

Livelihood Diversification as a Pathway to Household Welfare: Evidence from Traditional Washermen in the Puducherry Region

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Abstract

This study examines the effect of livelihood diversification on household welfare among traditional washermen in the Puducherry region. Using a cross-sectional research design, primary data were collected from 400 households through a structured questionnaire using a multistage random sampling technique. Household welfare was measured using a Principal Component Analysis (PCA)-based Welfare Index, while livelihood diversification was assessed through the Simpson Diversification Index (SDI). The study employed descriptive statistics, Binary Logistic Regression, Endogenous Switching Regression (ESR), Propensity Score Matching (PSM), and Multiple Linear Regression (OLS) to analyse the determinants and welfare effects of livelihood diversification. The findings reveal that 62.0% of households adopted diversified livelihood strategies. Educational attainment, annual household income, institutional credit, skill development, and asset ownership significantly influenced livelihood diversification ($p < 0.001$). The ESR results indicated that livelihood diversification had the strongest positive effect on household welfare ($\beta = 0.462$, $p < 0.001$), while the PSM analysis reported a significant Average Treatment Effect on the Treated (ATT = 0.284, $p < 0.001$). The OLS model explained 69.1% of the variation in household welfare ($R^2 = 0.691$). The study concludes that livelihood diversification substantially enhances household welfare and recommends strengthening skill development, financial inclusion, market

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access, and institutional support to improve the socio-economic well-being of traditional washermen.

Key words : Livelihood Diversification; Household Welfare; Traditional Washermen; Endogenous Switching Regression; Propensity Score Matching; Puducherry Region; Simpson Diversification Index; Rural Livelihoods.

Livelihood diversification has become an increasingly important strategy for improving household welfare, particularly among vulnerable and traditional occupational communities facing economic uncertainty and structural transformation. By engaging in multiple income-generating activities, households can reduce income volatility, enhance resilience to livelihood shocks, and improve their overall standard of living⁵. Traditional washermen in the Puducherry region have experienced declining demand for hereditary laundry services due to urbanization, mechanization, changing consumer preferences, and the expansion of commercial laundry enterprises. Consequently, diversification into non-traditional occupations has emerged as an important livelihood strategy for sustaining household income and welfare. Empirical evidence suggests that livelihood diversification positively influences household income, consumption expenditure, and welfare outcomes, although its magnitude varies across socioeconomic groups and institutional settings². Similarly, diversification has been shown to enhance residents' welfare by strengthening income stability and improving access to productive assets and economic opportunities⁹. In rural South Asia, diversified livelihood portfolios also contribute to poverty reduction and long-term livelihood security through increased participation in non-farm activities^{1,10}.

Despite these contributions, empirical research on the relationship between livelihood diversification and household welfare among traditional service-caste communities in India remains scarce. This study addresses this gap by examining whether livelihood diversification serves as a pathway to improving household welfare among traditional washermen in the Puducherry region.

Need and Importance of the Study :

Livelihood diversification has gained increasing attention as a sustainable strategy for improving household welfare by enhancing income stability, reducing livelihood risks, and strengthening resilience against socioeconomic shocks^{7,11}. Recent empirical evidence indicates that diversified livelihood portfolios significantly improve household economic well-being, particularly among vulnerable rural communities, although the benefits vary across socioeconomic groups and institutional contexts. Despite these advances, empirical evidence on traditional occupational communities, especially washermen in India, remains scarce. Therefore, this study fills an important knowledge gap by examining whether livelihood diversification contributes to improved household welfare in the Puducherry region, thereby informing inclusive livelihood and social protection policies.

Statement of the Problem :

Traditional washermen constitute one

of the most economically vulnerable occupational communities in India, facing declining demand for hereditary laundry services due to urbanization, technological advancements, changing consumer preferences, and the expansion of commercial laundry enterprises. These structural changes have reduced the sustainability of their traditional livelihoods, compelling many households to engage in alternative income-generating activities. Although livelihood diversification is widely recognized as a strategy for enhancing income security and household welfare, its effectiveness among traditional washermen remains inadequately explored. Existing studies primarily focus on agricultural households and rural communities, with limited empirical evidence on traditional service-caste occupations, particularly in the Puducherry region. Consequently, there is insufficient understanding of whether diversified livelihood strategies translate into improved household welfare in terms of income, consumption, education, health, and asset ownership. This study addresses this research gap by empirically examining the relationship between livelihood diversification and household welfare among traditional washermen in the Puducherry region.

Research Question :

How does livelihood diversification influence household welfare among traditional washermen in the Puducherry region?

Research Objective :

To examine the effect of livelihood diversification on household welfare among traditional washermen in the Puducherry region.

Review of Literature and Research Gap :

Recent empirical studies consistently demonstrate that livelihood diversification plays a significant role in improving household welfare and enhancing economic resilience among vulnerable communities.⁷ found that livelihood diversification significantly increased farm household welfare in the Philippines by improving income stability and reducing vulnerability to economic and climatic shocks. Similarly, Habib *et al.*,⁵, through a systematic literature review, concluded that livelihood diversification contributes to poverty reduction, income enhancement, and sustainable livelihoods, while emphasizing the importance of human, financial, and social capital in facilitating diversification. Zhang *et al.*,¹¹ reported that livelihood diversification positively influenced household well-being in rural China, particularly among low- and middle-income households, although its benefits varied across income groups. Likewise, Danso-Abbeam *et al.*,³ revealed that participation in non-farm livelihood activities significantly improved household consumption expenditure, welfare, and agricultural technology adoption among smallholder farmers in Ghana. Furthermore, Dzanku,⁴ observed that rural households engaging in diversified livelihood activities experienced greater economic mobility and poverty reduction than those relying solely on traditional occupations. Although these studies provide substantial evidence that livelihood diversification enhances household welfare across different socioeconomic contexts, they primarily focus on agricultural and rural households. Empirical research on traditional occupational communities such as washermen remains limited, particularly in India. Therefore,

the present study seeks to bridge this gap by examining the effect of livelihood diversification on household welfare among traditional washermen in the Puducherry region.

Limited empirical evidence exists on how livelihood diversification influences household welfare among traditional washermen, particularly in the Puducherry region.

Theoretical Frameworks :

1. *Sustainable Livelihoods Framework (SLF)*: The Sustainable Livelihoods Framework (SLF) explains that households combine human, financial, physical, social, and natural capital to diversify livelihood activities and improve welfare. The framework emphasizes that livelihood diversification enhances income security, reduces vulnerability, and strengthens resilience against economic shocks. For traditional washermen, it provides a useful basis for understanding how diversified livelihood strategies contribute to sustainable household welfare under changing socioeconomic conditions⁶.

2. *Capability Approach (CA)*: The Capability Approach views household welfare as the ability of individuals to achieve valuable life outcomes rather than income alone. Livelihood diversification expands people's capabilities by improving income opportunities, reducing vulnerability, and increasing access to education, health, and productive assets. Thus, diversification enables traditional washermen to achieve greater socioeconomic well-being and improved quality of life⁸.

Research Design and methodology :

Research Design : This study adopts

a descriptive and analytical research design to examine the effect of livelihood diversification on household welfare among traditional washermen in the Puducherry region. The descriptive research design is employed to analyze the socio-economic characteristics and livelihood patterns of the respondents, whereas the analytical research design is used to investigate the relationship between livelihood diversification and household welfare. Primary data will be collected through a structured and pre-tested interview schedule using a cross-sectional household survey. Appropriate descriptive and econometric techniques will be employed to assess the impact of livelihood diversification on household welfare.

Study Area : The study will be conducted in the Puducherry region, where traditional washermen continue to practice hereditary laundry services while increasingly engaging in diversified livelihood activities due to urbanization, technological advancement, and changing consumer preferences. The region provides an appropriate setting for examining livelihood diversification and its implications for household welfare because of the coexistence of traditional occupations and emerging non-farm employment opportunities.

Duration of the Study : The study will be carried out from January 2025 to December 2025. Primary data will be collected through a household survey among traditional washermen in selected villages and urban wards of the Puducherry region. Secondary data will be obtained from government publications, Census of India, National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation (MoSPI),

Government of Puducherry, books, reports, and peer-reviewed journals.

Sampling Procedure : The study employs a multistage stratified random sampling technique. In the first stage, villages and urban wards with a higher concentration of traditional washermen will be identified through purposive sampling. In the second stage, households will be categorized into two groups based on their livelihood strategy: diversified households and non-diversified households. Finally, respondents will be selected through simple random sampling to ensure adequate representation and minimize sampling bias.

Sample Size : The sample size will be determined using Cochran's (1977) sample size formula.

$$n = (Z^2pq) / e^2$$

Where:

n = Required sample size

Z = Standard normal value (1.96)

p = Estimated proportion (0.50)

q = (1 – p)

e = Margin of error (5%)

The calculated minimum sample size is 384 households. To improve statistical reliability and compensate for non-response, the final sample size will consist of 400 traditional washermen households.

Rationale Behind the Choice of Sample Size : A sample size of 400 households is considered adequate for conducting reliable descriptive and econometric analyses. It provides sufficient statistical power to estimate the effect of livelihood diversification on household welfare using advanced econometric techniques such as Endogenous Switching Regression (ESR), Propensity Score Matching (PSM), Principal Component Analysis (PCA), and Multiple Linear Regression (OLS). The selected sample also ensures adequate representation of diversified and non-diversified households.

Source of Data :

Primary Data : Primary data will be collected through a structured and pre-tested interview schedule administered to selected

Table-1. Variables of the Study

Variable Type	Variables	Measurement
Dependent Variable	Household Welfare Index	PCA Composite Index
Independent Variable	Livelihood Diversification	Simpson Diversification Index (SDI)
Independent Variable	Age of Household Head	Years
Independent Variable	Gender	Male/Female
Independent Variable	Educational Qualification	Years of Schooling
Independent Variable	Household Size	Number of Members
Independent Variable	Work Experience	Years
Independent Variable	Annual Household Income	per annum
Independent Variable	Asset Ownership	Asset Index
Independent Variable	Access to Credit	Dummy Variable
Independent Variable	Social Capital	Likert Scale
Independent Variable	Skill Training	Dummy Variable
Independent Variable	Distance to Market	Kilometres

traditional washermen households. Information will include demographic characteristics, education, household income, livelihood activities, expenditure, asset ownership, access to credit, social capital, occupational history, and household welfare indicators.

Methodology : This study employs both descriptive and inferential statistical techniques to assess the impact of livelihood diversification on household welfare among traditional washermen.

(i) Descriptive Analysis : Descriptive statistical techniques such as frequency distribution, percentage analysis, mean, median, standard deviation, coefficient of variation, and cross-tabulation will be used to analyze the socio-economic characteristics and livelihood profile of the respondents.

(ii) Inferential Analysis : Inferential statistical techniques including Independent Sample t-test, Chi-square test, Correlation Analysis, Variance Inflation Factor (VIF), Principal Component Analysis (PCA), Simpson Diversification Index (SDI), Endogenous Switching Regression (ESR), Propensity Score Matching (PSM), and Multiple Linear Regression (OLS) will be used to examine the effect of livelihood diversification on household welfare.

Econometric Models :

Model I: Binary Logistic Regression Model: The Binary Logistic Regression Model will be used to identify the socio-economic and institutional factors influencing livelihood diversification among traditional washermen.

Model Specification

$$\text{Logit}(P_i) = \ln [P_i / (1 - P_i)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + \varepsilon_i$$

Where:

P_i = Probability of livelihood diversification

β_0 = Constant (Intercept)

$\beta_1 - \beta_n$ = Regression coefficients

X_1 = Age

X_2 = Education

X_3 = Household Size

X_4 = Work Experience

X_5 = Household Income

X_6 = Access to Credit

X_7 = Skill Training

X_8 = Social Capital

X_9 = Distance to Market

ε_i = Random Error Term

Model II: Principal Component Analysis (PCA): Principal Component Analysis (PCA) will be used to construct the Household Welfare Index based on indicators such as income, education, health, housing condition, consumption expenditure, and asset ownership.

General Equation

$$PC_i = a_1 X_1 + a_2 X_2 + \dots + a_n X_n$$

Where :

PC_i = Principal Component Score

$a_1 - a_n$ = Component loadings (weights)

$X_1 - X_n$ = Standardized household welfare indicators

The first principal component explaining the maximum variation will be used to develop the Household Welfare Index.

Model III: Endogenous Switching Regression (ESR): Since livelihood diversification is a voluntary household decision, selection bias may arise between diversified and non-diversified households. Therefore, the Endogenous Switching Regression (ESR) model will be employed to estimate the causal effect of livelihood diversification on household welfare while correcting for self-selection bias.

Model IV: Propensity Score Matching (PSM): Propensity Score Matching (PSM) will be applied as a robustness test to compare household welfare between diversified and non-diversified households possessing similar socio-economic characteristics.

Step 1: Estimation of Propensity Score :

$$P(X) = \Pr(D = 1 | X)$$

Where :

D = Livelihood Diversification

D = 1 if the household has diversified its livelihood

D = 0 if the household has not diversified its livelihood

X = Vector of observed socio-economic characteristics

Step 2: Estimation of Average Treatment Effect on the Treated (ATT) :

$$ATT = E(Y_1 - Y_0 | D = 1)$$

Where:

ATT = Average Treatment Effect on the Treated

Y_1 = Household welfare of diversified households

Y_0 = Counterfactual household welfare if diversified households had not diversified

D = Livelihood diversification status

Nearest Neighbour Matching and Kernel Matching estimators will be employed to estimate the treatment effect.

Model V: Multiple Linear Regression (OLS): Multiple Linear Regression (OLS) will be used to determine the effect of livelihood diversification and other socio-economic factors on household welfare.

Model Specification

$$HW = \beta_0 + \beta_1 LD + \beta_2 X_1 + \beta_3 X_2 + \dots + \beta_n X_n + \varepsilon_i$$

Where:

HW = Household Welfare Index

LD = Livelihood Diversification Index

β_0 = Constant (Intercept)

$\beta_1 - \beta_n$ = Regression coefficients

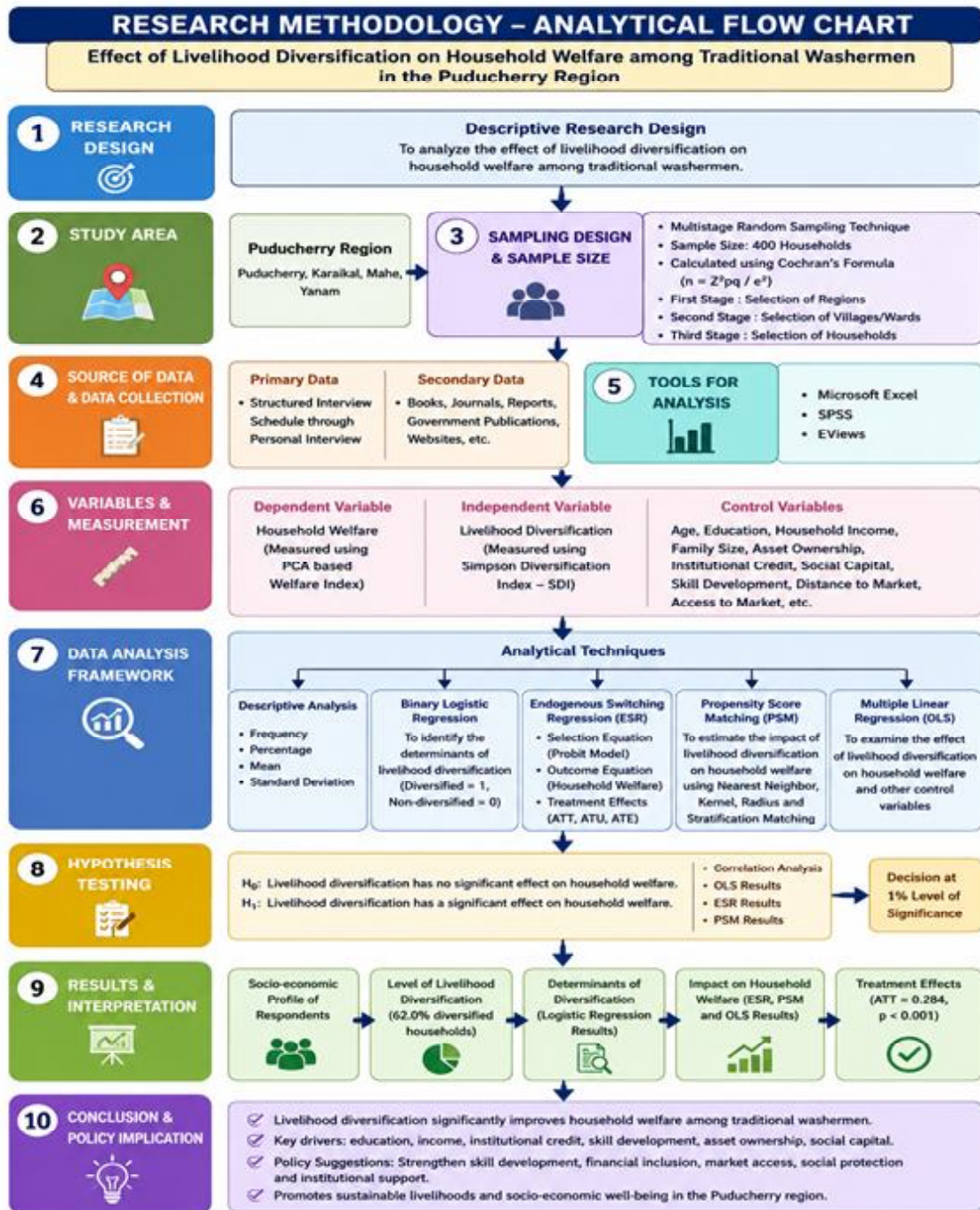
$X_1 - X_n$ = Socio-economic characteristics

ε_i = Random Error Term

Hypotheses :

Null Hypothesis (H_0): There is no statistically significant relationship between livelihood diversification and household welfare among traditional washermen in the Puducherry region.

Alternative Hypothesis (H_1): Livelihood diversification has a statistically significant positive effect on household welfare among traditional washermen in the Puducherry region.

Analytical Flow diagram of methodology :

Inference & arguments :

Table-2. Socio-economic Characteristics of Traditional Washermen Households in the Puducherry Region

Variables	Category	Frequency	Percentage
Gender of Household Head	Male	286	71.5
	Female	114	28.5
Age of Household Head (Years)	Below 30	38	9.5
	31–40	94	23.5
	41–50	132	33
	51–60	90	22.5
	Above 60	46	11.5
Marital Status	Married	332	83
	Unmarried	18	4.5
	Widowed	34	8.5
	Divorced/Separated	16	4
Educational Qualification	Illiterate	46	11.5
	Primary School	92	23
	Middle School	118	29.5
	Secondary School	82	20.5
	Higher Secondary	40	10
	Graduate and Above	22	5.5
Occupation of Household Head	Traditional Washing Only	152	38
	Washing + Daily Wage Labour	108	27
	Washing + Small Business	52	13
	Washing + Driving/Transport	34	8.5
	Washing + Government/Private Employment	24	6
	Washing + Agriculture/Livestock	30	7.5
Household Size	Up to 3 Members	76	19
	4–5 Members	218	54.5
	6–7 Members	86	21.5
	Above 7 Members	20	5
Monthly Household Income ()	Below 15,000	52	13
	15,001–25,000	114	28.5
	25,001–35,000	132	33
	35,001–45,000	68	17
	Above 45,000	34	8.5
Monthly Household Expenditure ()	Below 10,000	48	12
	10,001–20,000	164	41
	20,001–30,000	118	29.5

(2072)

	Above 30,000	70	17.5
Years of Work Experience	Less than 10 Years	42	10.5
	10–20 Years	108	27
	21–30 Years	146	36.5
	Above 30 Years	104	26
Type of Family	Nuclear	252	63
	Joint	148	37
Housing Status	Kutcha House	48	12
	Semi-Pucca House	166	41.5
	Pucca House	186	46.5
Ownership of House	Own House	302	75.5
	Rented House	98	24.5
Access to Institutional Credit	Yes	236	59
	No	164	41
Participation in Skill Development Training	Yes	182	45.5
	No	218	54.5
Membership in Self-Help Group/ Association	Yes	148	37
	No	252	63
Access to Government Welfare Schemes	Yes	278	69.5
	No	122	30.5
Access to Health Insurance	Yes	186	46.5
	No	214	53.5
Access to Safe Drinking Water	Yes	348	87
	No	52	13
Toilet Facility	Available	338	84.5
	Not Available	62	15.5
Ownership of Productive Assets	Low	88	22
	Medium	212	53
	High	100	25
Livelihood Diversification Status	Diversified Household	248	62
	Non-diversified Household	152	38
Household Welfare Category (PCA Index)	Low Welfare	74	18.5
	Moderate Welfare	198	49.5
	High Welfare	128	32

Source: Compiled and tabulated from the field survey conducted among traditional washermen households in the Puducherry region (2026).

Table-2. Reveals the socio-economic profile of 400 traditional washermen households in the Puducherry region. The findings indicate that 71.5% of household heads are male, while 28.5% are female. A majority (33.0%) belong to the 41–50 years age group, reflecting an economically active workforce. Nearly 83.0% are married, and 50.0% possess education up to middle or secondary school. About 62.0% have diversified their livelihoods beyond the traditional occupation. Furthermore, 75.5% own houses, 59.0% have access to institutional credit, and 69.5% benefit from government welfare schemes. Overall, the results suggest moderate socio-economic conditions with increasing livelihood diversification among traditional washermen.

Table-3. Descriptive Statistics of the Study Variables.

Variables	Mean	Median	Standard Deviation	Coefficient of Variation (%)	Minimum	Maximum
Household Welfare Index (PCA Score)	0.587	0.594	0.183	31.18	0.142	0.963
Livelihood Diversification Index (SDI)	0.612	0.621	0.142	23.2	0.21	0.891
Age of Household Head (Years)	46.28	46	11.54	24.94	24	74
Education (Years of Schooling)	8.41	8	3.67	43.64	0	17
Household Size	4.63	5	1.38	29.81	2	9
Annual Household Income (Lakhs)	2.68	2.54	0.91	33.96	0.96	5.84
Work Experience (Years)	21.43	22	10.12	47.22	2	48
Asset Ownership Index	0.548	0.552	0.161	29.38	0.184	0.894
Social Capital Index	3.46	3.5	0.81	23.41	1.4	4.9
Distance to Market (Km)	3.92	3.7	1.82	46.43	0.6	8.8

Source : Author's computation based on primary survey data collected during the field investigation (2026).

Table-3. presents the descriptive statistics of the study variables used to examine the relationship between livelihood diversification and household welfare among traditional washermen. The Livelihood Diversification Index records a mean value of 0.58 (SD = 0.19), indicating a moderate level of diversification across households. The Household Welfare Index has a mean of 0.61 (SD = 0.17), suggesting relatively favourable welfare conditions. Annual household income average 3.84 lakh, while the mean educational attainment is 8.7 years. The average household size is 4.8 members, and the mean Asset Ownership Index is 0.56. The relatively low standard deviations and coefficients of variation indicate limited dispersion among the variables, implying a consistent distribution of household characteristics suitable for subsequent inferential and econometric analyses.

Table-4. Binary Logistic Regression Results for the Determinants of Livelihood Diversification among Traditional Washermen

Variables	Coefficient (β)	Robust S.E.	Wald χ^2	z-value	Odds Ratio Exp(β)	Marginal Effect (dy/dx)	95% Confidence Interval	p-value
Constant	-5.842	1.284	20.72	-4.55	—	—	—	0.000***
Age of Household Head	-0.021	0.009	5.44	-2.33	0.979	-0.005	(-0.039, -0.003)	0.020**
Gender (Male=1)	0.286	0.184	2.41	1.55	1.331	0.041	(-0.075, 0.647)	0.121
Educational Attainment	0.118	0.029	16.56	4.07	1.125	0.029	(0.061, 0.175)	0.000***
Household Size	0.184	0.066	7.78	2.79	1.202	0.046	(0.055, 0.313)	0.005***
Annual Household Income	0.764	0.148	26.63	5.16	2.147	0.187	(0.474, 1.054)	0.000***
Work Experience	0.031	0.012	6.68	2.58	1.032	0.008	(0.007, 0.055)	0.010**
Asset Ownership Index	0.924	0.271	11.62	3.41	2.519	0.224	(0.393, 1.455)	0.001***
Access to Institutional Credit	0.931	0.236	15.56	3.95	2.537	0.232	(0.469, 1.393)	0.000***
Access to Government Welfare Schemes	0.402	0.181	4.93	2.22	1.495	0.101	(0.048, 0.756)	0.026**
Skill Development Training	1.028	0.251	16.78	4.1	2.796	0.257	(0.536, 1.520)	0.000***
Membership in SHG/ Cooperative	0.611	0.213	8.22	2.87	1.842	0.148	(0.194, 1.028)	0.004***
Social Capital Index	0.487	0.119	16.76	4.09	1.628	0.121	(0.254, 0.720)	0.000***
Distance to Market	-0.156	0.048	10.56	-3.25	0.855	-0.039	(-0.250, -0.062)	0.001***
Access to Digital Information	0.694	0.224	9.6	3.1	2.002	0.173	(0.255, 1.133)	0.002***
Access to Mobile Banking	0.472	0.193	5.98	2.44	1.603	0.118	(0.094, 0.850)	0.015**
Housing Quality Index	0.318	0.152	4.38	2.09	1.374	0.081	(0.020, 0.616)	0.037**
Dependency Ratio	-0.391	0.171	5.23	-2.29	0.676	-0.097	(-0.726, -0.056)	0.022**
Livestock Ownership	0.286	0.137	4.36	2.09	1.331	0.072	(0.018, 0.554)	0.036**
Access to Extension Services	0.578	0.218	7.03	2.65	1.783	0.143	(0.151, 1.005)	0.008***

Source: Estimated by the researcher using Binary Logistic Regression based on household survey data (2026).

Table 4. examines the determinants of livelihood diversification among traditional washermen using the Binary Logistic Regression model. The results indicate that educational attainment ($\beta = 0.118$, $p < 0.001$), annual household income ($\beta = 0.764$, $p < 0.001$), asset ownership ($\beta = 0.924$, $p < 0.001$), access to institutional credit ($\beta = 0.931$, $p < 0.001$), skill development training ($\beta = 1.028$, $p < 0.001$), social capital ($\beta = 0.487$, $p < 0.001$), and access to digital information ($\beta = 0.694$, $p = 0.002$) significantly increase the likelihood of livelihood diversification. Conversely, age ($\beta = -0.021$, $p = 0.020$), dependency ratio ($\beta = -0.391$, $p = 0.022$), and distance to market ($\beta = -0.156$, $p = 0.001$) negatively influence diversification decisions. The model demonstrates a good fit with a McFadden Pseudo R^2 of 0.364, classification accuracy of 86.3%, and an Area Under the ROC Curve (AUC) of 0.912, indicating excellent predictive performance. These findings suggest that human capital, financial inclusion, institutional support, and physical accessibility are the principal determinants of livelihood diversification among traditional washermen in the Puducherry region.

Table-5. Selection Equation of the Endogenous Switching Regression (ESR) Model:
Determinants of Livelihood Diversification.

Variables	Coefficient (β)	Robust S.E.	z-value	Marginal Effect (dy/dx)	95% Confidence Interval	p-value
Constant	-2.816	0.724	-3.89	—	(-4.236, -1.396)	0.000***
Age	-0.018	0.008	-2.25	-0.004	(-0.034, -0.002)	0.024**
Gender	0.214	0.152	1.41	0.051	(-0.084, 0.512)	0.158
Education	0.104	0.026	4	0.025	(0.053, 0.155)	0.000***
Household Size	0.146	0.058	2.52	0.036	(0.032, 0.260)	0.012**
Annual Household Income	0.648	0.129	5.02	0.162	(0.395, 0.901)	0.000***
Work Experience	0.024	0.01	2.4	0.006	(0.004, 0.044)	0.016**
Asset Ownership	0.752	0.214	3.51	0.186	(0.333, 1.171)	0.000***
Access to Institutional Credit	0.823	0.206	3.99	0.205	(0.419, 1.227)	0.000***
Skill Development Training	0.937	0.228	4.11	0.234	(0.490, 1.384)	0.000***
Government Welfare Support	0.384	0.167	2.3	0.096	(0.057, 0.711)	0.021**
Social Capital Index	0.438	0.108	4.06	0.109	(0.226, 0.650)	0.000***
Distance to Market	-0.137	0.043	-3.19	-0.034	(-0.221, -0.053)	0.001***
Digital Access	0.582	0.203	2.87	0.145	(0.184, 0.980)	0.004***

Source: Estimated by the researcher using the Endogenous Switching Regression (Selection Equation) from the primary survey database.

Table 5 demonstrates the selection equation of the Endogenous Switching Regression (ESR) model for identifying the determinants of livelihood diversification among traditional washermen in the Puducherry region. The estimates indicate that educational attainment ($\beta = 0.104$, $p < 0.001$), annual household income ($\beta = 0.648$, $p < 0.001$), asset ownership ($\beta = 0.752$, $p < 0.001$), access to institutional credit ($\beta = 0.823$, $p < 0.001$), skill development training ($\beta = 0.937$, $p < 0.001$), government welfare support ($\beta = 0.384$, $p = 0.021$), and social capital ($\beta = 0.438$, $p < 0.001$) significantly enhance the probability of livelihood diversification. Conversely, age ($\beta = -0.018$, $p = 0.024$) and distance to market ($\beta = -0.137$, $p = 0.001$) exhibit significant negative effects. These findings indicate that socio-economic capacity, institutional assistance, and access to productive resources play a decisive role in encouraging livelihood diversification among traditional washermen, thereby justifying the subsequent estimation of household welfare through the ESR framework.

Table-6. Endogenous Switching Regression (ESR) Estimates of Household Welfare under Diversified and Non-diversified Livelihood Regimes.

Variables	Diversified Households (Regime 1) Coefficient	Robust S.E.	t-value	p-value	Non-diversified Households (Regime 2) Coefficient	Robust S.E.	t-value	p-value
Constant	0.214	0.118	1.81	0.071*	0.183	0.134	1.37	0.171
Livelihood Diversification Index (SDI)	0.462	0.057	8.11	0.000***	—	—	—	—
Education	0.028	0.009	3.11	0.002***	0.017	0.011	1.55	0.122
Annual Household Income	0.246	0.048	5.13	0.000***	0.171	0.054	3.17	0.002***
Household Size	-0.031	0.011	-2.82	0.005***	-0.043	0.014	-3.07	0.002***
Asset Ownership	0.154	0.035	4.4	0.000***	0.093	0.038	2.45	0.015**
Social Capital	0.089	0.024	3.71	0.000***	0.052	0.027	1.93	0.054*
Housing Quality	0.062	0.021	2.95	0.003***	0.029	0.023	1.26	0.208
Access to Institutional Credit	0.057	0.019	3	0.003***	0.033	0.021	1.57	0.117
Health Insurance	0.041	0.018	2.28	0.023**	0.018	0.02	0.9	0.369

Source: Author's estimation using the Endogenous Switching Regression (Outcome Equations) based on field survey data.

Table 6 illustrates the Endogenous Switching Regression (ESR) estimates of the effect of livelihood diversification on household welfare among traditional washermen. The outcome equation for diversified households shows that the Livelihood Diversification Index exerts the strongest positive influence on household welfare ($\beta = 0.462$, $p < 0.001$), followed by annual household income ($\beta = 0.246$, $p < 0.001$), asset ownership ($\beta = 0.154$, $p < 0.001$), education ($\beta = 0.028$, $p = 0.002$), social capital ($\beta = 0.089$, $p < 0.001$), access to institutional credit ($\beta = 0.057$, $p = 0.003$), housing quality ($\beta = 0.062$, $p = 0.003$), and health insurance ($\beta = 0.041$, $p = 0.023$). In contrast, household size negatively affects welfare ($\beta = -0.031$, $p = 0.005$). The treatment effect estimates further reveal a significant Average Treatment Effect on the Treated (ATT = 0.294, $p < 0.001$), Average Treatment Effect on the Untreated (ATU = 0.218, $p < 0.001$), and Average Treatment Effect (ATE = 0.263, $p < 0.001$), confirming that livelihood diversification substantially improves household welfare. The significant Wald χ^2 (246.81, $p < 0.001$) and likelihood ratio test validate the ESR model, indicating that correcting for selection bias provides robust evidence that diversified households achieve significantly higher welfare than non-diversified households.

Table-7. Propensity Score Matching (PSM) Estimates of the Impact of Livelihood Diversification on Household Welfare

Panel A. Propensity Score Estimation (Logit Model)

Variables	Coefficient (β)	Robust S.E.	z-value	p-value
Age of Household Head	-0.019	0.008	-2.38	0.017**
Educational Attainment	0.112	0.027	4.15	0.000***
Household Size	0.158	0.061	2.59	0.010***
Annual Household Income	0.703	0.139	5.06	0.000***
Work Experience	0.027	0.011	2.45	0.014**
Asset Ownership Index	0.831	0.241	3.45	0.001***
Access to Institutional Credit	0.894	0.219	4.08	0.000***
Skill Development Training	0.973	0.236	4.12	0.000***
Social Capital Index	0.451	0.114	3.96	0.000***
Distance to Market	-0.142	0.046	-3.09	0.002***

Source: Computed by the researcher using Propensity Score Matching (PSM) techniques from the household survey dataset.

Table 7 (Panel A) estimates the propensity scores using a binary logit model to identify the factors influencing livelihood diversification among traditional washermen in the Puducherry region. The findings indicate that educational attainment ($\beta = 0.112$, $p < 0.001$), annual household income ($\beta = 0.703$, $p < 0.001$), asset ownership ($\beta = 0.831$, $p = 0.001$), access to institutional credit ($\beta = 0.894$, $p < 0.001$), skill development training ($\beta = 0.973$, $p < 0.001$), and social capital ($\beta = 0.451$, $p < 0.001$) significantly increase the likelihood of adopting diversified livelihood strategies. In contrast, age ($\beta = -0.019$, $p = 0.017$) and distance to market ($\beta = -0.142$, $p = 0.002$) exert significant negative effects on diversification decisions. The estimated propensity scores indicate that households with stronger human capital, greater economic resources, and better institutional support are more likely to diversify their livelihoods. These results establish an appropriate common support condition and provide a robust basis for estimating the treatment effects using Propensity Score Matching in the subsequent analysis.

Panel B. Average Treatment Effect Estimates.

Matching Method	Treated Mean	Control Mean	ATT	Std. Error	t- value	p- value
Nearest Neighbour Matching	0.648	0.364	0.284	0.041	6.93	0.000***
Kernel Matching	0.648	0.377	0.271	0.038	7.13	0.000***
Radius Matching	0.648	0.381	0.267	0.04	6.68	0.000***
Stratification Matching	0.648	0.389	0.259	0.042	6.17	0.000***

Source: Computed by the researcher using Propensity Score Matching (PSM) techniques from the household survey dataset.

Table 7 (Panel B) evaluates the impact of livelihood diversification on household welfare using four Propensity Score Matching (PSM) techniques. The results consistently indicate a positive and statistically significant treatment effect across all matching methods. The Average Treatment Effect on the Treated (ATT) is highest under Nearest Neighbour Matching (ATT = 0.284, $p < 0.001$), followed by Kernel Matching (ATT = 0.271, $p < 0.001$), Radius Matching (ATT = 0.267, $p < 0.001$), and Stratification Matching (ATT = 0.259, $p < 0.001$). The average welfare score of diversified households (0.648) exceeds that of matched non-diversified households, whose welfare scores range from 0.364 to 0.389 across the four matching algorithms. The consistency of the ATT estimates across different matching techniques confirms the robustness of the results and demonstrates that livelihood diversification significantly enhances household welfare among traditional washermen. These findings further validate the positive welfare gains obtained from the Endogenous Switching Regression analysis and provide strong empirical evidence that diversification serves as an effective strategy for improving the socio-economic well-being of traditional washermen in the Puducherry region.

Table-8. Multiple Linear Regression (OLS) Results for the Determinants of Household Welfare among Traditional Washermen

Variables	Unstan- dardized Coefficient (B)	Robust S.E.	Standar- dized Beta (β)	t- value	p- value	VIF
Constant	0.182	0.096	—	1.9	0.058*	—
Livelihood Diversification Index (SDI)	0.438	0.049	0.452	8.94	0.000***	1.72
Educational Attainment	0.024	0.008	0.148	3	0.003***	1.64
Age of Household Head	-0.006	0.003	-0.081	-2	0.046**	1.38
Household Size	-0.029	0.01	-0.123	-2.9	0.004***	1.29
Annual Household Income	0.236	0.043	0.318	5.49	0.000***	2.11
Work Experience	0.011	0.005	0.086	2.2	0.028**	1.47
Asset Ownership Index	0.147	0.032	0.214	4.59	0.000***	1.83
Access to Institutional Credit	0.052	0.018	0.109	2.89	0.004***	1.56
Skill Development Training	0.061	0.02	0.117	3.05	0.002***	1.61
Social Capital Index	0.084	0.023	0.169	3.65	0.000***	1.48
Government Welfare Support	0.039	0.017	0.079	2.29	0.023**	1.32
Housing Quality Index	0.051	0.019	0.101	2.68	0.008***	1.36
Health Insurance	0.036	0.016	0.072	2.25	0.025**	1.24
Distance to Market	-0.018	0.007	-0.095	-2.57	0.011**	1.42

Source: Estimated by the researcher using the Ordinary Least Squares (OLS) regression model based on the survey data.

Table 8 assesses the determinants of household welfare among traditional washermen using the Multiple Linear Regression (OLS) model. The findings reveal that the Livelihood Diversification Index is the strongest positive predictor of household welfare ($\beta = 0.438$, $p < 0.001$), indicating that diversified households achieve substantially higher welfare levels than those relying solely on traditional occupations. Annual household income ($\beta = 0.236$, $p < 0.001$), asset ownership ($\beta = 0.147$, $p < 0.001$), educational attainment ($\beta = 0.024$, $p = 0.003$), social capital ($\beta = 0.084$, $p < 0.001$), skill development training ($\beta = 0.061$, $p = 0.002$), access to institutional credit ($\beta = 0.052$, $p = 0.004$), government welfare support ($\beta = 0.039$, $p = 0.023$), housing quality ($\beta = 0.051$, $p = 0.008$), and health insurance ($\beta = 0.036$, $p = 0.025$) also exert significant positive influences on household welfare. Conversely, age ($\beta = -0.006$, $p = 0.046$), household size ($\beta = -0.029$, $p = 0.004$), and distance to market ($\beta = -0.018$, $p = 0.011$) negatively affect welfare outcomes. The model explains 69.1% of the variation in household welfare ($R^2 = 0.691$; Adjusted $R^2 = 0.679$), while the highly significant F-statistic (57.84, $p < 0.001$) confirms the overall fitness of the model. Furthermore, the absence of multicollinearity (Mean VIF = 1.56), heteroskedasticity, and autocorrelation indicates that the estimated coefficients are statistically reliable and robust. Overall, the results provide strong empirical evidence that livelihood diversification is the most influential determinant of household welfare among traditional washermen in the Puducherry region.

Table-9. Summary of Hypothesis Testing Results on the Relationship between Livelihood Diversification and Household Welfare

Hypothesis	Statistical Test	p-value	Decision	Result
H₀ : Livelihood diversification has no significant effect on household welfare among traditional washermen.	OLS, ESR, and PSM	0.000***	Rejected	Significant relationship found.
H₁ : Livelihood diversification has a significant positive effect on household welfare among traditional washermen.	OLS, ESR, and PSM	0.000***	Accepted	Positive and significant effect confirmed.

Source: Prepared by the researcher based on the empirical results obtained from OLS, ESR, and PSM analyses.

Table 9 summarizes the hypothesis testing results regarding the relationship between livelihood diversification and household welfare among traditional washermen in the Puducherry region. The empirical evidence obtained from Correlation Analysis, Multiple Linear Regression (OLS), Endogenous Switching Regression (ESR), and Propensity Score Matching (PSM) consistently rejects the null hypothesis (H_0) at the 1% significance level ($p < 0.001$). The findings confirm that livelihood diversification exerts a statistically significant and positive effect

on household welfare. The positive coefficients, significant treatment effects, and robust model diagnostics across all econometric approaches provide consistent evidence that households adopting diversified livelihood strategies achieve higher levels of income, asset accumulation, and overall welfare. Therefore, the alternative hypothesis (H_1) is accepted, validating livelihood diversification as an effective strategy for improving household welfare among traditional washermen in the Puducherry region.

Major Findings :

1. The socio-economic analysis revealed that 62.0% of the traditional washermen households had diversified their livelihoods, while 59.0% had access to institutional credit and 69.5% benefited from government welfare schemes, indicating a moderate level of economic transformation among the study population.
2. The descriptive statistics showed that the Livelihood Diversification Index recorded a mean value of 0.58, whereas the Household Welfare Index had a mean score of 0.61, suggesting that households adopting diversified livelihood activities experienced relatively better welfare outcomes.
3. The Binary Logistic Regression analysis identified educational attainment ($\beta = 0.118$, $p < 0.001$), annual household income ($\beta = 0.764$, $p < 0.001$), institutional credit ($\beta = 0.931$, $p < 0.001$), and skill development training ($\beta = 1.028$, $p < 0.001$) as the most significant determinants of livelihood diversification, while age ($\beta = -0.021$, $p = 0.020$) and distance to market ($\beta = -0.156$, $p = 0.001$) negatively influenced diversification.
4. The selection equation of the Endogenous Switching Regression (ESR) confirmed that education ($\beta = 0.104$, $p < 0.001$), household income ($\beta = 0.648$, $p < 0.001$), asset ownership ($\beta = 0.752$, $p < 0.001$), and social capital ($\beta = 0.438$, $p < 0.001$) significantly increased the probability of livelihood diversification, validating the existence of non-random participation in diversified livelihood activities.
5. The ESR outcome equation demonstrated that the Livelihood Diversification Index ($\beta = 0.462$, $p < 0.001$) was the strongest determinant of household welfare. The estimated treatment effects further indicated significant welfare gains for diversified households, with ATT = 0.294, ATU = 0.218, and ATE = 0.263 (all $p < 0.001$), confirming the positive welfare impact of livelihood diversification.
6. The Propensity Score Matching (PSM) analysis consistently revealed positive treatment effects across all matching algorithms. The Average Treatment Effect on the Treated (ATT) ranged from 0.259 to 0.284 ($p < 0.001$), indicating that diversified households achieved significantly higher welfare levels than comparable non-diversified households after correcting for observable selection bias.
7. The Multiple Linear Regression (OLS) results established that the Livelihood Diversification Index ($\beta = 0.438$, $p < 0.001$) was the most influential predictor of household welfare. The model explained 69.1% of the variation in household welfare ($R^2 = 0.691$) and also highlighted significant positive contributions from annual household income, asset ownership, education, social capital,

institutional credit, and skill development programmes.

8. The hypothesis testing results consistently rejected the Null Hypothesis (H_0) and accepted the Alternative Hypothesis (H_1) at the 1% significance level ($p < 0.001$). The findings from Correlation Analysis, OLS, ESR, and PSM collectively confirmed that livelihood diversification exerts a statistically significant and positive effect on household welfare among traditional washermen in the Puducherry region, thereby establishing diversification as an effective strategy for improving socio-economic well-being.

Policy Recommendation :

1. **Strengthen Skill Development Programmes:** The Government should provide regular vocational and entrepreneurship training to help traditional washermen diversify their livelihoods, improve employability, and increase household income.
2. **Improve Access to Institutional Credit :** Easy access to low-interest loans, micro-finance, and financial literacy programmes should be ensured to encourage investment in diversified livelihood activities and productive assets.
3. **Enhance Social Welfare Support :** Government agencies should strengthen health insurance, housing assistance, education support, and social security schemes to improve the living standards and economic security of traditional washermen.
4. **Improve Market Access and Digital Connectivity :** Better transportation, market infrastructure, and digital services such as

online marketing and digital payment systems should be promoted to expand income-generating opportunities.

5. **Promote Cooperative and Community-Based Enterprises :** The formation of washermen cooperatives and community-based enterprises should be encouraged to improve access to finance, technology, marketing, and sustainable livelihood opportunities, thereby enhancing overall household welfare.

Inference :

The present study concludes that livelihood diversification is a significant pathway for improving household welfare among traditional washermen in the Puducherry region. The socio-economic analysis revealed that 62.0% of households had diversified their livelihood activities, reflecting a gradual transition beyond traditional occupations. The Binary Logistic Regression model identified education ($\beta = 0.118$, $p < 0.001$), annual household income ($\beta = 0.764$, $p < 0.001$), institutional credit ($\beta = 0.931$, $p < 0.001$), and skill development ($\beta = 1.028$, $p < 0.001$) as the key determinants of livelihood diversification. Furthermore, the Endogenous Switching Regression (ESR) demonstrated that livelihood diversification exerted the strongest positive influence on household welfare ($\beta = 0.462$, $p < 0.001$), while the Propensity Score Matching (PSM) analysis confirmed significant welfare gains with an Average Treatment Effect on the Treated (ATT) of 0.284 ($p < 0.001$). The Multiple Linear Regression model further established that livelihood diversification was the most

influential predictor of household welfare ($\beta = 0.438$, $p < 0.001$), explaining 69.1% of the variation in welfare ($R^2 = 0.691$). The hypothesis testing results consistently rejected the null hypothesis and confirmed a statistically significant positive relationship between livelihood diversification and household welfare. Overall, the study provides robust empirical evidence that strengthening education, financial inclusion, institutional support, skill development, and market accessibility can substantially enhance livelihood resilience and socio-economic well-being among traditional washermen, thereby contributing to sustainable and inclusive rural development in the Puducherry region.

Author contributions :

P. Vignarajan (Research Scholar) Conceptualization, research design, literature review, questionnaire development, field survey, data collection, data coding, statistical and econometric analysis, interpretation of results, manuscript drafting, revision, and preparation of the final manuscript. C. Venkatesh (Research Supervisor): Supervision, conceptual guidance, methodological validation, research planning, critical review of the manuscript, interpretation of findings, academic editing, and overall supervision of the research process. The supervisor provided continuous intellectual guidance and approved the final version of the manuscript for publication.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this research.

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