strategies that positively influence both willingness and adaptive behaviors in response to environmental and industry challenges, highlighting the necessity of proactive approaches to enhance adaptive capacity.

Through the above analysis, several policy recommendations can be proposed. Given that community

impact negatively affects both willingness and behavioral transitions, it is important to strengthen community support and engagement by building supportive community networks and organizing regular forums to discuss transition opportunities and challenges. By understanding the multifaceted barriers to transition faced by fishermen, stakeholders can design targeted interventions that promote adaptability and resilience within fishing communities, addressing both cognitive readiness (willingness) and practical implementation (behavior) aspects of occupational transitions such as occupation training activity. Also, efforts should be made to enhance the quality and reach of internet infrastructure in coastal areas to reduce information asymmetry and empower informed decision-making. Regarding age and education, it is negatively associated with the willingness to transition, while work experience is negatively associated with actual transition behavior, policymakers should design targeted interventions that account for these differences. Specifically, vocational training and educational programs should be tailored to different age groups, levels of work experience, and educational backgrounds, for example, by offering flexible adult education subsidies and developing partnerships with local technical schools to ensure that support measures are relevant and effective for diverse segments of the fishing community. As the positive association between mitigation strategies and adaptive transitions, local governments should invest in infrastructure improvements, providing subsidy and fishery insurance, including storm shelters and resilient housing. Finally, policies should be informed by fishermen's perceptions of environmental change and their adaptive capacities to ensure that interventions are both relevant and effective.

Author Contributions

Conceptualization, M.L. and M.Y.; methodology, M.L.; software, M.L. and S.G.; validation, M.L., S.G. and M.Y.; formal analysis, M.L.; investigation, M.L.; writing—original draft preparation, M.L.; writing—review and editing, M.L. and M.Y.; visualization, S.G.; supervision, M.Y.; project administration, M.Y.; funding acquisition, M.Y. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Ethical review and approval were waived for this study because no formal application was submitted to the Institutional Review Board of Tokyo University of Agricultural and Technology. The survey was conducted online, targeting adult participants, and did not collect any personally identifiable or sensitive information. Participants provided informed consent before participating. The research posed minimal risk, but we acknowledge that a formal ethics review was not obtained, and we take full responsibility for maintaining participant confidentiality and ethical standards.

Informed Consent Statement

The online survey included a detailed informed consent statement at the very beginning. All participants were clearly notified of the study's purpose, data confidentiality, and their rights as participants. Participation was entirely voluntary and anonymous, and no personally identifiable information was collected. Consent was implied by the voluntary completion of the questionnaire. No signed or paper consent forms were collected, as is standard practice for anonymous, low-risk online surveys.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to approval by relevant institutional or ethical committees.

Conflicts of Interest

The authors declare no conflicts of interest regarding this manuscript.

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